# 2010 Index for Minnesota Area II and NPPGA

**Project Title:** Effective Pink Rot Disease Control and Management of Mefenoxam Resistance in *Phytophthora erythroseptica*

*Submitted to MN Area II Potato Growers*

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**Research Objectives:**

1. Determine the prevalence of mefenoxam-resistance in the *P. erythroseptica* population in Minnesota.
2. Determine the impact of an alternative fungicide, phosphorous acid, on the management of mefenoxam resistance.
3. Determine if phosphorous acid provides residual control of pink rot in storage that is not currently provided by mefenoxam.

**Procedures:**

*Pink rot survey*. *P. erythroseptica* isolates will be collected by transferring small pieces of infected tissue, approximately 25 mm3 in size, to culture dishes containing water agar amended with ampicillin (100 µg/ml) and incubated in the dark at 17 to 20ºC for 3 to 5 days. Colonies with mycelia resembling that of *P. erythroseptica* will be selected and purified by hyphal tipping.

*Mefenoxam sensitivity testing*. Mefenoxam (Ridomil Gold 4EC) sensitivity will be determined using an in vitro screening method. Tests will be conducted on modified V8 juice agar amended with fungicide in a 10-fold dilution series ranging from 0.01 to 100 µg/ml and control plates not amended with mefenoxam. A 5-mm-diameter disk containing mycelium and agar from the margin of actively growing colonies of 4- to 6-day-old cultures will be positioned in the center of a culture dish. Isolate growth will be determined by measuring colony diameters in two perpendicular directions after 6 days of incubation in the dark at 20 ± 1ºC. Measurements were averaged, the diameter of the mycelial plug will be subtracted, and relative growth reduction for each rate of fungicide will be calculated as follows: (100 – [growth with fungicide/growth in control plate] × 100). The $EC_{50}$ relative to the control will be estimated by plotting the percentage inhibition against the log-scale of fungicide concentration.

*Field plots and mefenoxam application.* Fungicide application trials will be conducted under center pivot irrigation over two consecutive growing seasons. Fungicide treatments will be established each year to provide different levels of pink rot control in treated versus non-treated tubers (Table 1). At planting, a 50:50 blend of mefenoxam sensitive and insensitive isolates of the pink rot pathogen will be applied in the seed piece zone. Fungicide treatments will be applied at the recommended label rate. Mefenoxam (Ridomil Gold 4EC or Ultrafluorish) as an in-furrow application of 200 g a.i./ha at planting followed by an additional side-dress application of 100 g a.i./ha 21 days later (Table 1). This split application of mefenoxam at these rates previously has been demonstrated to provide the highest level of pink rot control (Taylor et al., 2004). Another mefenoxam treatment will be two foliar applications of 100 g a.i./ha when tubers are approximately 10 mm in diameter and 14 days later. One, two and three phosphorous acid

(Phostrol) treatments will all be made at a rate of 11.65 L/ha (Table 1). No in furrow treatments will be used since these have been demonstrated to ineffective in controlling pink rot (Johnson, et al., 2004). The foliar phosphorous acid treatments will be applied when tubers are 10mm in diameter and 14 days later (2 applications) and the same treatment regime with a third application 14 days after the second application (total of three foliar applications). An additional phosphorous acid treatment will include a post-harvest application simulating tubers going into storage. Two treatments of cyazofamid (Ranman) will be used in this experiment (Table 1). The first will be an in furrow, at planting application at a rate of 450 mL/ha. The second treatment will be an in furrow treatment of 450 mL/ha followed by a sidedress application of 225 mL/ha.

*Disease evaluations at harvest.* Pink rot tubers will be obtained at harvest from all non-treated and all fungicide (2 treatments each of mefenoxam, 4 phosphorous acid and 2 cyazofamid) treated plots. These pink rot infected tubers will be taken to the laboratory and isolations for *P. erythroseptica* will be performed. All isolates obtained will be maintained on a treatment X replication basis and tested for their sensitivity to mefenoxam based on the methods previously described. The purpose of this portion of the proposed research is to determine the effect of non-mefenoxam fungicides on the mefenoxam sensitive and insensitive populations of *P. erythroseptica*.

*Post-harvest pink rot inoculations*. Plants will be killed by mechanical flailing 2 to 3 weeks prior to maturity to insure the availability of a sufficient quantity of tubers of the desired size and adequate skin set. After harvest, tubers were stored for 2 weeks at 15ºC and 90% relative humidity to facilitate wound healing. However, because levels of mefenoxam in tubers will decline over time, test tubers used in this study were stored at 10ºC for no longer than 4 months prior to testing. We do not know the length of residual control for phosphorous acid, but the experiments conducted here will provide that information and determine if this fungicide provides control of pink rot beyond harvest.

The level of residual, post-harvest control of pink rot will be determined using challenge inoculations conducted at 30 day intervals after harvest. Residual pink rot control studies will focus on the phosphorous acid treatments and comparing this to the known residual control provided by mefenoxam. We will not test the residual control potential of cyazofamid, since it is not a systemic fungicide (Table 1). Wounded and non-wounded tubers will be placed in plastic moist chamber boxes and inoculated with 10 µl of the zoospore suspension of *P. erythroseptica*. Inoculated tubers will be covered with four layers of paper towels moistened to saturation with deionized water. The chamber boxes will be sealed to establish high humidity to promote infection and incubated in the dark at ambient temperature at 20 to 22ºC for 10 days.

*Disease assessment*. Inoculated tubers will removed from the moist chambers and infection will be determined by cutting each tuber in half through the axis from the sites of inoculation on the apical bud end to the basal stem end. Split tubers will be covered with moist paper towels and incubated at ambient temperatures of 20 to 24ºC for approximately 30 min to enhance the development of the discoloration diagnostic of pink rot. Infected tubers will be counted and disease incidence calculated as (number of diseased tubers/number of inoculated tubers) × 100. To determine pink rot severity, the maximum width of rot (W) and the depth (D) of rot from the inoculation point will be measured and penetration (P) of rot was calculated as $P = (W/2 + [D -$

5])/2. Disease incidence will be transformed to percent disease control using the formula ([disease incidence of untreated control – disease incidence of treatment]/disease incidence of untreated control) × 100.

**Results:**

*Pink rot survey***.** The incidence of pink rot in Minnesota in 2009 was at an all time low over the nine years of the survey (Figures 1 & 2). Some of this can be attributed to the environmental conditions near the end of the growing season when tuber infections by *P. erythroseptica* take place, but it is also likely due to the increase use of phosphorous acid to control the disease. Phosphorous acid controls mefenoxam-sensitive and resistant populations of the pink rot pathogen (see below) and its increased use in the state has obviously reduced pink rot disease pressure. Pink rot disease pressure is also very low in North Dakota (Figures 3 & 4).

*Management of pink rot with phosphorous acid.* The incidence of pink rot in field plots conducted in a grower field in Park Rapids, MN was low, at 2.5%, in non-treated control plots (Table 1). The low incidence of pink rot in this field with historically high disease pressure corroborates the observation of low pink rot incidence in Minnesota discussed above. Nonetheless, significant reductions were observed in field plots treated with in furrow followed by sidedress applications of mefenoxam as well as in furrow followed by foliar applications of mefenoxam (Table 1). Two and three applications of phosphorous acid applied to the foliage were also very effective in significantly reducing pink rot, however, a single application of phosphorous acid was insufficient to provide effective disease control. Interestingly, in contrast to results obtained in previous years, post-harvest applications of phosphorous acid did not significantly reduce pink rot (Table 1). This is likely due to the length of time between harvest and post-harvest applications of phosphorous acid took place (10 days) which allowed the pink rot pathogen to gain entry through wounds made at harvest.

*Residual control of pink rot with phosphorous acid.* Results obtained in 2007 suggested that foliar and post-harvest applications of phosphorous acid provided excellent residual control of pink rot in storage, up to 150 days after harvest. Those data also clearly demonstrated that phosphorous acid control mefenoxam-resistant and mefenoxam-sensitive populations of *P. erythroseptica* with equal efficacy. To date, we have conducted a 91 DAH assessment which continues to demonstrate excellent residual control of pink rot using two and three foliar applications of phosphorous acid (Table 2, Figure 5). We will continue to challenge inoculate tubers from these trials to determine if phosphorous acid treatments provide residual pink rot control well into the storage period.

**Literature Cited:**

Abu-El Samen FM, Oberoi K, Taylor RJ, Secor GA, Gudmestad NC (2005) Inheritance of mefenoxam resistance in two selfed generations of the homothallic *Phytophthora erythroseptica* (Pethybr.). *American Journal of Potato Research* **82**, 105-115.

Bruin GCA, Edgington LV, Ripley BD (1982) Bioactivity of the fungicide metalaxyl in potato tubers after foliar sprays. *Canadian Journal of Plant Pathology* **4**, 353-356.

Johnson DA, Inglis DA, Miller JS (2004) Control of potato tuber rots caused by oomycetes with foliar applications of phosphorous acid. *Plant Disease* **88**, 1153-1159.

Lambert D, Salas B (2001) Pink rot. In: Compendium of Potato Diseases, 2nd Edition. American Phytopathological Press, Minneapolis, MN. Pp 33-34.

Lulai EC, Weiland JJ, Suttle JC, Sabba RP, Bussan AJ (2006) Pink eye is an unusual periderm disorder characterized by aberrant suberization: A cytological analysis. *American Journal of Potato Research* **83**, 409-421.

Miller JS, Olsen N, Woodell L, Porter LD, Clayson S (2006) Post-harvest applications of zoxamide and phosphite for control of potato tuber rots caused by oomycetes at harvest. *American Journal of Potato Research* **83**, 269-278.

Porter LD, Miller JS, Nolte P, Price WJ (2007) In vitro somatic growth and reproduction of phenylamide-resistant and –sensitive isolates of *Phytophthora erythroseptica* from infected potato tubers in Idaho. *Plant Pathology* **56**, (in press).

Salas B, Secor GA (2001) Leak. In: Compendium of Potato Diseases, 2nd Edition. American Phytopathological Press, Minneapolis, MN. Pp 30-31.

Salas B, Stack RW, Secor GA, Gudmestad NC (2000) Effect of wounding, temperature and inoculum on the development of pink rot of potato caused by *Phytophthora erythroseptica*. *Plant Disease* **84**, 1327-1333.

Salas B, Secor GA, Taylor RJ, Gudmestad NC (2003) Assessment of resistance in tubers of potato cultivars to *Phytophthora erythroseptica* and *Pythium ultimum*. *Plant Disease* **87**, 91-97.

Taylor RJ, Salas B, Secor GA, Rivera V, Gudmestad NC (2002) Sensitivity of North American isolates of *Phytophthora erythroseptica* and *Pythium ultimum* to mefenoxam (metalaxyl). *Plant Disease* **86**, 797-802.

Taylor RJ, Salas B, Gudmestad NC (2004) Differences in etiology affects mefenoxam efficacy and the control of pink rot and leak tuber diseases of potato. *Plant Disease* **88**, 301-307.

Taylor RJ, Pasche JS, Gudmestad NC (2006) Biological significance of mefenoxam resistance in *Phytophthora erythroseptica* and its implications for the management of pink rot of potato. *Plant Disease* **90**, 927-934.

Thompson AL, Taylor RJ, Pasche JS, Novy RG, Gudmestad NC (2006) Resistance to *Phytophthora erythroseptica* and *Pythium ultimum* in a potato clone derived from *S. berthaultii* and *S. etuberosum*. *American Journal Potato Research* (in press).

Wicks TJ, Davoren CW, Hall BH (2000) Fungicidal control of *Phytophthora erythroseptica*: The cause of pink rot on potato. *American Journal of Potato Research* **77**, 233-240.

Table 1. Percentage tuber rot among treatments evaluated at harvest and 25 to 27 days after harvest (DAH). Mean separation based on Fisher's protected least significant difference (LSD) test (*P* = 0.05).

| Treatment | | Rate | Application Timing | Percent Tuber Rot | |
|---|---|---|---|---|---|
| | | | | At Harvest | 25 to 27 DAH |
| 3301 | Non-treated | - | - | 2.5 | 0.65 |
| 3302 | Ridomil 4EC | 6.1 oz / a | in-furrow | 1.9 | 0.68 |
| 3303 | Ridomil 4EC | 12.2 oz / a | in-furrow | 1.7 | 0.35 |
| 3304 | Ridomil 4EC | 6.1 oz / a | in-furrow | 0.9 | 0.45 |
| | Ridomil 4EC | 6.1 oz / a | sidedress | | |
| 3305 | Ridomil 4EC | 6.1 oz / a | in-furrow | 0.8 | 0.41 |
| | Ridomil MZ | 2.0 lb / a | tuber set | | |
| 3306 | Ridomil MZ | 2.0 lb / a | tuber set | 1.3 | 0.69 |
| | Ridomil MZ | 2.0 lb / a | tuber set + 14 days | | |
| 3307 | Phostrol | 10.0 pt / a | tuber set | 1.2 | 0.37 |
| 3308 | Phostrol | 10.0 pt / a | tuber set | 0.9 | 0.04 |
| | Phostrol | 10.0 pt / a | tuber set + 14 days | | |
| 3309 | Phostrol | 10.0 pt / a | tuber set | 0.4 | 0.01 |
| | Phostrol | 10.0 pt / a | tuber set + 14 days | | |
| | Phostrol | 10.0 pt / a | tuber set + 28 days | | |
| 3310 | Phostrol | 12.8 fl oz / ton | 10 days post-harvest | 2.8 | 0.41 |
| LSD$_{P = 0.05}$ | | | | 1.4 | NS |

Table 2. Percentage tuber rot among treatments challenge inoculated with a mefenoxam resistant and sensitive isolate of *Phytophthora erythroseptica* at 29, 64, 78, and 91 days after harvest (DAH). Mean separation based on Fisher's protected least significant difference (LSD) test ($P = 0.05$).

| Treatment | Rate | Application Timing | *P. erythroseptica* isolate | *P. erythroseptica* challenge inoculation (% incidence) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 29 DAH | 64 DAH | 78 DAH | 91 DAH |
| Non-treated | - | - | Mefenoxam Resistant | 40.0 | 15.0 | 42.5 | 22.5 |
| Ridomil 4EC | 6.1 oz / a | in-furrow | Mefenoxam Resistant | 30.0 | 17.5 | 32.5 | 20.0 |
| Ridomil 4EC | 12.2 oz / a | in-furrow | Mefenoxam Resistant | 37.5 | 25.0 | 35.0 | 20.0 |
| Ridomil 4EC<br>Ridomil 4EC | 6.1 oz / a<br>6.1 oz / a | in-furrow<br>sidedress | Mefenoxam Resistant | 30.0 | 27.5 | 25.0 | 15.0 |
| Ridomil 4EC<br>Ridomil MZ | 6.1 oz / a<br>2.0 lb / a | in-furrow<br>tuber set | Mefenoxam Resistant | 30.0 | 35.0 | 30.0 | 27.5 |
| Ridomil MZ<br>Ridomil MZ | 2.0 lb / a<br>2.0 lb / a | tuber set<br>tuber set + 14 days | Mefenoxam Resistant | 37.5 | 15.0 | 37.5 | 15.0 |
| Phostrol | 10.0 pt / a | tuber set | Mefenoxam Resistant | 35.0 | 10.0 | 20.0 | 12.5 |
| Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days | Mefenoxam Resistant | 7.5 | 2.5 | 2.5 | 2.5 |
| Phostrol<br>Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days<br>tuber set + 28 days | Mefenoxam Resistant | 2.5 | 2.5 | 7.5 | 10.0 |
| Phostrol | 12.8 fl oz / ton | 10 days post-harvest | Mefenoxam Resistant | 0.0 | 0.0 | 0.0 | 0.0 |
| LSD$_{P\ =\ 0.06}$ | | | | 21.7 | 13.4 | 19.8 | 16.6 |
| Non-treated | - | - | Mefenoxam Sensitive | 32.5 | 15.0 | 17.5 | 40.0 |
| Ridomil 4EC | 6.1 oz / a | in-furrow | Mefenoxam Sensitive | 5.0 | 0.0 | 10.0 | 7.5 |
| Ridomil 4EC | 12.2 oz / a | in-furrow | Mefenoxam Sensitive | 7.5 | 2.5 | 5.0 | 7.5 |
| Ridomil 4EC<br>Ridomil 4EC | 6.1 oz / a<br>6.1 oz / a | in-furrow<br>sidedress | Mefenoxam Sensitive | 0.0 | 0.0 | 2.5 | 7.5 |
| Ridomil 4EC<br>Ridomil MZ | 6.1 oz / a<br>2.0 lb / a | in-furrow<br>tuber set | Mefenoxam Sensitive | 5.0 | 7.5 | 10.0 | 7.5 |
| Ridomil MZ<br>Ridomil MZ | 2.0 lb / a<br>2.0 lb / a | tuber set<br>tuber set + 14 days | Mefenoxam Sensitive | 0.0 | 5.0 | 7.5 | 5.0 |
| Phostrol | 10.0 pt / a | tuber set | Mefenoxam Sensitive | 25.0 | 20.0 | 7.5 | 17.5 |
| Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days | Mefenoxam Sensitive | 7.5 | 2.5 | 5.0 | 0.0 |
| Phostrol<br>Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days<br>tuber set + 28 days | Mefenoxam Sensitive | 2.5 | 0.0 | 0.0 | 0.0 |
| Phostrol | 12.8 fl oz / ton | 10 days post-harvest | Mefenoxam Sensitive | 0.0 | 0.0 | 0.0 | 0.0 |
| LSD$_{P\ =\ 0.06}$ | | | | 15.0 | 8.8 | 8.5 | 13.1 |

Table 2. Con't).

| Treatment | Rate | Application Timing | *P. erythroseptica* isolate | *P. erythroseptica* challenge inoculation (% incidence) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 29 DAH | 64 DAH | 78 DAH | 91 DAH |
| Non-treated | - | - | | 36.3 | 15.0 | 30.0 | 31.3 |
| Ridomil 4EC | 6.1 oz / a | in-furrow | | 17.5 | 8.8 | 21.3 | 13.8 |
| Ridomil 4EC | 12.2 oz / a | in-furrow | | 22.5 | 13.8 | 20.0 | 13.8 |
| Ridomil 4EC<br>Ridomil 4EC | 6.1 oz / a<br>6.1 oz / a | in-furrow<br>sidedress | | 15.0 | 13.8 | 13.8 | 11.3 |
| Ridomil 4EC<br>Ridomil MZ | 6.1 oz / a<br>2.0 lb / a | in-furrow<br>tuber set | | 17.5 | 21.3 | 20.0 | 17.5 |
| Ridomil MZ<br>Ridomil MZ | 2.0 lb / a<br>2.0 lb / a | tuber set<br>tuber set + 14 days | | 18.8 | 10.0 | 22.5 | 10.0 |
| Phostrol | 10.0 pt / a | tuber set | | 31.3 | 15.0 | 13.8 | 15.0 |
| Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days | | 7.5 | 2.5 | 3.8 | 1.3 |
| Phostrol<br>Phostrol<br>Phostrol | 10.0 pt / a<br>10.0 pt / a<br>10.0 pt / a | tuber set<br>tuber set + 14 days<br>tuber set + 28 days | | 2.5 | 1.3 | 3.8 | 5.0 |
| Phostrol | 12.8 fl oz / ton | 10 days post-harvest | | 0.0 | 0.0 | 0.0 | 0.0 |
| LSD$_{P = 0.06}$ | | | | 13.4 | 8.0 | 10.3 | 10.4 |
| | | | Mefenoxam Resistant | 25.3 | 15.0 | 23.3 | 14.5 |
| | | | Mefenoxam Sensitive | 8.5 | 5.3 | 6.5 | 9.3 |
| LSD$_{P = 0.06}$ | | | | 6.0 | 3.6 | 4.6 | 4.7 |

Note: Interaction of main effects of treatment and mefenoxam resistance were significant for all inoculation dates ($P$ = 0.05)

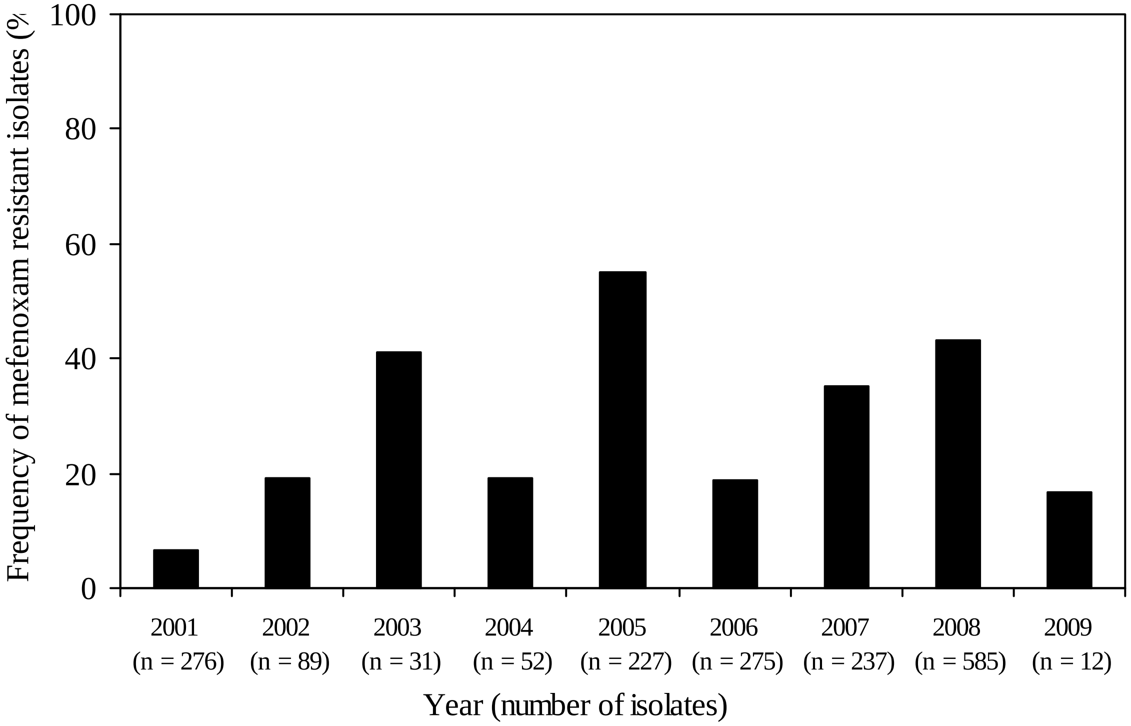

Figure 1. Frequency of mefenoxam resistance in *Phytophthora erythroseptica* in Minnesota from 2001to 2009.

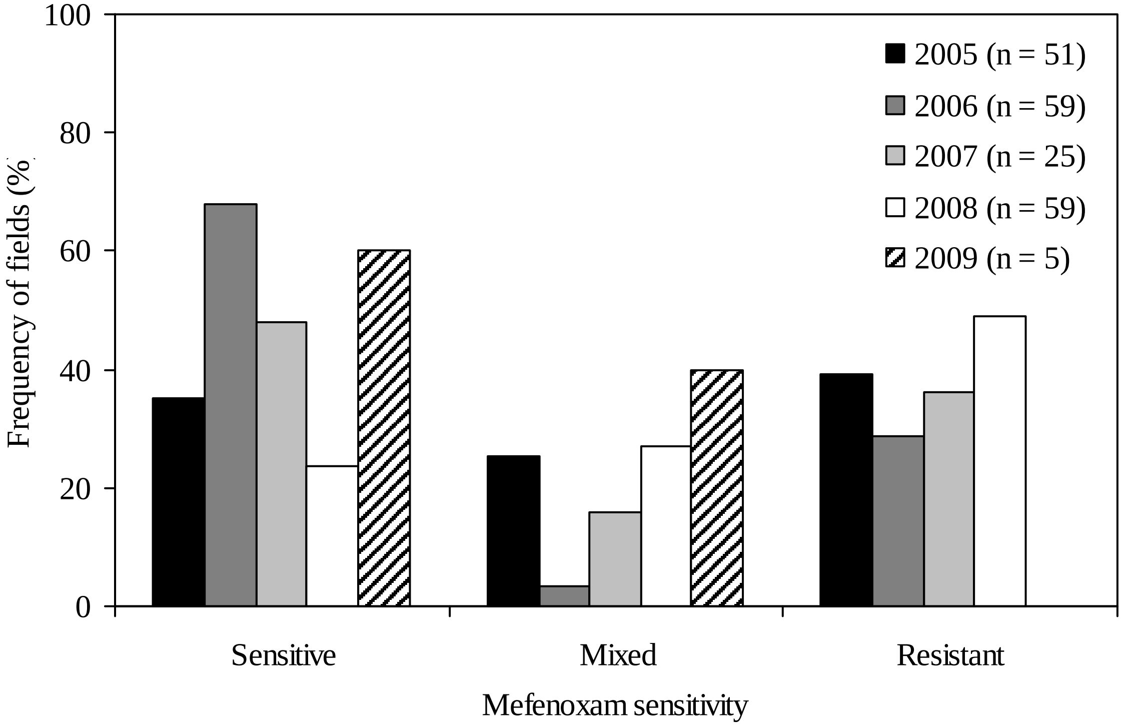

Figure 2. Frequency of potato fields with mefenoxam sensitive, resistant or mixed populations of *Phytophthora erythroseptica* in Minnesota from 2005 to 2009. Number of fields in the survey each year given parenthetically.

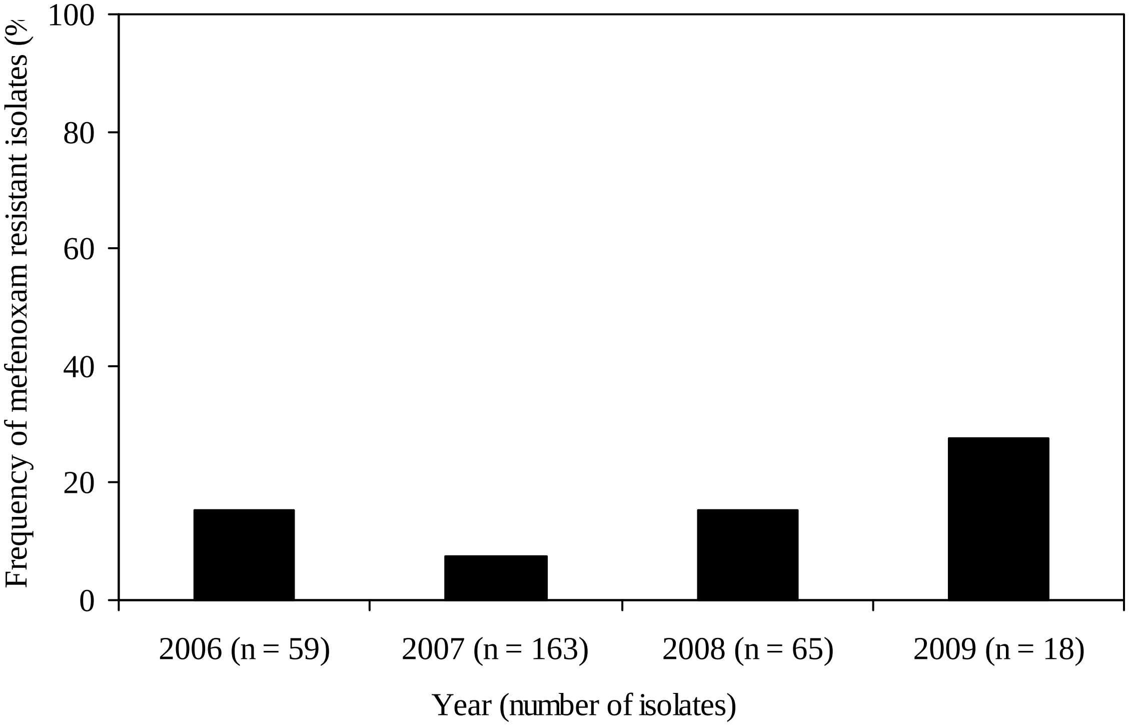

Figure 3. Frequency of mefenoxam resistance in *Phytophthora erythroseptica* in North Dakota from 2006 to 2009.

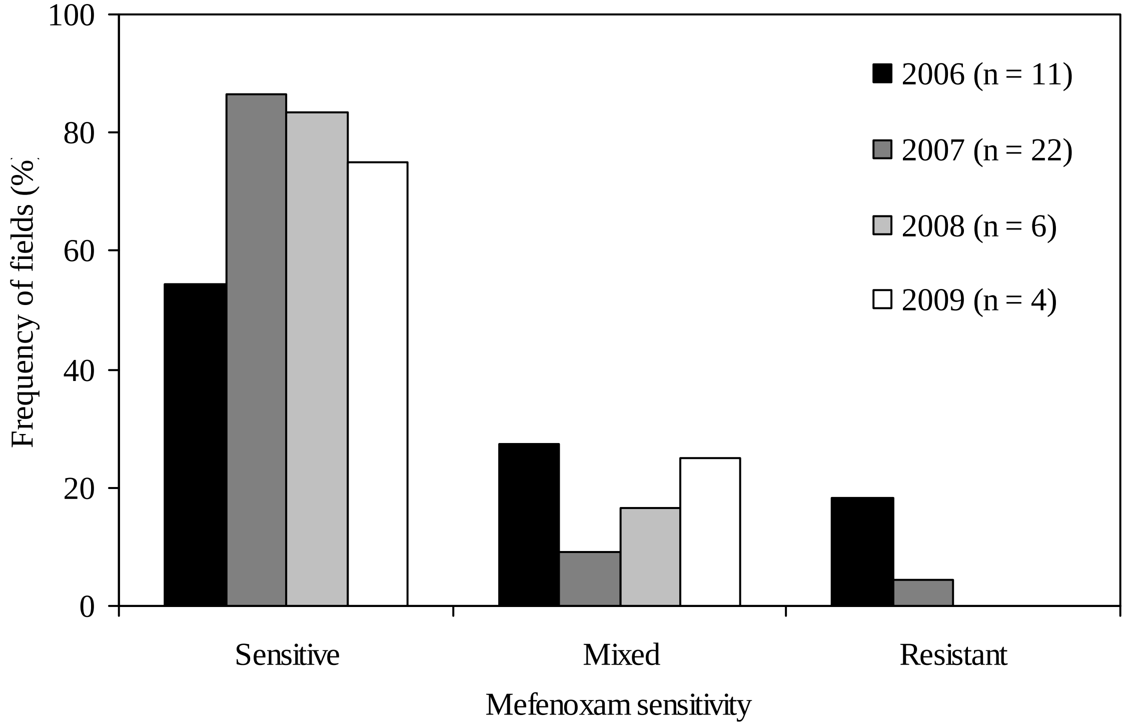

Figure 4. Frequency of potato fields with mefenoxam sensitive, resistant or mixed populations of *Phytophthora erythroseptica* in North Dakota from 2006 to 2009.

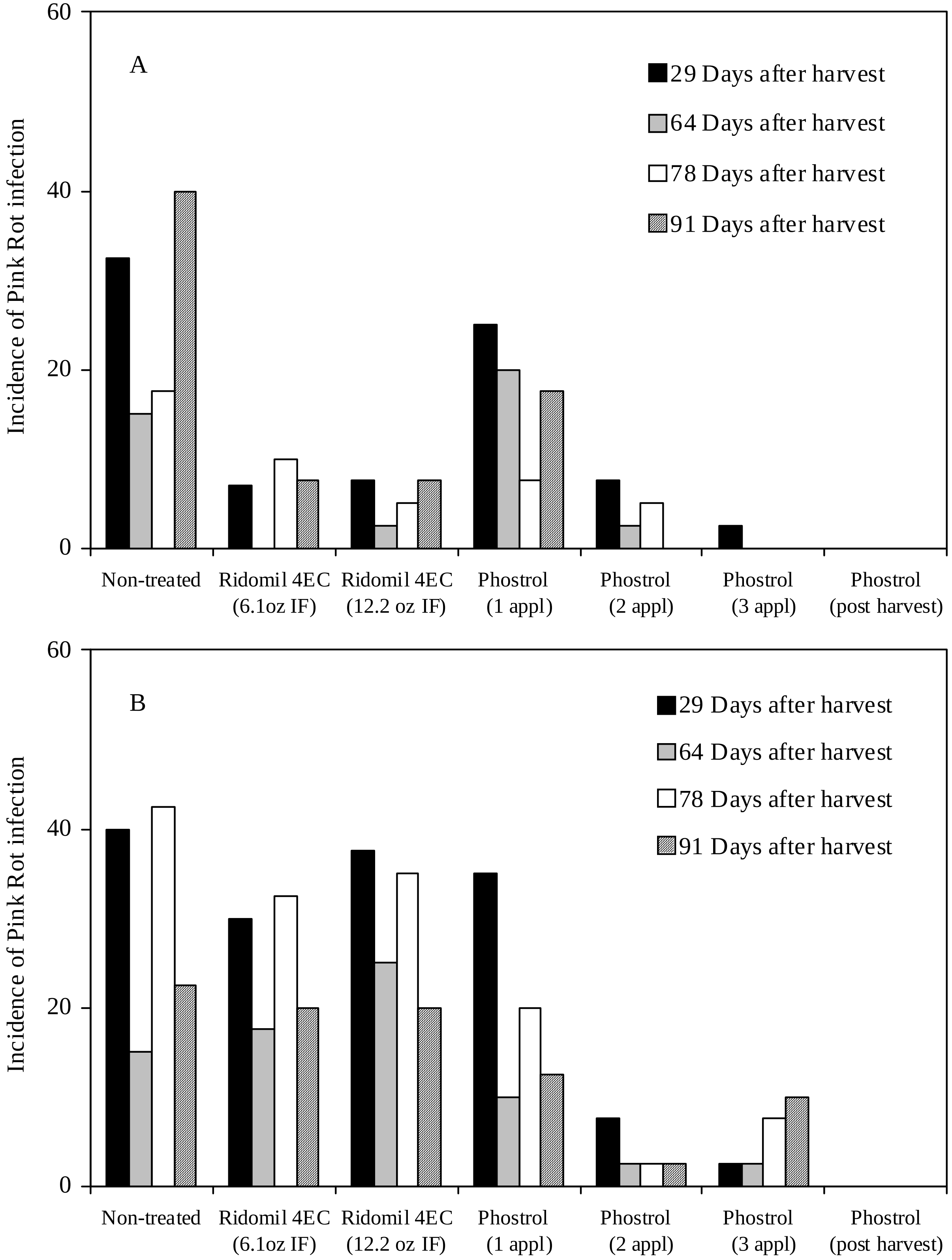

Figure 5. Incidence of pink rot caused by mefenoxam sensitive (A) and resistant (B) isolates of *Phytophthora erythrosetpica* in potato tubers treated with mefenoxam or phosphorus acid.

**Title:** Quantification of soil-borne pathogens of potato using real-time PCR

*Submitted to Minnesota Area II Potato Growers and NPPGA*

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## Research Objectives:

1) Develop a multiplex real-time PCR method for the detection and quantification of *V. dahliae, C. coccodes,* and *S. subterranea* from field soil.
2) Develop soil sampling and soil processing procedures to optimize DNA extraction from soilborne pathogens.

## Research Plan:

The PCR primers for *C. coccodes* and *V. dahliae* PCR have been combined into a duplex reaction that will permit the quantification of these two pathogens in a single reaction. Further studies were undertaken to use the powdery scab PCR method of Qu et al. (2006) with the methods already developed in our laboratory.

Mycelia of *V. dahliae* and *C. coccodes* will be added in known quantities to the soil samples. DNA will be extracted from 5 g soil samples with the MegaPrep DNA extraction kit (Mo Bio Inc.) and multiplex real-time PCR will be performed using 10 μL of the soil DNA extract in a 50 μL reaction volume. The amount of each respective pathogen detected in the soil sample will be determined based on standard curves using purified pathogen DNA as template. Serial dilutions of the DNA extracts from pathogen infested soil will be made and examined by real-time PCR to determine threshold levels for reliable detection of each pathogen. DNA extracted from the original soil sample prior to infestation by the four respective pathogens will also be amplified by real-time PCR to examine baseline levels of detection from non-infested soil.

After verifying the sensitivity and specificity of the multiplex real-time PCR assays with purified pathogen DNAs, soil will be collected from potato fields from throughout the region to test for the level *V. dahliae, C. coccodes*, and *S. subterranea*. To date 186 fields have been tested for powdery scab and 85 fields have been tested for Verticillium wilt in a beta testing format.

## Results:

The real-time PCR assay for the powdery scab pathogen works well over a range of soils. Although we cannot quantify the number of spore balls of *S. subterranea* per gram of soil due to the non-culturability of the pathogen, we have developed a standard curve for the quantity of DNA of the pathogen in soil (Figure 1). We have applied this method across several soil types among the 186 samples we have processed from growers fields and have found the method to be sensitive across all samples processed to date (Figure 2).

The development of a PCR assay for *V. dahliae* that will work with soil detection has been a significant challenge, one we did not face with *C. coccodes* or *S. subterranea*. The detection of microorganisms in soil by PCR provides many challenges, including the presence of inhibiting compounds such as humic acids. These inhibitory compounds have been very problematic for *V. dahliae* detection, more so than for the other pathogens we have been working with in soil extracts. Many researchers have developed protocols for DNA extraction from soil which have been successful for the detection of a target organism using particular primer sets, but these techniques may not work for different organisms or even different primers sets designed to the same organism. The protocol developed in this study was developed by incorporating techniques used in DNA extraction protocols for several different systems and was successful in detecting DNA of *V. dahliae* extracted from soil using a conventional PCR and real-time PCR assay.

While there have been numerous sets of PCR primers developed for the detection of *V. dahliae*, many of these have not been evaluated for efficacy in detecting the organism in soil. Among the two primers sets developed using the TRP gene, TRP1 and TRP7/3, only TRP1 primers were effective at consistently detecting DNA extracted from microsclerotia of *V. dahliae*. While this primer works very well to quantify *V. dahliae* from potato tissue and is a useful tool for potato breeding, we could not make this primer work with DNA extracted from soil. Another primer set designed from the ribosomal intergenic sequences, VDITS1/2, was also successful in detecting microsclerotial DNA, but it too was unsuccessful in detecting microsclerotial DNA extracted from soil. The most successful detection of *V. dahliae* from soil has been with the VertBtF/VertBtR primers. However, the standard curve is too flat and we have difficulty distinguishing between high and low microsclerotial numbers in soil (Figure 3). This ultimately means we have difficulty in separating fields with high amounts of Verticillium from those that have low populations of the pathogen (Figure 4).

Unfortunately, we believe we will have to do further primer development to identify gene sequences that will be useful for detecting *V. dahliae* in soil. We believe this will be possible now that the entire genome of the *V. dahliae* fungus has been sequenced.

**Literature Cited:**

Cullen DW, Lees AK, Toth IK, and Duncan JM. 2002. Plant Pathol. 51:281-292.

Davis, JR and Johnson, DA. 2001. Black dot. In Compendium of Potato Diseases, 2nd edition. American Phytopathology Press, St. Paul, MN. 106pp.

Dobinson KF, Harrington MA, Omer M, and Rowe RC. 2000. Plant Dis. 84:1241-1245.

Gudmestad NC, Pasche JS, and Taylor RJ. 2005. Infection frequency of *Colletotrichum coccodes* during the growing season. Proceedings of the 16th Triennial European Association forPotato Research Conference p. 765-769.

Gudmestad, NC, Taylor, RJ, and Pasche, JS. 2007. Austral. Plant Pathol. 36:109-115.

Johnson, DA. 1994. Plant Dis. 78:1075-1078.

Lees, AK, Cullen, DW, Sullivan, L, and Nicolson, MJ. 2002. Plant Pathol. 51:293-302.

Qu, X, Kavanagh, JA, Egan, D, and Christ, B. 2006. Am. J. Potato Res. 83:21-30.

Read, P.J. and Hide, G.A. 1988. Potato Res. 31:493-500.

Tsror (Lahkim) L., Erlich, O. and Hazanovsky, M. 1999. Plant Dis. 83:561-565.

Vandemark, G. J., B. M. Barker and M. A. Gritsenko. 2002. Phytopathology 92:265-272.

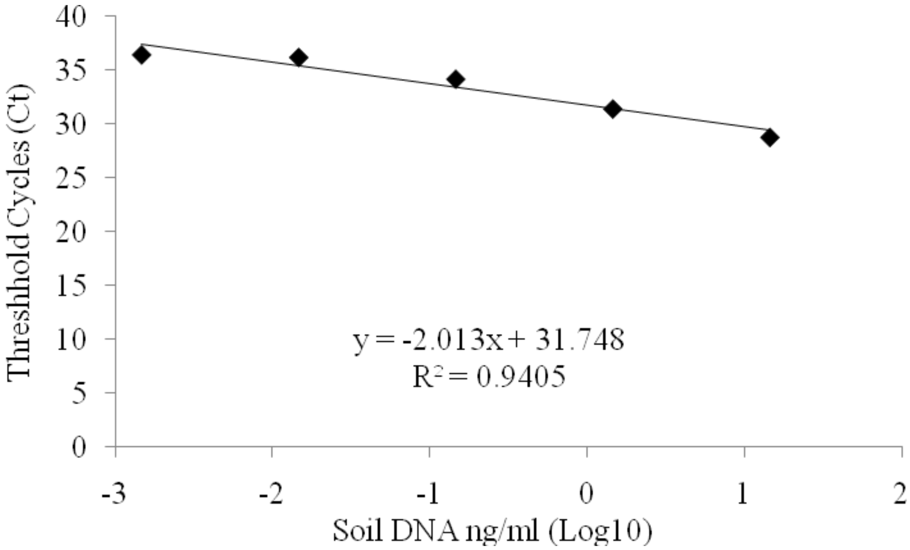

Figure 1. Relationship between ng/DNA from soil and the number of threshold cycles for real-time PCR amplification of *Spongospora subterrania* at 10-fold serial dilutions of DNA using primers SSTqF1/SSR1 and Taqman probe SSTqP1.

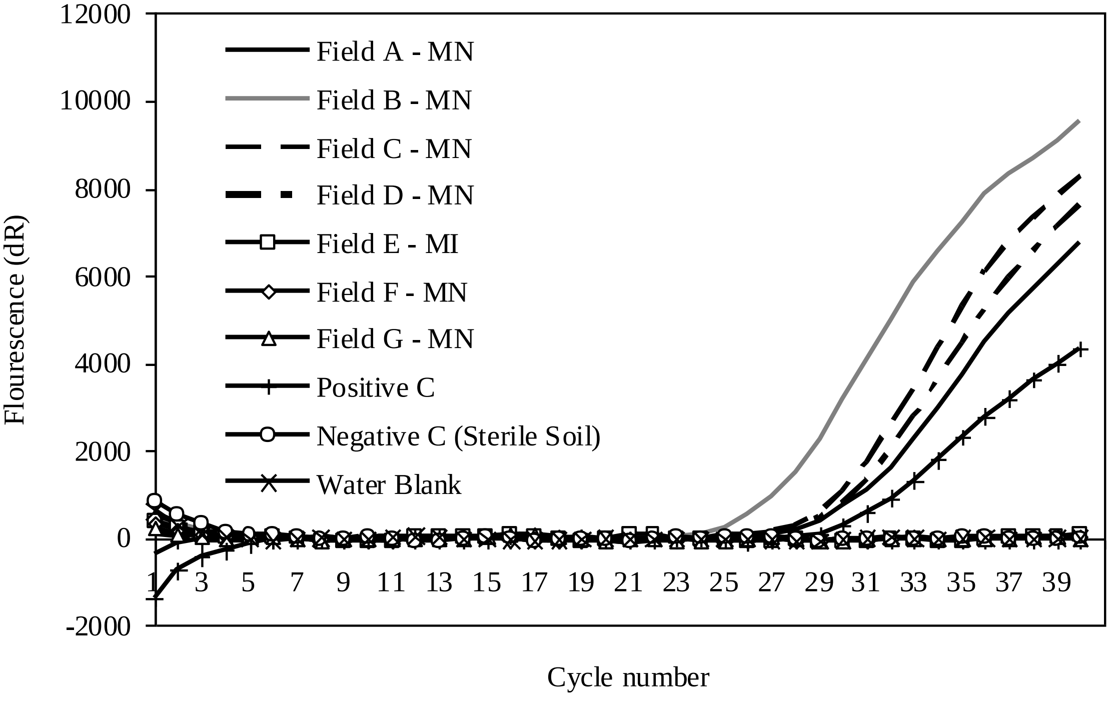

Figure 2. Quantitative PCR amplification of DNA extracted from soil using primers and Taqman probe specific for *Spongospora subterranean*.

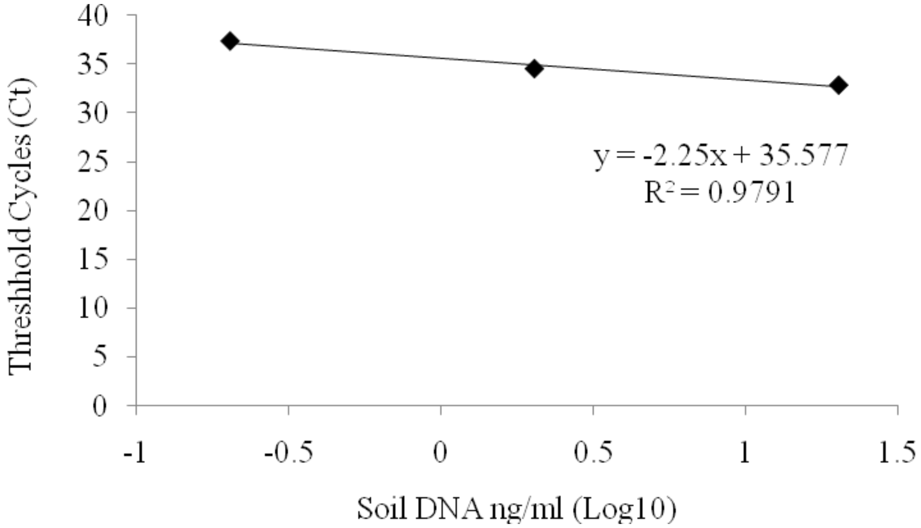

Figure 3. Relationship between ng/DNA from soil and the number of threshold cycles for real-time PCR amplification of *Verticillium dahliae* at 10-fold serial dilutions of DNA using primers VertBtF/VertBtR and Taqman probe VertBtP.

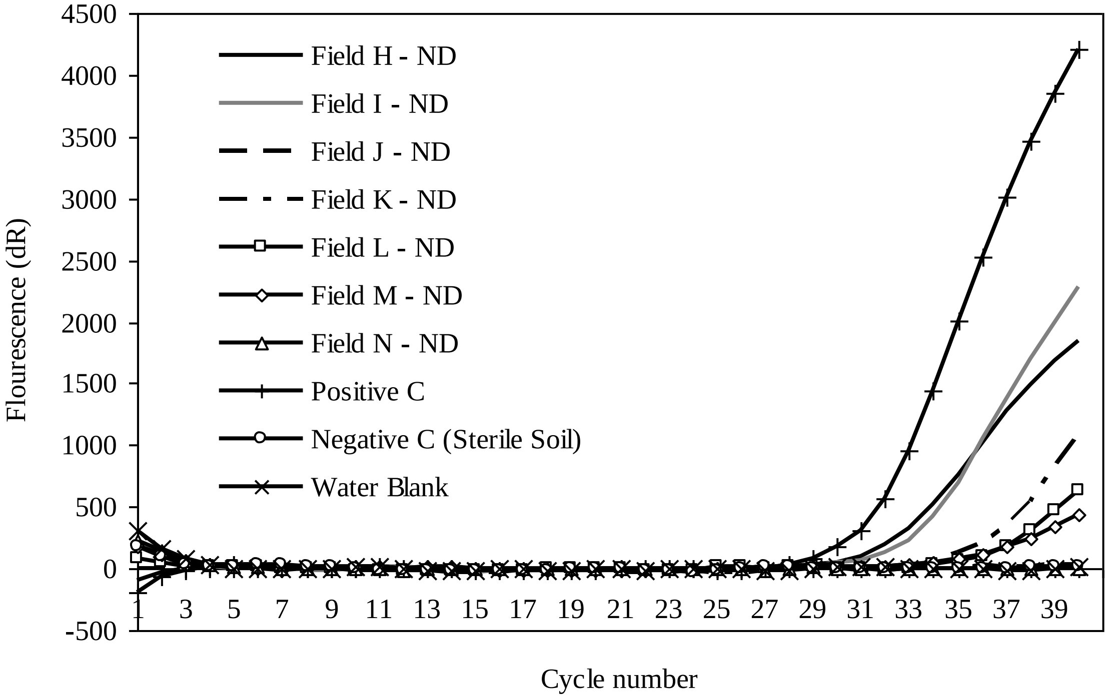

Figure 4. Quantitative PCR amplification of DNA extracted from soil using primers VertBtF/VertBtR and Taqman probe VertBtP specific for *Verticillium dahliae*.

# University of Minnesota Potato Breeding & Genetics

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# Minnesota Potato Breeding and Genetics
# 2009

University of Minnesota
College of Food, Agricultural, & Natural Resource Sciences

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Benoit Bizimungu, Agriculture and Agri-Foods Canada, Lethbridge, AB

**Breeding Objectives:**

Objective 1: Develop and evaluate enhanced potato germplasm for resistance to potato diseases and having improved yield, yield stability, and marketing quality. This includes Red skinned, white and yellow fleshed cultivars, Round white chip processors, and long russet/LW FF processing and fresh market cultivars.

Objective 2: Determine post-harvest storage requirements and subsequent processing characteristics for sugar ends and cold induced sweetening resistance of breeding lines and development of novel breeding procedures to increase the breeding efficiency for these traits.

Objective 3: Determine the occurrence of symptom-less expression to potato viruses $PVY^{O/N}$ in breeding populations, and breed for host plant resistance to potato viruses.

**Report Contents**

The scope of this report is on the clones that have undergone field testing this past year (2009). The data presented here is for yields, external/internal defects, specific gravities, chipping & processing data, along with disease resistance evaluations for common scab & late blight.

**Yield, Grade and Quality Evaluations** – Breeding selections advancing in our program were compared to commercial cultivars in field trials at irrigated locations in Minnesota and North Dakota. Typical yield, grade, and quality information were collected at harvest. These data include plant maturity, stand, total and US #1 marketable and size distribution yield, percentage of U.S. No. 1 yield and graded defect weights (malformed tubers, severe growth cracking, etc.), specific gravity, incidence and type of internal and external defects, and processing color. Then, evaluations for storability and processing were determined after 1-, 3-months storage at 40 and 45F.

**Minnesota Table A. 2009. Location, planting, vine kill (Days after planting, DAP), and harvest (DAP) dates of MN research trials at irrigated and non-irrigated locations.**

| | | | **Kill** | **Harvest** |
|---|---|---|---|---|
| **Location** | **Irrigation** | **Planted** | **DAP** | **DAP** |
| **Grand Forks, ND** – Seed increase | Non irrigated | 11 June | 100 | 110 |
| – G1's & Single Hills | Non irrigated | 12 June | 100 | 110 |
| | | | | |
| **Becker, MN** - Yield | Irrigated | 8 May | 110 | 130 |
| - G1's & Single Hills | Irrigated | 26 May | 110 | 125 |
| - Common Scab | Irrigated | 8 May | 120 | 140 |
| | | | | |
| **Williston, ND** - Yield | Irrigated | 18 May | 120 | 140 |
| - G1's & Single Hills | Irrigated | 27 May | 120 | 140 |
| | | | | |
| **Rosemount, MN -** Late Blight | Irrigated | 11 June | 90 | 110 |
| - PLRV / PVY | Non irrigated | 11 June | 100 | 120 |
| | | | | |

## Clonal Evaluations and Procedures

**Minnesota Table B. 2009. Number of MN clonal selections and cultivars at replicated yield trial and disease resistance trial locations.**

| | | **Number of MN Clonal selections and cultivars** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Stages of development $^{1}$** | | | | | |
| **Clonal Market type** | | **Elite** | **Intermediate** | **Early** | | **Checks** | **Total** |
| **Chipping** | | 8 | 10 | 63 | 3 | Atlantic, NorValley, Snowden | 81 |
| **Processing** | | 7 | 27 | 72 | 2 | R. Burbank, Shepody | 107 |
| **Fresh** | | 17 | 7 | 35 | 4 | R. Norkotah, Red Norland, Red Pontiac, Yukon Gold | 59 |
| | | | | | | | |
| **1st year selections** | | | | | | | 376 |
| | | | | | | | |
| **NCR** | | **FF/FM** | **Chip** | **Fresh** | | | |
| Dakota North | | | 2 | 2 | | | 4 |
| Wisconsin | | | 2 | 1 | | | 3 |
| Michigan | | | 2 | 2 | | | 4 |
| Canada | | 2 | | 2 | | | 4 |
| Minnesota | | 1 | | 3 | | | 4 |
| | | | | | | | |
| **Quad State** | | | | | | | 134 |
| | | | | | | | |
| **Other Germplasm Enhancement** | | 2 | 673 | 23 | | | |
| | | | | | | | |
| **Disease Screening Trials** | | Clones Screened | | | | | |
| Late Blight - Natl | | 49 | | | | | 49 |
| Late Blight - Breeding | | 206 | | | | | 206 |
| Late Blight - Family selection | | 518 | | | | | 518 |
| PVY expression | | 204 | | | | | 204 |
| C. Scab - Natl | | 21 | | | | | 21 |
| C. Scab - Breeding | | 211 | | | | | 211 |
| | | | | | | | |
| **New hybrid generation (Single-hills)** | | | | 70,000 | | | |

## Project Description

The University of Minnesota potato breeding research is emphasizing the development, evaluation, and distribution of potato cultivars and germplasm with improved yield, quality, and disease resistance by developing new hybrid progenies and evaluating them in multiple dryland and irrigated locations. Post harvest storage and quality characterizations are performed from 40, 42, 45, and 48F throughout the 7 month storage season; focusing on sugar end and cold induced sweetening. The most advanced selections will be evaluated for Nitrogen use efficiency, N timing and spacing. Novel breeding methods and germplasm enhancement strategies are pursued to increase the efficiency of determining disease and pest resistance characterization early in the breeding effort. A focus is on foliar and tuber late blight, common scab, PVY and PLRV symptom expression, common scab, CPB, aphids, *Verticillium* wilt, and sugar end and cold induced sweetening.

**Grand Forks, ND** – Evaluate (~30,000) and select new hybrids from breeding crosses for marketing potential. Evaluate enhanced potato germplasm for improved yield, yield stability, and marketing quality. Characterize germplasm for resistance to sugar end, cold induced sweetening and to *Verticillium* wilt.

**Becker, MN** – Evaluate (~30,000) and select new hybrids from breeding crosses for marketing potential. Evaluate enhanced potato germplasm for improved yield, yield stability, and marketing quality. Characterize germplasm for resistance to sugar end, cold induced sweetening and to common scab. Determine the Nitrogen use efficiency, N-timing, and spacing requirements of potato breeding lines advancing from the potato breeding program.

**Rosemount, MN** – Determine the occurrence of symptom-less expression to potato viruses $PVY^{O/N}$ in breeding populations, and breed for host plant resistance to potato viruses. Exploit novel breeding methods for determining genetic gain for late blight resistance earlier in breeding, and develop foliar and tuber late blight resistance germplasm. Determine genomic differences, identifying genes involved in the reproductive biology of potato, and analyze post-zygotic crossing barriers that inhibit gene introgression between wild *Solanum* species and cultivated potato for late blight resistance.

**Williston, ND** – Evaluate (~30,000) and select new hybrids from breeding crosses for marketing potential. Evaluate enhanced potato germplasm for improved yield, yield stability, and marketing quality. Characterize germplasm for resistance to sugar end, and cold induced sweetening.

### *Breeding for host plant resistance to potato pests and diseases*

A breeder should not focus heavily first on disease and pest resistance, then marketability traits, or the reverse. A balanced approach is necessary since varieties having superior disease and pest resistance lacking marketability traits will be limited in commercial use, and varieties lacking disease and pest resistance will likely not sustain the viability of our industry. Most notable are susceptibilities to multiple diseases, pests, and viruses such as *Verticillium* wilt, late and early blight, storage rots *Fusarium* and *Erwinia*, common scab, Colorado potato beetle, green peach aphids, potato leafhoppers, and all common viruses. In the UM potato breeding program evaluations are made for resistance to multiple diseases and pests. We also evaluate germplasm from north central and other US breeding programs. In UM breeding populations we apply EGS procedures to our screened populations.

### *Promising New Potato Varieties*

This list is focusing on some of the advanced & more promising University of Minnesota clones. All of these clones have gone through tissue culture to rid the clones of disease & are available as virus free tissue culture plantlets.

| | | | | |
|---|---|---|---|---|
| | | | **Color** | |
| **Sort** | **Clone** | **Mkt** | **Skin** | **Flesh** |
| | | | | |
| 1 | MN 96072-4 | FM | Red | W |
| 2 | MN 96013-1 | FM | Red | W |
| 3 | MN 02 616 | FM | Red | Yel-dk |
| 4 | MN 02 467 | FM | Rus | Yel-lt |
| 5 | ATMN 03505-3 | FM | Red | W |
| 6 | COMN 03021-1 | FM | Red | W |
| 7 | COMN 03027-1 | FM | Red | W |
| 8 | MN 99380-1 | Chip/FM | W | Yel-dk |
| 9 | MN 15620 | FF | Red | Yel |
| 10 | MN 02 419 | FF | LW | Cream |
| 11 | AOMN 03178-2 | FF | Rus-lt | Cream |
| 12 | MN 18747 | FF | LW | W |
| | | | | |

## Table 1. External & Internal Defects, Gravities & Chip scores of FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 1 | **Dk. Red Norland** | B | **Chk** | FM | Red | W | 0 | | 13 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.062 | 7.5 |
| 2 | | W | | | | | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1.070 | 8.0 |
| 3 | **R. Norkotah** | B | **Chk** | FM | Rus | Cream | 20 | 2 | 0 | 0 | 0 | 0 | 20 | 0 | 10 | 0 | 0 | 1.061 | 1 |
| 4 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 17 | 1.081 | 2 |
| 5 | **Red LaSoda** | B | **Chk** | FM | Red | Cream | 0 | | 14 | 0 | 7 | 0 | 36 | 0 | 0 | 7 | 0 | 1.063 | 7.8 |
| 6 | | W | | | | | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 1.081 | 8.0 |
| 7 | **Red Norland** | B | **Chk** | FM | Red | W | 0 | | 0 | 6 | 6 | 6 | 6 | 0 | 0 | 0 | 0 | 1.064 | 7.5 |
| 8 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 8.5 |
| 9 | **Y. Gold** | B | **Chk** | FM | W | Yel | 0 | | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 1.084 | 7.0 |
| 10 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 6 | 1.090 | 9.0 |
| 11 | MN 19298 | B | G16 | FM | Red | Yel | 0 | | 0 | 6 | 25 | 0 | 13 | 0 | 6 | 0 | 13 | 1.072 | 8.0 |
| 12 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1.079 | 8.0 |
| 13 | MN 96013-1 | B | G13 | FM | Red | Yel-dk | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 13 | 1.072 | 7.0 |
| 14 | | W | | | | | 0 | | 0 | 0 | 19 | 6 | 0 | 0 | 0 | 0 | 38 | 1.083 | 7.0 |
| 15 | MN 96072-4 | B | G13 | FM | Red | W | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 1.057 | 7.0 |
| 16 | | W | | | | | 0 | | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 9.5 |
| 17 | MN 99460-14 | B | G10 | FM | Red | W | 0 | | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 6.0 |
| 18 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 9.0 |
| 19 | MN 02 616 | B | G7 | FM | Red | Yel-dk | 0 | | 0 | 0 | 13 | 0 | 6 | 0 | 0 | 0 | 38 | 1.083 | 5.8 |
| 20 | | W | | | | | 0 | | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.080 | 6.5 |
| 21 | ATMN 03505-3 | B | G6 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.069 | 6.0 |
| 22 | | W | | | | | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 8.5 |
| 23 | COMN 03021-1 | B | G6 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.066 | 8.0 |
| 24 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1.069 | 8.3 |
| 25 | COMN 03024-6 | B | G6 | FM | Red | Cream | 0 | | 13 | 19 | 13 | 0 | 6 | 0 | 13 | 0 | 0 | 1.062 | 6.3 |
| 26 | | W | | | | | 0 | | 0 | 0 | 31 | 6 | 0 | 0 | 0 | 0 | 6 | 1.074 | 7.5 |
| 27 | COMN 03027-1 | B | G6 | FM | Red | Cream | 19 | 2 | 0 | 6 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 1.070 | 7.0 |
| 28 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.087 | 8.0 |
| 29 | NDMN 03376-1 | B | G6 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.065 | 7.5 |
| 30 | | W | | | | | 6 | 3 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 13 | 1.081 | 9.0 |
| 31 | NDMN 03382-2 | B | G6 | FM | Red | W | 0 | | 0 | 6 | 19 | 0 | 0 | 0 | 0 | 0 | 6 | 1.072 | 7.0 |
| 32 | | W | | | | | 0 | | 0 | 0 | 31 | 0 | 0 | 0 | 0 | 0 | 13 | 1.074 | 7.3 |

## Table 1. External & Internal Defects, Gravities & Chip scores of FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 33 | COMN 04697-02 | B | G5 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.060 | 5.5 |
| 34 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 25 | 1.074 | 7.0 |
| 35 | NDMN 04916-01 | B | G5 | FM | Red | W | 0 | | 0 | 0 | 25 | 0 | 13 | 0 | 0 | 0 | 31 | 1.087 | 6.5 |
| 36 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 1.081 | 7.5 |
| 37 | NDMN 04927-01 | B | G5 | FM | Red | Cream | 0 | | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.063 | 8.0 |
| 38 | | W | | | | | 6 | 1 | 56 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 8.5 |
| 39 | MN 05001-016 | B | G4 | FM | Red | Cream | 0 | | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 25 | 1.072 | 7.0 |
| 40 | | W | | | | | 13 | 1 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 6 | 1.077 | 9.0 |
| 41 | COMN 06353-04 | B | G3 | FM | Red | Cream | 0 | | 13 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 19 | 1.067 | 8.0 |
| 42 | | W | | | | | 0 | | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.067 | 8.0 |
| 43 | COMN 06438-02 | B | G3 | FM | Red | W | 0 | | 6 | 0 | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 1.067 | 6.5 |
| 44 | | W | | | | | 0 | | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 8.0 |
| 45 | WIMN 06030-01 | B | G3 | FM | Red | W | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 6.0 |
| 46 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.080 | 6.5 |
| 47 | COMN07-B182BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.065 | 8.0 |
| 48 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.078 | 8.0 |
| 49 | COMN07-B182WG1 | B | G2 | FM | Red | W | 0 | | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1.072 | 8.0 |
| 50 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.080 | 9.0 |
| 51 | COMN07-B183WG1 | B | G2 | FM | Red | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 7.0 |
| 52 | | W | | | | | 0 | | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 13 | 25 | 1.081 | 7.0 |
| 53 | COMN07-B186WG1 | B | G2 | FM | Red | W | 0 | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 1.077 | 6.0 |
| 54 | | W | | | | | 0 | | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.091 | 7.0 |
| 55 | COMN07-B196BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 1.078 | 7.0 |
| 56 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 1.096 | 9.0 |
| 57 | COMN07-B198BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.072 | 8.0 |
| 58 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 1.078 | 7.0 |
| 59 | COMN07-B211WG1 | B | G2 | FM | Red | W | 0 | | 13 | 0 | 25 | 13 | 25 | 0 | 25 | 0 | 0 | 1.065 | 7.5 |
| 60 | | W | | | | | 0 | | 25 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.076 | 9.5 |
| 61 | COMN07-B214BG1 | B | G2 | FM | Purple | Yel-dk. | 0 | | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.061 | 8.0 |
| 62 | | W | | | | | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 8.0 |
| 63 | COMN07-B216BG1 | B | G2 | FM | Red | Yel-lt. | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 1.070 | 7.0 |
| 64 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 8.0 |
| 65 | COMN07-B217BG1 | B | G2 | FM | Red | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 7.0 |
| 66 | | W | | | | | 13 | 4 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 1.090 | 8.0 |

## Table 1. External & Internal Defects, Gravities & Chip scores of FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Scab** | **Severity** | **GC** | **Knobs** | **Bruised** | **Green** | **HH** | **IN** | **VD** | **BC** | **Bruised** | **SG** | **Chip** |
| 67 | COMN07-B218BG1 | B | G2 | FM | Red | W | 0 | | 13 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 1.091 | 5.5 |
| 68 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 8.0 |
| 69 | COMN07-B228WG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 13 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 1.071 | 7.0 |
| 70 | | W | | | | | 0 | | 0 | 0 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 1.070 | 8.0 |
| 71 | COMN07-B229BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 7.0 |
| 72 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 8.0 |
| 73 | COMN07-B229WG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 7.0 |
| 74 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 8.0 |
| 75 | COMN07-B248WG1 | B | G2 | FM | Red | Yel | 0 | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 6.0 |
| 76 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 25 | 1.077 | 9.0 |
| 77 | COMN07-GF271BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.066 | 8.0 |
| 78 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 1.078 | 8.0 |
| 79 | COMN07-GF286BG1 | B | G2 | FM | Red | Yel | 0 | | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 8.0 |
| 80 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 9.0 |
| 81 | COMN07-W065WG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1.063 | 8.0 |
| 82 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.067 | 9.0 |
| 83 | COMN07-W073BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.066 | 7.0 |
| 84 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 6.5 |
| 85 | COMN07-W080BG1 | B | G2 | FM | Red | Cream/red splash | 0 | | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.066 | 8.0 |
| 86 | | W | | | | | 0 | | 25 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 9.0 |
| 87 | COMN07-W082WG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 33 | 0 | 17 | 0 | 0 | 0 | 0 | 1.047 | 8.0 |
| 88 | | W | | | | | 0 | | 0 | 0 | 50 | 0 | 0 | 0 | 13 | 25 | 0 | 1.057 | 9.0 |
| 89 | COMN07-W109BG1 | B | G2 | FM | Red | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 6.5 |
| 90 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 7.0 |
| 91 | COMN07-W112BG1 | B | G2 | FM | W/Purple | Purple/W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.073 | Purple/W |
| 92 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.091 | Purple/W |
| 93 | NDMN07-B167BG1 | B | G2 | FM | Red | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.068 | 7.0 |
| 94 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 13 | 1.082 | 7.0 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.

2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 2. Yield data for FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | Cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | Cwtyld | % US #1's | %B's | %A's |
| 1 | **Dk. Red Norland** | B | **Chk** | FM | Red | Cream | 143 | 450.5 | 14 | 84.2 | 157 | 534.7 | 43.2 | 211.3 | 196.0 | 407.3 | 76.2 | 9.6 | 90.4 |
| 2 | | W | | | | | 86 | 278.7 | 0 | 0.0 | 86 | 278.7 | 16.7 | 148.0 | 114.1 | 262.0 | 94.0 | 6.0 | 94.0 |
| 3 | **Red LaSoda** | B | **Chk** | FM | Red | W | 190 | 570.5 | 8 | 52.1 | 198 | 622.6 | 60.0 | 302.9 | 207.6 | 510.5 | 82.0 | 10.5 | 89.5 |
| 4 | | W | | | | | 123 | 346.1 | 0 | 0.0 | 123 | 346.1 | 37.4 | 206.3 | 102.4 | 308.7 | 89.2 | 10.8 | 89.2 |
| 5 | **Red Norland** | B | **Chk** | FM | W | W | 143 | 576.4 | 3 | 12.6 | 146 | 589.0 | 37.3 | 170.8 | 368.3 | 539.1 | 91.5 | 6.5 | 93.5 |
| 6 | | W | | | | | 99 | 320.3 | 1 | 3.8 | 99 | 324.1 | 21.4 | 152.7 | 146.2 | 298.9 | 92.2 | 6.7 | 93.3 |
| 7 | **Y. Gold** | B | G7 | FM | W | Yel | 261 | 782.3 | 2 | 7.8 | 263 | 790.1 | 81.9 | 447.0 | 253.4 | 700.5 | 88.7 | 10.5 | 89.5 |
| 8 | | W | | | | | 124 | 393.5 | 2 | 8.9 | 125 | 402.5 | 36.5 | 183.3 | 173.7 | 357.0 | 88.7 | 9.3 | 90.7 |
| 9 | MN 02 616 | B | G16 | FM | Red | Yel-dk | 204 | 568.4 | 1 | 0.9 | 204 | 569.3 | 71.8 | 324.4 | 172.2 | 496.6 | 87.2 | 12.6 | 87.4 |
| 10 | | W | | | | | 164 | 367.9 | 1 | 2.9 | 165 | 370.8 | 70.9 | 232.6 | 64.4 | 297.0 | 80.1 | 19.3 | 80.7 |
| 11 | MN 19298 | B | G13 | FM | Red | Yel-dk | 185 | 559.5 | 2 | 7.8 | 187 | 567.2 | 55.5 | 302.5 | 201.5 | 504.0 | 88.9 | 9.9 | 90.1 |
| 12 | | W | | | | | 117 | 401.6 | 1 | 1.6 | 118 | 403.2 | 20.6 | 202.4 | 178.7 | 381.0 | 94.5 | 5.1 | 94.9 |
| 13 | MN 96013-1 | B | G13 | FM | Red | Yel | 199 | 312.9 | 0 | 0.0 | 199 | 312.9 | 138.0 | 170.1 | 4.8 | 174.9 | 55.9 | 44.1 | 55.9 |
| 14 | | W | | | | | 122 | 197.5 | 0 | 0.0 | 122 | 197.5 | 68.5 | 124.6 | 4.3 | 129.0 | 65.3 | 34.7 | 65.3 |
| 15 | MN 96072-4 | B | G10 | FM | Red | W | 109 | 240.7 | 0 | 0.0 | 109 | 240.7 | 55.1 | 166.7 | 19.0 | 185.6 | 77.1 | 22.9 | 77.1 |
| 16 | | W | | | | | 95 | 189.8 | 0 | 0.0 | 95 | 189.8 | 36.9 | 143.7 | 9.2 | 152.9 | 80.5 | 19.5 | 80.5 |
| 17 | MN 99460-14 | B | G6 | FM | Red | Cream | 168 | 408.7 | 0 | 0.0 | 168 | 408.7 | 83.4 | 241.1 | 84.2 | 325.3 | 79.6 | 20.4 | 79.6 |
| 18 | | W | | | | | 143 | 260.4 | 0 | 0.0 | 143 | 260.4 | 86.8 | 173.7 | 0.0 | 173.7 | 66.7 | 33.3 | 66.7 |
| 19 | ATMN 03505-3 | B | G6 | FM | Red | Cream | 224 | 397.6 | 2 | 6.9 | 226 | 404.5 | 154.2 | 189.6 | 53.8 | 243.5 | 60.2 | 38.8 | 61.2 |
| 20 | | W | | | | | 110 | 184.0 | 0 | 0.0 | 110 | 184.0 | 68.9 | 89.4 | 25.7 | 115.1 | 62.5 | 37.5 | 62.5 |
| 21 | COMN 03021-1 | B | G6 | FM | Red | Cream | 125 | 228.1 | 22 | 55.3 | 147 | 283.4 | 75.0 | 100.3 | 52.7 | 153.0 | 54.0 | 32.9 | 67.1 |
| 22 | | W | | | | | 142 | 236.2 | 1 | 2.3 | 143 | 238.5 | 91.2 | 129.6 | 15.5 | 145.0 | 60.8 | 38.6 | 61.4 |
| 23 | COMN 03024-6 | B | G6 | FM | Red | Cream | 175 | 311.7 | 1 | 2.3 | 176 | 314.0 | 115.5 | 170.5 | 25.6 | 196.1 | 62.5 | 37.1 | 62.9 |
| 24 | | W | | | | | 100 | 225.7 | 0 | 0.0 | 100 | 225.7 | 44.3 | 149.7 | 31.6 | 181.3 | 80.4 | 19.6 | 80.4 |
| 25 | COMN 03027-1 | B | G6 | FM | Red | Cream | 103 | 248.0 | 5 | 14.0 | 108 | 262.1 | 49.6 | 146.4 | 52.1 | 198.5 | 75.7 | 20.0 | 80.0 |
| 26 | | W | | | | | 111 | 214.4 | 2 | 5.6 | 113 | 219.9 | 52.3 | 152.3 | 9.7 | 162.1 | 73.7 | 24.4 | 75.6 |
| 27 | NDMN 03376-1 | B | G6 | FM | Red | Cream | 210 | 420.4 | 13 | 46.9 | 223 | 467.3 | 121.9 | 268.3 | 30.2 | 298.5 | 63.9 | 29.0 | 71.0 |
| 28 | | W | | | | | 103 | 175.1 | 1 | 2.2 | 104 | 177.3 | 74.0 | 84.2 | 16.9 | 101.1 | 57.0 | 42.3 | 57.7 |
| 29 | NDMN 03382-2 | B | G5 | FM | Red | W | 243 | 377.9 | 0 | 0.0 | 243 | 377.9 | 168.4 | 194.6 | 14.9 | 209.5 | 55.4 | 44.6 | 55.4 |
| 30 | | W | | | | | 142 | 193.4 | 0 | 0.0 | 142 | 193.4 | 107.1 | 77.6 | 8.7 | 86.3 | 44.6 | 55.4 | 44.6 |
| 31 | COMN 04697-02 | B | G5 | FM | Red | Cream | 174 | 447.8 | 2 | 7.4 | 176 | 455.2 | 68.9 | 258.7 | 120.3 | 379.0 | 83.2 | 15.4 | 84.6 |
| 32 | | W | | | | | 146 | 280.2 | 0 | 0.0 | 146 | 280.2 | 73.2 | 190.3 | 16.7 | 207.0 | 73.9 | 26.1 | 73.9 |
| 33 | NDMN 04916-01 | B | G5 | FM | Red | W | 124 | 182.8 | 15 | 31.1 | 139 | 213.9 | 97.1 | 85.7 | 0.0 | 85.7 | 40.1 | 53.1 | 46.9 |
| 34 | | W | | | | | 118 | 191.6 | 9 | 16.7 | 126 | 208.3 | 86.0 | 105.6 | 0.0 | 105.6 | 50.7 | 44.9 | 55.1 |

## Table 2. Yield data for FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | Cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | Cwtyld | % US #1's | %B's | %A's |
| 35 | NDMN 04927-01 | B | G4 | FM | Red | Cream | 198 | 371.5 | 0 | 0.0 | 198 | 371.5 | 121.8 | 212.6 | 37.1 | 249.7 | 67.2 | 32.8 | 67.2 |
| 36 | | W | | | | | 85 | 181.9 | 0 | 0.0 | 85 | 181.9 | 43.5 | 92.7 | 45.7 | 138.4 | 76.1 | 23.9 | 76.1 |
| 37 | MN 05001-016 | B | G3 | FM | Red | Cream | 219 | 466.0 | 3 | 8.7 | 221 | 474.8 | 113.0 | 297.8 | 55.2 | 353.0 | 74.4 | 24.2 | 75.8 |
| 38 | | W | | | | | 104 | 223.3 | 1 | 2.8 | 105 | 226.0 | 49.0 | 137.1 | 37.2 | 174.3 | 77.1 | 21.9 | 78.1 |
| 39 | COMN 06353-04 | B | G3 | XX | Red | Cream | 144 | 499.9 | 2 | 4.1 | 146 | 504.0 | 33.0 | 225.7 | 241.3 | 467.0 | 92.6 | 6.6 | 93.4 |
| 40 | | W | | | | | 98 | 290.5 | 0 | 0.0 | 98 | 290.5 | 20.5 | 192.0 | 77.9 | 270.0 | 92.9 | 7.1 | 92.9 |
| 41 | COMN 06438-02 | B | G3 | FM | Red | W | 230 | 414.1 | 2 | 4.7 | 231 | 418.8 | 164.0 | 213.9 | 36.3 | 250.1 | 59.7 | 39.6 | 60.4 |
| 42 | | W | | | | | 173 | 198.9 | 0 | 0.0 | 173 | 198.9 | 136.7 | 62.3 | 0.0 | 62.3 | 31.3 | 68.7 | 31.3 |
| 43 | WIMN 06030-01 | B | G2 | FM | Red | W | 185 | 271.8 | 0 | 0.0 | 185 | 271.8 | 146.3 | 114.8 | 10.7 | 125.5 | 46.2 | 53.8 | 46.2 |
| 44 | | W | | | | | 162 | 217.9 | 0 | 0.0 | 162 | 217.9 | 116.7 | 101.3 | 0.0 | 101.3 | 46.5 | 53.5 | 46.5 |
| 45 | COMN07-B182BG1 | B | G2 | FM | Red | Cream | 248 | 473.8 | 0 | 0.0 | 248 | 473.8 | 156.9 | 283.2 | 33.7 | 316.9 | 66.9 | 33.1 | 66.9 |
| 46 | | W | | | | | 152 | 214.9 | 0 | 0.0 | 152 | 214.9 | 113.2 | 101.6 | 0.0 | 101.6 | 47.3 | 52.7 | 47.3 |
| 47 | COMN07-B182WG1 | B | G2 | FM | Red | W | 146 | 322.6 | 0 | 0.0 | 146 | 322.6 | 71.2 | 203.2 | 48.2 | 251.4 | 77.9 | 22.1 | 77.9 |
| 48 | | W | | | | | 105 | 175.4 | 0 | 0.0 | 105 | 175.4 | 65.3 | 110.1 | 0.0 | 110.1 | 62.8 | 37.2 | 62.8 |
| 49 | COMN07-B183WG1 | B | G2 | FM | Red | W | 159 | 343.6 | 17 | 48.9 | 176 | 392.5 | 76.3 | 221.3 | 46.0 | 267.3 | 68.1 | 22.2 | 77.8 |
| 50 | | W | | | | | 118 | 237.7 | 6 | 20.8 | 124 | 258.4 | 57.6 | 145.4 | 34.7 | 180.1 | 69.7 | 24.2 | 75.8 |
| 51 | COMN07-B186WG1 | B | G2 | FM | Red | W | 185 | 372.8 | 0 | 0.0 | 185 | 372.8 | 111.0 | 245.8 | 16.0 | 261.8 | 70.2 | 29.8 | 70.2 |
| 52 | | W | | | | | 99 | 248.8 | 0 | 0.0 | 99 | 248.8 | 26.0 | 195.0 | 27.8 | 222.8 | 89.5 | 10.5 | 89.5 |
| 53 | COMN07-B196BG1 | B | G2 | FM | Red | Cream | 200 | 510.4 | 0 | 0.0 | 200 | 510.4 | 91.5 | 243.8 | 175.2 | 418.9 | 82.1 | 17.9 | 82.1 |
| 54 | | W | | | | | 125 | 234.1 | 0 | 0.0 | 125 | 234.1 | 62.3 | 152.3 | 19.5 | 171.8 | 73.4 | 26.6 | 73.4 |
| 55 | COMN07-B198BG1 | B | G2 | FM | Red | Cream | 190 | 339.4 | 3 | 10.8 | 193 | 350.2 | 112.3 | 187.7 | 39.4 | 227.1 | 64.9 | 33.1 | 66.9 |
| 56 | | W | | | | | 126 | 214.1 | 0 | 0.0 | 126 | 214.1 | 82.1 | 107.4 | 24.6 | 132.0 | 61.7 | 38.3 | 61.7 |
| 57 | COMN07-B211WG1 | B | G2 | FM | Purple | W | 449 | 737.2 | 0 | 0.0 | 449 | 737.2 | 302.5 | 418.8 | 15.9 | 434.6 | 59.0 | 41.0 | 59.0 |
| 58 | | W | | | | | 268 | 450.0 | 0 | 0.0 | 268 | 450.0 | 143.0 | 298.2 | 8.8 | 307.0 | 68.2 | 31.8 | 68.2 |
| 59 | COMN07-B214BG1 | B | G2 | FM | Red | Yel-dk. | 124 | 352.1 | 0 | 0.0 | 124 | 352.1 | 50.1 | 150.7 | 151.3 | 302.0 | 85.8 | 14.2 | 85.8 |
| 60 | | W | | | | | 89 | 159.0 | 0 | 0.0 | 89 | 159.0 | 62.1 | 66.1 | 30.8 | 96.9 | 61.0 | 39.0 | 61.0 |
| 61 | COMN07-B216BG1 | B | G2 | FM | Red | Yel-lt. | 270 | 476.1 | 0 | 0.0 | 270 | 476.1 | 185.5 | 290.6 | 0.0 | 290.6 | 61.0 | 39.0 | 61.0 |
| 62 | | W | | | | | 190 | 349.5 | 0 | 0.0 | 190 | 349.5 | 103.2 | 246.3 | 0.0 | 246.3 | 70.5 | 29.5 | 70.5 |
| 63 | COMN07-B217BG1 | B | G2 | FM | Red | W | 120 | 268.8 | 0 | 0.0 | 120 | 268.8 | 69.1 | 158.8 | 40.9 | 199.7 | 74.3 | 25.7 | 74.3 |
| 64 | | W | | | | | 101 | 175.9 | 0 | 0.0 | 101 | 175.9 | 65.9 | 104.9 | 5.1 | 110.0 | 62.6 | 37.4 | 62.6 |
| 65 | COMN07-B218BG1 | B | G2 | FM | Red | W | 129 | 307.7 | 7 | 25.0 | 136 | 332.7 | 58.2 | 182.1 | 67.3 | 249.4 | 75.0 | 18.9 | 81.1 |
| 66 | | W | | | | | 63 | 121.1 | 1 | 2.1 | 64 | 123.2 | 29.5 | 81.9 | 9.8 | 91.6 | 74.4 | 24.3 | 75.7 |
| 67 | COMN07-B228WG1 | B | G2 | FM | Red | Cream | 247 | 419.7 | 0 | 0.0 | 247 | 419.7 | 178.9 | 204.8 | 36.0 | 240.8 | 57.4 | 42.6 | 57.4 |
| 68 | | W | | | | | 131 | 265.9 | 0 | 0.0 | 131 | 265.9 | 64.7 | 169.1 | 32.2 | 201.3 | 75.7 | 24.3 | 75.7 |

## Table 2. Yield data for FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | Cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | Cwtyld | % US #1's | %B's | %A's |
| 69 | COMN07-B229BG1 | B | G2 | FM | Red | Cream | 253 | 359.8 | 0 | 0.0 | 253 | 359.8 | 181.1 | 174.0 | 4.7 | 178.7 | 49.7 | 50.3 | 49.7 |
| 70 | | W | | | | | 167 | 310.5 | 0 | 0.0 | 167 | 310.5 | 87.5 | 218.0 | 5.0 | 223.0 | 71.8 | 28.2 | 71.8 |
| 71 | COMN07-B229WG1 | B | G2 | FM | Red | Cream | 121 | 308.6 | 0 | 0.0 | 121 | 308.6 | 56.8 | 181.2 | 70.6 | 251.8 | 81.6 | 18.4 | 81.6 |
| 72 | | W | | | | | 114 | 345.0 | 0 | 0.0 | 114 | 345.0 | 35.1 | 176.1 | 133.8 | 309.9 | 89.8 | 10.2 | 89.8 |
| 73 | COMN07-B248WG1 | B | G2 | FM | Red | Yel | 100 | 343.3 | 0 | 0.0 | 100 | 343.3 | 23.6 | 187.4 | 132.3 | 319.7 | 93.1 | 6.9 | 93.1 |
| 74 | | W | | | | | 52 | 149.3 | 0 | 0.0 | 52 | 149.3 | 19.4 | 63.8 | 66.2 | 130.0 | 87.0 | 13.0 | 87.0 |
| 75 | COMN07-GF271BG1 | B | G2 | FM | Red | Cream | 228 | 634.4 | 0 | 0.0 | 228 | 634.4 | 96.6 | 365.5 | 172.3 | 537.8 | 84.8 | 15.2 | 84.8 |
| 76 | | W | | | | | 202 | 462.0 | 0 | 0.0 | 202 | 462.0 | 95.9 | 242.8 | 123.3 | 366.1 | 79.2 | 20.8 | 79.2 |
| 77 | COMN07-GF286BG1 | B | G2 | FM | Red | Yel | 104 | 251.1 | 7 | 50.7 | 111 | 301.8 | 54.9 | 117.7 | 78.5 | 196.2 | 65.0 | 21.9 | 78.1 |
| 78 | | W | | | | | 76 | 235.1 | 5 | 26.3 | 81 | 261.5 | 24.1 | 105.4 | 105.7 | 211.1 | 80.7 | 10.2 | 89.8 |
| 79 | COMN07-W065WG1 | B | G2 | FM | Red | Cream | 327 | 515.3 | 0 | 0.0 | 327 | 515.3 | 229.3 | 276.5 | 9.5 | 286.0 | 55.5 | 44.5 | 55.5 |
| 80 | | W | | | | | 184 | 361.7 | 0 | 0.0 | 184 | 361.7 | 88.3 | 259.8 | 13.6 | 273.4 | 75.6 | 24.4 | 75.6 |
| 81 | COMN07-W073BG1 | B | G2 | FM | Red | Cream | 209 | 324.5 | 0 | 0.0 | 209 | 324.5 | 151.4 | 151.7 | 21.4 | 173.1 | 53.4 | 46.6 | 53.4 |
| 82 | | W | | | | | 165 | 248.7 | 17 | 37.6 | 182 | 286.2 | 116.2 | 132.5 | 0.0 | 132.5 | 46.3 | 46.7 | 53.3 |
| 83 | COMN07-W080BG1 | B | G2 | FM | Red | Cream/red splash | 66 | 144.6 | 0 | 0.0 | 66 | 144.6 | 39.5 | 79.8 | 25.2 | 105.0 | 72.7 | 27.3 | 72.7 |
| 84 | | W | | | | | 74 | 187.2 | 0 | 0.0 | 74 | 187.2 | 25.0 | 122.5 | 39.7 | 162.2 | 86.6 | 13.4 | 86.6 |
| 85 | COMN07-W082WG1 | B | G2 | FM | Red | Cream | 362 | 344.9 | 0 | 0.0 | 362 | 344.9 | 308.4 | 36.6 | 0.0 | 36.6 | 10.6 | 89.4 | 10.6 |
| 86 | | W | | | | | 202 | 170.4 | 0 | 0.0 | 202 | 170.4 | 168.6 | 1.7 | 0.0 | 1.7 | 1.0 | 99.0 | 1.0 |
| 87 | COMN07-W109BG1 | B | G2 | FM | W/Purple | Cream | 333 | 522.7 | 0 | 0.0 | 333 | 522.7 | 232.8 | 252.1 | 37.7 | 289.9 | 55.5 | 44.5 | 55.5 |
| 88 | | W | | | | | 223 | 332.6 | 0 | 0.0 | 223 | 332.6 | 139.7 | 192.9 | 0.0 | 192.9 | 58.0 | 42.0 | 58.0 |
| 89 | COMN07-W112BG1 | B | G2 | FM | Red | Purple/W | 206 | 569.8 | 0 | 0.0 | 206 | 569.8 | 83.4 | 338.6 | 147.9 | 486.4 | 85.4 | 14.6 | 85.4 |
| 90 | | W | | | | | 149 | 410.2 | 0 | 0.0 | 149 | 410.2 | 30.1 | 299.0 | 81.1 | 380.1 | 92.7 | 7.3 | 92.7 |
| 91 | NDMN07-B167BG1 | B | G2 | FM | Red | W | 206 | 569.8 | 0 | 0.0 | 206 | 569.8 | 83.4 | 338.6 | 147.9 | 486.4 | 85.4 | 14.6 | 85.4 |
| 92 | | W | | | | | 149 | 410.2 | 0 | 0.0 | 149 | 410.2 | 30.1 | 299.0 | 81.1 | 380.1 | 92.7 | 7.3 | 92.7 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.

2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 3. Common Scab & LB disease resistance values for FM clones grown in Becker & Rosemount, MN, respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Trial** | **Mkt** | **Skin** | **Flesh** | | **Rep 1** | **Rep 2** | **Final** |
| 1 | **Atlantic (All Red)** | **Chk** | FM | Red | W | 4.7 | H | H | 9.0 |
| 2 | **Dk. Red Norland** | **Chk** | FM | Red | W | 3.5 | L | M | 9.0 |
| 3 | **R. Norkotah** | **Chk** | FM | Rus | Cream | 4.5 | M | H | 9.0 |
| 4 | **Red LaSoda** | **Chk** | FM | Red | Cream | 5.0 | L | M | 9.0 |
| 5 | **Red Norland** | **Chk** | FM | Red | W | 4.0 | H | H | 9.0 |
| 6 | **Y. Gold** | **Chk** | FM | W | Yel | 4.5 | H | H | 9.0 |
| 7 | MN 19298 | G16 | FM | Red | Yel | 4.0 | H | H | 9.0 |
| 8 | MN 96013-1 | G13 | FM | Red | Yel-dk | 4.5 | M | M | 9.0 |
| 9 | MN 96072-4 | G13 | FM | Red | W | 2.5 | T | L | 9.0 |
| 10 | MN 99460-14 | G10 | FM | Red | W | 4.5 | H | M | 9.0 |
| 11 | MN 02 467 | G7 | FM | Rus | Yel-lt | 3.0 | T | H | 7.0 |
| 12 | MN 02 616 | G7 | FM | Red | Yel-dk | 4.0 | L | T | 9.0 |
| 13 | ATMN 03505-3 | G6 | FM | Red | Cream | 3.5 | L | M | 9.0 |
| 14 | COMN 03021-1 | G6 | FM | Red | Cream | 3.0 | T | H | 9.0 |
| 15 | COMN 03024-6 | G6 | FM | Red | Cream | 3.0 | M | L | 9.0 |
| 16 | COMN 03027-1 | G6 | FM | Red | Cream | 5.0 | H | H | 9.0 |
| 17 | NDMN 03376-1 | G6 | FM | Red | Cream | 4.0 | L | H | 9.0 |
| 18 | NDMN 03382-2 | G6 | FM | Red | W | 2.5 | L | M | 9.0 |
| 19 | COMN 04697-02 | G5 | FM | Red | Cream | 4.0 | H | N/A | 9.0 |
| 20 | NDMN 04916-01 | G5 | FM | Red | W | 3.5 | H | H | 9.0 |
| 21 | NDMN 04927-01 | G5 | FM | Red | Cream | 2.0 | L | M | 8.0 |
| 22 | MN 05001-016 | G4 | FM | Red | Cream | 4.0 | L | L | N/A |
| 23 | COMN 06353-04 | G3 | FM | Red | Cream | 5.0 | H | H | 9.0 |
| 24 | COMN 06438-02 | G3 | FM | Red | W | 5.0 | M | H | 9.0 |
| 25 | WIMN 06030-01 | G3 | FM | Red | W | 5.0 | M | M | 9.0 |
| 26 | WIMN 06057-03 | G3 | FM | Red | Cream | N/A | N/A | N/A | 9.0 |
| 27 | COMN07-B182BG1 | G2 | FM | Red | Cream | 5.0 | H | N/A | 9.0 |
| 28 | COMN07-B182WG1 | G2 | FM | Red | W | 5.0 | H | N/A | 9.0 |
| 29 | COMN07-B183WG1 | G2 | FM | Red | W | 4.0 | M | N/A | N/A |
| 30 | COMN07-B186WG1 | G2 | FM | Red | W | 5.0 | M | N/A | N/A |
| 31 | COMN07-B196BG1 | G2 | FM | Red | Cream | 5.0 | L | N/A | 9.0 |
| 32 | COMN07-B198BG1 | G2 | FM | Red | Cream | 5.0 | M | N/A | 9.0 |
| 33 | COMN07-B210BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |
| 34 | COMN07-B211BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |
| 35 | COMN07-B211WG1 | G2 | FM | Red | W | 4.0 | H | N/A | N/A |
| 36 | COMN07-B214BG1 | G2 | FM | Purple | Yel-dk. | 5.0 | H | N/A | 7.0 |
| 37 | COMN07-B216BG1 | G2 | FM | Red | Yel | 5.0 | H | N/A | 9.0 |
| 38 | COMN07-B217BG1 | G2 | FM | Red | W | 5.0 | L | N/A | 9.0 |
| 39 | COMN07-B218BG1 | G2 | FM | Red | W | 5.0 | H | N/A | 9.0 |
| 40 | COMN07-B225BG1 | G2 | FM | Purple | N/A | N/A | N/A | N/A | 9.0 |
| 41 | COMN07-B228WG1 | G2 | FM | Red | Cream | 5.0 | M | N/A | N/A |
| 42 | COMN07-B229BG1 | G2 | FM | Red | Cream | 4.0 | M | N/A | 9.0 |
| 43 | COMN07-B229WG1 | G2 | FM | Red | Cream | 3.0 | L | N/A | 9.0 |
| 44 | COMN07-B241BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |
| 45 | COMN07-B248WG1 | G2 | FM | Red | Yel | 4.0 | H | N/A | 8.0 |
| 46 | COMN07-GF241BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |
| 47 | COMN07-GF271BG1 | G2 | FM | Red | Cream | 3.0 | H | N/A | 9.0 |
| 48 | COMN07-GF286BG1 | G2 | FM | Red | Yel | 5.0 | L | N/A | 9.0 |
| 49 | COMN07-W065WG1 | G2 | FM | Red | Cream | 5.0 | L | N/A | N/A |
| 50 | COMN07-W073BG1 | G2 | FM | Red | Cream | 4.0 | M | N/A | 8.0 |

## Table 3. Common Scab & LB disease resistance values for FM clones grown in Becker & Rosemount, MN, respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Trial | Mkt | Skin | Flesh | | Rep 1 | Rep 2 | Final |
| 51 | COMN07-W080BG1 | G2 | FM | Red | Cream/red splash | 3.0 | M | N/A | 9.0 |
| 52 | COMN07-W082WG1 | G2 | FM | Red | Cream | 5.0 | H | N/A | N/A |
| 53 | COMN07-W090BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |
| 54 | COMN07-W109BG1 | G2 | FM | Red | Cream | 5.0 | M | N/A | 9.0 |
| 55 | COMN07-W112BG1 | G2 | FM | W/Purple | Purple/W | 5.0 | H | N/A | 9.0 |
| 56 | NDMN07-B167BG1 | G2 | FM | Red | W | 5.0 | M | N/A | 9.0 |
| 57 | NDMN07-GF040BG1 | G2 | FM | Red | N/A | N/A | N/A | N/A | 9.0 |

| | | | |
|---|---|---|---|
| 1) | **MN Scale =** | 0 = No Scab | **Coverage[2]** |
| | | 1= < 1mm | T = Trace |
| | | 2 = 2 to 3 mm | L = 1 - 5% |
| | | 3 = 3 to 4 mm | M = 5 to 50% |
| | | 4 = 4 to 5 mm | H = > 50% |
| | | 5 = > 5 mm | |

| | |
|---|---|
| 3) | MN Scale range = 1 - 9.<br>% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100 |

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## Table 4. External & Internal Defects, Gravities & Chip scores of Chipping/FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 1 | **NorValley** | B | **Chk** | C | W | Cream | 0 | | 0 | 0 | 0 | 13 | 13 | 0 | 0 | 0 | 0 | 1.081 | 3.8 |
| 2 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 4.8 |
| 3 | MN 99380-1 | B | G10 | C/FM | W | Yel-dk | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.077 | 4.0 |
| 4 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 4.5 |
| 5 | MN 00467-4 | B | G9 | C | W | W | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 5.0 |
| 6 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.090 | 7.0 |
| 7 | MN 02 574 | B | G7 | C/FM | W | Yel | 13 | 3 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 1.087 | 7.0 |
| 8 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 1.093 | 5.5 |
| 9 | MN 02 582 | B | G7 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.081 | 6.0 |
| 10 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.095 | 6.0 |
| 11 | MN 02 586 | B | G7 | C/FM | W | Yel-lt | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 1.081 | 4.0 |
| 12 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.093 | 5.5 |
| 13 | MN 02 588 | B | G7 | C | W | W | 0 | | 25 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.080 | 5.5 |
| 14 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.095 | 3.0 |
| 15 | MN 02 598 | B | G7 | C/FM | W | Yel-lt | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 1.085 | 5.5 |
| 16 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.090 | 6.0 |
| 17 | NDMN 03324-4 | B | G6 | C | W | Cream | 7 | 3 | 0 | 0 | 14 | 7 | 0 | 0 | 0 | 0 | 7 | 1.086 | 3.8 |
| 18 | | W | | | | | 0 | | 13 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 13 | 1.092 | 5.3 |
| 19 | COMN 04674-02 | B | G5 | C | W | Cream | 0 | | 0 | 0 | 19 | 6 | 13 | 0 | 0 | 0 | 6 | 1.073 | 7.0 |
| 20 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 1.087 | 7.0 |
| 21 | NDMN 04910-01 | B | G5 | C | W | Cream | 13 | 4 | 19 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 1.080 | 4.3 |
| 22 | | W | | | | | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1.096 | 6.0 |
| 23 | NDMN 04911-01 | B | G5 | C | W | W | 44 | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 1.077 | 3.5 |
| 24 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 4.8 |
| 25 | NDMN 04960-01 | B | G5 | C | W | W | 6 | 4 | 0 | 0 | 0 | 0 | 38 | 6 | 6 | 0 | 0 | 1.072 | 2.3 |
| 26 | | W | | | | | 0 | | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 13 | 1.100 | 3.0 |
| 27 | WIMN 04844-01 | B | G5 | C | W | Cream | 0 | | 6 | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 1.076 | 2.5 |
| 28 | | W | | | | | 0 | | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 13 | 1.085 | 5.8 |
| 29 | WIMN 04844-03 | B | G5 | C | W | Yel | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 88 | 0 | 1.071 | 5.5 |
| 30 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 1.080 | 8.0 |
| 31 | WIMN 04844-06 | B | G5 | C | W | Cream | 0 | | 0 | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 1.069 | 4.3 |
| 32 | | W | | | | | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 1.091 | 5.0 |

## Table 4. External & Internal Defects, Gravities & Chip scores of Chipping/FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 33 | WIMN 04855-02 | B | G5 | C | W | Cream | 6 | 1 | 25 | 0 | 0 | 0 | 6 | 0 | 0 | 25 | 0 | 1.078 | 4.5 |
| 34 | | W | | | | | 0 | | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 1.092 | 5.3 |
| 35 | AOMN 06150-02 | B | G3 | C | W | Cream | 0 | | 0 | 0 | 19 | 0 | 6 | 0 | 0 | 0 | 0 | 1.085 | 3.8 |
| 36 | | W | | | | | 6 | 5 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 5.0 |
| 37 | COMN 06471-02 | B | G3 | C/FM | W | Yel | 6 | 4 | 19 | 0 | 19 | 0 | 19 | 0 | 0 | 0 | 6 | 1.067 | 5.8 |
| 38 | | W | | | | | 0 | | 13 | 0 | 63 | 0 | 0 | 0 | 0 | 0 | 50 | 1.086 | 6.3 |
| 39 | WIMN 06035-01 | B | G3 | C | W | Cream | 6 | 4 | 0 | 6 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 1.081 | 5.5 |
| 40 | | W | | | | | 0 | | 13 | 0 | 19 | 0 | 13 | 0 | 0 | 0 | 0 | 1.081 | 7.0 |
| 41 | COMN07-B062BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.068 | 7.0 |
| 42 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 9.0 |
| 43 | COMN07-B212BG1 | B | G2 | C | W | Yel/red splash | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 13 | 0 | 0 | 1.073 | 7.0 |
| 44 | | W | | | | | 38 | 1 | 50 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 9.0 |
| 45 | COMN07-GF299BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 13 | 0 | 13 | 0 | 0 | 0 | 0 | 1.087 | 6.0 |
| 46 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 13 | 0 | 0 | 0 | 13 | 1.071 | 8.0 |
| 47 | COMN07-GF299WG1 | B | G2 | C | W | Cream | 0 | | 38 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.072 | 6.0 |
| 48 | | W | | | | | 0 | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.090 | 6.0 |
| 49 | COMN07-GF307BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.068 | 5.5 |
| 50 | | W | | | | | 0 | | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 63 | 1.070 | 8.0 |
| 51 | COMN07-GF307WG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 5.0 |
| 52 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 0 |
| 53 | COMN07-GF310BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 13 | 0 | 25 | 0 | 0 | 0 | 0 | 1.054 | 3.0 |
| 54 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.064 | 7.0 |
| 55 | COMN07-W203BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 4.5 |
| 56 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 0 |
| 57 | NDMN07-B277BG1 | B | G2 | C | W | W | 0 | | 13 | 0 | 25 | 0 | 0 | 0 | 0 | 13 | 0 | 1.088 | 6.0 |
| 58 | | W | | | | | 0 | | 0 | 0 | 88 | 0 | 0 | 0 | 0 | 0 | 38 | 1.101 | 7.0 |
| 59 | NDMN07-B302BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.100 | 4.0 |
| 60 | | W | | | | | 13 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.100 | 4.5 |
| 61 | NDMN07-B303BG1 | B | G2 | C | W | W | 0 | | 13 | 13 | 0 | 0 | 0 | 13 | 13 | 13 | 0 | 1.083 | 7.0 |
| 62 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 | 1.094 | 7.0 |
| 63 | NDMN07-B309BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 13 | 1.096 | 2.0 |
| 64 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.097 | 3.0 |
| 65 | NDMN07-B311BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 13 | 0 | 25 | 0 | 0 | 0 | 0 | 1.063 | 5.0 |
| 66 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 7.0 |

## Table 4. External & Internal Defects, Gravities & Chip scores of Chipping/FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 67 | NDMN07-B312BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 2.0 |
| 68 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 3.0 |
| 69 | NDMN07-B316WG1 | B | G2 | C | W | Cream | 0 | | 25 | 0 | 0 | 0 | 13 | 13 | 0 | 0 | 0 | 1.062 | 3.0 |
| 70 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.073 | 4.5 |
| 71 | NDMN07-B318WG1 | B | G2 | C | W | Cream | 25 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 3.0 |
| 72 | | W | | | | | 25 | 3 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.083 | 4.5 |
| 73 | NDMN07-B319BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 6.0 |
| 74 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 6.0 |
| 75 | NDMN07-B322BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 25 | 0 | 0 | 1.090 | 2.0 |
| 76 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.099 | 2.0 |
| 77 | NDMN07-B324BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 13 | 38 | 0 | 0 | 0 | 0 | 1.066 | 6.0 |
| 78 | | W | | | | | 0 | | 0 | 0 | 63 | 13 | 13 | 0 | 0 | 0 | 0 | 1.075 | 5.0 |
| 79 | NDMN07-B326BG1 | B | G2 | C | W | Yel-lt. | 13 | 3 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.078 | 3.5 |
| 80 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 4.5 |
| 81 | NDMN07-B330BG1 | B | G2 | C | W | Cream/red splash | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.081 | 4.5 |
| 82 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.094 | 7.0 |
| 83 | NDMN07-GF056BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.067 | 3.0 |
| 84 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 4.5 |
| 85 | NDMN07-GF056WG1 | B | G2 | C | W | Yel-lt. | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1.073 | 2.0 |
| 86 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 13 | 1.088 | 3.5 |
| 87 | NDMN07-GF059WG1 | B | G2 | C | W | W | 75 | 2 | 25 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.076 | 2.0 |
| 88 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 2.0 |
| 89 | NDMN07-GF066BG1 | B | G2 | C | W | W | 0 | | 13 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.075 | 2.0 |
| 90 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.099 | 6.0 |
| 91 | NDMN07-GF071BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 3.0 |
| 92 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 3.0 |
| 93 | NDMN07-GF080BG1 | B | G2 | C | W | W | 13 | 2 | 25 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 1.065 | 2.0 |
| 94 | | W | | | | | 0 | | 0 | 0 | 25 | 13 | 0 | 0 | 0 | 0 | 0 | 1.083 | 8.0 |
| 95 | NDMN07-GF092BG1 | B | G2 | C | W | Cream | 13 | 4 | 0 | 13 | 25 | 0 | 0 | 0 | 0 | 13 | 0 | 1.074 | 3.0 |
| 96 | | W | | | | | 25 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 4.0 |
| 97 | NDMN07-GF106BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 17 | 0 | 0 | 1.087 | 2.5 |
| 98 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 4.5 |
| 99 | NDMN07-GF136BG1 | B | G2 | C | W | W | 13 | 1 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 2.0 |
| 100 | | W | | | | | 13 | 4 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 13 | 1.077 | 3.5 |

## Table 4. External & Internal Defects, Gravities & Chip scores of Chipping/FM clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | Chip |
| 101 | NDMN07-GF150BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 17 | 0 | 33 | 0 | 0 | 0 | 17 | 1.076 | 00 |
| 102 | | W | | | | | 0 | | 50 | 0 | 25 | 0 | 13 | 0 | 0 | 0 | 0 | 1.065 | 6.5 |
| 103 | NDMN07-GF168WG1 | B | G2 | C | W | W | 13 | 4 | 13 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 3.5 |
| 104 | | W | | | | | 0 | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.086 | 4.0 |
| 105 | NDMN07-W152BG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 1.086 | 5.0 |
| 106 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 1.094 | 5.5 |
| 107 | NDMN07-W153BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 83 | 0 | 0 | 0 | 0 | 1.061 | 6.0 |
| 108 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.080 | 0 |
| 109 | NDMN07-W159BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 50 | 0 | 1.077 | 3.5 |
| 110 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 1.090 | 5.0 |
| 111 | NDMN07-W161BG1 | B | G2 | C | W | W | 25 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 1.084 | 3.0 |
| 112 | | W | | | | | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.092 | 4.5 |
| 113 | NDMN07-W162WG1 | B | G2 | C | W | Cream | 88 | 1 | 0 | 0 | 0 | 0 | 25 | 13 | 0 | 0 | 0 | 1.070 | 5.5 |
| 114 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 4.5 |
| 115 | NDMN07-W180WG1 | B | G2 | C | W | W | 0 | | 0 | 0 | 25 | 0 | 13 | 0 | 0 | 0 | 0 | 1.057 | 7.0 |
| 116 | | W | | | | | 0 | | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 0 | 13 | 1.075 | 7.5 |
| 117 | NDMN07-W181WG1 | B | G2 | C | W | W | 0 | | 13 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1.064 | 4.0 |
| 118 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1.077 | 6.0 |
| 119 | NDMN07-W184WG1 | B | G2 | C | W | Cream | 25 | 3 | 0 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 1.078 | 3.5 |
| 120 | | W | | | | | 0 | | 0 | 0 | 13 | 0 | 38 | 0 | 0 | 0 | 0 | 1.089 | 6.0 |
| 121 | NDMN07-W186WG1 | B | G2 | C | W | Cream/red splash | 0 | | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 5.5 |
| 122 | | W | | | | | 0 | | 0 | 0 | 63 | 0 | 0 | 0 | 0 | 0 | 13 | 1.083 | 6.0 |
| 123 | NDMN07-W187BG1 | B | G2 | C | W | Cream | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 13 | 0 | 75 | 1.104 | 5.0 |
| 124 | | W | | | | | 13 | 3 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 1.104 | 5.5 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.

2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 5. Yield data for Chipping/FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 1 | **NorValley** | B | **Chk** | C | W | Cream | 215 | 538.2 | 0 | 0.0 | 215 | 538.2 | 109.7 | 284.8 | 143.7 | 428.5 | 79.6 | 20.4 | 79.6 |
| 2 | | W | | | | | 141 | 342.4 | 0 | 0.0 | 141 | 342.4 | 50.7 | 194.4 | 97.3 | 291.6 | 85.2 | 14.8 | 85.2 |
| 3 | MN 99380-1 | B | G10 | C/FM | W | Yel-dk | 183 | 525.3 | 0 | 0.0 | 183 | 525.3 | 61.6 | 289.0 | 174.8 | 463.8 | 88.3 | 11.7 | 88.3 |
| 4 | | W | | | | | 135 | 271.4 | 0 | 0.0 | 135 | 271.4 | 74.7 | 187.7 | 9.1 | 196.8 | 72.5 | 27.5 | 72.5 |
| 5 | MN 00467-4 | B | G9 | C | W | W | 149 | 494.6 | 0 | 0.0 | 149 | 494.6 | 34.4 | 280.7 | 179.6 | 460.3 | 93.1 | 6.9 | 93.1 |
| 6 | | W | | | | | 126 | 336.3 | 0 | 0.0 | 126 | 336.3 | 42.9 | 187.0 | 106.5 | 293.5 | 87.3 | 12.7 | 87.3 |
| 7 | MN 02 574 | B | G7 | C/FM | W | Yel | 429 | 772.5 | 0 | 0.0 | 429 | 772.5 | 317.4 | 419.1 | 36.0 | 455.1 | 58.9 | 41.1 | 58.9 |
| 8 | | W | | | | | 315 | 491.2 | 0 | 0.0 | 315 | 491.2 | 221.5 | 255.0 | 14.7 | 269.7 | 54.9 | 45.1 | 54.9 |
| 9 | MN 02 582 | B | G7 | C | W | Cream | 304 | 586.4 | 0 | 0.0 | 304 | 586.4 | 177.0 | 362.4 | 47.0 | 409.4 | 69.8 | 30.2 | 69.8 |
| 10 | | W | | | | | 198 | 474.6 | 0 | 0.0 | 198 | 474.6 | 73.5 | 305.0 | 96.1 | 401.1 | 84.5 | 15.5 | 84.5 |
| 11 | MN 02 586 | B | G7 | C/FM | W | Yel-lt | 289 | 570.7 | 0 | 0.0 | 289 | 570.7 | 158.0 | 344.4 | 68.3 | 412.7 | 72.3 | 27.7 | 72.3 |
| 12 | | W | | | | | 214 | 478.3 | 0 | 0.0 | 214 | 478.3 | 91.3 | 314.5 | 72.5 | 387.0 | 80.9 | 19.1 | 80.9 |
| 13 | MN 02 588 | B | G7 | C | W | W | 199 | 466.6 | 0 | 0.0 | 199 | 466.6 | 98.4 | 278.6 | 89.7 | 368.2 | 78.9 | 21.1 | 78.9 |
| 14 | | W | | | | | 159 | 336.3 | 0 | 0.0 | 159 | 336.3 | 80.1 | 227.6 | 28.6 | 256.2 | 76.2 | 23.8 | 76.2 |
| 15 | MN 02 598 | B | G7 | C/FM | W | Yel-lt | 240 | 565.9 | 0 | 0.0 | 240 | 565.9 | 103.3 | 424.3 | 38.4 | 462.7 | 81.8 | 18.2 | 81.8 |
| 16 | | W | | | | | 139 | 335.9 | 1 | 2.1 | 140 | 338.1 | 43.3 | 230.4 | 62.2 | 292.6 | 86.6 | 12.9 | 87.1 |
| 17 | NDMN 03324-4 | B | G6 | C | W | Cream | 190 | 488.8 | 0 | 0.0 | 190 | 488.8 | 92.8 | 222.1 | 173.8 | 396.0 | 81.0 | 19.0 | 81.0 |
| 18 | | W | | | | | 149 | 353.2 | 1 | 2.3 | 150 | 355.4 | 62.6 | 228.3 | 62.3 | 290.6 | 81.8 | 17.7 | 82.3 |
| 19 | COMN 04674-02 | B | G5 | C | W | Cream | 110 | 442.9 | 0 | 0.0 | 110 | 442.9 | 24.8 | 140.9 | 277.2 | 418.1 | 94.4 | 5.6 | 94.4 |
| 20 | | W | | | | | 85 | 309.1 | 3 | 10.2 | 87 | 319.3 | 16.4 | 143.9 | 148.7 | 292.6 | 91.7 | 5.3 | 94.7 |
| 21 | NDMN 04910-01 | B | G5 | C | W | Cream | 243 | 625.3 | 0 | 0.0 | 243 | 625.3 | 108.7 | 358.8 | 157.8 | 516.7 | 82.6 | 17.4 | 82.6 |
| 22 | | W | | | | | 199 | 389.8 | 2 | 4.9 | 201 | 394.7 | 105.4 | 233.2 | 51.1 | 284.4 | 72.1 | 27.0 | 73.0 |
| 23 | NDMN 04911-01 | B | G5 | C | W | W | 193 | 521.6 | 0 | 0.0 | 193 | 521.6 | 78.9 | 303.0 | 139.7 | 442.7 | 84.9 | 15.1 | 84.9 |
| 24 | | W | | | | | 141 | 249.5 | 0 | 0.0 | 141 | 249.5 | 86.1 | 151.1 | 12.3 | 163.4 | 65.5 | 34.5 | 65.5 |
| 25 | NDMN 04960-01 | B | G5 | C | W | W | 140 | 341.7 | 6 | 31.1 | 146 | 372.8 | 67.4 | 198.8 | 75.4 | 274.2 | 73.6 | 19.7 | 80.3 |
| 26 | | W | | | | | 114 | 173.9 | 0 | 0.0 | 114 | 173.9 | 88.3 | 85.7 | 0.0 | 85.7 | 49.3 | 50.7 | 49.3 |
| 27 | WIMN 04844-01 | B | G5 | C | W | Cream | 86 | 249.0 | 0 | 0.0 | 86 | 249.0 | 38.7 | 103.8 | 106.4 | 210.2 | 84.4 | 15.6 | 84.4 |
| 28 | | W | | | | | 108 | 209.5 | 0 | 0.0 | 108 | 209.5 | 60.2 | 118.5 | 30.8 | 149.3 | 71.3 | 28.7 | 71.3 |
| 29 | WIMN 04844-03 | B | G5 | C | W | Yel | 176 | 425.9 | 3 | 12.0 | 179 | 437.9 | 87.0 | 225.7 | 113.3 | 339.0 | 77.4 | 20.4 | 79.6 |
| 30 | | W | | | | | 81 | 158.5 | 0 | 0.0 | 81 | 158.5 | 47.4 | 85.0 | 26.1 | 111.0 | 70.1 | 29.9 | 70.1 |
| 31 | WIMN 04844-06 | B | G5 | C | W | Cream | 89 | 251.9 | 0 | 0.0 | 89 | 251.9 | 38.8 | 120.7 | 92.4 | 213.1 | 84.6 | 15.4 | 84.6 |
| 32 | | W | | | | | 110 | 249.2 | 0 | 0.0 | 110 | 249.2 | 47.5 | 168.8 | 32.9 | 201.7 | 80.9 | 19.1 | 80.9 |
| 33 | WIMN 04855-02 | B | G5 | C | W | Cream | 132 | 409.0 | 7 | 45.9 | 138 | 454.9 | 42.5 | 194.8 | 171.6 | 366.4 | 80.6 | 10.4 | 89.6 |
| 34 | | W | | | | | 98 | 297.7 | 0 | 0.0 | 98 | 297.7 | 29.1 | 145.8 | 122.9 | 268.6 | 90.2 | 9.8 | 90.2 |

## Table 5. Yield data for Chipping/FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Cnt** | **Cwtyld** | **Cnt** | **Cwtyld** | **cnt** | **Cwtyld** | **Cwtyld** | **Cwtyld** | **Cwtyld** | **cwtyld** | **% US #1's** | **%B's** | **%A's** |
| 35 | AOMN 06150-02 | B | G3 | C | W | Cream | 254 | 635.4 | 0 | 0.0 | 254 | 635.4 | 112.2 | 429.7 | 93.5 | 523.2 | 82.3 | 17.7 | 82.3 |
| 36 | | W | | | | | 182 | 287.1 | 0 | 0.0 | 182 | 287.1 | 134.9 | 145.0 | 7.1 | 152.2 | 53.0 | 47.0 | 53.0 |
| 37 | COMN 06471-02 | B | G3 | C/FM | W | Yel | 179 | 306.8 | 0 | 0.0 | 179 | 306.8 | 129.5 | 149.0 | 28.3 | 177.3 | 57.8 | 42.2 | 57.8 |
| 38 | | W | | | | | 161 | 292.1 | 0 | 0.0 | 161 | 292.1 | 97.0 | 171.4 | 23.8 | 195.2 | 66.8 | 33.2 | 66.8 |
| 39 | WIMN 06035-01 | B | G3 | C | W | Cream | 140 | 397.0 | 0 | 0.0 | 140 | 397.0 | 56.6 | 226.3 | 114.1 | 340.4 | 85.7 | 14.3 | 85.7 |
| 40 | | W | | | | | 75 | 181.1 | 2 | 8.5 | 77 | 189.6 | 26.4 | 115.5 | 39.2 | 154.7 | 81.6 | 14.6 | 85.4 |
| 41 | COMN07-B062BG1 | B | G2 | C | W | W | 170 | 554.4 | 2 | 11.0 | 172 | 565.4 | 37.0 | 302.5 | 214.9 | 517.4 | 91.5 | 6.7 | 93.3 |
| 42 | | W | | | | | 110 | 274.9 | 0 | 0.0 | 110 | 274.9 | 31.0 | 205.0 | 38.8 | 243.9 | 88.7 | 11.3 | 88.7 |
| 43 | COMN07-B212BG1 | B | G2 | C | W | Yel/red splash | 240 | 550.4 | 2 | 14.5 | 242 | 564.9 | 117.5 | 295.2 | 137.7 | 432.9 | 76.6 | 21.3 | 78.7 |
| 44 | | W | | | | | 147 | 271.7 | 11 | 25.7 | 158 | 297.4 | 86.8 | 145.3 | 39.5 | 184.9 | 62.2 | 31.9 | 68.1 |
| 45 | COMN07-GF299BG1 | B | G2 | C | W | Cream | 236 | 678.2 | 0 | 0.0 | 236 | 678.2 | 93.5 | 386.0 | 198.8 | 584.8 | 86.2 | 13.8 | 86.2 |
| 46 | | W | | | | | 131 | 379.2 | 0 | 0.0 | 131 | 379.2 | 34.7 | 214.3 | 130.3 | 344.6 | 90.9 | 9.1 | 90.9 |
| 47 | COMN07-GF299WG1 | B | G2 | C | W | Cream | 153 | 404.2 | 10 | 50.4 | 163 | 454.6 | 64.2 | 259.8 | 80.2 | 340.0 | 74.8 | 15.9 | 84.1 |
| 48 | | W | | | | | 176 | 418.2 | 0 | 0.0 | 176 | 418.2 | 65.0 | 227.8 | 125.5 | 353.2 | 84.5 | 15.5 | 84.5 |
| 49 | COMN07-GF307BG1 | B | G2 | C | W | W | 202 | 648.7 | 0 | 0.0 | 202 | 648.7 | 57.1 | 334.9 | 256.6 | 591.6 | 91.2 | 8.8 | 91.2 |
| 50 | | W | | | | | 113 | 354.4 | 0 | 0.0 | 113 | 354.4 | 32.3 | 175.2 | 147.0 | 322.2 | 90.9 | 9.1 | 90.9 |
| 51 | COMN07-GF307WG1 | B | G2 | C | W | W | 121 | 416.0 | 0 | 0.0 | 121 | 416.0 | 39.7 | 159.1 | 217.2 | 376.3 | 90.5 | 9.5 | 90.5 |
| 52 | | W | | | | | 78 | 256.0 | 0 | 0.0 | 78 | 256.0 | 21.7 | 107.0 | 127.3 | 234.3 | 91.5 | 8.5 | 91.5 |
| 53 | COMN07-GF310BG1 | B | G2 | C | W | W | 149 | 454.1 | 0 | 0.0 | 149 | 454.1 | 48.1 | 232.3 | 173.7 | 406.0 | 89.4 | 10.6 | 89.4 |
| 54 | | W | | | | | 99 | 226.7 | 0 | 0.0 | 99 | 226.7 | 49.6 | 114.8 | 62.3 | 177.1 | 78.1 | 21.9 | 78.1 |
| 55 | COMN07-W203BG1 | B | G2 | C | W | Cream | 219 | 609.0 | 0 | 0.0 | 219 | 609.0 | 83.8 | 385.0 | 140.2 | 525.2 | 86.2 | 13.8 | 86.2 |
| 56 | | W | | | | | 163 | 360.8 | 0 | 0.0 | 163 | 360.8 | 87.1 | 225.4 | 48.2 | 273.6 | 75.9 | 24.1 | 75.9 |
| 57 | NDMN07-B277BG1 | B | G2 | C | W | W | 289 | 554.7 | 0 | 0.0 | 289 | 554.7 | 161.0 | 337.1 | 56.6 | 393.7 | 71.0 | 29.0 | 71.0 |
| 58 | | W | | | | | 217 | 289.5 | 0 | 0.0 | 217 | 289.5 | 163.7 | 121.4 | 4.4 | 125.8 | 43.4 | 56.6 | 43.4 |
| 59 | NDMN07-B302BG1 | B | G2 | C | W | W | 289 | 527.5 | 0 | 0.0 | 289 | 527.5 | 213.7 | 297.7 | 16.1 | 313.8 | 59.5 | 40.5 | 59.5 |
| 60 | | W | | | | | 202 | 360.1 | 0 | 0.0 | 202 | 360.1 | 122.0 | 218.6 | 19.4 | 238.0 | 66.1 | 33.9 | 66.1 |
| 61 | NDMN07-B303BG1 | B | G2 | C | W | W | 349 | 474.6 | 0 | 0.0 | 349 | 474.6 | 292.0 | 182.5 | 0.0 | 182.5 | 38.5 | 61.5 | 38.5 |
| 62 | | W | | | | | 243 | 264.6 | 0 | 0.0 | 243 | 264.6 | 196.5 | 68.1 | 0.0 | 68.1 | 25.7 | 74.3 | 25.7 |
| 63 | NDMN07-B309BG1 | B | G2 | C | W | W | 202 | 386.8 | 0 | 0.0 | 202 | 386.8 | 110.4 | 256.1 | 20.4 | 276.4 | 71.5 | 28.5 | 71.5 |
| 64 | | W | | | | | 170 | 216.4 | 0 | 0.0 | 170 | 216.4 | 117.3 | 99.1 | 0.0 | 99.1 | 45.8 | 54.2 | 45.8 |
| 65 | NDMN07-B311BG1 | B | G2 | C | W | Cream | 295 | 795.8 | 0 | 0.0 | 295 | 795.8 | 109.9 | 539.8 | 146.1 | 685.9 | 86.2 | 13.8 | 86.2 |
| 66 | | W | | | | | 164 | 418.8 | 0 | 0.0 | 164 | 418.8 | 59.6 | 229.3 | 129.9 | 359.3 | 85.8 | 14.2 | 85.8 |
| 67 | NDMN07-B312BG1 | B | G2 | C | W | W | 190 | 586.9 | 0 | 0.0 | 190 | 586.9 | 35.1 | 410.6 | 141.3 | 551.8 | 94.0 | 6.0 | 94.0 |
| 68 | | W | | | | | 135 | 298.3 | 0 | 0.0 | 135 | 298.3 | 65.7 | 193.4 | 39.3 | 232.6 | 78.0 | 22.0 | 78.0 |

## Table 5. Yield data for Chipping/FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 69 | NDMN07-B316WG1 | B | G2 | C | W | Cream | 165 | 382.4 | 0 | 0.0 | 165 | 382.4 | 90.6 | 190.6 | 101.1 | 291.8 | 76.3 | 23.7 | 76.3 |
| 70 | | W | | | | | 76 | 241.4 | 0 | 0.0 | 76 | 241.4 | 28.0 | 58.3 | 155.1 | 213.4 | 88.4 | 11.6 | 88.4 |
| 71 | NDMN07-B318WG1 | B | G2 | C | W | Cream | 155 | 480.3 | 4 | 22.6 | 159 | 503.0 | 56.1 | 182.8 | 241.3 | 424.2 | 84.3 | 11.7 | 88.3 |
| 72 | | W | | | | | 139 | 308.6 | 0 | 0.0 | 139 | 308.6 | 75.5 | 155.1 | 77.9 | 233.1 | 75.5 | 24.5 | 75.5 |
| 73 | NDMN07-B319BG1 | B | G2 | C | W | W | 247 | 543.1 | 0 | 0.0 | 247 | 543.1 | 128.9 | 336.8 | 77.3 | 414.1 | 76.3 | 23.7 | 76.3 |
| 74 | | W | | | | | 111 | 297.3 | 0 | 0.0 | 111 | 297.3 | 51.8 | 160.3 | 85.2 | 245.5 | 82.6 | 17.4 | 82.6 |
| 75 | NDMN07-B322BG1 | B | G2 | C | W | Cream | 430 | 658.6 | 0 | 0.0 | 430 | 658.6 | 351.7 | 297.6 | 9.3 | 306.9 | 46.6 | 53.4 | 46.6 |
| 76 | | W | | | | | 258 | 376.5 | 0 | 0.0 | 258 | 376.5 | 193.2 | 178.8 | 4.6 | 183.4 | 48.7 | 51.3 | 48.7 |
| 77 | NDMN07-B324BG1 | B | G2 | C | W | Cream | 146 | 372.4 | 3 | 15.0 | 149 | 387.4 | 48.4 | 259.2 | 64.9 | 324.1 | 83.6 | 13.0 | 87.0 |
| 78 | | W | | | | | 106 | 218.1 | 0 | 0.0 | 106 | 218.1 | 55.5 | 111.2 | 51.5 | 162.6 | 74.6 | 25.4 | 74.6 |
| 79 | NDMN07-B326BG1 | B | G2 | W | W | Yel-lt. | 351 | 565.7 | 0 | 0.0 | 351 | 565.7 | 272.3 | 274.1 | 19.4 | 293.4 | 51.9 | 48.1 | 51.9 |
| 80 | | W | | | | | 247 | 315.1 | 0 | 0.0 | 247 | 315.1 | 200.4 | 114.7 | 0.0 | 114.7 | 36.4 | 63.6 | 36.4 |
| 81 | NDMN07-B330BG1 | B | G2 | C | W | Cream/red splash | 249 | 594.3 | 0 | 0.0 | 249 | 594.3 | 104.0 | 380.1 | 110.2 | 490.3 | 82.5 | 17.5 | 82.5 |
| 82 | | W | | | | | 149 | 361.2 | 0 | 0.0 | 149 | 361.2 | 56.9 | 229.8 | 74.5 | 304.3 | 84.3 | 15.7 | 84.3 |
| 83 | NDMN07-GF056BG1 | B | G2 | C | W | Cream | 114 | 277.9 | 5 | 26.6 | 119 | 304.5 | 37.3 | 224.7 | 15.9 | 240.5 | 79.0 | 13.4 | 86.6 |
| 84 | | W | | | | | 68 | 211.5 | 0 | 0.0 | 68 | 211.5 | 19.2 | 88.2 | 104.2 | 192.3 | 90.9 | 9.1 | 90.9 |
| 85 | NDMN07-GF056WG1 | B | G2 | C | W | Yel-lt. | 143 | 426.5 | 3 | 24.0 | 146 | 450.5 | 61.8 | 166.2 | 198.6 | 364.8 | 81.0 | 14.5 | 85.5 |
| 86 | | W | | | | | 107 | 314.2 | 4 | 28.7 | 111 | 342.9 | 37.4 | 151.8 | 125.0 | 276.8 | 80.7 | 11.9 | 88.1 |
| 87 | NDMN07-GF059WG1 | B | G2 | C | W | W | 206 | 324.0 | 0 | 0.0 | 206 | 324.0 | 157.6 | 161.6 | 4.8 | 166.4 | 51.4 | 48.6 | 51.4 |
| 88 | | W | | | | | 144 | 230.3 | 0 | 0.0 | 144 | 230.3 | 96.0 | 129.9 | 4.4 | 134.3 | 58.3 | 41.7 | 58.3 |
| 89 | NDMN07-GF066BG1 | B | G2 | C | W | W | 151 | 283.3 | 0 | 0.0 | 151 | 283.3 | 101.4 | 167.8 | 14.0 | 181.9 | 64.2 | 35.8 | 64.2 |
| 90 | | W | | | | | 68 | 119.7 | 0 | 0.0 | 68 | 119.7 | 49.1 | 65.2 | 5.4 | 70.6 | 59.0 | 41.0 | 59.0 |
| 91 | NDMN07-GF071BG1 | B | G2 | C | W | Cream | 186 | 339.5 | 0 | 0.0 | 186 | 339.5 | 122.6 | 180.7 | 36.2 | 216.8 | 63.9 | 36.1 | 63.9 |
| 92 | | W | | | | | 231 | 291.7 | 0 | 0.0 | 231 | 291.7 | 178.5 | 108.4 | 4.8 | 113.2 | 38.8 | 61.2 | 38.8 |
| 93 | NDMN07-GF080BG1 | B | G2 | C | W | W | 223 | 435.2 | 0 | 0.0 | 223 | 435.2 | 123.4 | 276.3 | 35.5 | 311.8 | 71.6 | 28.4 | 71.6 |
| 94 | | W | | | | | 93 | 185.9 | 0 | 0.0 | 93 | 185.9 | 54.3 | 108.1 | 23.5 | 131.6 | 70.8 | 29.2 | 70.8 |
| 95 | NDMN07-GF092BG1 | B | G2 | C | W | Cream | 166 | 430.9 | 0 | 0.0 | 166 | 430.9 | 61.9 | 281.5 | 87.5 | 369.0 | 85.6 | 14.4 | 85.6 |
| 96 | | W | | | | | 144 | 286.7 | 0 | 0.0 | 144 | 286.7 | 75.9 | 193.9 | 16.9 | 210.8 | 73.5 | 26.5 | 73.5 |
| 97 | NDMN07-GF106BG1 | B | G2 | C | W | Cream | 98 | 192.6 | 0 | 0.0 | 98 | 192.6 | 58.3 | 119.1 | 15.2 | 134.3 | 69.7 | 30.3 | 69.7 |
| 98 | | W | | | | | 51 | 84.5 | 0 | 0.0 | 51 | 84.5 | 40.5 | 39.6 | 4.4 | 44.0 | 52.1 | 47.9 | 52.1 |
| 99 | NDMN07-GF136BG1 | B | G2 | C | W | W | 145 | 291.7 | 0 | 0.0 | 145 | 291.7 | 95.5 | 151.4 | 44.8 | 196.1 | 67.3 | 32.7 | 67.3 |
| 100 | | W | | | | | 33 | 86.9 | 10 | 43.5 | 43 | 130.3 | 9.7 | 71.8 | 5.3 | 77.1 | 59.2 | 11.2 | 88.8 |
| 101 | NDMN07-GF150BG1 | B | G2 | C | W | Cream | 224 | 372.1 | 0 | 0.0 | 224 | 372.1 | 162.0 | 180.4 | 29.6 | 210.1 | 56.5 | 43.5 | 56.5 |
| 102 | | W | | | | | 185 | 244.4 | 4 | 14.2 | 189 | 258.7 | 139.0 | 105.5 | 0.0 | 105.5 | 40.8 | 56.8 | 43.2 |

## Table 5. Yield data for Chipping/FM clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 103 | NDMN07-GF168WG1 | B | G2 | C | W | W | 272 | 798.8 | 0 | 0.0 | 272 | 798.8 | 93.8 | 414.2 | 290.9 | 705.0 | 88.3 | 11.7 | 88.3 |
| 104 | | W | | | | | 194 | 496.0 | 0 | 0.0 | 194 | 496.0 | 74.1 | 276.4 | 145.5 | 421.9 | 85.1 | 14.9 | 85.1 |
| 105 | NDMN07-W152BG1 | B | G2 | C | W | W | 257 | 634.5 | 0 | 0.0 | 257 | 634.5 | 90.3 | 464.7 | 79.5 | 544.2 | 85.8 | 14.2 | 85.8 |
| 106 | | W | | | | | 156 | 380.8 | 0 | 0.0 | 156 | 380.8 | 66.5 | 201.0 | 113.2 | 314.3 | 82.5 | 17.5 | 82.5 |
| 107 | NDMN07-W153BG1 | B | G2 | C | W | Cream | 286 | 574.4 | 0 | 0.0 | 286 | 574.4 | 171.9 | 361.6 | 41.0 | 402.6 | 70.1 | 29.9 | 70.1 |
| 108 | | W | | | | | 233 | 378.7 | 0 | 0.0 | 233 | 378.7 | 161.3 | 198.4 | 19.0 | 217.4 | 57.4 | 42.6 | 57.4 |
| 109 | NDMN07-W159BG1 | B | G2 | C | W | Cream | 280 | 377.4 | 0 | 0.0 | 280 | 377.4 | 224.8 | 152.6 | 0.0 | 152.6 | 40.4 | 59.6 | 40.4 |
| 110 | | W | | | | | 204 | 249.4 | 0 | 0.0 | 204 | 249.4 | 165.7 | 83.8 | 0.0 | 83.8 | 33.6 | 66.4 | 33.6 |
| 111 | NDMN07-W161BG1 | B | G2 | C | W | W | 232 | 483.5 | 0 | 0.0 | 232 | 483.5 | 114.9 | 313.0 | 55.6 | 368.6 | 76.2 | 23.8 | 76.2 |
| 112 | | W | | | | | 150 | 261.0 | 0 | 0.0 | 150 | 261.0 | 98.2 | 149.4 | 13.4 | 162.8 | 62.4 | 37.6 | 62.4 |
| 113 | NDMN07-W162WG1 | B | G2 | C | W | Cream | 112 | 254.0 | 0 | 0.0 | 112 | 254.0 | 61.1 | 150.5 | 42.4 | 192.9 | 75.9 | 24.1 | 75.9 |
| 114 | | W | | | | | 129 | 256.3 | 0 | 0.0 | 129 | 256.3 | 69.9 | 170.5 | 16.0 | 186.5 | 72.7 | 27.3 | 72.7 |
| 115 | NDMN07-W180WG1 | B | G2 | C | W | W | 106 | 281.8 | 8 | 17.9 | 114 | 299.8 | 47.6 | 123.0 | 111.3 | 234.2 | 78.1 | 16.9 | 83.1 |
| 116 | | W | | | | | 99 | 216.6 | 0 | 0.0 | 99 | 216.6 | 49.0 | 131.9 | 35.7 | 167.6 | 77.4 | 22.6 | 77.4 |
| 117 | NDMN07-W181WG1 | B | G2 | C | W | W | 226 | 434.3 | 6 | 32.9 | 232 | 467.2 | 132.2 | 269.5 | 32.6 | 302.1 | 64.7 | 30.4 | 69.6 |
| 118 | | W | | | | | 185 | 297.9 | 1 | 5.5 | 186 | 303.4 | 113.5 | 175.5 | 8.9 | 184.4 | 60.8 | 38.1 | 61.9 |
| 119 | NDMN07-W184WG1 | B | G2 | C | W | Cream | 169 | 494.3 | 0 | 0.0 | 169 | 494.3 | 61.0 | 251.4 | 181.9 | 433.3 | 87.7 | 12.3 | 87.7 |
| 120 | | W | | | | | 131 | 266.5 | 0 | 0.0 | 131 | 266.5 | 71.9 | 161.7 | 32.9 | 194.6 | 73.0 | 27.0 | 73.0 |
| 121 | NDMN07-W186WG1 | B | G2 | C | W | Cream/red splash | 267 | 613.7 | 0 | 0.0 | 267 | 613.7 | 129.5 | 383.9 | 100.3 | 484.2 | 78.9 | 21.1 | 78.9 |
| 122 | | W | | | | | 175 | 328.6 | 0 | 0.0 | 175 | 328.6 | 105.0 | 182.9 | 40.7 | 223.6 | 68.0 | 32.0 | 68.0 |
| 123 | NDMN07-W187BG1 | B | G2 | C | W | Cream | 267 | 613.7 | 0 | 0.0 | 267 | 613.7 | 129.5 | 383.9 | 100.3 | 484.2 | 78.9 | 21.1 | 78.9 |
| 124 | | W | | | | | 175 | 328.6 | 0 | 0.0 | 175 | 328.6 | 105.0 | 182.9 | 40.7 | 223.6 | 68.0 | 32.0 | 68.0 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.
2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 6. Common Scab & LB disease resistance values for Chipping/FM clones grown in Becker & Rosemount, MN, respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Trial | Mkt | Skin | Flesh | | Rep 1 | Rep 2 | Final |
| 1 | **Atlantic** | **Chk** | C | W | Cream | 4.7 | H | H | 9.0 |
| 2 | **NorValley** | **Chk** | C | W | Cream | 4.5 | H | M | 9.0 |
| 3 | **Superior** | **Chk** | C | W | W | 4.0 | L | M | N/A |
| 4 | MN 99380-1 | G10 | C/FM | W | Yel-dk | 4.0 | L | L | 9.0 |
| 5 | MN 00467-4 | G9 | C | W | W | 2.5 | M | L | 9.0 |
| 6 | MN 02 574 | G7 | C/FM | W | Yel | 5.0 | L | H | 9.0 |
| 7 | MN 02 582 | G7 | C | W | Cream | 4.5 | H | H | 9.0 |
| 8 | MN 02 586 | G7 | C/FM | W | Yel-lt | 4.5 | H | H | 9.0 |
| 9 | MN 02 588 | G7 | C | W | W | 4.0 | L | H | 9.0 |
| 10 | MN 02 598 | G7 | C/FM | W | Yel-lt | 5.0 | M | H | 9.0 |
| 11 | MN 02 696 | G7 | C | W | W | N/A | N/A | N/A | 9.0 |
| 12 | WIMN 04844-07 | G5 | C/FM | W | Yel | N/A | N/A | N/A | 9.0 |
| 13 | NDMN 03324-4 | G6 | C | W | Cream | 3.0 | L | L | 9.0 |
| 14 | COMN 04674-02 | G5 | C | W | Cream | 4.0 | H | H | 9.0 |
| 15 | NDMN 04910-01 | G5 | C | W | Cream | 4.0 | H | H | 9.0 |
| 16 | NDMN 04911-01 | G5 | C | W | W | 3.5 | L | H | 9.0 |
| 17 | NDMN 04960-01 | G5 | C | W | W | 5.0 | H | H | 9.0 |
| 18 | WIMN 04844-01 | G5 | C | W | Cream | 4.0 | L | H | 9.0 |
| 19 | WIMN 04844-03 | G5 | C | W | Yel | 5.0 | M | N/A | 8.5 |
| 20 | WIMN 04844-06 | G5 | C | W | Cream | 3.5 | H | H | 9.0 |
| 21 | WIMN 04855-02 | G5 | C | W | Cream | 2.0 | T | H | 9.0 |
| 22 | AOMN 06150-02 | G3 | C | W | Cream | 4.0 | L | L | 9.0 |
| 23 | COMN 06471-02 | G3 | C/FM | W | Yel | 4.0 | H | M | 8.0 |
| 24 | WIMN 06035-01 | G3 | C | W | Cream | 5.0 | H | H | 9.0 |
| 25 | COMN07-B062BG1 | G2 | C | W | W | 1.0 | L | N/A | 9.0 |
| 26 | COMN07-B212BG1 | G2 | C | W | Yel/red splash | 4.0 | M | N/A | 9.0 |
| 27 | COMN07-GF299BG1 | G2 | C | W | Cream | 5.0 | M | N/A | 9.0 |
| 28 | COMN07-GF299WG1 | G2 | C | W | Cream | 5.0 | H | N/A | 9.0 |
| 29 | COMN07-GF307BG1 | G2 | C | W | W | 5.0 | H | N/A | 9.0 |
| 30 | COMN07-GF307WG1 | G2 | C | W | W | 5.0 | M | N/A | 9.0 |
| 31 | COMN07-GF310BG1 | G2 | C | W | W | 3.0 | H | N/A | 9.0 |
| 32 | COMN07-W203BG1 | G2 | C | W | Cream | 4.0 | L | N/A | 9.0 |
| 33 | NDMN07-B277BG1 | G2 | C | W | W | 4.0 | L | N/A | 9.0 |
| 34 | NDMN07-B302BG1 | G2 | C | W | W | 5.0 | H | N/A | 9.0 |
| 35 | NDMN07-B303BG1 | G2 | C | W | w | 5.0 | M | N/A | 9.0 |
| 36 | NDMN07-B309BG1 | G2 | C | W | W | 3.0 | M | N/A | 9.0 |
| 37 | NDMN07-B311BG1 | G2 | C | W | Cream | 5.0 | M | N/A | 9.0 |
| 38 | NDMN07-B312BG1 | G2 | C | W | W | 3.0 | M | N/A | 9.0 |
| 39 | NDMN07-B316WG1 | G2 | C | W/Red splash | Cream | 2.0 | L | N/A | 9.0 |
| 40 | NDMN07-B318WG1 | G2 | C | W | Cream | 5.0 | L | N/A | N/A |
| 41 | NDMN07-B319BG1 | G2 | C | W | W | 5.0 | M | N/A | 9.0 |
| 42 | NDMN07-B322BG1 | G2 | C | W | Cream | 5.0 | H | N/A | 9.0 |
| 43 | NDMN07-B324BG1 | G2 | C | W | Cream | 5.0 | M | N/A | 9.0 |
| 44 | NDMN07-B326BG1 | G2 | C | W | Yel-lt. | 5.0 | M | N/A | 9.0 |
| 45 | NDMN07-B330BG1 | G2 | C | W/Red splash | Cream/red splash | 4.0 | H | N/A | 9.0 |

## Table 6. Common Scab & LB disease resistance values for Chipping/FM clones grown in Becker & Rosemount, MN, respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Trial | Mkt | Skin | Flesh | | Rep 1 | Rep 2 | Final |
| 46 | NDMN07-GF056BG1 | G2 | C | W | Cream | 5.0 | M | N/A | 9.0 |
| 47 | NDMN07-GF056WG1 | G2 | C | W | Yel-lt. | 4.0 | T | N/A | N/A |
| 48 | NDMN07-GF059WG1 | G2 | C | W | W | 2.0 | M | N/A | 9.0 |
| 49 | NDMN07-GF066BG1 | G2 | C | W | W | 5.0 | M | N/A | 9.0 |
| 50 | NDMN07-GF071BG1 | G2 | C | W | Cream | 4.0 | M | N/A | 9.0 |
| 51 | NDMN07-GF080BG1 | G2 | C | W | W | 5.0 | H | N/A | 9.0 |
| 52 | NDMN07-GF092BG1 | G2 | C | W | Cream | 5.0 | H | N/A | 9.0 |
| 53 | NDMN07-GF106BG1 | G2 | C | W | Cream | 4.0 | H | N/A | 9.0 |
| 54 | NDMN07-GF136BG1 | G2 | C | W | W | 5.0 | M | N/A | 9.0 |
| 55 | NDMN07-GF150BG1 | G2 | C | W | Cream | 2.0 | L | N/A | 9.0 |
| 56 | NDMN07-GF168WG1 | G2 | C | W | W | 5.0 | H | N/A | N/A |
| 57 | NDMN07-W152BG1 | G2 | C | W | W | 4.0 | H | N/A | 9.0 |
| 58 | NDMN07-W153BG1 | G2 | C | W | Cream | 3.0 | H | N/A | 5.0 |
| 59 | NDMN07-W159BG1 | G2 | C | W | Cream | 5.0 | H | N/A | 9.0 |
| 60 | NDMN07-W161BG1 | G2 | C | W | W | 5.0 | L | N/A | 9.0 |
| 61 | NDMN07-W162WG1 | G2 | C | W | Cream | 1.0 | L | N/A | 9.0 |
| 62 | NDMN07-W180WG1 | G2 | C | W | W | 4.0 | H | N/A | 8.0 |
| 63 | NDMN07-W181WG1 | G2 | C | W | W | 4.0 | M | N/A | N/A |
| 64 | NDMN07-W184WG1 | G2 | C | W | Cream | 4.0 | H | N/A | 9.0 |
| 65 | NDMN07-W186WG1 | G2 | C | W | Cream/red splash | 3.0 | T | N/A | 9.0 |
| 66 | NDMN07-W187BG1 | G2 | C | W | Cream | 5.0 | H | N/A | 9.0 |
| 67 | COMN07-B004BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 68 | COMN07-GF298BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 69 | COMN07-GF315BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 70 | COMN07-W201BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 71 | NDMN07-B266BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 72 | NDMN07-B272BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 73 | NDMN07-B289BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 74 | NDMN07-B299BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 75 | NDMN07-W151BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 76 | NDMN07-W160BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |
| 77 | NDMN07-W162WG1 | G2 | C | W | Cream | N/A | N/A | N/A | 9.0 |
| 78 | NDMN07-W173BG1 | G2 | C | W | N/A | N/A | N/A | N/A | 9.0 |

1) **MN Scale =**
0 = No Scab
1= < 1mm
2 = 2 to 3 mm
3 = 3 to 4 mm
4 = 4 to 5 mm
5 = > 5 mm

**Coverage[2]**
T = Trace
L = 1 - 5%
M = 5 to 50%
H = > 50%

3) MN Scale range = 1 - 9.
% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | FF |
| 1 | **Shepody** | B | **Chk** | FF | LW | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 00 |
| 2 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 0 |
| 3 | MN 18747 | B | G16 | FF | LW | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.070 | 00 |
| 4 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 0 |
| 5 | MN 02 419 | B | G7 | FF | LW | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 0 |
| 6 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.092 | 0 |
| 7 | AOMN 041101-01 | B | G5 | FF | LW | W | 0 | | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.062 | 00 |
| 8 | | W | | | | | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 1 |
| 9 | **R. Burbank** | B | **Chk** | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 1.078 | 0 |
| 10 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 2 |
| 11 | MN 15620 | B | G16 | FF | Red | Yel | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 1.082 | 00 |
| 12 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 0 |
| 13 | MN 02 467 | B | G7 | FF/FM | Rus | Yel-lt | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 1.083 | 00 |
| 14 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.086 | 1 |
| 15 | AOMN 03178-2 | B | G6 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 1.071 | 00 |
| 16 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.089 | 1 |
| 17 | COMN 04692-10 | B | G5 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.060 | 000 |
| 18 | | W | | | | | 0 | | 11 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 11 | 1.074 | 1 |
| 19 | COMN 04702-03 | B | G5 | FF | Rus | Cream | 0 | | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.067 | 00 |
| 20 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.075 | 2 |
| 21 | MN 05001-033 | B | G4 | FF | Rus | Cream | 0 | | 20 | 0 | 0 | 10 | 10 | 0 | 0 | 0 | 0 | 1.081 | 00 |
| 22 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.093 | 1 |
| 23 | MN 05001-074 | B | G4 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 1.080 | 00 |
| 24 | | W | | | | | 0 | | 17 | 0 | 0 | 0 | 17 | 0 | 17 | 0 | 0 | 1.086 | 2 |
| 25 | MN 05001-124 | B | G4 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 1.081 | 00 |
| 26 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 1.090 | 2 |
| 27 | AOMN 06077-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 1.079 | 00 |
| 28 | | W | | | | | 0 | | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.091 | 1 |
| 29 | AOMN 06077-03 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.070 | 00 |
| 30 | | W | | | | | 0 | | 17 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 3 |

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Scab** | **Severity** | **GC** | **Knobs** | **Bruised** | **Green** | **HH** | **IN** | **VD** | **BC** | **Bruised** | **SG** | **FF** |
| 31 | AOMN 06107-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 00 |
| 32 | | W | | | | | 0 | | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 33 | AOMN 06118-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 1.067 | 0 |
| 34 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 2 |
| 35 | AOMN 06126-02 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 1.077 | 00 |
| 36 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 2 |
| 37 | AOMN 06131-01 | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.073 | 000 |
| 38 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.084 | 1 |
| 39 | AOMN 06147-05 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.084 | 00 |
| 40 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.092 | 2 |
| 41 | AOMN 06153-01 S.D. | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.064 | 00 |
| 42 | | W | | | | | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 43 | AOMN 06156-02 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 00 |
| 44 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.085 | 1 |
| 45 | AOMN 06162-02 | B | G3 | FF | Rus | Cream | 0 | | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 00 |
| 46 | | W | | | | | 0 | | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 1 |
| 47 | AOMN 06174-01 S.D. | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 00 |
| 48 | | W | | | | | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 1.086 | 1 |
| 49 | COMN 06332-01 | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.086 | 00 |
| 50 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.091 | 1 |
| 51 | COMN 06344-03 | B | G3 | FF/FM | Rus | Yel | 0 | | 0 | 0 | 0 | 20 | 0 | 0 | 10 | 0 | 0 | 1.095 | 00 |
| 52 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.100 | 2 |
| 53 | COMN 06358-02 | B | G3 | FF/FM | Rus | Yel-lt. | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.059 | 00 |
| 54 | | W | | | | | 0 | | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 55 | COMN 06360-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.080 | 0 |
| 56 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.080 | 1 |
| 57 | COMN 06363-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 00 |
| 58 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 1 |
| 59 | COMN 06379-02 | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.095 | 00 |
| 60 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.101 | 1 |

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | FF |
| 61 | COMN 06392-01 | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 00 |
| 62 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.080 | 0 |
| 63 | COMN 06393-01 | B | G3 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.060 | 00 |
| 64 | | W | | | | | 0 | | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.067 | 1 |
| 65 | COMN 06433-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 1.063 | 00 |
| 66 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 67 | MN 061788-01 | B | G3 | FF | Rus | Cream | 0 | | 0 | 20 | 30 | 20 | 20 | 0 | 0 | 0 | 0 | 1.073 | 0 |
| 68 | | W | | | | | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 1.080 | 1 |
| 69 | MN 061910-03 | B | G3 | FF | Rus | Yel | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 1.082 | 00 |
| 70 | | W | | | | | 0 | | 0 | 0 | 27 | 0 | 0 | 0 | 9 | 18 | 18 | 1.091 | 0 |
| 71 | WIMN 06002-02 | B | G3 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.069 | 00 |
| 72 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 2 |
| 73 | COMN07-B021WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 38 | 1.057 | 6.0 |
| 74 | | W | | | | | 0 | | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 33 | 1.079 | 1 |
| 75 | COMN07-B023BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.071 | 00 |
| 76 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 1 |
| 77 | COMN07-B025BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 00 |
| 78 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 1 |
| 79 | COMN07-B028BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.081 | 00 |
| 80 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.089 | 0 |
| 81 | COMN07-B035BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 00 |
| 82 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.085 | 2 |
| 83 | COMN07-B041BG1 | B | G2 | FF | Rus lt. | W | 17 | 4 | 0 | 0 | 17 | 0 | 0 | 0 | 17 | 0 | 17 | 1.079 | 0 |
| 84 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 3 |
| 85 | COMN07-B047BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 86 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.064 | 2 |
| 87 | COMN07-B050BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 1.082 | 2 |
| 88 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 67 | 1.087 | 1 |
| 89 | COMN07-B051BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 00 |
| 90 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.081 | 1 |

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Scab** | **Severity** | **GC** | **Knobs** | **Bruised** | **Green** | **HH** | **IN** | **VD** | **BC** | **Bruised** | **SG** | **FF** |
| 91 | COMN07-B052BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.080 | 2 |
| 92 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.084 | 0 |
| 93 | COMN07-B061BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 1.079 | 00 |
| 94 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 0 |
| 95 | COMN07-B063BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.076 | 00 |
| 96 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 33 | 1.087 | 00 |
| 97 | COMN07-B071BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 17 | 0 | 33 | 0 | 0 | 0 | 0 | 1.078 | 00 |
| 98 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.080 | 1 |
| 99 | COMN07-B083BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.073 | 2 |
| 100 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 33 | 1.072 | 1 |
| 101 | COMN07-B084BG1 | B | G2 | FF | Rus lt. | W | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.089 | 0 |
| 102 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.091 | 3 |
| 103 | COMN07-B087BG1 | B | G2 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 1.080 | 00 |
| 104 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.086 | 0 |
| 105 | COMN07-B095BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.086 | 0 |
| 106 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.086 | 0 |
| 107 | COMN07-B117BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 0 | 50 | 0 | 17 | 0 | 0 | 1.069 | 00 |
| 108 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.085 | 0 |
| 109 | COMN07-B123WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.068 | 1 |
| 110 | | W | | | | | 0 | | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 1.079 | 0 |
| 111 | COMN07-B128WG1 | B | G2 | FF | Rus | Yel | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.069 | 00 |
| 112 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.076 | 2 |
| 113 | COMN07-B132BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 17 | 33 | 17 | 0 | 0 | 0 | 0 | 1.085 | 00 |
| 114 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.092 | 1 |
| 115 | COMN07-B134BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.095 | 0 |
| 116 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 1 |
| 117 | COMN07-B139BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 33 | 17 | 17 | 0 | 0 | 0 | 17 | 1.069 | 1 |
| 118 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 50 | 1.079 | 2 |
| 119 | COMN07-B141BG1 | B | G2 | FF | Rus lt. | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.076 | 00 |
| 120 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.086 | 1 |

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## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | FF |
| 121 | COMN07-B142BG1 | B | G2 | FF | Rus lt. | Cream | 17 | 5 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 17 | 1.079 | 1 |
| 122 | | W | | | | | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.083 | 2 |
| 123 | COMN07-B143BG1 | B | G2 | FF | Rus lt. | Yel | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 00 |
| 124 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.086 | 0 |
| 125 | COMN07-B144BG1 | B | G2 | FF | Rus | Cream | 0 | | 17 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 50 | 1.064 | 0 |
| 126 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 17 | 17 | 1.086 | 0 |
| 127 | COMN07-B149BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 1.078 | 0 |
| 128 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 1.090 | 0 |
| 129 | COMN07-B151BG1 | B | G2 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.073 | 0 |
| 130 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.076 | 1 |
| 131 | COMN07-B153BG1 | B | G2 | FF | Rus lt. | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 0 |
| 132 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 0 |
| 133 | COMN07-GF169WG1 | B | G2 | FF | Rus | Cream | 0 | | 17 | 33 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 1.074 | 0 |
| 134 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 33 | 1.087 | 1 |
| 135 | COMN07-GF170WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 1.067 | 00 |
| 136 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 17 | 0 | 0 | 0 | 0 | 1.091 | 2 |
| 137 | COMN07-GF173BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.072 | 1 |
| 138 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 1 |
| 139 | COMN07-GF174WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 50 | 0 | 33 | 1.081 | 1 |
| 140 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 33 | 50 | 1.083 | 1 |
| 141 | COMN07-GF176BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.084 | 0 |
| 142 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 13 | 1.073 | 8.0 |
| 143 | COMN07-GF179BG1 | B | G2 | FF | Rus | W | 0 | | 17 | 0 | 17 | 17 | 0 | 0 | 0 | 0 | 17 | 1.087 | 00 |
| 144 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.083 | 0 |
| 145 | COMN07-GF180WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.072 | 0 |
| 146 | | W | | | | | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 17 | 1.090 | 0 |
| 147 | COMN07-GF188BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 17 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.075 | 0 |
| 148 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.083 | 1 |
| 149 | COMN07-GF193BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.080 | 0 |
| 150 | | W | | | | | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 1.088 | 00 |

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | FF |
| 151 | COMN07-GF198BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.072 | 2 |
| 152 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.077 | 1 |
| 153 | COMN07-GF203BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.063 | 1 |
| 154 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 33 | 1.064 | 3 |
| 155 | COMN07-GF205BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1.069 | 1 |
| 156 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 33 | 1.071 | 0 |
| 157 | COMN07-GF206BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.083 | 0 |
| 158 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.087 | 00 |
| 159 | COMN07-GF216BG1 | B | G2 | FF | Rus lt. | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.074 | 1 |
| 160 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 1 |
| 161 | COMN07-GF222WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.079 | 1 |
| 162 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 0 |
| 163 | COMN07-W034WG1 | B | G2 | FF | Rus | W | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.091 | 1 |
| 164 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.088 | 2 |
| 165 | COMN07-W048BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.069 | 1 |
| 166 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 2 |
| 167 | COMN07-W067BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.083 | 0 |
| 168 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.084 | 0 |
| 169 | NDMN07-W146BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 1.076 | 00 |
| 170 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.082 | 1 |
| 171 | ORMN07-B257BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 1.083 | 00 |
| 172 | | W | | | | | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 17 | 1.094 | 1 |
| 173 | ORMN07-B258BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 17 | 0 | 33 | 0 | 17 | 1.078 | 1 |
| 174 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.081 | 00 |
| 175 | ORMN07-B260WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.078 | 0 |
| 176 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.089 | 2 |
| 177 | ORMN07-GF011BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 1.079 | 0 |
| 178 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.087 | 0 |
| 179 | ORMN07-GF014BG1 | B | G2 | FF | Rus lt. | W | 0 | | 0 | 0 | 0 | 17 | 0 | 0 | 17 | 0 | 0 | 1.097 | 0 |
| 180 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1.098 | 1 |

## Table 7. External & Internal Defects, Gravities & FF scores of Processing clones grown in 2 irrigated locations in Minnesota[1] & ND[2].

| | | | | | Color | | External Defects (%) | | | | | | Internal Defects (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Scab | Severity | GC | Knobs | Bruised | Green | HH | IN | VD | BC | Bruised | SG | FF |
| 181 | ORMN07-W125BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 00 |
| 182 | | W | | | | | 0 | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 50 | 1.085 | 0 |
| 183 | ORMN07-W125WG1 | B | G2 | FF | Rus | W | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 00 |
| 184 | | W | | | | | 0 | | 0 | 0 | 117 | 0 | 17 | 0 | 0 | 0 | 0 | 1.089 | 0 |
| 185 | ORMN07-W127WG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.071 | 00 |
| 186 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.090 | 00 |
| 187 | ORMN07-W128BG1 | B | G2 | FF | Rus | Cream | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.075 | 0 |
| 188 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 1.088 | 0 |
| 189 | ORMN07-W129WG1 | B | G2 | FF | Rus | W | 0 | | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.083 | 000 |
| 190 | | W | | | | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.099 | 0 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.

2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 1 | **Shepody** | B | **Chk** | FF | LW | W | 132 | 542.3 | 4 | 10.0 | 136 | 552.3 | 29.3 | 187.8 | 325.2 | 513.0 | 92.9 | 5.4 | 94.6 |
| 2 | | W | | | | | 110 | 448.0 | 1 | 5.8 | 111 | 453.9 | 16.6 | 151.3 | 280.2 | 431.5 | 95.1 | 3.7 | 96.3 |
| 3 | MN 18747 | B | G16 | FF | LW | W | 152 | 576.3 | 0 | 0.0 | 152 | 576.3 | 49.6 | 201.6 | 325.1 | 526.7 | 91.4 | 8.6 | 91.4 |
| 4 | | W | | | | | 97 | 303.9 | 0 | 0.0 | 97 | 303.9 | 25.5 | 159.9 | 118.6 | 278.4 | 91.6 | 8.4 | 91.6 |
| 5 | MN 02 419 | B | G7 | FF | LW | Cream | 149 | 456.9 | 0 | 0.0 | 149 | 456.9 | 44.5 | 249.6 | 162.8 | 412.4 | 90.3 | 9.7 | 90.3 |
| 6 | | W | | | | | 105 | 232.3 | 0 | 0.0 | 105 | 232.3 | 41.7 | 171.4 | 19.2 | 190.6 | 82.0 | 18.0 | 82.0 |
| 7 | AOMN 041101-01 | B | G5 | FF | LW | W | 124 | 504.0 | 0 | 0.0 | 124 | 504.0 | 22.4 | 189.1 | 292.5 | 481.6 | 95.6 | 4.4 | 95.6 |
| 8 | | W | | | | | 96 | 316.8 | 0 | 0.0 | 96 | 316.8 | 13.1 | 177.1 | 126.7 | 303.8 | 95.9 | 4.1 | 95.9 |
| 9 | | | | | | | | | | | | | | | | | | | |
| 10 | **R. Burbank** | B | **Chk** | FF | Rus | Cream | 207 | 696.6 | 9 | 29.6 | 216 | 726.3 | 62.3 | 301.3 | 333.0 | 634.3 | 87.3 | 8.9 | 91.1 |
| 11 | | W | | | | | 167 | 503.3 | 2 | 4.4 | 169 | 507.7 | 41.5 | 280.5 | 181.3 | 461.9 | 91.0 | 8.2 | 91.8 |
| 12 | **R. Norkotah** | B | **Chk** | FM | Rus | Cream | 156 | 561.4 | 7 | 27.5 | 163 | 588.9 | 43.1 | 228.5 | 289.8 | 518.3 | 88.0 | 7.7 | 92.3 |
| 13 | | W | | | | | 138 | 462.7 | 1 | 2.3 | 138 | 465.0 | 31.9 | 223.0 | 207.9 | 430.9 | 92.7 | 6.9 | 93.1 |
| 14 | MN 15620 | B | G16 | FF | Red | Yel | 207 | 585.6 | 4 | 7.2 | 211 | 592.8 | 81.4 | 315.2 | 189.0 | 504.2 | 85.1 | 13.9 | 86.1 |
| 15 | | W | | | | | 122 | 379.7 | 0 | 0.0 | 122 | 379.7 | 27.2 | 224.6 | 127.9 | 352.6 | 92.8 | 7.2 | 92.8 |
| 16 | MN 02 467 | B | G7 | FM | Rus | Yel-lt | 176 | 668.6 | 1 | 5.5 | 177 | 674.0 | 46.7 | 241.2 | 380.6 | 621.8 | 92.3 | 7.0 | 93.0 |
| 17 | | W | | | | | 127 | 459.9 | 0 | 0.0 | 127 | 459.9 | 22.8 | 198.4 | 238.7 | 437.1 | 95.0 | 5.0 | 95.0 |
| 18 | AOMN 03178-2 | B | G6 | FF | Rus lt. | W | 112 | 430.0 | 0 | 0.0 | 112 | 430.0 | 22.3 | 158.8 | 248.9 | 407.7 | 94.8 | 5.2 | 94.8 |
| 19 | | W | | | | | 80 | 268.8 | 0 | 0.0 | 80 | 268.8 | 14.0 | 133.7 | 121.1 | 254.8 | 94.8 | 5.2 | 94.8 |
| 20 | COMN 04692-10 | B | G5 | FF | Rus | Cream | 183 | 448.3 | 0 | 0.0 | 183 | 448.3 | 72.5 | 296.8 | 79.1 | 375.9 | 83.8 | 16.2 | 83.8 |
| 21 | | W | | | | | 128 | 295.7 | 0 | 0.0 | 128 | 295.7 | 56.6 | 182.8 | 56.3 | 239.1 | 80.9 | 19.1 | 80.9 |
| 22 | COMN 04702-03 | B | G5 | FF | Rus | Cream | 99 | 445.2 | 0 | 0.0 | 99 | 445.2 | 16.6 | 124.2 | 304.3 | 428.6 | 96.3 | 3.7 | 96.3 |
| 23 | | W | | | | | 69 | 224.9 | 0 | 0.0 | 69 | 224.9 | 17.6 | 119.0 | 88.4 | 207.3 | 92.2 | 7.8 | 92.2 |
| 24 | MN 05001-033 | B | G4 | FF | Rus | Cream | 115 | 397.5 | 9 | 46.4 | 124 | 443.9 | 21.8 | 224.2 | 151.5 | 375.7 | 84.6 | 5.5 | 94.5 |
| 25 | | W | | | | | 87 | 274.2 | 1 | 2.0 | 88 | 276.2 | 13.1 | 168.2 | 92.9 | 261.1 | 94.5 | 4.8 | 95.2 |
| 26 | MN 05001-074 | B | G4 | FF | Rus | Cream | 113 | 427.9 | 0 | 0.0 | 113 | 427.9 | 21.4 | 158.9 | 247.6 | 406.5 | 95.0 | 5.0 | 95.0 |
| 27 | | W | | | | | 65 | 202.0 | 0 | 0.0 | 65 | 202.0 | 16.0 | 93.1 | 93.0 | 186.1 | 92.1 | 7.9 | 92.1 |
| 28 | MN 05001-124 | B | G4 | FF | Rus | Cream | 116 | 333.5 | 0 | 0.0 | 116 | 333.5 | 37.5 | 183.9 | 112.1 | 296.0 | 88.7 | 11.3 | 88.7 |
| 29 | | W | | | | | 108 | 252.2 | 0 | 0.0 | 108 | 252.2 | 40.5 | 156.9 | 54.7 | 211.6 | 83.9 | 16.1 | 83.9 |
| 30 | AOMN 06077-01 | B | G3 | FF | Rus | Cream | 173 | 472.2 | 0 | 0.0 | 173 | 472.2 | 74.6 | 239.7 | 157.9 | 397.6 | 84.2 | 15.8 | 84.2 |
| 31 | | W | | | | | 128 | 326.7 | 0 | 0.0 | 128 | 326.7 | 45.5 | 182.4 | 98.8 | 281.2 | 86.1 | 13.9 | 86.1 |
| 32 | AOMN 06077-03 | B | G3 | FF | Rus | Cream | 103 | 402.7 | 0 | 0.0 | 103 | 402.7 | 21.6 | 153.1 | 228.0 | 381.1 | 94.6 | 5.4 | 94.6 |
| 33 | | W | | | | | 65 | 252.6 | 0 | 0.0 | 65 | 252.6 | 13.3 | 83.6 | 155.7 | 239.3 | 94.7 | 5.3 | 94.7 |

## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Cnt** | **Cwtyld** | **Cnt** | **Cwtyld** | **cnt** | **Cwtyld** | **Cwtyld** | **Cwtyld** | **Cwtyld** | **cwtyld** | **% US #1's** | **%B's** | **%A's** |
| 34 | AOMN 06107-01 | B | G3 | FF | Rus | Cream | 110 | 427.4 | 5 | 14.0 | 115 | 441.4 | 24.0 | 136.9 | 266.5 | 403.4 | 91.4 | 5.6 | 94.4 |
| 35 | | W | | | | | 69 | 248.7 | 2 | 9.5 | 71 | 258.3 | 11.6 | 122.3 | 114.8 | 237.1 | 91.8 | 4.7 | 95.3 |
| 36 | AOMN 06118-01 | B | G3 | FF | Rus | Cream | 102 | 442.1 | 1 | 1.7 | 103 | 443.8 | 19.5 | 157.6 | 264.9 | 422.5 | 95.2 | 4.4 | 95.6 |
| 37 | | W | | | | | 58 | 221.0 | 1 | 2.3 | 59 | 223.3 | 11.4 | 77.9 | 131.6 | 209.6 | 93.9 | 5.2 | 94.8 |
| 38 | AOMN 06126-02 | B | G3 | FF | Rus | Cream | 169 | 559.4 | 0 | 0.0 | 169 | 559.4 | 55.4 | 246.0 | 258.0 | 504.0 | 90.1 | 9.9 | 90.1 |
| 39 | | W | | | | | 110 | 331.5 | 0 | 0.0 | 110 | 331.5 | 26.2 | 186.1 | 119.2 | 305.3 | 92.1 | 7.9 | 92.1 |
| 40 | AOMN 06131-01 | B | G3 | FF | Rus | W | 108 | 384.7 | 5 | 25.4 | 113 | 410.1 | 25.9 | 145.4 | 213.4 | 358.8 | 87.5 | 6.7 | 93.3 |
| 41 | | W | | | | | 97 | 322.2 | 1 | 4.7 | 98 | 327.0 | 21.2 | 149.2 | 151.9 | 301.1 | 92.1 | 6.6 | 93.4 |
| 42 | AOMN 06147-05 | B | G3 | FF | Rus | Cream | 115 | 422.4 | 1 | 5.2 | 115 | 427.6 | 26.8 | 178.1 | 217.5 | 395.6 | 92.5 | 6.3 | 93.7 |
| 43 | | W | | | | | 111 | 298.6 | 1 | 1.7 | 112 | 300.2 | 37.0 | 212.8 | 48.8 | 261.6 | 87.1 | 12.4 | 87.6 |
| 44 | AOMN 06153-01 S.D. | B | G3 | FF | Rus | W | 154 | 468.3 | 1 | 3.0 | 155 | 471.3 | 45.9 | 270.6 | 151.8 | 422.3 | 89.6 | 9.8 | 90.2 |
| 45 | | W | | | | | 103 | 291.4 | 0 | 0.0 | 103 | 291.4 | 28.2 | 182.3 | 80.9 | 263.2 | 90.3 | 9.7 | 90.3 |
| 46 | AOMN 06156-02 | B | G3 | FF | Rus | Cream | 88 | 330.5 | 1 | 4.0 | 89 | 334.5 | 25.5 | 109.3 | 195.7 | 305.0 | 91.2 | 7.7 | 92.3 |
| 47 | | W | | | | | 77 | 259.6 | 0 | 0.0 | 77 | 259.6 | 15.4 | 112.4 | 131.8 | 244.2 | 94.1 | 5.9 | 94.1 |
| 48 | AOMN 06162-02 | B | G3 | FF | Rus | Cream | 111 | 327.5 | 23 | 74.1 | 133 | 401.6 | 35.4 | 189.7 | 102.4 | 292.1 | 72.7 | 10.8 | 89.2 |
| 49 | | W | | | | | 49 | 183.7 | 15 | 80.5 | 64 | 264.2 | 4.7 | 86.9 | 92.1 | 179.0 | 67.7 | 2.6 | 97.4 |
| 50 | AOMN 06174-01 S.D. | B | G3 | FF | Rus | Cream | 102 | 357.8 | 0 | 0.0 | 102 | 357.8 | 29.2 | 170.1 | 158.5 | 328.6 | 91.8 | 8.2 | 91.8 |
| 51 | | W | | | | | 103 | 259.7 | 0 | 0.0 | 103 | 259.7 | 40.9 | 163.4 | 55.4 | 218.8 | 84.3 | 15.7 | 84.3 |
| 52 | COMN 06332-01 | B | G3 | FF | Rus | W | 149 | 554.3 | 0 | 0.0 | 149 | 554.3 | 38.3 | 208.0 | 307.9 | 515.9 | 93.1 | 6.9 | 93.1 |
| 53 | | W | | | | | 86 | 283.9 | 1 | 5.2 | 86 | 289.1 | 11.8 | 165.9 | 106.1 | 272.1 | 94.1 | 4.2 | 95.8 |
| 54 | COMN 06344-03 | B | G3 | FF/FM | Rus | Yel | 173 | 505.1 | 0 | 0.0 | 173 | 505.1 | 57.3 | 295.2 | 152.6 | 447.8 | 88.7 | 11.3 | 88.7 |
| 55 | | W | | | | | 129 | 264.9 | 0 | 0.0 | 129 | 264.9 | 61.8 | 171.4 | 31.7 | 203.0 | 76.7 | 23.3 | 76.7 |
| 56 | COMN 06358-02 | B | G3 | FF/FM | Rus | Yel-lt. | 71 | 156.9 | 0 | 0.0 | 71 | 156.9 | 40.6 | 87.9 | 28.4 | 116.4 | 74.2 | 25.8 | 74.2 |
| 57 | | W | | | | | 80 | 178.1 | 4 | 16.3 | 84 | 194.4 | 40.7 | 114.0 | 23.4 | 137.5 | 70.7 | 22.8 | 77.2 |
| 58 | COMN 06360-01 | B | G3 | FF | Rus | Cream | 155 | 479.7 | 0 | 0.0 | 155 | 479.7 | 50.0 | 260.6 | 169.2 | 429.7 | 89.6 | 10.4 | 89.6 |
| 59 | | W | | | | | 131 | 301.5 | 0 | 0.0 | 131 | 301.5 | 61.1 | 159.6 | 80.7 | 240.3 | 79.7 | 20.3 | 79.7 |
| 60 | COMN 06363-01 | B | G3 | FF | Rus | Cream | 126 | 538.4 | 0 | 0.0 | 126 | 538.4 | 25.3 | 176.1 | 337.1 | 513.2 | 95.3 | 4.7 | 95.3 |
| 61 | | W | | | | | 84 | 302.3 | 0 | 0.0 | 84 | 302.3 | 13.7 | 127.4 | 161.2 | 288.6 | 95.5 | 4.5 | 95.5 |
| 62 | COMN 06379-02 | B | G3 | FF | Rus | W | 186 | 536.3 | 0 | 0.0 | 186 | 536.3 | 71.5 | 304.9 | 159.8 | 464.7 | 86.7 | 13.3 | 86.7 |
| 63 | | W | | | | | 81 | 229.5 | 1 | 1.9 | 81 | 231.5 | 27.6 | 120.6 | 81.4 | 202.0 | 87.3 | 12.0 | 88.0 |
| 64 | COMN 06392-01 | B | G3 | FF | Rus | W | 159 | 526.7 | 0 | 0.0 | 159 | 526.7 | 46.1 | 249.8 | 230.9 | 480.7 | 91.3 | 8.7 | 91.3 |
| 65 | | W | | | | | 121 | 313.7 | 0 | 0.0 | 121 | 313.7 | 38.3 | 216.5 | 59.0 | 275.4 | 87.8 | 12.2 | 87.8 |

## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 66 | COMN 06393-01 | B | G3 | FM | Red | W | 195 | 377.5 | 9 | 31.8 | 204 | 409.2 | 118.2 | 212.3 | 47.0 | 259.3 | 63.4 | 31.3 | 68.7 |
| 67 | | W | | | | | 115 | 189.9 | 5 | 13.0 | 120 | 202.9 | 69.4 | 116.1 | 4.4 | 120.5 | 59.4 | 36.5 | 63.5 |
| 68 | COMN 06433-01 | B | G3 | FF | Rus | Cream | 104 | 470.6 | 0 | 0.0 | 104 | 470.6 | 22.1 | 125.6 | 322.9 | 448.5 | 95.3 | 4.7 | 95.3 |
| 69 | | W | | | | | 90 | 315.0 | 0 | 0.0 | 90 | 315.0 | 10.1 | 157.8 | 147.1 | 304.9 | 96.8 | 3.2 | 96.8 |
| 70 | MN 061788-01 | B | G3 | FF | Rus | Cream | 180 | 536.7 | 3 | 16.1 | 183 | 552.8 | 56.0 | 322.5 | 158.2 | 480.7 | 87.0 | 10.4 | 89.6 |
| 71 | | W | | | | | 144 | 333.2 | 0 | 0.0 | 144 | 333.2 | 64.8 | 208.3 | 60.1 | 268.4 | 80.5 | 19.5 | 80.5 |
| 72 | MN 061910-03 | B | G3 | FF | Rus | Yel | 171 | 570.0 | 1 | 2.3 | 172 | 572.3 | 56.2 | 232.3 | 281.5 | 513.8 | 89.8 | 9.9 | 90.1 |
| 73 | | W | | | | | 102 | 333.8 | 1 | 2.1 | 103 | 335.9 | 25.1 | 129.2 | 179.5 | 308.7 | 91.9 | 7.5 | 92.5 |
| 74 | WIMN 06002-02 | B | G3 | FF | Rus | Cream | 110 | 531.0 | 1 | 3.2 | 111 | 534.3 | 16.8 | 142.8 | 371.4 | 514.2 | 96.2 | 3.2 | 96.8 |
| 75 | | W | | | | | 88 | 270.7 | 0 | 0.0 | 88 | 270.7 | 24.2 | 139.6 | 106.8 | 246.4 | 91.0 | 9.0 | 91.0 |
| 76 | COMN07-B021WG1 | B | G2 | FF | Rus | Cream | 80 | 320.9 | 0 | 0.0 | 80 | 320.9 | 31.1 | 66.2 | 223.6 | 289.8 | 90.3 | 9.7 | 90.3 |
| 77 | | W | | | | | 71 | 247.3 | 0 | 0.0 | 71 | 247.3 | 12.5 | 108.0 | 126.8 | 234.8 | 95.0 | 5.0 | 95.0 |
| 78 | COMN07-B023BG1 | B | G2 | FF | Rus | Cream | 162 | 581.1 | 0 | 0.0 | 162 | 581.1 | 48.9 | 203.0 | 329.2 | 532.2 | 91.6 | 8.4 | 91.6 |
| 79 | | W | | | | | 132 | 336.0 | 0 | 0.0 | 132 | 336.0 | 36.8 | 237.5 | 61.6 | 299.2 | 89.0 | 11.0 | 89.0 |
| 80 | COMN07-B025BG1 | B | G2 | FF | Rus | Cream | 203 | 407.7 | 0 | 0.0 | 203 | 407.7 | 120.4 | 217.6 | 69.6 | 287.3 | 70.5 | 29.5 | 70.5 |
| 81 | | W | | | | | 188 | 267.3 | 0 | 0.0 | 188 | 267.3 | 120.6 | 135.7 | 11.0 | 146.7 | 54.9 | 45.1 | 54.9 |
| 82 | COMN07-B028BG1 | B | G2 | FF | Rus lt. | Cream | 149 | 436.8 | 0 | 0.0 | 149 | 436.8 | 55.2 | 254.2 | 127.5 | 381.7 | 87.4 | 12.6 | 87.4 |
| 83 | | W | | | | | 83 | 201.5 | 1 | 2.6 | 84 | 204.1 | 34.8 | 119.8 | 47.0 | 166.7 | 81.7 | 17.3 | 82.7 |
| 84 | COMN07-B035BG1 | B | G2 | FF | Rus lt. | Cream | 143 | 261.1 | 0 | 0.0 | 143 | 261.1 | 91.7 | 159.9 | 9.5 | 169.4 | 64.9 | 35.1 | 64.9 |
| 85 | | W | | | | | 140 | 250.7 | 0 | 0.0 | 140 | 250.7 | 84.4 | 150.5 | 15.9 | 166.3 | 66.3 | 33.7 | 66.3 |
| 86 | COMN07-B041BG1 | B | G2 | FF | Rus lt. | W | 231 | 739.0 | 0 | 0.0 | 231 | 739.0 | 70.4 | 375.6 | 293.0 | 668.6 | 90.5 | 9.5 | 90.5 |
| 87 | | W | | | | | 143 | 386.1 | 0 | 0.0 | 143 | 386.1 | 48.4 | 228.9 | 108.7 | 337.7 | 87.5 | 12.5 | 87.5 |
| 88 | COMN07-B047BG1 | B | G2 | FF | Rus | Cream | 261 | 588.6 | 0 | 0.0 | 261 | 588.6 | 148.2 | 372.4 | 67.9 | 440.3 | 74.8 | 25.2 | 74.8 |
| 89 | | W | | | | | 95 | 162.0 | 0 | 0.0 | 95 | 162.0 | 60.1 | 97.3 | 4.6 | 101.9 | 62.9 | 37.1 | 62.9 |
| 90 | COMN07-B050BG1 | B | G2 | FF | Rus lt. | Cream | 179 | 637.2 | 2 | 6.5 | 181 | 643.6 | 41.3 | 275.6 | 320.2 | 595.8 | 92.6 | 6.5 | 93.5 |
| 91 | | W | | | | | 110 | 376.2 | 0 | 0.0 | 110 | 376.2 | 19.7 | 187.2 | 169.4 | 356.6 | 94.8 | 5.2 | 94.8 |
| 92 | COMN07-B051BG1 | B | G2 | FF | Rus lt. | Cream | 176 | 725.3 | 0 | 0.0 | 176 | 725.3 | 28.4 | 270.6 | 426.3 | 696.9 | 96.1 | 3.9 | 96.1 |
| 93 | | W | | | | | 108 | 326.2 | 0 | 0.0 | 108 | 326.2 | 27.4 | 188.8 | 109.9 | 298.8 | 91.6 | 8.4 | 91.6 |
| 94 | COMN07-B052BG1 | B | G2 | FF | Rus lt. | Cream | 134 | 376.3 | 0 | 0.0 | 134 | 376.3 | 57.1 | 187.8 | 131.3 | 319.2 | 84.8 | 15.2 | 84.8 |
| 95 | | W | | | | | 103 | 229.1 | 1 | 4.8 | 104 | 233.8 | 48.6 | 145.4 | 35.1 | 180.4 | 77.2 | 21.2 | 78.8 |
| 96 | COMN07-B061BG1 | B | G2 | FF | Rus lt. | Cream | 165 | 605.9 | 0 | 0.0 | 165 | 605.9 | 45.2 | 266.7 | 294.0 | 560.7 | 92.5 | 7.5 | 92.5 |
| 97 | | W | | | | | 127 | 405.7 | 0 | 0.0 | 127 | 405.7 | 43.2 | 169.2 | 193.2 | 362.4 | 89.3 | 10.7 | 89.3 |

## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 98 | COMN07-B063BG1 | B | G2 | FF | Rus | Cream | 233 | 519.6 | 0 | 0.0 | 233 | 519.6 | 139.1 | 312.8 | 67.7 | 380.6 | 73.2 | 26.8 | 73.2 |
| 99 | | W | | | | | 124 | 196.3 | 0 | 0.0 | 124 | 196.3 | 96.1 | 95.8 | 4.5 | 100.3 | 51.1 | 48.9 | 51.1 |
| 100 | COMN07-B071BG1 | B | G2 | FF | Rus | Cream | 110 | 449.0 | 0 | 0.0 | 110 | 449.0 | 27.1 | 148.2 | 273.6 | 421.8 | 94.0 | 6.0 | 94.0 |
| 101 | | W | | | | | 88 | 247.8 | 1 | 10.2 | 89 | 258.0 | 31.6 | 130.5 | 85.7 | 216.2 | 83.8 | 12.7 | 87.3 |
| 102 | COMN07-B083BG1 | B | G2 | FF | Rus lt. | Cream | 127 | 498.5 | 0 | 0.0 | 127 | 498.5 | 16.8 | 254.6 | 227.2 | 481.7 | 96.6 | 3.4 | 96.6 |
| 103 | | W | | | | | 81 | 255.2 | 0 | 0.0 | 81 | 255.2 | 20.6 | 137.4 | 97.2 | 234.6 | 91.9 | 8.1 | 91.9 |
| 104 | COMN07-B084BG1 | B | G2 | FF | Rus lt. | W | 141 | 268.0 | 0 | 0.0 | 141 | 268.0 | 89.4 | 169.5 | 9.2 | 178.7 | 66.7 | 33.3 | 66.7 |
| 105 | | W | | | | | 72 | 98.1 | 0 | 0.0 | 72 | 98.1 | 54.4 | 43.6 | 0.0 | 43.6 | 44.5 | 55.5 | 44.5 |
| 106 | COMN07-B087BG1 | B | G2 | FF | Rus | W | 219 | 575.3 | 0 | 0.0 | 219 | 575.3 | 80.9 | 344.3 | 150.1 | 494.4 | 85.9 | 14.1 | 85.9 |
| 107 | | W | | | | | 105 | 236.7 | 0 | 0.0 | 105 | 236.7 | 41.3 | 167.5 | 27.9 | 195.5 | 82.6 | 17.4 | 82.6 |
| 108 | COMN07-B095BG1 | B | G2 | FF | Rus | Cream | 225 | 571.0 | 0 | 0.0 | 225 | 571.0 | 106.7 | 329.0 | 135.3 | 464.3 | 81.3 | 18.7 | 81.3 |
| 109 | | W | | | | | 174 | 288.5 | 0 | 0.0 | 174 | 288.5 | 106.2 | 172.0 | 10.3 | 182.3 | 63.2 | 36.8 | 63.2 |
| 110 | COMN07-B117BG1 | B | G2 | FF | Rus lt. | Cream | 177 | 531.6 | 0 | 0.0 | 177 | 531.6 | 65.9 | 256.0 | 209.7 | 465.7 | 87.6 | 12.4 | 87.6 |
| 111 | | W | | | | | 116 | 317.9 | 0 | 0.0 | 116 | 317.9 | 38.7 | 164.8 | 114.4 | 279.2 | 87.8 | 12.2 | 87.8 |
| 112 | COMN07-B123WG1 | B | G2 | FF | Rus | Cream | 76 | 151.1 | 0 | 0.0 | 76 | 151.1 | 43.2 | 86.5 | 21.5 | 108.0 | 71.4 | 28.6 | 71.4 |
| 113 | | W | | | | | 45 | 127.1 | 0 | 0.0 | 45 | 127.1 | 11.3 | 64.7 | 51.1 | 115.8 | 91.1 | 8.9 | 91.1 |
| 114 | COMN07-B128WG1 | B | G2 | FF | Rus | Yel | 172 | 508.7 | 0 | 0.0 | 172 | 508.7 | 67.0 | 252.2 | 189.5 | 441.7 | 86.8 | 13.2 | 86.8 |
| 115 | | W | | | | | 104 | 236.9 | 0 | 0.0 | 104 | 236.9 | 54.6 | 140.1 | 42.1 | 182.3 | 77.0 | 23.0 | 77.0 |
| 116 | COMN07-B132BG1 | B | G2 | FF | Rus | Cream | 123 | 369.1 | 0 | 0.0 | 123 | 369.1 | 48.6 | 134.6 | 186.0 | 320.6 | 86.8 | 13.2 | 86.8 |
| 117 | | W | | | | | 107 | 227.6 | 0 | 0.0 | 107 | 227.6 | 50.3 | 147.0 | 30.3 | 177.3 | 77.9 | 22.1 | 77.9 |
| 118 | COMN07-B134BG1 | B | G2 | FF | Rus lt. | Cream | 189 | 533.5 | 0 | 0.0 | 189 | 533.5 | 84.3 | 251.1 | 198.0 | 449.2 | 84.2 | 15.8 | 84.2 |
| 119 | | W | | | | | 131 | 248.0 | 0 | 0.0 | 131 | 248.0 | 76.7 | 142.7 | 28.6 | 171.3 | 69.1 | 30.9 | 69.1 |
| 120 | COMN07-B139BG1 | B | G2 | FF | Rus lt. | Cream | 135 | 356.1 | 0 | 0.0 | 135 | 356.1 | 45.6 | 217.7 | 92.9 | 310.6 | 87.2 | 12.8 | 87.2 |
| 121 | | W | | | | | 108 | 214.3 | 0 | 0.0 | 108 | 214.3 | 53.8 | 150.9 | 9.7 | 160.5 | 74.9 | 25.1 | 74.9 |
| 122 | COMN07-B141BG1 | B | G2 | FF | Rus lt. | W | 141 | 589.4 | 0 | 0.0 | 141 | 589.4 | 36.3 | 168.3 | 384.8 | 553.1 | 93.8 | 6.2 | 93.8 |
| 123 | | W | | | | | 100 | 304.4 | 0 | 0.0 | 100 | 304.4 | 24.4 | 164.7 | 115.3 | 280.0 | 92.0 | 8.0 | 92.0 |
| 124 | COMN07-B142BG1 | B | G2 | FF | Rus lt. | Cream | 138 | 410.7 | 0 | 0.0 | 138 | 410.7 | 51.8 | 203.7 | 155.3 | 358.9 | 87.4 | 12.6 | 87.4 |
| 125 | | W | | | | | 88 | 178.6 | 0 | 0.0 | 88 | 178.6 | 47.2 | 113.5 | 17.9 | 131.4 | 73.6 | 26.4 | 73.6 |
| 126 | COMN07-B143BG1 | B | G2 | FF | Rus lt. | Yel | 215 | 392.3 | 0 | 0.0 | 215 | 392.3 | 134.3 | 219.6 | 38.4 | 258.0 | 65.8 | 34.2 | 65.8 |
| 127 | | W | | | | | 184 | 234.1 | 0 | 0.0 | 184 | 234.1 | 151.3 | 82.8 | 0.0 | 82.8 | 35.4 | 64.6 | 35.4 |
| 128 | COMN07-B144BG1 | B | G2 | FF | Rus | Cream | 149 | 640.2 | 0 | 0.0 | 149 | 640.2 | 29.5 | 208.5 | 402.2 | 610.7 | 95.4 | 4.6 | 95.4 |
| 129 | | W | | | | | 101 | 340.9 | 0 | 0.0 | 101 | 340.9 | 30.0 | 139.9 | 171.0 | 310.8 | 91.2 | 8.8 | 91.2 |

## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 130 | COMN07-B149BG1 | B | G2 | FF | Rus | Cream | 195 | 306.3 | 0 | 0.0 | 195 | 306.3 | 145.1 | 146.4 | 14.7 | 161.2 | 52.6 | 47.4 | 52.6 |
| 131 | | W | | | | | 122 | 224.8 | 0 | 0.0 | 122 | 224.8 | 67.2 | 128.7 | 28.8 | 157.5 | 70.1 | 29.9 | 70.1 |
| 132 | COMN07-B151BG1 | B | G2 | FF | Rus | W | 245 | 598.2 | 0 | 0.0 | 245 | 598.2 | 114.6 | 376.1 | 107.5 | 483.6 | 80.8 | 19.2 | 80.8 |
| 133 | | W | | | | | 101 | 190.6 | 0 | 0.0 | 101 | 190.6 | 56.3 | 102.1 | 32.2 | 134.3 | 70.5 | 29.5 | 70.5 |
| 134 | COMN07-B153BG1 | B | G2 | FF | Rus lt. | W | 162 | 368.3 | 0 | 0.0 | 162 | 368.3 | 89.6 | 209.9 | 68.9 | 278.7 | 75.7 | 24.3 | 75.7 |
| 135 | | W | | | | | 128 | 218.3 | 0 | 0.0 | 128 | 218.3 | 85.0 | 133.3 | 0.0 | 133.3 | 61.1 | 38.9 | 61.1 |
| 136 | COMN07-GF169WG1 | B | G2 | FF | Rus | Cream | 163 | 414.4 | 5 | 16.2 | 168 | 430.6 | 71.6 | 201.7 | 141.1 | 342.8 | 79.6 | 17.3 | 82.7 |
| 137 | | W | | | | | 132 | 347.9 | 12 | 36.8 | 144 | 384.7 | 53.0 | 218.3 | 76.6 | 294.9 | 76.7 | 15.2 | 84.8 |
| 138 | COMN07-GF170WG1 | B | G2 | FF | Rus | Cream | 114 | 357.7 | 0 | 0.0 | 114 | 357.7 | 37.7 | 167.7 | 152.4 | 320.0 | 89.5 | 10.5 | 89.5 |
| 139 | | W | | | | | 115 | 379.8 | 0 | 0.0 | 115 | 379.8 | 26.9 | 168.8 | 184.2 | 352.9 | 92.9 | 7.1 | 92.9 |
| 140 | COMN07-GF173BG1 | B | G2 | FF | Rus | Cream | 100 | 270.3 | 0 | 0.0 | 100 | 270.3 | 39.3 | 148.1 | 82.9 | 231.0 | 85.5 | 14.5 | 85.5 |
| 141 | | W | | | | | 95 | 164.6 | 0 | 0.0 | 95 | 164.6 | 59.6 | 85.6 | 19.4 | 105.1 | 63.8 | 36.2 | 63.8 |
| 142 | COMN07-GF174WG1 | B | G2 | FF | Rus | Cream | 126 | 441.6 | 18 | 105.3 | 144 | 546.8 | 40.6 | 178.8 | 222.2 | 400.9 | 73.3 | 9.2 | 90.8 |
| 143 | | W | | | | | 119 | 388.8 | 0 | 0.0 | 119 | 388.8 | 30.0 | 171.5 | 187.3 | 358.9 | 92.3 | 7.7 | 92.3 |
| 144 | COMN07-GF176BG1 | B | G2 | FF | Rus | Cream | 225 | 478.7 | 0 | 0.0 | 225 | 478.7 | 124.4 | 292.9 | 61.3 | 354.2 | 74.0 | 26.0 | 74.0 |
| 145 | | W | | | | | 146 | 237.0 | 0 | 0.0 | 146 | 237.0 | 101.0 | 131.7 | 4.4 | 136.1 | 57.4 | 42.6 | 57.4 |
| 146 | COMN07-GF179BG1 | B | G2 | FF | Rus | W | 140 | 483.3 | 0 | 0.0 | 140 | 483.3 | 41.6 | 181.6 | 260.1 | 441.7 | 91.4 | 8.6 | 91.4 |
| 147 | | W | | | | | 98 | 325.4 | 0 | 0.0 | 98 | 325.4 | 29.7 | 132.8 | 163.0 | 295.8 | 90.9 | 9.1 | 90.9 |
| 148 | COMN07-GF180WG1 | B | G2 | FF | Rus | Cream | 109 | 358.8 | 0 | 0.0 | 109 | 358.8 | 36.3 | 167.9 | 154.6 | 322.5 | 89.9 | 10.1 | 89.9 |
| 149 | | W | | | | | 77 | 162.5 | 0 | 0.0 | 77 | 162.5 | 28.0 | 116.2 | 18.3 | 134.4 | 82.8 | 17.2 | 82.8 |
| 150 | COMN07-GF188BG1 | B | G2 | FF | Rus | Cream | 226 | 665.1 | 0 | 0.0 | 226 | 665.1 | 65.2 | 390.7 | 209.2 | 599.8 | 90.2 | 9.8 | 90.2 |
| 151 | | W | | | | | 107 | 277.8 | 0 | 0.0 | 107 | 277.8 | 42.2 | 150.1 | 85.5 | 235.6 | 84.8 | 15.2 | 84.8 |
| 152 | COMN07-GF193BG1 | B | G2 | FF | Rus | Cream | 185 | 509.7 | 0 | 0.0 | 185 | 509.7 | 69.9 | 300.4 | 139.4 | 439.8 | 86.3 | 13.7 | 86.3 |
| 153 | | W | | | | | 128 | 240.3 | 0 | 0.0 | 128 | 240.3 | 74.7 | 160.7 | 5.0 | 165.7 | 68.9 | 31.1 | 68.9 |
| 154 | COMN07-GF198BG1 | B | G2 | FF | Rus | Cream | 153 | 553.0 | 0 | 0.0 | 153 | 553.0 | 32.4 | 258.9 | 261.8 | 520.7 | 94.1 | 5.9 | 94.1 |
| 155 | | W | | | | | 129 | 334.8 | 0 | 0.0 | 129 | 334.8 | 44.0 | 225.0 | 65.9 | 290.8 | 86.9 | 13.1 | 86.9 |
| 156 | COMN07-GF203BG1 | B | G2 | FF | Rus | Cream | 91 | 332.5 | 0 | 0.0 | 91 | 332.5 | 22.2 | 121.7 | 188.7 | 310.4 | 93.3 | 6.7 | 93.3 |
| 157 | | W | | | | | 58 | 129.9 | 0 | 0.0 | 58 | 129.9 | 27.0 | 88.5 | 14.3 | 102.9 | 79.2 | 20.8 | 79.2 |
| 158 | COMN07-GF205BG1 | B | G2 | FF | Rus | Cream | 144 | 412.6 | 0 | 0.0 | 144 | 412.6 | 51.1 | 237.6 | 123.9 | 361.5 | 87.6 | 12.4 | 87.6 |
| 159 | | W | | | | | 94 | 160.1 | 0 | 0.0 | 94 | 160.1 | 56.5 | 99.1 | 4.5 | 103.6 | 64.7 | 35.3 | 64.7 |
| 160 | COMN07-GF206BG1 | B | G2 | FF | Rus | Cream | 110 | 359.0 | 0 | 0.0 | 110 | 359.0 | 31.0 | 174.3 | 153.6 | 327.9 | 91.4 | 8.6 | 91.4 |
| 161 | | W | | | | | 98 | 293.8 | 0 | 0.0 | 98 | 293.8 | 26.6 | 158.0 | 109.2 | 267.3 | 91.0 | 9.0 | 91.0 |

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## Table 8. Yield data for Processing clones grown in 2 irrigated locations in MN[1] & ND[2].

| | | | | | Color | | Useable Yld | | Culls | | Total Yld | | < 4 oz | >= 4 < 10 oz | >= 10 oz | US #1's | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Loc | Trial | Mkt | Skin | Flesh | Cnt | Cwtyld | Cnt | Cwtyld | cnt | Cwtyld | Cwtyld | Cwtyld | Cwtyld | cwtyld | % US #1's | %B's | %A's |
| 162 | COMN07-GF216BG1 | B | G2 | FF | Rus lt. | Cream | 198 | 705.8 | 0 | 0.0 | 198 | 705.8 | 41.2 | 337.3 | 327.3 | 664.6 | 94.2 | 5.8 | 94.2 |
| 163 | | W | | | | | 134 | 217.3 | 0 | 0.0 | 134 | 217.3 | 87.6 | 129.7 | 0.0 | 129.7 | 59.7 | 40.3 | 59.7 |
| 164 | COMN07-GF222WG1 | B | G2 | FF | Rus | Cream | 143 | 446.9 | 0 | 0.0 | 143 | 446.9 | 46.1 | 227.7 | 173.1 | 400.8 | 89.7 | 10.3 | 89.7 |
| 165 | | W | | | | | 126 | 264.2 | 0 | 0.0 | 126 | 264.2 | 70.5 | 158.7 | 34.9 | 193.7 | 73.3 | 26.7 | 73.3 |
| 166 | COMN07-W034WG1 | B | G2 | FF | Rus | W | 145 | 509.8 | 0 | 0.0 | 145 | 509.8 | 27.2 | 244.8 | 237.8 | 482.6 | 94.7 | 5.3 | 94.7 |
| 167 | | W | | | | | 84 | 252.1 | 2 | 8.4 | 86 | 260.5 | 22.8 | 139.3 | 89.9 | 229.3 | 88.0 | 9.0 | 91.0 |
| 168 | COMN07-W048BG1 | B | G2 | FF | Rus | Cream | 232 | 668.3 | 2 | 5.4 | 234 | 673.7 | 90.7 | 333.6 | 244.1 | 577.7 | 85.7 | 13.6 | 86.4 |
| 169 | | W | | | | | 173 | 368.1 | 0 | 0.0 | 173 | 368.1 | 82.0 | 223.2 | 62.9 | 286.1 | 77.7 | 22.3 | 77.7 |
| 170 | COMN07-W067BG1 | B | G2 | FF | Rus lt. | Cream | 217 | 634.5 | 0 | 0.0 | 217 | 634.5 | 86.0 | 291.6 | 256.9 | 548.5 | 86.4 | 13.6 | 86.4 |
| 171 | | W | | | | | 157 | 485.9 | 0 | 0.0 | 157 | 485.9 | 49.4 | 213.0 | 223.4 | 436.5 | 89.8 | 10.2 | 89.8 |
| 172 | NDMN07-W146BG1 | B | G2 | FF | WRus | Cream | 243 | 659.7 | 0 | 0.0 | 243 | 659.7 | 98.0 | 383.7 | 178.0 | 561.7 | 85.1 | 14.9 | 85.1 |
| 173 | | W | | | | | 120 | 396.1 | 0 | 0.0 | 120 | 396.1 | 30.8 | 193.6 | 171.7 | 365.3 | 92.2 | 7.8 | 92.2 |
| 174 | ORMN07-B257BG1 | B | G2 | FF | Rus | Cream | 185 | 558.1 | 0 | 0.0 | 185 | 558.1 | 42.7 | 405.2 | 110.2 | 515.4 | 92.4 | 7.6 | 92.4 |
| 175 | | W | | | | | 157 | 382.3 | 0 | 0.0 | 157 | 382.3 | 59.4 | 243.5 | 79.4 | 322.8 | 84.4 | 15.6 | 84.4 |
| 176 | ORMN07-B258BG1 | B | G2 | FF | Rus | Cream | 146 | 323.3 | 0 | 0.0 | 146 | 323.3 | 73.1 | 210.0 | 40.2 | 250.2 | 77.4 | 22.6 | 77.4 |
| 177 | | W | | | | | 46 | 118.6 | 0 | 0.0 | 46 | 118.6 | 19.6 | 64.6 | 34.5 | 99.1 | 83.5 | 16.5 | 83.5 |
| 178 | ORMN07-B260WG1 | B | G2 | FF | Rus | Cream | 156 | 443.4 | 0 | 0.0 | 156 | 443.4 | 66.8 | 214.5 | 162.1 | 376.6 | 84.9 | 15.1 | 84.9 |
| 179 | | W | | | | | 102 | 228.5 | 2 | 5.7 | 104 | 234.2 | 46.4 | 156.9 | 25.1 | 182.1 | 77.8 | 20.3 | 79.7 |
| 180 | ORMN07-GF011BG1 | B | G2 | FF | Rus | Cream | 233 | 698.2 | 0 | 0.0 | 233 | 698.2 | 82.0 | 407.8 | 208.3 | 616.1 | 88.2 | 11.8 | 88.2 |
| 181 | | W | | | | | 181 | 443.7 | 0 | 0.0 | 181 | 443.7 | 76.7 | 241.6 | 125.4 | 367.0 | 82.7 | 17.3 | 82.7 |
| 182 | ORMN07-GF014BG1 | B | G2 | FF | Rus lt. | W | 184 | 522.8 | 0 | 0.0 | 184 | 522.8 | 57.8 | 317.3 | 147.6 | 464.9 | 88.9 | 11.1 | 88.9 |
| 183 | | W | | | | | 129 | 270.0 | 0 | 0.0 | 129 | 270.0 | 67.0 | 157.9 | 45.1 | 203.0 | 75.2 | 24.8 | 75.2 |
| 184 | ORMN07-W125BG1 | B | G2 | FF | Rus | Cream | 114 | 527.1 | 6 | 51.3 | 120 | 578.3 | 10.3 | 141.7 | 375.1 | 516.8 | 89.4 | 1.9 | 98.1 |
| 185 | | W | | | | | 99 | 397.7 | 0 | 0.0 | 99 | 397.7 | 9.1 | 160.2 | 228.4 | 388.6 | 97.7 | 2.3 | 97.7 |
| 186 | ORMN07-W125WG1 | B | G2 | FF | Rus | W | 0 | 0.0 | 73 | 347.9 | 73 | 347.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 187 | | W | | | | | 73 | 284.5 | 0 | 0.0 | 73 | 284.5 | 6.8 | 114.8 | 163.0 | 277.8 | 97.6 | 2.4 | 97.6 |
| 188 | ORMN07-W127WG1 | B | G2 | FF | Rus | Cream | 139 | 464.2 | 2 | 6.5 | 141 | 470.6 | 41.2 | 209.3 | 213.7 | 423.0 | 89.9 | 8.9 | 91.1 |
| 189 | | W | | | | | 115 | 317.3 | 0 | 0.0 | 115 | 317.3 | 38.4 | 164.7 | 114.3 | 279.0 | 87.9 | 12.1 | 87.9 |
| 190 | ORMN07-W128BG1 | B | G2 | FF | Rus | Cream | 124 | 394.0 | 5 | 9.5 | 129 | 403.4 | 39.2 | 209.5 | 145.2 | 354.8 | 87.9 | 9.9 | 90.1 |
| 191 | | W | | | | | 72 | 174.9 | 4 | 19.7 | 76 | 194.7 | 21.7 | 135.5 | 17.8 | 153.3 | 78.7 | 12.4 | 87.6 |
| 192 | ORMN07-W129WG1 | B | G2 | FF | Rus | W | 146 | 390.5 | 4 | 17.8 | 150 | 408.3 | 56.9 | 222.3 | 111.3 | 333.6 | 81.7 | 14.6 | 85.4 |
| 193 | | W | | | | | 142 | 378.9 | 0 | 0.0 | 142 | 378.9 | 50.3 | 229.0 | 99.7 | 328.7 | 86.7 | 13.3 | 86.7 |

1) Becker planted: 8. May & harvested 14.September. Analyzed 17 - 21. Jan.2010 @ 4 mo 55F.

2) Williston planted: 18.May & harvested 6.October. Analyzed 17 - 21.Jan.2010 @ 3 mo 55F.

## Table 9. Common Scab & LB disease resistance values for Processing clones grown in Becker & Rosemount, MN respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Trial** | **Mkt** | **Skin** | **Flesh** | | **Rep 1** | **Rep 2** | **Final** |
| 1 | **Shepody** | **Chk** | FF | LW | W | 4.5 | H | H | 9.0 |
| 2 | MN 18747 | G16 | FF | LW | W | 5.0 | T | H | 9.0 |
| 3 | MN 02 419 | G7 | FF | LW | Cream | 4.5 | H | H | 9.0 |
| 4 | AOMN 041101-01 | G5 | FF | LW | W | 3.5 | L | H | 8.5 |
| 5 | | | | | | | | | |
| 6 | **Ranger Russet** | **Chk** | FF | Rus | Cream | 4.3 | M | H | N/A |
| 7 | **Russet Burbank** | **Chk** | FF | Rus | Cream | 1.7 | T | T | 9.0 |
| 8 | MN 15620 | G16 | FF | Red | Yel | 5.0 | H | H | 9.0 |
| 9 | AOMN 03178-2 | G6 | FF | Rus lt. | W | 3.5 | L | H | 9.0 |
| 10 | COMN 04692-10 | G5 | FF | Rus | Cream | 3.0 | L | M | 9.0 |
| 11 | COMN 04702-03 | G5 | FF | Rus | Cream | 4.0 | H | H | 9.0 |
| 12 | MN 05001-031 | G4 | FF | Rus | Cream | | N/A | N/A | N/A |
| 13 | MN 05001-033 | G4 | FF | Rus | Cream | 5.0 | H | H | 9.0 |
| 14 | MN 05001-074 | G4 | FF | Rus | Cream | 5.0 | M | H | 8.5 |
| 15 | MN 05001-124 | G4 | FF | Rus | Cream | 4.0 | H | N/A | 9.0 |
| 16 | AOMN 06077-01 | G3 | FF | Rus | Cream | 4.0 | L | H | 9.0 |
| 17 | AOMN 06077-03 | G3 | FF | Rus | Cream | 4.0 | M | H | 9.0 |
| 18 | AOMN 06107-01 | G3 | FF | Rus | Cream | 2.0 | T | H | 9.0 |
| 19 | AOMN 06118-01 | G3 | FF | Rus | Cream | 1.5 | T | L | 9.0 |
| 20 | AOMN 06126-02 | G3 | FF | Rus | Cream | 5.0 | H | H | 9.0 |
| 21 | AOMN 06131-01 | G3 | FF | Rus | W | 5.0 | H | L | 9.0 |
| 22 | AOMN 06147-05 | G3 | FF | Rus | Cream | 3.5 | M | H | 8.5 |
| 23 | AOMN 06153-01 S.D. | G3 | FF | Rus | W | 5.0 | H | M | 9.0 |
| 24 | AOMN 06156-02 | G3 | FF | Rus | Cream | 1.5 | 0 | H | 9.0 |
| 25 | AOMN 06162-02 | G3 | FF | Rus | Cream | 1.5 | M | T | 9.0 |
| 26 | AOMN 06174-01 S.D. | G3 | FF | Rus | Cream | 4.0 | T | H | 9.0 |
| 27 | COMN 06332-01 | G3 | FF | Rus | W | 4.5 | H | M | 9.0 |
| 28 | COMN 06344-03 | G3 | FF/FM | Rus | Yel | 4.5 | H | H | 9.0 |
| 29 | COMN 06358-02 | G3 | FF/FM | Rus | Yel-lt. | 2.0 | L | L | 9.0 |
| 30 | COMN 06360-01 | G3 | FF | Rus | Cream | 4.0 | H | H | 9.0 |
| 31 | COMN 06363-01 | G3 | FF | Rus | Cream | 2.5 | L | L | 9.0 |
| 32 | COMN 06379-02 | G3 | FF | Rus | W | 3.5 | M | H | 9.0 |
| 33 | COMN 06392-01 | G3 | FF | Rus | W | 3.5 | H | M | 8.5 |
| 34 | COMN 06393-01 | G3 | FF | Rus | W | 3.5 | H | H | 9.0 |
| 35 | COMN 06433-01 | G3 | FF | Rus | Cream | 3.5 | L | H | 9.0 |
| 36 | MN 061788-01 | G3 | FF | Rus | Cream | 5.0 | M | H | 9.0 |
| 37 | MN 061910-03 | G3 | FF | Rus | Yel | 3.5 | T | H | N/A |
| 38 | WIMN 06002-02 | G3 | FF | Rus | Cream | 3.5 | M | T | 9.0 |
| 39 | COMN07-B001BG1 | G2 | FF | Rus lt. | N/A | N/A | N/A | N/A | 9.0 |
| 40 | COMN07-B018BG1 | G2 | FF | Rus lt. | N/A | N/A | N/A | N/A | 9.0 |
| 41 | COMN07-B021WG1 | G2 | FF | Rus | Cream | 4.0 | H | N/A | N/A |
| 42 | COMN07-B023BG1 | G2 | FF | Rus | Cream | 3.0 | H | N/A | 9.0 |
| 43 | COMN07-B025BG1 | G2 | FF | Rus | Cream | 3.0 | M | N/A | 9.0 |
| 44 | COMN07-B028BG1 | G2 | FF | Rus | Cream | 4.0 | M | N/A | 9.0 |
| 45 | COMN07-B035BG1 | G2 | FF | Rus | Cream | 4.0 | T | N/A | 9.0 |
| 46 | COMN07-B041BG1 | G2 | FF | Rus | W | 5.0 | H | N/A | 9.0 |
| 47 | COMN07-B047BG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |

## Table 9. Common Scab & LB disease resistance values for Processing clones grown in Becker & Rosemount, MN respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Trial | Mkt | Skin | Flesh | | Rep 1 | Rep 2 | Final |
| 48 | COMN07-B049BG1 | G2 | FF | Rus lt. | N/A | N/A | N/A | N/A | N/A |
| 49 | COMN07-B050BG1 | G2 | FF | Rus | Cream | 4.0 | M | N/A | 9.0 |
| 50 | COMN07-B051BG1 | G2 | FF | Rus | Cream | 3.0 | L | N/A | 9.0 |
| 51 | COMN07-B052BG1 | G2 | FF | Rus | Cream | 2.0 | L | N/A | 9.0 |
| 52 | COMN07-B061BG1 | G2 | FF | Rus | Cream | 2.0 | H | N/A | 9.0 |
| 53 | COMN07-B063BG1 | G2 | FF | Rus-lt. | Cream | 5.0 | H | N/A | N/A |
| 54 | COMN07-B063BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 7.0 |
| 55 | COMN07-B071BG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |
| 56 | COMN07-B083BG1 | G2 | FF | Rus | Cream | 4.0 | L | N/A | 9.0 |
| 57 | COMN07-B084BG1 | G2 | FF | Rus | W | 4.0 | M | N/A | N/A |
| 58 | COMN07-B087BG1 | G2 | FF | Rus | W | 4.0 | M | N/A | 9.0 |
| 59 | COMN07-B089BG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | 9.0 |
| 60 | COMN07-B095BG1 | G2 | FF | Rus | Cream | 3.0 | H | N/A | 9.0 |
| 61 | COMN07-B117BG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |
| 62 | COMN07-B120BG1 | G2 | FF | Rus lt. | N/A | N/A | N/A | N/A | 9.0 |
| 63 | COMN07-B123WG1 | G2 | FF | Rus | Cream | 1.0 | L | N/A | N/A |
| 64 | COMN07-B128WG1 | G2 | FF | Rus | Yel | 5.0 | H | N/A | 9.0 |
| 65 | COMN07-B132BG1 | G2 | FF | Rus | Cream | 2.0 | L | N/A | 9.0 |
| 66 | COMN07-B134BG1 | G2 | FF | Rus | Cream | 5.0 | M | N/A | 9.0 |
| 67 | COMN07-B139BG1 | G2 | FF | Rus | Cream | Missing | Missing | Missing | 9.0 |
| 68 | COMN07-B141BG1 | G2 | FF | Rus | W | 5.0 | L | N/A | 9.0 |
| 69 | COMN07-B142BG1 | G2 | FF | Rus | Cream | 4.0 | H | N/A | 9.0 |
| 70 | COMN07-B143BG1 | G2 | FF | Rus | Yel | 4.0 | T | N/A | 9.0 |
| 71 | COMN07-B144BG1 | G2 | FF | Rus | Cream | 1.0 | T | N/A | 9.0 |
| 72 | COMN07-B149BG1 | G2 | FF | Rus | Cream | 3.0 | T | N/A | 9.0 |
| 73 | COMN07-B151BG1 | G2 | FF | Rus | W | 5.0 | H | N/A | 9.0 |
| 74 | COMN07-B153BG1 | G2 | FF | Rus | W | 5.0 | L | N/A | 9.0 |
| 75 | COMN07-GF169WG1 | G2 | FF | Rus | Cream | 2.0 | L | N/A | N/A |
| 76 | COMN07-GF170WG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 8.0 |
| 77 | COMN07-GF173BG1 | G2 | FF | Rus | Cream | 4.0 | H | N/A | 9.0 |
| 78 | COMN07-GF174WG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | N/A |
| 79 | COMN07-GF176BG1 | G2 | FF | Rus | Cream | 4.0 | H | N/A | 9.0 |
| 80 | COMN07-GF179BG1 | G2 | FF | Rus | W | 3.0 | L | N/A | 9.0 |
| 81 | COMN07-GF179WG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 82 | COMN07-GF180WG1 | G2 | FF | Rus | Cream | 4.0 | L | N/A | 9.0 |
| 83 | COMN07-GF184WG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 84 | COMN07-GF186WG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 85 | COMN07-GF188BG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |
| 86 | COMN07-GF189WG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 87 | COMN07-GF193BG1 | G2 | FF | Rus-lt. | Cream | 4.0 | T | N/A | N/A |
| 88 | COMN07-GF193BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 9.0 |
| 89 | COMN07-GF198BG1 | G2 | FF | Rus-lt. | Cream | 4.0 | L | N/A | N/A |
| 90 | COMN07-GF198BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 9.0 |
| 91 | COMN07-GF203BG1 | G2 | FF | Rus | Cream | 2.0 | L | N/A | 9.0 |
| 92 | COMN07-GF205BG1 | G2 | FF | Rus | Cream | 5.0 | T | N/A | 9.0 |
| 93 | COMN07-GF206BG1 | G2 | FF | Rus-lt. | Cream | 2.0 | L | N/A | N/A |
| 94 | COMN07-GF206BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 8.0 |

## Table 9. Common Scab & LB disease resistance values for Processing clones grown in Becker & Rosemount, MN respectively.

| | | | | Color | | Score[1] | Coverage[2] | | LB[3] |
|---|---|---|---|---|---|---|---|---|---|
| Sort 1 | Clone | Trial | Mkt | Skin | Flesh | | Rep 1 | Rep 2 | Final |
| 95 | COMN07-GF216BG1 | G2 | FF | Rus-lt. | Cream | 4.0 | L | N/A | N/A |
| 96 | COMN07-GF216BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 9.0 |
| 97 | COMN07-GF217BG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 98 | COMN07-GF222WG1 | G2 | FF | Rus | Cream | 3.0 | M | N/A | N/A |
| 99 | COMN07-W034WG1 | G2 | FF | Rus | W | 3.0 | L | N/A | 9.0 |
| 100 | COMN07-W048BG1 | G2 | FF | Rus-lt. | Cream | 5.0 | M | N/A | N/A |
| 101 | COMN07-W048BG1 | G2 | FF | Rus-lt. | Cream | N/A | N/A | N/A | 9.0 |
| 102 | COMN07-W067BG1 | G2 | FF | Rus It | Cream | 1.0 | T | N/A | N/A |
| 103 | COMN07-W067BG1 | G2 | FF | Rus It | Cream | N/A | N/A | N/A | 9.0 |
| 104 | COMN07-W199BG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | 9.0 |
| 105 | NDMN07-W146BG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |
| 106 | ORMN07-B257BG1 | G2 | FF | Rus | Cream | 3.0 | M | N/A | 9.0 |
| 107 | ORMN07-B258BG1 | G2 | FF | Rus | Cream | 5.0 | M | N/A | 9.0 |
| 108 | ORMN07-B260WG1 | G2 | FF | Rus | Cream | 5.0 | M | N/A | 9.0 |
| 109 | ORMN07-GF008BG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | 9.0 |
| 110 | ORMN07-GF011BG1 | G2 | FF | Rus | Cream | 4.0 | H | N/A | 9.0 |
| 111 | ORMN07-GF014BG1 | G2 | FF | Rus | W | 4.0 | M | N/A | 9.0 |
| 112 | ORMN07-W124BG1 | G2 | FF | Rus | N/A | N/A | N/A | N/A | N/A |
| 113 | ORMN07-W125BG1 | G2 | FF | Rus | W | 5.0 | M | N/A | 9.0 |
| 114 | ORMN07-W125WG1 | G2 | FF | Rus | W | 5.0 | H | N/A | 9.0 |
| 115 | ORMN07-W127WG1 | G2 | FF | Rus | Cream | 5.0 | H | N/A | 9.0 |
| 116 | ORMN07-W128BG1 | G2 | FF | Rus | Cream | 4.0 | L | N/A | 9.0 |
| 117 | ORMN07-W129WG1 | G2 | FF | Rus | W | 4.0 | H | N/A | N/A |

| | | | |
|---|---|---|---|
| 1) | MN Scale = | 0 = No Scab | **Coverage[2]** |
| | | 1= < 1mm | T = Trace |
| | | 2 = 2 to 3 mm | L = 1 - 5% |
| | | 3 = 3 to 4 mm | M = 5 to 50% |
| | | 4 = 4 to 5 mm | H = > 50% |
| | | 5 = > 5 mm | |

| | |
|---|---|
| 3) | MN Scale range = 1 - 9.<br>% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100 |

## Table 10. Common Scab disease resistance values for NCRPVT & Natl Scab clones grown in Becker, MN.

**Planted: 8.May.2009**
**Scored: 15.Sept.2009**

| | | | | Color | | Score[1] | Coverage[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Trial** | **Mkt** | **Skin** | **Flesh** | | **Rep 1** | **Rep 2** | **Rep 3** |
| 1 | **Atlantic** | **Chk** | C | W | Cream | 4.7 | H | H | H |
| 2 | **NorValley** | **Chk** | C | W | Cream | 4.5 | H | M | N/A |
| 3 | **Superior** | **Chk** | C | W | W | 4.0 | L | M | L |
| 4 | **Ranger Russet** | **Chk** | FF | Rus | Cream | 4.3 | M | H | H |
| 5 | **Russet Burbank** | **Chk** | FF | Rus | Cream | 1.7 | T | T | T |
| 6 | **Shepody** | **Chk** | FF | LW | W | 4.5 | H | H | N/A |
| 7 | **Dk. Red Norland** | **Chk** | FM | Red | W | 3.5 | L | M | N/A |
| 8 | **R. Norkotah** | **Chk** | FM | Rus | Cream | 4.5 | M | H | N/A |
| 9 | **Red LaSoda** | **Chk** | FM | Red | Cream | 5.0 | L | M | N/A |
| 10 | **Red Norland** | **Chk** | FM | Red | W | 4.0 | H | H | N/A |
| 11 | **Y. Gold** | **Chk** | FM | W | Yel | 4.5 | H | H | N/A |
| 12 | ATND98459-1RY | NCR | FM | Red | Yel | 4.0 | M | H | N/A |
| 13 | CV01238-3 | NCR | FF | Rus | Yel | 4.0 | H | H | N/A |
| 14 | CV99073-1 | NCR | FM | Red | x | 4.5 | H | M | N/A |
| 15 | Missaukee (MSJ461-1) | NCR | x | x | x | 4.5 | L | H | N/A |
| 16 | MSL268-D | NCR | x | x | x | 3.5 | H | M | N/A |
| 17 | MSM171-A | NCR | x | x | x | 4.5 | H | H | N/A |
| 18 | MSN170-A | NCR | x | x | x | 3.5 | L | M | N/A |
| 19 | ND028842-1RY | NCR | FM | Red | Yel-lt | 5.0 | L | H | N/A |
| 20 | ND8304-2 | NCR | C | W | W | 5.0 | M | M | N/A |
| 21 | ND8305-1 | NCR | C | W | W | 5.0 | H | H | N/A |
| 22 | W2978-3 | NCR | FM | W | W | 4.5 | M | H | N/A |
| 23 | W5015-12 | NCR | C | W | W | 4.0 | M | H | N/A |
| 24 | W5767-1R | NCR | FM | Red | W | 4.5 | L | H | N/A |
| 25 | WV4992-1 | NCR | FF | Rus | Yel | 5.0 | H | H | N/A |
| 26 | WV5843-6 | NCR | FM | Red | x | 5.0 | L | H | N/A |
| 27 | A0008-1TE | NScab | x | x | x | 1.0 | T | L | T |
| 28 | A00286-3Y | NScab | x | x | x | 4.0 | M | H | H |
| 29 | AC99375-1RU | NScab | x | x | x | 3.0 | T | H | T |
| 30 | AF2497-2 | NScab | x | x | x | 4.0 | H | M | H |
| 31 | AF2936-2 | NScab | x | x | x | 4.7 | T | H | H |
| 32 | AF3000-1 | NScab | x | x | x | 3.3 | M | L | H |
| 33 | B1992-106 | NScab | x | x | x | 2.7 | L | L | T |
| 34 | BNC49-1 | NScab | x | x | x | 3.3 | T | H | H |
| 35 | CO98012-5R | NScab | x | x | x | 5.0 | L | H | M |

| | | | |
|---|---|---|---|
| 1) | **MN Scale =** | 0 = No Scab<br>1= < 1mm<br>2 = 2 to 3 mm<br>3 = 3 to 4 mm<br>4 = 4 to 5 mm<br>5 = > 5 mm | **Coverage[2]**<br>T = Trace<br>L = 1 - 5%<br>M = 5 to 50%<br>H = > 50% |

# Table 10. Common Scab disease resistance values for NCRPVT & Natl Scab clones grown in Becker, MN.

**Planted: 8.May.2009**
**Scored: 15.Sept.2009**

| | | | | Color | | Score[1] | Coverage[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sort 1** | **Clone** | **Trial** | **Mkt** | **Skin** | **Flesh** | | **Rep 1** | **Rep 2** | **Rep 3** |
| 36 | CO98067-7RU | NScab | x | x | x | 2.3 | T | L | T |
| 37 | CO98368-2RU | NScab | x | x | x | 4.0 | H | H | M |
| 38 | MSH228-6 | NScab | x | x | x | 3.0 | H | L | L |
| 39 | MSJ126-9Y | NScab | x | x | x | 3.3 | T | L | M |
| 40 | MSN170-A | NScab | x | x | x | 3.7 | H | M | H |
| 41 | MSQ070-1 | NScab | x | x | x | 3.7 | H | H | H |
| 42 | NDA7985-1R | NScab | x | x | x | 2.7 | L | M | T |
| 43 | PA00N14-2 | NScab | x | x | x | 1.7 | T | M | T |

1) **MN Scale =** {
0 = No Scab
1= < 1mm
2 = 2 to 3 mm
3 = 3 to 4 mm
4 = 4 to 5 mm
5 = > 5 mm

**Coverage[2]**
T = Trace
L = 1 - 5%
M = 5 to 50%
H = > 50%

# Table 11. Late Blight disease resistance values for National Late Blight clones grown in Rosemount, MN.

**Planted: 11.June.2009**
**LB field inoculated: 12.August.2009**
**Final Reading: 16.Sept.2009**

| | | | | | Color | | |
|---|---|---|---|---|---|---|---|
| **Sort 3** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Final[1]** |
| 1 | **Atlantic (All Red)** | Rsmt | **Chk** | FM | Red | Red | 9.0 |
| 2 | **Dk. Red Norland** | Rsmt | **Chk** | FM | Red | W | 9.0 |
| 3 | **R. Norkotah** | Rsmt | **Chk** | FM | Rus | Cream | 9.0 |
| 4 | **Red LaSoda (FILLER)** | Rsmt | **Chk** | FM | Red | Cream | 9.0 |
| 5 | **Red Norland** | Rsmt | **Chk** | FM | Red | W | 9.0 |
| 6 | **Y. Gold** | Rsmt | **Chk** | FM | W | Yel | 9.0 |
| 7 | A0008-1TE | Rsmt | NLB | x | x | x | 9.0 |
| 8 | A00286-3Y | Rsmt | NLB | x | x | x | 8.0 |
| 9 | A00324-1 | Rsmt | NLB | x | x | x | 7.0 |
| 10 | A96814-65LB | Rsmt | NLB | x | x | x | 6.0 |
| 11 | A97066-42LB | Rsmt | NLB | x | x | x | 5.3 |
| 12 | A98345-1 | Rsmt | NLB | x | x | x | 7.7 |
| 13 | A99331-2RY | Rsmt | NLB | x | x | x | 9.0 |
| 14 | AC99375-1RU | Rsmt | NLB | x | x | x | 6.0 |
| 15 | AF2376-5 | Rsmt | NLB | x | x | x | 6.7 |
| 16 | AF2574-1 | Rsmt | NLB | x | x | x | 6.3 |
| 17 | AF3317-15 | Rsmt | NLB | x | x | x | 5.3 |
| 18 | AF4121-3 | Rsmt | NLB | x | x | x | 4.7 |
| 19 | Alpine Russet (A9305-10) | Rsmt | NLB | x | x | x | 9.0 |
| 20 | AO96141-3 | Rsmt | NLB | x | x | x | 9.0 |
| 21 | AO96305-3 | Rsmt | NLB | x | x | x | 9.0 |
| 22 | AO96365-2 | Rsmt | NLB | x | x | x | 9.0 |
| 23 | AWN86514-2 | Rsmt | NLB | x | x | x | 3.3 |
| 24 | B0692-4 | Rsmt | NLB | x | x | x | 4.7 |
| 25 | B0718-3 | Rsmt | NLB | x | x | x | 3.7 |
| 26 | B2152-17 | Rsmt | NLB | x | x | x | 9.0 |
| 27 | B2423-65 | Rsmt | NLB | x | x | x | 5.7 |
| 28 | B2431-23 | Rsmt | NLB | x | x | x | 6.0 |
| 29 | B2492-7 | Rsmt | NLB | x | x | x | 9.0 |
| 30 | B2501-10 | Rsmt | NLB | x | x | x | 9.0 |

| | |
|---|---|
| 1) | MN Scale range = 1 - 9.<br>% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100 |

## Table 11. Late Blight disease resistance values for National Late Blight clones grown in Rosemount, MN.

**Planted: 11.June.2009**
**LB field inoculated: 12.August.2009**
**Final Reading: 16.Sept.2009**

| | | | | Color | | | |
|---|---|---|---|---|---|---|---|
| **Sort 3** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Final[1]** |
| 31 | B2634-3 | Rsmt | NLB | x | x | x | 9.0 |
| 32 | BNC182-5 | Rsmt | NLB | x | x | x | 9.0 |
| 33 | BNC49-1 | Rsmt | NLB | x | x | x | 9.0 |
| 34 | Classic Russet (A95109-1) | Rsmt | NLB | x | x | x | 9.0 |
| 35 | Clearwater Russet (AOA95154-1) | Rsmt | NLB | x | x | x | 8.7 |
| 36 | CO98012-5R | Rsmt | NLB | x | x | x | 9.0 |
| 37 | CO98067-7RU | Rsmt | NLB | x | x | x | 9.0 |
| 38 | CO98368-2RU | Rsmt | NLB | x | x | x | 9.0 |
| 39 | CO99053-3RU | Rsmt | NLB | x | x | x | 7.7 |
| 40 | CO99053-4RU | Rsmt | NLB | x | x | x | 9.0 |
| 41 | CO99100-1RU | Rsmt | NLB | x | x | x | 9.0 |
| 42 | LBR1R2R3R4 | Rsmt | NLB | x | x | x | 7.7 |
| 43 | LBR5 | Rsmt | NLB | x | x | x | 8.7 |
| 44 | LBR7 | Rsmt | NLB | x | x | x | 8.0 |
| 45 | LBR9 | Rsmt | NLB | x | x | x | 9.0 |
| 46 | MSL268-D | Rsmt | NLB | x | x | x | 8.0 |
| 47 | MSM171-A | Rsmt | NLB | x | x | x | 9.0 |
| 48 | MSM182-1 | Rsmt | NLB | x | x | x | 6.3 |
| 49 | MSQ070-1 | Rsmt | NLB | x | x | x | 5.0 |
| 50 | MSQ176-5 | Rsmt | NLB | x | x | x | 6.0 |
| 51 | OR03029-2 | Rsmt | NLB | x | x | x | 6.0 |
| 52 | Owyhee (AO96160-3) | Rsmt | NLB | x | x | x | 9.0 |
| 53 | Patagonia | Rsmt | NLB | x | x | x | 5.7 |
| 54 | Sage (AO06164-1) | Rsmt | NLB | x | x | x | 9.0 |
| 55 | Yukon Gem (NDA5507-3Y) | Rsmt | NLB | x | x | x | 7.3 |
| 56 | Liang 1 | Rsmt | Special | x | x | x | 9.0 |
| 57 | Liang 10 | Rsmt | Special | x | x | x | 7.0 |
| 58 | Liang 12 | Rsmt | Special | x | x | x | 5.0 |
| 59 | Liang 2 | Rsmt | Special | x | x | x | 6.0 |
| 60 | Liang 3 | Rsmt | Special | x | x | x | 9.0 |

| | |
|---|---|
| 1) | MN Scale range = 1 - 9.<br>% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100 |

## Table 11. Late Blight disease resistance values for National Late Blight clones grown in Rosemount, MN.

**Planted: 11.June.2009**
**LB field inoculated: 12.August.2009**
**Final Reading: 16.Sept.2009**

| | | | | | Color | | |
|---|---|---|---|---|---|---|---|
| **Sort 3** | **Clone** | **Loc** | **Trial** | **Mkt** | **Skin** | **Flesh** | **Final[1]** |
| 61 | Liang 4 | Rsmt | Special | x | x | x | 7.0 |
| 62 | Liang 5 | Rsmt | Special | x | x | x | 9.0 |
| 63 | Liang 6 | Rsmt | Special | x | x | x | 5.0 |
| 64 | Liang 7 | Rsmt | Special | x | x | x | 9.0 |
| 65 | Liang 8 | Rsmt | Special | x | x | x | 6.0 |
| 66 | Liang 9 | Rsmt | Special | x | x | x | 9.0 |
| 67 | Liang11 | Rsmt | Special | x | x | x | 9.0 |
| 68 | RB FILLER | Rsmt | Special | x | x | x | 8.0 |
| 69 | SJ1 | Rsmt | Special | x | x | x | 9.0 |
| 70 | SJ10 | Rsmt | Special | x | x | x | 6.0 |
| 71 | SJ11 | Rsmt | Special | x | x | x | 3.0 |
| 72 | SJ12 | Rsmt | Special | x | x | x | 3.0 |
| 73 | SJ13 | Rsmt | Special | x | x | x | 8.0 |
| 74 | SJ14 | Rsmt | Special | x | x | x | 9.0 |
| 75 | SJ15 | Rsmt | Special | x | x | x | 6.0 |
| 76 | SJ16 | Rsmt | Special | x | x | x | 6.0 |
| 77 | SJ17 | Rsmt | Special | x | x | x | 7.0 |
| 78 | SJ18 | Rsmt | Special | x | x | x | 3.0 |
| 79 | SJ19 | Rsmt | Special | x | x | x | 8.0 |
| 80 | SJ2 | Rsmt | Special | x | x | x | 7.0 |
| 81 | SJ20 | Rsmt | Special | x | x | x | 7.0 |
| 82 | SJ21 | Rsmt | Special | x | x | x | 6.0 |
| 83 | SJ22 | Rsmt | Special | x | x | x | 6.0 |
| 84 | SJ23 | Rsmt | Special | x | x | x | 5.0 |
| 85 | SJ24 | Rsmt | Special | x | x | x | 3.0 |
| 86 | SJ3 | Rsmt | Special | x | x | x | 5.0 |
| 87 | SJ4 | Rsmt | Special | x | x | x | 7.0 |
| 88 | SJ5 | Rsmt | Special | x | x | x | 8.0 |
| 89 | SJ6 | Rsmt | Special | x | x | x | 3.0 |
| 90 | SJ7 | Rsmt | Special | x | x | x | 7.0 |
| 91 | SJ8 | Rsmt | Special | x | x | x | 9.0 |
| 92 | SJ9 | Rsmt | Special | x | x | x | 6.0 |

| | |
|---|---|
| 1) | MN Scale range = 1 - 9.<br>% Defoliation; 1=0, 2=0<5, 3=5<15, 4=15<35, 5=35<65, 6=65<85, 7=85<95, 8=95<100, 9=100 |

# Response of Processing Potato Varieties to Nitrogen Source, Rate, and Timing

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**Summary:** A field experiment was conducted at the Sand Plain Research Farm in Becker, Minn. to evaluate the effects of nitrogen rate, source and timing on yield and quality of four processing russet potato varieties/selections: Russet Burbank, Umatilla Russet, Premier Russet, and Bannock Russet. Ten N treatments were evaluated. Six of the ten treatments were conventional N sources with the following N rates (lb/A): 30, 120, 180, 240 (early), 240 (late) and 300. Four of the ten treatments were ESN: 180 and 240 lb N/A preplant and 180 and 240 lb N/A at emergence. A starter N rate of 30 lb N/A as monoammonium phosphate was included in the total N rate applied. Release of N from ESN was similar to that recorded in 2008 and tended to be 20-30 days faster than that recorded prior to 2008, suggesting that the coating may have been more abraded than in previous years. In general, marketable and total yields of all varieties increased with increasing N rate with optimum yield between 240 lb N/A and 300 lb N/A depending on timing and source. For conventional N at the 240 lb N/A rate, more up front N was optimum for all varieties. Unlike 2008 when Umatilla responded favorably to late season applied, Umatilla vines died back early in 2009 due to disease, which apparently prevented efficient use of late season applied N. Russet Burbank tended to be the highest yielding variety followed by Bannock and Premier, and then Umatilla. Premier, Bannock, and Umatilla all had fewer misshaped potatoes than Russet Burbank with Premier having the fewest #2 potatoes. Tubers greater than 6 and 10 oz were highest for Premier followed by Bannock, Russet Burbank and then Umatilla. Hollow heart incidence was highest in Bannock, followed by Premier, Russet Burbank, and then Umatilla. Surface scab incidence was highest with Umatilla, followed by Russet Burbank and then Bannock and Premier. Specific gravity was highest in Russet Burbank and Umatilla, followed by Premier, and then Bannock. Stem and bud end chip color was darkest for Russet Burbank and lowest for Premier. AGT scores were highest for Premier and lowest for Russet Burbank. Stem end glucose concentrations were highest for Russet Burbank followed by Bannock, and then Premier and Umatilla.

**Background:** Studies with ESN, a controlled release N fertilizer, have been conducted for a number of years using ‘Russet Burbank’ as the test cultivar. The main findings have shown that the fertilizer can be used as a substitute for many split applications of UAN with fertigation. In 2008, a study was initiated to evaluate this product as well as characterize N response of some of the newer cultivars available for processing. The cultivars evaluated in 2008 included: ‘Umatilla Russet’, ‘Premier Russet’ from the northwest breeding program and a new selection, AOND95249-1Rus, from the NDSU breeding program. In addition, ‘Russet Burbank’ was included as the conventional cultivar. In 2009, ‘Russet Burbank’, ‘Umatilla Russet’, ‘Premier Russet’ and Bannock Russet (also from the Northwest breeding program) were evaluated. Specific advantages of the new cultivars/selections include better tuber uniformity and less susceptibility to sugar ends. The best results with ESN indicate an early sidedress application provides the best yield and quality. However, there is interest in using ESN as a preplant fertilizer. In previous studies, use of ESN shows the greatest advantage of reducing nitrate leaching when excessive rainfall occurs in May and June. Because the release characteristics of ESN can affect tuber set and bulking of potatoes, evaluation of this new technology is

essential for adoption. The use of newer cultivars in combination with newer cost effective urea coated fertilizer technology has the potential to greatly improve N use efficiency in potato and reduce nitrate losses. Research over different growing seasons is needed to evaluate the N response and use efficiency characteristics of new cultivars in comparison with Russet Burbank, as well as to estimate an N budget (inputs vs. outputs). These data will be useful for growers to more efficiently manage N for these cultivars.
The overall goal of this research is to optimize N fertilizer management for new processing potato cultivars under Minnesota growing conditions. Specific objectives include: a) Determine the effect of N rate and source on tuber yield and quality of new cultivars/selections potato cultivars, and b) Evaluate the effectiveness of a cost-effective coated urea product on tuber yield and quality of the potato cultivars/selections. This is the second year of the study.

## Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6“): pH, 4.9; organic matter, 2.2%; Bray P1, 19 ppm; ammonium acetate extractable K, Ca, and Mg, 62, 319, and 37 ppm, respectively; Ca-phosphate extractable $SO_4$-S, 3.3 ppm; and DTPA extractable Zn, Cu, Fe, and Mn, 1.2, 0.5, 99.1, and 31.6 ppm, respectively. Extractable nitrate-N and ammonium-N in the top 2 ft of soil were 10.9 and 14.1 lb/A, respectively.

Prior to planting, 250 lb/A 0-0-60 and 250 lb/A 0-0-22 were broadcast and incorporated with a moldboard plow. Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole “B” seed of Russet Burbank, and cut “A” seed of Umatilla, Premier, and Bannock were hand planted in furrows on April 24, 2009. Row spacing was 12 inches within each row and 36 inches between rows. Each treatment was replicated four times for each variety in a randomized complete block design. Admire Pro was applied in-furrow for beetle control, along with the systemic fungicides Quadris and Ultra Flourish. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Each cultivar was subjected to ten N treatments with different N sources, rates, and application timing as described in Table 1 below. A complete factorial arrangement was used with cultivar and N treatment as main effects.

Preplant ESN fertilizer was applied 8 days before planting on April 16 and disked in. The 30-lb N/A application at planting as MAP was banded 3 inches to each side and 2 inches below the seed piece using a belt type applicator. For all treatments, banded fertilizer at planting included 130 lb $P_2O_5$/A as monommonium phosphate, 180 lb $K_2O$/A as potassium chloride and potassium magnesium sulfate, and 20 lb Mg/A and 45 lb S/A as potassium magnesium sulfate. Emergence N applications were supplied as urea and mechanically incorporated during hilling. Also at emergence, 950 lb/A gypsum was applied and incorporated into the hill. Post-hilling N was applied by hand as 50%

granular urea-N and 50% ammonium nitrate-N, which was watered-in with overhead irrigation to simulate fertigation with a 28% UAN solution. Emergence fertilizer was applied on May 15 and post-hilling N was applied on June 15, June 25, July 6, and July 16.

A WatchDog weather station from Spectrum Technologies was used to monitor rainfall, air temperature, soil moisture and soil temperature at the fertilizer band depth. Measured amounts of ESN fertilizer were placed in plastic mesh bags and buried at the depth of fertilizer placement when both the preplant and emergence applications were made. Bags were removed on April 28, May 11, May 22, June 3, June 16, July 1, July 22, Aug 12, Sept 23, and Oct 20 to track N release over time. Plant stands and stem number per plant were measured on June 9. Petiole samples were collected from the 4th leaf from the terminal on three dates: June 24, July 7, and July 21. Petioles were analyzed for nitrate-N on a dry weight basis.

Table 1. Nitrogen treatments tested on processing potato varieties.

| Treatment | Preplant | Planting | Emergence | Post-hilling** | Total |
|---|---|---|---|---|---|
| | ------------------------ N sources* and rates (lb N/A) ------------------------ | | | | |
| 1 | 0 | 30 MAP | 0 | 0 | 30 |
| 2 | 0 | 30 MAP | 50 Urea | 10 UAN x 4 | 120 |
| 3 | 0 | 30 MAP | 70 Urea | 20 UAN x 4 | 180 |
| 4 | 0 | 30 MAP | 90 Urea | 30 UAN x 4 | 240 |
| 5 | 0 | 30 MAP | 50 Urea | 40 UAN x 4 | 240 |
| 6 | 0 | 30 MAP | 90 Urea | 45 UAN x 4 | 300 |
| 7 | 150 ESN | 30 MAP | 0 | 0 | 180 |
| 8 | 210 ESN | 30 MAP | 0 | 0 | 240 |
| 9 | 0 | 30 MAP | 150 ESN | 0 | 180 |
| 10 | 0 | 30 MAP | 210 ESN | 0 | 240 |

*ESN = Environmentally Smart Nitrogen (44-0-0), MAP = monoammonium phosphate, urea = 46-0-0, UAN = a combination of granular urea and ammonium nitrate.
**Post-hilling N was applied 4 times at 10-11 day intervals.

Vines were harvested on Sept 22 from two, 10-ft sections of row, followed by mechanically beating the vines over the entire plot area. Plots were machine harvested on Sept 30 and total tuber yield and graded yield were measured. Sub-samples of vines and tubers were collected to determine moisture percentage and N concentrations, which were then used to calculate N uptake and distribution within the plant (Note: all the data for N uptake were not available at the time of this report and therefore will be presented at a later time). Tuber sub-samples were also used to determine tuber specific gravity and the incidence of hollow heart and brown center. Stem and bud end sugar contents after frying were determined after harvest. Additional fry tests will be made after six months of storage at about 45 F.

# RESULTS

## Weather

Rainfall and irrigation for the 2009 growing season are provided in Figure 1. From April 21 to September 22, approximately 13.4 inches of rainfall was supplemented with 16.2 inches of irrigation. There were no leaching events early in the season. Leaching events (greater than 1 inch of water) occurred at 53, 106, and 117 days after planting. Air temperature measurements and soil temperature and moisture measurements in the hill (4-5 inches below the top of the hill) are provided in Figure 2.

## Nitrogen Release from ESN

Figure 3 shows release of N from ESN applied preplant and at emergence. Release of N from ESN tended to be faster than that recorded in previous years. In 2007, approximately 90% of N was released by 70 days after planting for preplanted fertilizer and by 80 days after planting for ESN applied at emergence. In 2008, 80% had been released by 40 days after planting for the preplant application and by about 50 days for the emergence application. In 2009, 80% had been released by 40 days after planting for the preplant application and by about 55 days for the emergence application. Differences in release rate are likely due to difference in abrasion of the coating as well as temperature difference. Temperatures in 2009 were cooler than those in 2008.

## Tuber Yield, Stand Count, Stem Number, and Vine Dry Matter

### *Nitrogen rate, source, and timing comparisons on yield*

Tables 2-5 show the effects of N application rate, source, and timing on tuber yield and size distribution as well as stand count, stem number and vine dry matter at harvest for the four processing varieties. For Russet Burbank (Table 2), marketable and total yields increased with increasing N rate with optimum yield between 240 and 300 lb N/A depending on timing and source. As in 2008, numerically highest total, marketable and #1 yields were with ESN applied preplant at the 240 lb N/A rate. Yields with preplant ESN tended to be higher than those with emergence applied ESN, although these differences were not significant. Within conventional N sources at the 240 lb N/A rate, N applied earlier (treatment 4) resulted in yields that were statistically the same as N applied later in the season (treatment 5). At equivalent N rates, N source did not significantly affect yield. For Umatilla (Table 3), marketable and total yields increased with increasing N rate with optimum yield between 240 to 300 lb N/A depending on timing and source. Numerically highest yields were with conventional N 300 lb N/A rate, while numerically highest total yields were with ESN applied preplant at the 240 lb N/A rate. Yields with preplant ESN tended to be higher than those with emergence applied ESN. At the 240 lb N/A rate, yields with emergence applied ESN tended to be lower than prelant applied ESN and conventional N applied at 300 lb N/A. Within conventional N sources at the 240 lb N/A rate, N applied earlier (treatment 4) resulted in yields that were statistically the same as N applied later in the season (treatment 5). At equivalent N rates, N source did not significantly affect yield. For Premier, (Table 4), marketable and total yields increased with increasing N rate with optimum yield between 180 and 240 lb N/A depending on timing and source. Numerically highest total, marketable and #1 yields were with ESN applied preplant at the 240 lb N/A rate. Yields with preplant ESN were significantly higher than those with emergence applied ESN at the 180 lb N/A rate, but no significant differences due to timing were observed at the 240 lb N/A rate with ESN. Within conventional N sources at the 240 lb N/A rate, N applied earlier (treatment 4) resulted in yields that were statistically the same as N applied later in the season (treatment 5). At equivalent N rates, N source did not significantly affect marketable yield. For Bannock, (Table 5), marketable and total yields increased with increasing N rate with optimum yield between 180 to 240 lb N/A depending on timing and source. Numerically highest total, marketable and #1 yields were with ESN applied preplant at the 240 lb N/A rate. Yields with preplant ESN tended to be higher than those with emergence applied ESN, although statistically there were not differences among the ESN rates or timing tested. Within conventional N sources at the 240 lb N/A rate, N applied later (treatment 4) tended to result in numerically higher yields than N applied earlier in the season (treatment 5), although differences were not statistically significant. At the equivalent N rates, N source/timing did not significantly affect yield; although ESN treatments resulted in smaller tuber size than conventional N treatments. Tubers greater than 10 ounces increased with increasing N rate regardless of source/timing for all varieties.

### *General varietal comparisons for yield*

Russet Burbank tended to be the highest yielding variety followed by Bannock and Premier, and then Umatilla. Premier, Bannock, and Umatilla all had fewer misshaped potatoes than Russet Burbank with Premier having the fewest #2 potatoes. Tubers greater than 6 and 10 oz were highest for Premier followed by Bannock, Russet Burbank and then Umatilla.

### *Nitrogen rate, source, and timing comparisons for stand count, stem number and vine dry matter at harvest*

Stand count was generally not affected by N treatment, although for Premier, there was a slight reduction of 3% in stand in the control and 300 lb N/A rate compared with the other N treatments. Reasons for this reduction are not clear and probably not significant from a practical standpoint. In general, averaged over N treatments, stand was significantly lower for Bannock (~90%) compared with the other three varieties (> 98%). Stems per plant were not significantly affected by N treatments. The highest stem number per plant was with Bannock (4.8) followed by Umatilla (3.5) and then Premier (3.0) and Russet Burbank (2.9). This result is surprising since "B" seed, which usually results in higher stem number, was used for Russet Burbank, while cut "A" seed was used for the other varieties. Vine dry matter at harvest increased with increasing N rate for all varieties regardless of source. For Umatilla, late season N at the 240 lb N/A rate resulted in lower vine yield than early season applied at the same rate. Overall, vines died back earlier for Umatilla than the other varieties resulting in lowest vine yields. It is not know why Umatilla vines died back early, but it was probably due to disease. Early vine dieback in Umatilla resulted in poor utilization of late season applied N.

## Tuber Quality

### *Nitrogen rate, source, and timing comparisons for tuber quality*

Tables 6 to 9 show the effects of N application rate, source, and timing on tuber hollow heart, specific gravity and frying quality for the four processing varieties. Surface scab incidence was not affected by N treatment for any of the varieties. For Russet Burbank (Table 6), incidence of hollow heart ranged from 1 to 12% with inconsistent effects due to N treatment. The 180 lb N/A rate with conventional N resulted in the highest incidence while ESN applied at emergence at 240 lb N/A and the conventional N applied at 300 lb N/A had the lowest incidence. Timing of conventional N at the 240 lb N/A rate did not affect hollow hear in this year. Specific gravity was not affected by treatment and generally in the optimum for all treatments. Stem end chip color was not consistently affected by N treatments, but tended to be lighter with early applied N. It was darker for the control, ESN preplant 180 lb/A and late N 240 lb N/A rate treatments, while lightest for the conventional N at 180, early N at 240 lb N/A and ESN preplant at 240 lb N/A. Stem end AGT score was lowest in the control and highest with conventional N applied at 180 and 300 lb N/A. Stem end sucrose was not affected by treatment. Stem end glucose was highest in the control and lowest with preplant applied ESN at the 240 lb N/A rate. In general, stem end glucose decreased with increasing N rate and late season N tended increase stem end glucose. Bud end chip color, AGT score, sucrose and glucose were not affected by N treatment. For Umatilla (Table 7), incidence of hollow heart was quite low ranging from 0 to 4% with no effect due to N treatment. Specific gravity decreased with increasing conventional N rate and was lowest with late season N and N applied at the 300 lb N/A rate. ESN at the 240 lb N/A rate applied at emergence resulted in the highest specific gravity reading. Stem end chip color, AGT score, and glucose levels were not affected by N treatment. Stem end sucrose decreased with increasing N rate and was lower with preplant applied ESN than planting applied ESN. Bud end chip color, AGT score sucrose and glucose were not affected by treatment. For Premier (Table 8), incidence of hollow heart ranged from 3 to 16% and was not significantly affected by treatment. Specific gravity tended to decrease with increasing conventional N rate and was lowest with late season N and N applied at the 300 lb N/A rate. At equivalent N rates, ESN resulted in higher specific gravity than conventional N. Frying quality was also not affected by treatment. For Bannock (Table 9), incidence of hollow heart ranged from 6 to 15% and was not affected by treatment. Specific gravity ranged from 1.075 to 1.082 and was not affected by N treatment. Frying quality was also not affected by N treatment.

### *General varietal comparisons for tuber quality*

Averaged over N treatments, hollow heart incidence was highest in Bannock, followed by Premier, Russet Burbank, and then Umatilla. Surface scab incidence was highest with Umatilla, followed by Russet Burbank and then Bannock and Premier. Specific gravity was highest in Russet Burbank and Umatilla and followed by Premier and then Bannock.

Stem and bud chip color was darkest for Russet Burbank and lowest for Premier. AGT scores were highest for Premier and lowest for Russet Burbank. Stem end glucose concentrations were highest for Russet Burbank followed by Bannock, and then Premier, and Umatilla. Stem end sucrose was highest with Umatilla and Premier followed by Bannock and then Russet Burbank. Bud end glucose concentrations were highest for Bannock and Russet Burbank, followed by Umatilla and then Premier. Bud end sucrose was highest with Premier and Russet Burbank followed by Umatilla and Bannock.

## Petiole Nitrate-N Concentrations

### *Nitrogen rate, source, and timing comparisons*

Petiole $NO_3$-N concentrations on three dates as affected by N rate, N source, and N timing are presented in Tables 10-13. As expected, petiole $NO_3$-N generally increased with increasing N rate for all varieties and decreased as the season progressed. Petiole $NO_3$-N levels with the 300 lb N/A rate applied through the season were generally the highest of any treatment, especially later in the season. Late season applied conventional N at the 240 lb N/A rate had inconsistent effects on petiole $NO_3$-N. For Russet Burbank and Premier, petiole $NO_3$-N was lower at all sampling dates with late applied N compared with early applied N. For Umatilla and Bannock, this trend was the same for the first two sampling dates, but by the third sampling date petiole $NO_3$-N with late season N was higher than with early season N, which is what would be expected. Reasons for the lower petiole $NO_3$-N concentrations for Russet Burbank and Premier with late season N are not known.

At equivalent N rates, differences between urea and ESN treatments depended on the time of the season. For the first sampling date (June 24), petiole $NO_3$-N concentrations were similar between the two N sources for preplant applied ESN and early applied conventional N. Concentrations were higher with early applied N than when ESN was applied at planting and when late season N was applied. The similarity between ESN and split applied conventional N is consistent with the release of N from the polymer, which appears to be faster than in earlier studies. By the second sampling date (July 7), planting ESN treatments tended to result in petiole $NO_3$-N levels higher than conventional N especially at the 240 lb N/A rate. Preplant applied ESN resulted in petiole $NO_3$-N levels that were either the same or slightly lower than conventional. By the last sampling date (July 21), petiole $NO_3$-N levels were lower with ESN compared with conventional N when applied at equivalent N rates. These lower petiole $NO_3$-N levels with ESN later in the season are again consistent with the faster release from the polymer than in previous years.

### *General varietal comparisons for petiole $NO_3$-N*

At the June 24 sampling date, petiole nitrate levels were higher for Umatilla and Premier and Bannock than for Russet Burbank. Difference became less distinct towards the July 7 sampling date. However, Umatilla petiole $NO_3$-N levels were higher than those for the other cultivars.  Based on yield responses to N, petiole nitrate levels should be higher for Umatilla during the growing season than other varieties tested.

## CONCLUSIONS

As in 2008, release of N from ESN was 20-30 days faster in 2009 than that recorded in previous years, suggesting that the there was more abrasion of the coated with the ESN source used the past two years.  In general, marketable and total yields of all varieties increased with increasing N rate, with optimum yield between 240 lb N/A and 300 lb N/A depending on timing and source.   For conventional N at the 240 lb N/A rate more up front N resulted in higher yields than late applied N for all varieties.  This is in contrast to 2008 when Umatilla responded better to late season-applied N.  The difference in 2009 was that Umatilla vines died back early due to disease and were not able to fully utilize the late applied N.   At equivalent N rates, yields with ESN applied preplant were generally higher than those when ESN was applied at emergence and when conventional N was split applied.

Russet Burbank tended to be the highest yielding variety followed by Bannock and Premier, and then Umatilla.  Premier, Bannock, and Umatilla all had fewer misshaped potatoes than Russet Burbank with Premier having the fewest #2 potatoes.  Tubers greater than 6 and 10 oz were highest for Premier followed by Bannock, Russet Burbank and then Umatilla.  Surprisingly, hollow heart incidence was highest in Bannock, followed by Premier, Russet Burbank, and then Umatilla.  Surface scab incidence was highest with Umatilla, followed by Russet Burbank and then Bannock and Premier. Specific gravity was highest in Russet Burbank and Umatilla and followed by Premier and then Bannock. Stem and bud end chip color were darkest for Russet Burbank and lowest for Premier.

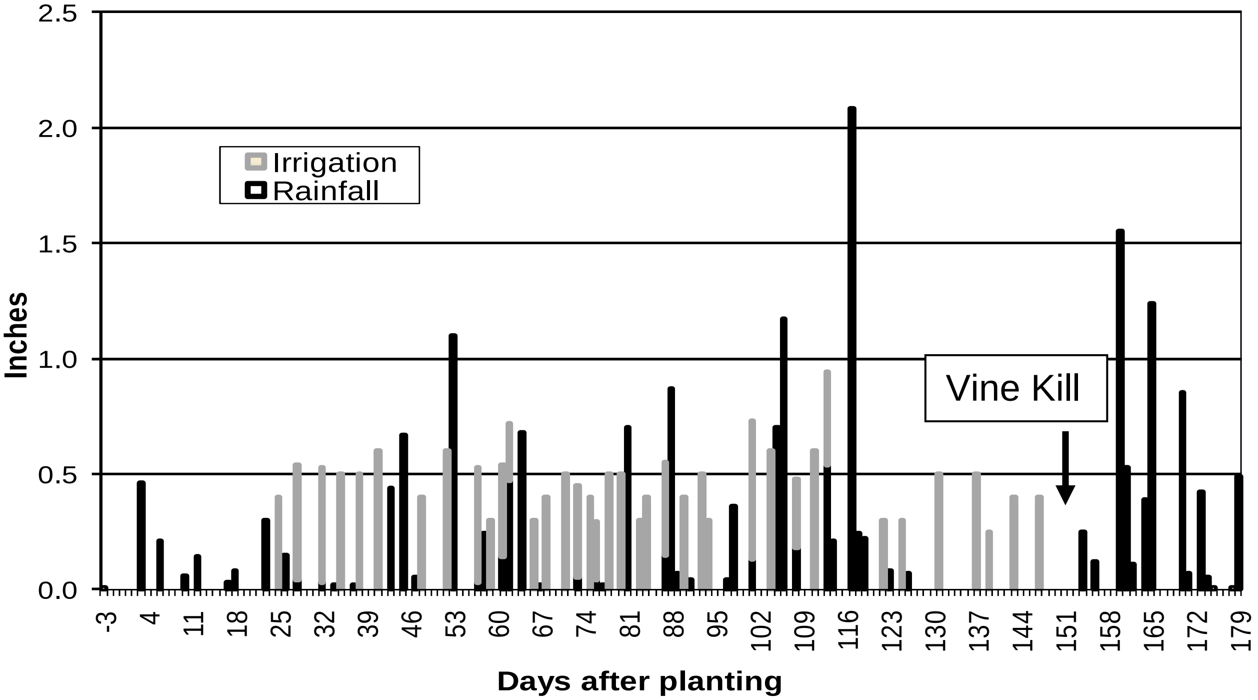

Figure 1. Rainfall and irrigation over the 2009 growing season.

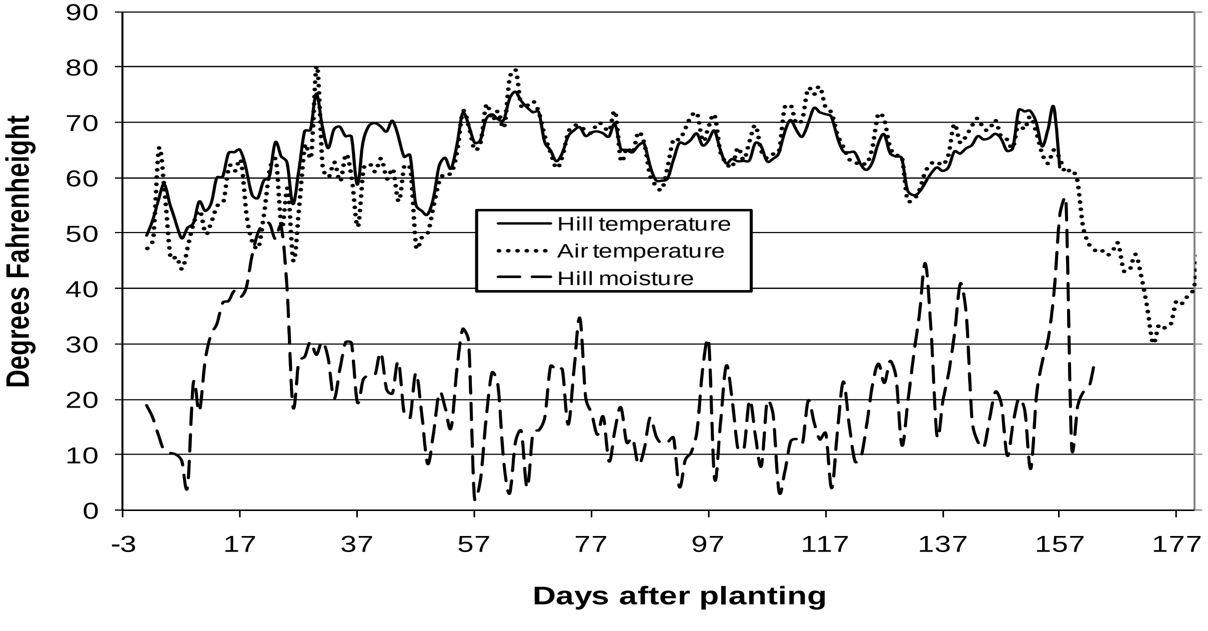

Figure 2. Average daily air temperature and soil moisture and temperature at the 4-5 inch inch depth below the top of the hill over the growing season.

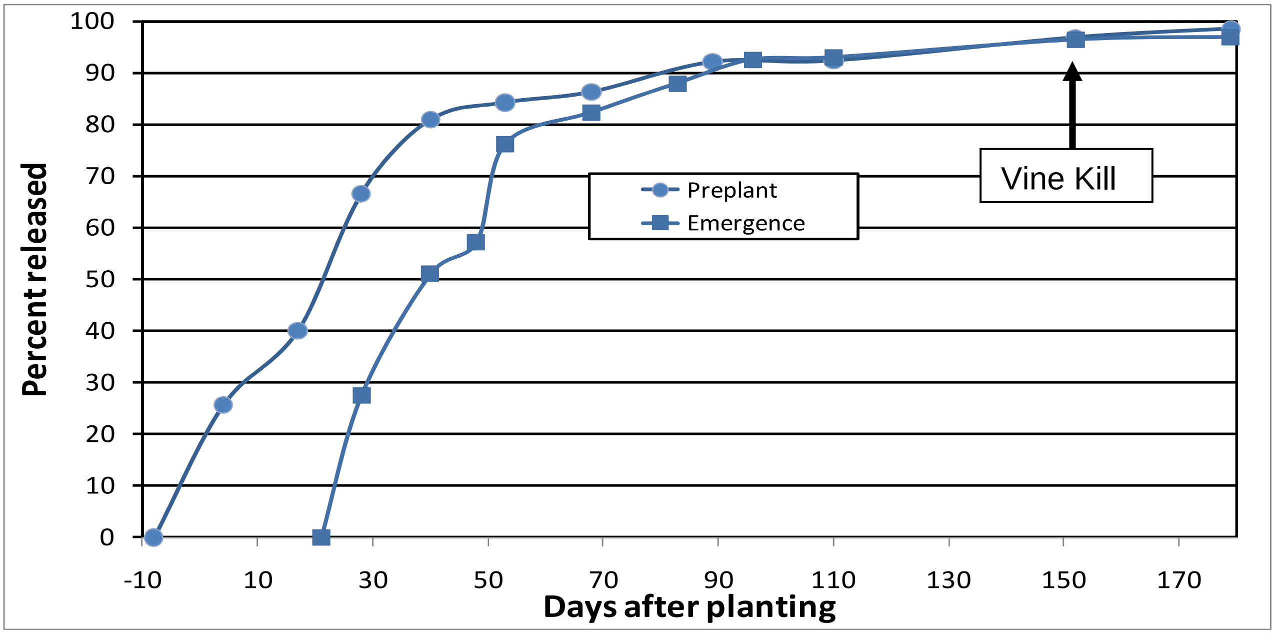

Figure 3. N released from ESN applied preplant and at emergence in 2009.

Table 2. Effect of N rate, source, and timing on Russet Burbank tuber yield and size distribution, stand count, stem number and vine dry matter at harvest.

| Nitrogen Treatments | | | | Tuber Yield | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trtmt | N Source | N Rate | N Timing[1] | 0-3 oz | 3-6 oz | 6-10 oz | 10-14 oz | > 14 oz | Total | #1 > 3 oz | # 2 > 3 oz | Total marketable | > 6 oz | > 10 oz | Stand | Stems | Vine DM |
| # | | lb N / A | PP, P, E, PH | ---------- cwt / A ---------- | | | | | | | | | ---------- % ---------- | | % | per Plant | Tons/Acre |
| 1 | control | 30 | 0, 30, 0, 0 | 69.6 | 264.2 | 165.1 | 35.0 | 15.7 | 549.6 | 270.4 | 209.6 | 480.0 | 39.2 | 9.0 | 99.3 | 3.2 | 0.47 |
| 2 | urea | 120 | 0, 30, 50, 40 | 69.4 | 234.3 | 173.9 | 68.5 | 46.7 | 592.8 | 321.4 | 202.0 | 523.4 | 48.8 | 19.5 | 99.3 | 2.7 | 0.62 |
| 3 | urea | 180 | 0, 30, 70, 80 | 72.9 | 210.4 | 188.7 | 71.6 | 84.0 | 627.7 | 364.9 | 189.9 | 554.8 | 54.9 | 24.9 | 100.0 | 2.8 | 0.97 |
| 4 | urea | 240 | 0, 30, 90, 120 | 59.4 | 167.6 | 202.8 | 105.5 | 144.9 | 680.2 | 413.6 | 207.2 | 620.8 | 66.3 | 36.4 | 99.3 | 3.1 | 1.01 |
| 5 | urea | 240 | 0, 30, 50, 160 | 64.9 | 188.2 | 195.3 | 105.6 | 125.9 | 679.9 | 413.8 | 201.2 | 615.0 | 62.5 | 33.6 | 99.3 | 3.0 | 1.01 |
| 6 | urea | 300 | 0, 30, 90, 180 | 47.8 | 159.3 | 196.5 | 116.1 | 167.8 | 687.5 | 439.9 | 199.8 | 639.7 | 69.9 | 41.4 | 98.5 | 2.6 | 1.12 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 63.7 | 194.7 | 209.0 | 110.8 | 82.4 | 660.7 | 439.7 | 157.3 | 597.0 | 61.0 | 29.4 | 100.0 | 3.0 | 0.88 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 54.2 | 170.1 | 206.7 | 120.3 | 149.6 | 700.9 | 461.5 | 185.2 | 646.7 | 68.0 | 38.5 | 99.3 | 2.8 | 1.24 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 59.4 | 209.9 | 231.2 | 87.8 | 80.3 | 668.6 | 400.9 | 208.3 | 609.2 | 59.6 | 25.1 | 100.0 | 3.0 | 0.63 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 61.7 | 210.2 | 231.1 | 104.1 | 86.3 | 693.4 | 414.7 | 217.0 | 631.7 | 60.7 | 27.3 | 100.0 | 2.9 | 0.94 |
| Significance[2] | | | | * | ** | ** | ** | ** | ** | ** | NS | ** | ** | ** | NS | NS | ** |
| LSD (0.10) | | | | 14.3 | 44.6 | 33.0 | 22.5 | 50.0 | 39.9 | 41.9 | -- | 39.8 | 6.3 | 8.4 | -- | -- | 0.29 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 3. . Effect of N rate, source, and timing on Umatilla Russet tuber yield and size distribution, stand count, stem number and vine dry matter at harvest.

| Nitrogen Treatments | | | | Tuber Yield | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trtmt | N Source | N Rate | N Timing[1] | 0-3 oz | 3-6 oz | 6-10 oz | 10-14 oz | > 14 oz | Total | #1 > 3 oz | # 2 > 3 oz | Total marketable | > 6 oz | > 10 oz | Stand | Stems | Vine DM |
| # | | lb N / A | PP, P, E, PH | ---------- cwt / A ---------- | | | | | | | | | ---------- % ---------- | | % | per Plant | Tons/Acre |
| 1 | control | 30 | 0, 30, 0, 0 | 72.9 | 212.3 | 114.0 | 8.3 | 0.0 | 407.4 | 329.6 | 5.0 | 334.6 | 30.0 | 2.0 | 99.3 | 3.6 | 0.25 |
| 2 | Urea | 120 | 0, 30, 50, 40 | 72.7 | 218.2 | 201.1 | 17.2 | 6.5 | 515.7 | 434.5 | 8.5 | 443.0 | 42.9 | 4.4 | 98.5 | 3.5 | 0.30 |
| 3 | Urea | 180 | 0, 30, 70, 80 | 70.7 | 238.3 | 226.0 | 48.5 | 14.5 | 598.0 | 497.7 | 29.5 | 527.3 | 48.3 | 10.6 | 98.0 | 3.6 | 0.45 |
| 4 | Urea | 240 | 0, 30, 90, 120 | 62.0 | 197.8 | 244.6 | 68.5 | 31.4 | 604.3 | 498.6 | 43.7 | 542.3 | 56.9 | 16.5 | 97.0 | 3.6 | 0.62 |
| 5 | Urea | 240 | 0, 30, 50, 160 | 66.2 | 211.3 | 223.3 | 57.3 | 25.9 | 584.1 | 470.4 | 47.5 | 517.9 | 52.3 | 14.1 | 96.5 | 3.3 | 0.44 |
| 6 | Urea | 300 | 0, 30, 90, 180 | 58.5 | 211.2 | 225.3 | 68.8 | 58.0 | 621.8 | 494.9 | 68.4 | 563.3 | 56.5 | 20.4 | 97.3 | 3.3 | 0.49 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 65.7 | 202.5 | 240.8 | 72.6 | 37.4 | 619.0 | 510.1 | 43.2 | 553.3 | 56.4 | 17.7 | 98.5 | 3.9 | 0.49 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 56.9 | 217.7 | 230.7 | 72.3 | 47.5 | 625.0 | 520.3 | 47.8 | 568.1 | 56.0 | 19.1 | 100.0 | 3.5 | 0.52 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 65.8 | 217.1 | 227.8 | 40.3 | 19.4 | 570.5 | 486.0 | 18.7 | 504.7 | 50.4 | 10.4 | 97.8 | 3.8 | 0.41 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 55.2 | 195.4 | 238.9 | 67.7 | 26.9 | 584.0 | 470.9 | 57.9 | 528.9 | 57.1 | 16.2 | 98.5 | 3.5 | 0.49 |
| Significance[2] | | | | NS | NS | ** | ** | ** | ** | ** | ** | ** | ** | ** | NS | NS | ** |
| LSD (0.10) | | | | -- | -- | 33.5 | 15.3 | 16.1 | 41.5 | 39.8 | 18.0 | 42.4 | 5.8 | 3.7 | -- | -- | 0.16 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 4. Effect of N rate, source, and timing on Premier Russet tuber yield and size distribution, stand count, stem number and vine dry matter at harvest.

| Nitrogen Treatments | | | | Tuber Yield | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | | | | | | | #1 | # 2 | Total | | | | | Vine |
| Trtmt | Source | Rate | Timing[1] | 0-3 oz | 3-6 oz | 6-10 oz | 10-14 oz | > 14 oz | Total | > 3 oz | > 3 oz | marketable | > 6 oz | > 10 oz | Stand | Stems | DM |
| # | | lb N / A | PP, P, E, PH | ------------------------------------------------------ cwt / A ------------------------------------------------------ | | | | | | | | | ----------- % -------------- | | % | per Plant | Tons/Acre |
| 1 | control | 30 | 0, 30, 0, 0 | 22.0 | 94.6 | 197.6 | 103.7 | 49.9 | 467.8 | 442.4 | 3.5 | 445.8 | 74.9 | 32.7 | 97.0 | 2.9 | 0.47 |
| 2 | Urea | 120 | 0, 30, 50, 40 | 17.9 | 77.6 | 175.2 | 133.5 | 126.8 | 530.9 | 501.8 | 11.3 | 513.1 | 81.9 | 48.7 | 100.0 | 2.7 | 0.54 |
| 3 | Urea | 180 | 0, 30, 70, 80 | 18.6 | 66.7 | 159.9 | 113.3 | 196.5 | 554.9 | 529.0 | 7.4 | 536.4 | 84.6 | 55.8 | 100.0 | 3.1 | 0.87 |
| 4 | Urea | 240 | 0, 30, 90, 120 | 18.7 | 66.4 | 140.0 | 114.4 | 219.1 | 558.6 | 528.8 | 11.1 | 539.9 | 84.8 | 59.7 | 100.0 | 3.1 | 0.95 |
| 5 | Urea | 240 | 0, 30, 50, 160 | 15.1 | 73.4 | 158.6 | 124.7 | 189.9 | 561.5 | 514.4 | 32.1 | 546.5 | 84.2 | 56.1 | 99.3 | 2.8 | 0.90 |
| 6 | Urea | 300 | 0, 30, 90, 180 | 18.4 | 52.6 | 136.3 | 116.6 | 241.2 | 565.2 | 525.7 | 21.1 | 546.8 | 87.4 | 63.3 | 97.8 | 2.6 | 1.02 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 22.7 | 79.8 | 164.1 | 127.5 | 174.3 | 568.3 | 528.7 | 17.0 | 545.7 | 81.9 | 53.0 | 100.0 | 3.2 | 0.77 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 19.0 | 63.8 | 165.5 | 123.3 | 216.7 | 588.3 | 537.5 | 31.8 | 569.3 | 85.9 | 57.4 | 99.3 | 3.1 | 1.20 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 19.5 | 70.9 | 175.6 | 122.6 | 139.7 | 528.3 | 497.9 | 10.9 | 508.8 | 82.9 | 49.7 | 100.0 | 3.3 | 0.86 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 17.4 | 57.9 | 153.8 | 142.2 | 198.0 | 569.3 | 524.3 | 27.6 | 551.9 | 86.8 | 59.9 | 100.0 | 3.1 | 0.98 |
| | | | Significance[2] | NS | ** | NS | NS | ** | ** | ** | ** | ** | ** | ** | * | NS | ** |
| | | | LSD (0.10) | -- | 14.1 | -- | -- | 51.5 | 27.3 | 27.5 | 8.6 | 28.1 | 3.3 | 8.3 | 2.0 | -- | 0.23 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

Table 5. Effect of N rate, source, and timing on Bannock Russet tuber yield and size distribution, stand count, stem number and vine dry matter at harvest.

| Nitrogen Treatments | | | | Tuber Yield | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | | | | | | | #1 | # 2 | Total | | | | | Vine |
| Trtmt | Source | Rate | Timing[1] | 0-3 oz | 3-6 oz | 6-10 oz | 10-14 oz | > 14 oz | Total | > 3 oz | > 3 oz | marketable | > 6 oz | > 10 oz | Stand | Stems | DM |
| # | | lb N / A | PP, P, E, PH | ------------------------------------------------------ cwt / A ------------------------------------------------------ | | | | | | | | | ---------- % -------------- | | % | per Plant | Tons/Acre |
| 1 | control | 30 | 0, 30, 0, 0 | 42.8 | 154.6 | 188.4 | 62.9 | 18.7 | 467.3 | 413.2 | 11.3 | 424.5 | 57.6 | 17.4 | 87.0 | 4.8 | 0.46 |
| 2 | urea | 120 | 0, 30, 50, 40 | 30.9 | 131.7 | 206.8 | 118.7 | 59.7 | 547.9 | 498.2 | 18.8 | 517.0 | 70.4 | 32.7 | 90.3 | 4.8 | 0.68 |
| 3 | urea | 180 | 0, 30, 70, 80 | 33.5 | 115.0 | 202.5 | 139.2 | 95.9 | 585.9 | 524.4 | 28.1 | 552.5 | 74.9 | 40.3 | 89.0 | 5.1 | 1.19 |
| 4 | urea | 240 | 0, 30, 90, 120 | 29.4 | 94.5 | 200.8 | 136.9 | 119.8 | 581.4 | 517.1 | 34.9 | 552.0 | 79.1 | 45.2 | 90.3 | 4.9 | 1.40 |
| 5 | urea | 240 | 0, 30, 50, 160 | 27.0 | 99.6 | 198.2 | 143.6 | 130.0 | 598.4 | 517.5 | 53.9 | 571.4 | 78.8 | 45.9 | 91.5 | 4.7 | 1.57 |
| 6 | urea | 300 | 0, 30, 90, 180 | 28.3 | 95.0 | 189.0 | 130.1 | 156.7 | 599.1 | 530.6 | 40.2 | 570.8 | 79.6 | 47.9 | 89.0 | 4.6 | 1.65 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 38.7 | 147.4 | 224.6 | 113.0 | 77.1 | 600.7 | 540.1 | 21.9 | 562.0 | 69.3 | 31.9 | 90.3 | 5.0 | 1.06 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 27.7 | 124.9 | 191.1 | 128.9 | 135.4 | 608.0 | 548.3 | 32.1 | 580.3 | 75.0 | 43.3 | 93.8 | 4.3 | 1.42 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 33.4 | 127.5 | 239.3 | 120.0 | 83.2 | 603.5 | 540.3 | 29.8 | 570.1 | 73.3 | 33.6 | 93.5 | 4.8 | 1.14 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 31.8 | 128.5 | 189.3 | 116.2 | 135.3 | 601.1 | 542.0 | 27.3 | 569.3 | 73.3 | 41.8 | 88.3 | 4.6 | 1.41 |
| | | | Significance[2] | NS | * | NS | ** | ** | * | * | ** | ** | ** | ** | NS | NS | ** |
| | | | LSD (0.10) | -- | 34.0 | -- | 21.8 | 28.9 | 74.7 | 64.4 | 18.2 | 64.5 | 5.3 | 6.1 | -- | -- | 0.38 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 6. Effect of N rate, source, and timing on Russet Burbank tuber quality, frying quality, and sucrose and glucose levels.

| Nitrogen Treatments | | | | Tuber Quality | | | Frying Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | STEM | | | | BUD | | | |
| Trtmt # | N Source | N Rate lb N / A | N Timing[1] PP, P, E, PH | Hollow Heart % | Scab % | Specific Gravity | Chip Color | AGT Score | Sucrose | Glucose | Chip Color | AGT Score | Sucrose | Glucose |
| 1 | control | 30 | 0, 30, 0, 0 | 4.0 | 14.0 | 1.0827 | 3.0 | 48.8 | 1.122 | 4.499 | 2.5 | 55.0 | 1.704 | 0.465 |
| 2 | urea | 120 | 0, 30, 50, 40 | 9.0 | 12.0 | 1.0854 | 2.5 | 53.8 | 0.405 | 3.590 | 2.5 | 56.0 | 1.825 | 0.536 |
| 3 | urea | 180 | 0, 30, 70, 80 | 12.0 | 14.3 | 1.0849 | 2.0 | 56.0 | 0.395 | 3.142 | 2.8 | 53.8 | 1.650 | 0.294 |
| 4 | urea | 240 | 0, 30, 90, 120 | 2.0 | 14.0 | 1.0851 | 2.3 | 55.3 | 0.602 | 2.131 | 2.8 | 53.5 | 1.301 | 0.285 |
| 5 | urea | 240 | 0, 30, 50, 160 | 4.0 | 16.0 | 1.0852 | 3.0 | 53.8 | 0.437 | 3.043 | 2.8 | 53.5 | 1.604 | 0.352 |
| 6 | urea | 300 | 0, 30, 90, 180 | 1.0 | 18.5 | 1.0848 | 2.3 | 56.5 | 0.795 | 2.385 | 2.5 | 55.0 | 1.587 | 0.540 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 8.0 | 16.0 | 1.0860 | 3.0 | 52.5 | 0.441 | 2.930 | 3 | 52.0 | 1.687 | 0.407 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 8.0 | 18.3 | 1.0879 | 2.3 | 54.8 | 0.692 | 1.520 | 2.5 | 55.3 | 1.772 | 0.477 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 3.0 | 7.0 | 1.0874 | 2.8 | 52.5 | 0.570 | 3.255 | 2.8 | 52.3 | 1.716 | 0.724 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 1.0 | 14.0 | 1.0844 | 2.8 | 54.3 | 0.829 | 2.501 | 2.5 | 55.5 | 1.971 | 0.442 |
| Significance[2] | | | | * | NS | NS | ** | ** | NS | ++ | NS | NS | NS | NS |
| LSD (0.10) | | | | 6.6 | - - | - - | 0.5 | 3.4 | -- | 1.857 | -- | -- | -- | -- |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 7. Effect of N rate, source, and timing on Umatilla Russet tuber quality, frying quality, and sucrose and glucose levels.

| Nitrogen Treatments | | | | Tuber Quality | | | Frying Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | STEM | | | | BUD | | | |
| Trtmt # | N Source | N Rate lb N / A | N Timing[1] PP, P, E, PH | Hollow Heart % | Scab % | Specific Gravity | Chip Color | AGT Score | Sucrose | Glucose | Chip Color | AGT Score | Sucrose | Glucose |
| 1 | control | 30 | 0, 30, 0, 0 | 0.0 | 11.0 | 1.0867 | 2.0 | 56.5 | 1.145 | 0.933 | 2.5 | 54.0 | 1.489 | 0.442 |
| 2 | urea | 120 | 0, 30, 50, 40 | 3.0 | 15.0 | 1.0868 | 2.3 | 54.5 | 1.251 | 0.691 | 2.5 | 54.3 | 1.516 | 0.393 |
| 3 | urea | 180 | 0, 30, 70, 80 | 3.0 | 17.0 | 1.0841 | 2.0 | 58.0 | 1.066 | 0.890 | 2.3 | 56.5 | 1.731 | 0.288 |
| 4 | urea | 240 | 0, 30, 90, 120 | 3.0 | 30.0 | 1.0836 | 2.0 | 56.0 | 1.080 | 0.811 | 2.0 | 57.0 | 1.922 | 0.575 |
| 5 | urea | 240 | 0, 30, 50, 160 | 3.0 | 13.0 | 1.0814 | 2.3 | 55.3 | 1.055 | 1.026 | 2.5 | 53.8 | 1.340 | 0.376 |
| 6 | urea | 300 | 0, 30, 90, 180 | 4.0 | 22.0 | 1.0768 | 2.0 | 57.5 | 1.111 | 0.955 | 2.0 | 57.5 | 1.681 | 0.281 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 1.0 | 22.3 | 1.0835 | 2.3 | 56.0 | 0.993 | 0.845 | 2.5 | 53.8 | 1.460 | 0.363 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 0.0 | 24.0 | 1.0838 | 2.3 | 56.5 | 0.985 | 0.899 | 2.5 | 54.8 | 1.703 | 0.380 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 2.0 | 16.3 | 1.0885 | 2.0 | 58.3 | 1.717 | 1.276 | 2.3 | 55.3 | 1.736 | 0.405 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 3.0 | 22.0 | 1.0911 | 2.0 | 57.5 | 1.471 | 1.026 | 2.3 | 56.3 | 1.642 | 0.433 |
| Significance[2] | | | | NS | NS | * | NS | NS | * | NS | NS | NS | NS | NS |
| LSD (0.10) | | | | -- | -- | 0.0078 | -- | -- | 0.3987 | -- | -- | -- | -- | -- |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 8. Effect of N rate, source, and timing on Premier Russet tuber quality, frying quality, and sucrose and glucose levels.

| Nitrogen Treatments | | | | Tuber Quality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | Hollow | | Specific | Frying Quality | | | | | | | |
| Trtmt | Source | Rate | Timing[1] | Heart | Scab | Gravity | STEM | | | | BUD | | | |
| # | | lb N / A | PP, P, E, PH | % | % | | Chip Color | AGT Score | Sucrose | Glucose | Chip Color | AGT Score | Sucrose | Glucose |
| 1 | control | 30 | 0, 30, 0, 0 | 10.0 | 11.0 | 1.0829 | 1.8 | 60.8 | 1.239 | 1.085 | 2.0 | 59.8 | 1.861 | 0.271 |
| 2 | urea | 120 | 0, 30, 50, 40 | 13.0 | 11.3 | 1.0852 | 2.3 | 59.3 | 0.886 | 1.259 | 2.0 | 61.3 | 1.705 | 0.327 |
| 3 | urea | 180 | 0, 30, 70, 80 | 10.3 | 10.3 | 1.0838 | 2.0 | 60.3 | 1.045 | 0.788 | 2.0 | 60.3 | 1.683 | 0.302 |
| 4 | urea | 240 | 0, 30, 90, 120 | 3.0 | 13.0 | 1.0817 | 2.0 | 58.3 | 1.140 | 0.770 | 2.0 | 61.8 | 1.520 | 0.326 |
| 5 | urea | 240 | 0, 30, 50, 160 | 7.0 | 13.0 | 1.0793 | 2.0 | 59.3 | 1.029 | 0.835 | 2.0 | 59.3 | 1.935 | 0.138 |
| 6 | urea | 300 | 0, 30, 90, 180 | 8.0 | 11.0 | 1.0800 | 2.0 | 60.5 | 1.160 | 0.842 | 2.0 | 60.8 | 1.785 | 0.150 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 16.0 | 10.0 | 1.0859 | 2.0 | 58.0 | 1.235 | 1.011 | 2.3 | 58.5 | 1.816 | 0.409 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 4.3 | 7.8 | 1.0863 | 2.0 | 61.3 | 1.125 | 0.538 | 2.0 | 60.0 | 1.965 | 0.195 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 4.0 | 10.0 | 1.0896 | 2.0 | 61.0 | 1.334 | 0.914 | 2.0 | 59.5 | 1.864 | 0.099 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 8.0 | 8.0 | 1.0848 | 1.8 | 60.3 | 1.014 | 0.577 | 2.0 | 58.5 | 1.957 | 0.186 |
| Significance[2] | | | | NS | NS | * | NS | NS | NS | NS | NS | NS | NS | NS |
| LSD (0.10) | | | | -- | -- | 0.0052 | -- | -- | -- | -- | -- | -- | -- | -- |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 9. Effect of N rate, source, and timing on Bannock Russet tuber quality, frying quality, and sucrose and glucose levels.

| Nitrogen Treatments | | | | Tuber Quality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | Hollow | | Specific | Frying Quality | | | | | | | |
| Trtmt | Source | Rate | Timing[1] | Heart | Scab | Gravity | STEM | | | | BUD | | | |
| # | | lb N / A | PP, P, E, PH | % | % | | Chip Color | AGT Score | Sucrose | Glucose | Chip Color | AGT Score | Sucrose | Glucose |
| 1 | control | 30 | 0, 30, 0, 0 | 15.0 | 12.0 | 1.0778 | 2.8 | 54.0 | 0.806 | 2.171 | 2.0 | 56.0 | 1.226 | 0.851 |
| 2 | urea | 120 | 0, 30, 50, 40 | 9.0 | 7.0 | 1.0816 | 2.8 | 53.0 | 0.597 | 1.911 | 2.5 | 55.8 | 1.437 | 0.449 |
| 3 | urea | 180 | 0, 30, 70, 80 | 8.0 | 13.0 | 1.0808 | 2.8 | 53.3 | 0.676 | 2.503 | 2.0 | 57.3 | 1.388 | 0.475 |
| 4 | urea | 240 | 0, 30, 90, 120 | 9.0 | 12.0 | 1.0802 | 2.3 | 55.0 | 1.017 | 2.174 | 2.3 | 55.5 | 1.700 | 0.613 |
| 5 | urea | 240 | 0, 30, 50, 160 | 11.0 | 11.0 | 1.0801 | 2.3 | 55.3 | 0.840 | 1.690 | 2.5 | 55.0 | 1.538 | 0.285 |
| 6 | urea | 300 | 0, 30, 90, 180 | 6.0 | 3.0 | 1.0788 | 2.3 | 55.0 | 0.756 | 1.928 | 2.5 | 57.0 | 1.713 | 0.504 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 15.0 | 18.0 | 1.0819 | 2.5 | 53.8 | 0.959 | 2.024 | 2.5 | 55.3 | 1.477 | 0.807 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 14.3 | 9.3 | 1.0752 | 2.3 | 56.0 | 0.826 | 1.906 | 2.3 | 55.3 | 1.553 | 0.483 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 6.0 | 10.0 | 1.0822 | 2.8 | 53.8 | 0.870 | 1.430 | 2.0 | 57.5 | 1.248 | 0.502 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 10.0 | 14.0 | 1.0775 | 2.8 | 53.5 | 0.790 | 1.502 | 2.3 | 56.0 | 1.504 | 0.306 |
| Significance[2] | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| LSD (0.10) | | | | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively; 4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 10. Effect of N rate, source, and timing on Russet Burbank petiole nitrate-N levels.

| Nitrogen Treatments | | | | $NO_3$-N, ppm | | |
|---|---|---|---|---|---|---|
| | N | N | N | | | |
| Trtmt | Source | Rate | Timing[1] | | | |
| # | | lb N / A | PP, P, E, PH | June 24 | July 7 | July 21 |
| 1 | control | 30 | 0, 30, 0, 0 | 6939 | 512 | 192 |
| 2 | urea | 120 | 0, 30, 50, 40 | 13433 | 5710 | 2224 |
| 3 | urea | 180 | 0, 30, 70, 80 | 16598 | 9488 | 8740 |
| 4 | urea | 240 | 0, 30, 90, 120 | 18429 | 13467 | 13690 |
| 5 | urea | 240 | 0, 30, 50, 160 | 16130 | 10511 | 11498 |
| 6 | urea | 300 | 0, 30, 90, 180 | 17618 | 14558 | 14035 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 16147 | 10866 | 4865 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 17319 | 13425 | 8819 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 16028 | 11623 | 6003 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 15755 | 13488 | 9844 |
| | | | Significance[2] | ** | ** | ** |
| | | | LSD (0.10) | 1468 | 1676 | 1863 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively;

4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 11. Effect of N rate, source, and timing on Umatilla Russet petiole nitrate-N levels.

| Nitrogen Treatments | | | | $NO_3$-N, ppm | | |
|---|---|---|---|---|---|---|
| | N | N | N | | | |
| Trtmt | Source | Rate | Timing[1] | | | |
| # | | lb N / A | PP, P, E, PH | June 24 | July 7 | July 21 |
| 1 | control | 30 | 0, 30, 0, 0 | 8159 | 1478 | 510 |
| 2 | urea | 120 | 0, 30, 50, 40 | 14060 | 7638 | 3041 |
| 3 | urea | 180 | 0, 30, 70, 80 | 18391 | 11933 | 8276 |
| 4 | urea | 240 | 0, 30, 90, 120 | 19571 | 16143 | 11657 |
| 5 | urea | 240 | 0, 30, 50, 160 | 18280 | 13742 | 12021 |
| 6 | urea | 300 | 0, 30, 90, 180 | 20757 | 17278 | 13350 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 19686 | 10393 | 5949 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 21088 | 16371 | 11241 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 17963 | 13680 | 6568 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 19555 | 17101 | 11687 |
| | | | Significance[2] | ** | ** | ** |
| | | | LSD (0.10) | 1821 | 2119 | 2229 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively;

4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 12. Effect of N rate, source, and timing on Premier Russet petiole nitrate-N levels.

| Nitrogen Treatments | | | | $NO_3$-N, ppm | | |
|---|---|---|---|---|---|---|
| | N | N | N | | | |
| Trtmt | Source | Rate | Timing[1] | | | |
| # | | lb N / A | PP, P, E, PH | June 24 | July 7 | July 21 |
| 1 | control | 30 | 0, 30, 0, 0 | 8373 | 678 | 320 |
| 2 | urea | 120 | 0, 30, 50, 40 | 16267 | 6640 | 3052 |
| 3 | urea | 180 | 0, 30, 70, 80 | 18834 | 10370 | 8233 |
| 4 | urea | 240 | 0, 30, 90, 120 | 20492 | 13747 | 11409 |
| 5 | urea | 240 | 0, 30, 50, 160 | 17723 | 12400 | 9589 |
| 6 | urea | 300 | 0, 30, 90, 180 | 22119 | 16050 | 13994 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 16844 | 6878 | 3202 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 20657 | 14091 | 8513 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 17628 | 12305 | 5363 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 19098 | 15100 | 10236 |
| | | | Significance[2] | ** | ** | ** |
| | | | LSD (0.10) | 2371 | 2102 | 1771 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively;
4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 13. Effect of N rate, source, and timing on Bannock Russet petiole nitrate-N levels.

| Nitrogen Treatments | | | | $NO_3$-N, ppm | | |
|---|---|---|---|---|---|---|
| | N | N | N | | | |
| Trtmt | Source | Rate | Timing[1] | | | |
| # | | lb N / A | PP, P, E, PH | June 24 | July 7 | July 21 |
| 1 | control | 30 | 0, 30, 0, 0 | 7773 | 3189 | 377 |
| 2 | urea | 120 | 0, 30, 50, 40 | 14305 | 6546 | 4212 |
| 3 | urea | 180 | 0, 30, 70, 80 | 18794 | 9227 | 8985 |
| 4 | urea | 240 | 0, 30, 90, 120 | 20850 | 14480 | 11714 |
| 5 | urea | 240 | 0, 30, 50, 160 | 18004 | 11397 | 12935 |
| 6 | urea | 300 | 0, 30, 90, 180 | 21177 | 15971 | 13994 |
| 7 | ESN | 180 | 150, 30, 0, 0 | 16803 | 7823 | 4283 |
| 8 | ESN | 240 | 210, 30, 0, 0 | 21220 | 14419 | 9673 |
| 9 | ESN | 180 | 0, 30, 150, 0 | 19017 | 12001 | 7474 |
| 10 | ESN | 240 | 0, 30, 210, 0 | 19289 | 15074 | 10491 |
| | | | Significance[2] | ** | ** | ** |
| | | | LSD (0.10) | 1397 | 2463 | 1577 |

[1] PP, P, E, PH = Preplant, Planting, Emergence, and Post-Hilling, respectively;
4 post-hilling applications were as follows: 20%, 20%, 30%, 30%.

[2] NS = Non-significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

# Evaluation of Kingenta and ESN Controlled Release Fertilizers For Irrigated Russet Burbank Potato Production

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**Summary:** This was the third year for field experiments conducted at the Sand Plain Research Farm in Becker, MN comparing controlled release fertilizers made by Kingenta (a Chinese company) with ESN and conventional N sources. Treatments compared differences between N sources at 160 lb N/A and 240 lb N/A and differences between preplant and planting applications of the controlled release fertilizers. Nitrogen release rate from the Kingenta product K3 was slower and less complete than from ESN, but more rapid and complete than from the Kingenta product KB. Tuber yields were lower at 160 lb N/A than 240 lb N/A for urea, K3, and ESN, due to greater amounts of small tubers and lower amounts of large tubers. There were no significant yield differences between preplant vs. planting/postplant applications of urea, K3, KB, and ESN, but application timing did affect tuber size for K3 and ESN. Preplant application of these CRF's resulted in significantly greater amounts of small tubers and lower amounts of large tubers. The treatment with 240 lb N/A mostly applied as urea preplant had the highest yield, but averaged over all treatments yields were similar for urea, K3, and ESN when applied at equivalent N rates. Marketable yields and tuber size tended to be lower for K3 than ESN, although the differences were not significant. KB generally had lower yields than the other fertilizer sources, although most of these differences were also not significant. Nitrogen source and timing did not affect tuber quality, except that the KB treatments had the highest specific gravities. This has not occurred previously and the reason for it is unclear. Vine dry matter was generally lower for K3 and KB than for urea and ESN, probably due to delayed N release. Petiole nitrate-N was significantly lower with 160 lb N/A than with 240 lb N/A for all N sources, which is consistent with the fertilizer rate effects on yield. Nitrate-N tended to be lower for K3 and KB than ESN, except on the first sampling date when petiole concentrations were highest for KB. Other than KB on the first sampling date, these trends were consistent with differences in N release from the three CRF's. The two KB treatments had the highest amounts of residual inorganic soil N one month after harvest, which was consistent with the late-season N release from KB. For the 240 lb N/A treatments with most of the N applied at planting, urea had significantly lower residual soil N than K3, KB, or ESN.

**Background:** Studies with ESN, a controlled release N fertilizer, have been conducted for a number of years. The main findings have shown that the fertilizer can be used as a substitute for many split applications of 28-0-0. The best results indicate an early sidedress application provides the best yield and quality. However, growers would be more likely to adopt the fertilizer if it could be used preplant. In this study, we compared three controlled release fertilizers (CRF's) to each other and with conventional fertilization practices. One of the CRF's is manufactured by Agrium and called ESN. The other two, K3 and KB, are manufactured by Kingenta (a fertilizer company in China). The objectives of this study were to 1) evaluate the effects of ESN, K3, and KB applications on yield and quality of 'Russet Burbank' potato, 2) compare various N rates, sources, and timing on Russet Burbank yield and quality, and 3) determine if nitrate leaching can be reduced with use of CRF's. This study is in its third year.

## Materials and Methods

The study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand using the cultivar Russet Burbank. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6"): water pH, 4.9; buffer pH, 5.8; organic matter, 2.4%; Bray P1, 25 ppm; ammonium acetate extractable K, Ca, and Mg, 66, 335, and 40 ppm, respectively; hot water extractable B, 0.3 ppm; Ca-phosphate extractable $SO_4$-S, 5.0 ppm; and DTPA extractable Zn, Cu, Fe, and Mn, 1.4, 0.5, 114.2, and 37.6 ppm, respectively. Extractable nitrate-N and ammonium-N in the top 2 ft prior to planting were 10.8 and 13.1 lb/A, respectively.

Four, 20 ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed was hand planted in furrows on April 28, 2009. Spacing was 36 inches between rows and 12 inches within each row. Each treatment was replicated four times in a randomized complete block design. Admire Pro was applied in-furrow for beetle control, along with the fungicides Quadris and Ultra Flourish. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Three types of CRF's were tested in this study, along with uncoated urea (46-0-0). Shandong Kingenta Ecological Engineering Co., Ltd manufactures a polymer coated urea (K3, 43-0-0) and a polymer coated, blended fertilizer (KB, 20-8-10). Agrium, Inc. produces Environmentally Smart Nitrogen (ESN, 44-0-0), which is also a polymer coated urea. Twelve treatments were tested and are listed below.

Nitrogen treatments tested in the controlled release fertilizer study.

| Treatment | Preplant | Planting | Emergence | Post-hilling** | Total |
|---|---|---|---|---|---|
| | ------------------------ N sources* and rates (lb N/A) ------------------------ | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 40 D | 60 U | UAN: 30 + 3x10 | 160 |
| 3 | 0 | 40 D | 100 U | UAN: 50 + 3x16.7 | 240 |
| 4 | 200 U | 40 D | 0 | 0 | 240 |
| 5 | 120 K3 | 40 D | 0 | 0 | 160 |
| 6 | 200 K3 | 40 D | 0 | 0 | 240 |
| 7 | 0 | 40 D + 200 K3 | 0 | 0 | 240 |
| 8 | 240 KB | 0 | 0 | 0 | 240 |
| 9 | 0 | 240 KB | 0 | 0 | 240 |
| 10 | 120 E | 40 D | 0 | 0 | 160 |
| 11 | 200 E | 40 D | 0 | 0 | 240 |
| 12 | 0 | 40 D + 200 E | 0 | 0 | 240 |

*K3 = Kingenta 43-0-0, KB = Kingenta 20-8-10, E = ESN 44-0-0, D = diammonium phosphate (DAP), U = urea, UAN = a combination of granular urea and ammonium nitrate.
**Post-hilling N was applied 4 times at 10-11 day intervals.

On April 13, 150 lb $K_2O$/A as potassium chloride was broadcast on all plots and later incorporated by plowing. Preplant CRF's were applied the day before planting on April 28 and incorporated with a field cultivator. At the same time, 150 lb $K_2O$/A as potassium chloride was applied and incorporated on all plots. Controlled release fertilizer at planting was banded 3 inches to each side and 2 inches below the seed piece using a belt type applicator. The same starter fertilizer was band-applied to all plots, except for the 0 N control and the three KB treatments. It consisted of 40 lb N/A and 100 lb $P_2O_5$/A as diammonium phosphate (DAP), 200 lb $K_2O$/A as potassium chloride and potassium magnesium sulfate, 30 lb Mg/A and 60 lb S/A as potassium magnesium sulfate, 2 lb Zn/A as zinc oxide, and 0.5 lb B/A as boric acid. For the control plots and the KB treatments, a modified starter without the N and P from DAP was used. It consisted of the same amounts and sources of $K_2O$, Mg, S, B, and Zn, but equivalent $P_2O_5$ rates were supplied to the control by triple superphosphate (TSP) and to the KB treatments by the P contained in the KB fertilizer. Treatments 7 and 8, therefore, received their P preplant when the KB was applied.

Plant emergence N applications were sidedressed as urea on May 22 and mechanically incorporated. Post-hilling N was applied by hand as 50% granular urea and 50% granular ammonium nitrate and watered-in with overhead irrigation to simulate fertigation with 28% N. The four post-hilling applications took place on June 15, June 25, July 6, and July 16.

Stand and stem counts were done on June 9. Petiole samples were collected from the 4th leaf from the terminal on June 24, July 7, and July 21. Petioles were analyzed for nitrate-N on a dry weight basis. Vines were harvested from two, 10-ft sections of row on September 17, followed by mechanically beating the vines over the entire plot area. On September 21, plots were machine-harvested and total tuber yield, graded yield, tuber specific gravity, and the incidence of hollow heart and brown center were measured. Subsamples of vines and tubers were collected to determine moisture percentage and N concentrations, which were then used to calculate N uptake and distribution. Uptake results were not available at the time of this report.

Measured amounts of K3 and ESN fertilizer were placed in plastic mesh bags and buried at the depth of fertilizer placement when both the preplant and planting applications were made. Bags were removed on May 11, May 22, June 3, June 16, July 1, July 16, July 29, Aug 12, Sept 17, and Oct 20 to track N release over time. Soil samples from the 0-2 ft depth were collected on Oct 20 to measure residual inorganic N levels. Each sample consisted of six soil cores that were composited, air dried, extracted with 2 N KCl, and analyzed for nitrate-N and ammonium-N. A WatchDog weather station from Spectrum Technologies was used to monitor rainfall, air temperature, soil temperature, and soil moisture. Soil temperature and soil moisture were measured at two depths: 1) about 4 inches below the top of the hill and 2 inches in from the side of the hill and 2) about 12 inches below the top of the hill at the fertilizer band depth. Rainfall and irrigation amounts are shown in Fig. 1 and air temperature, soil temperature, and soil moisture in Fig. 2.

Suction cup lysimeters were installed at the 4-ft soil depth on May 5 to measure the amount of inorganic N leaching below the crop root zone. Three plots per treatment in treatments 3, 6, 8, and 11 were monitored. These treatments all received total N applications of 240 lb N/A. They included a conventional treatment and the K3, KB, and ESN treatments where the controlled release fertilizer was applied preplant. Water samples were collected on a weekly basis, or more often when a leaching rainfall event occurred, and analyzed for nitrate-N and ammonium-N.

Sampling continued after harvest until the ground was frozen. Leaching results were not available at the time of this report.

## Results

**Nitrogen release:** Release curves for the K3, KB, and ESN controlled release fertilizers are presented in Fig. 3. Preplant and planting applications had similar release curves for all three CRF's, which is not surprising since they were applied only one day apart. The largest differences between planting and preplant applications on any of the sampling dates were less than 10%. Nitrogen release from ESN was more rapid and more complete than from K3 and N release from K3 was more rapid and complete than from KB. The release curves had similar shapes, but N release from ESN more closely matched the N uptake pattern of Russet Burbank potatoes. Russet Burbank takes up the majority of its N between 40 and 80 days after planting. ESN had released about 80 to 85% of its N by 50 days after planting, while K3 had released only 50% and KB less than 25% of their N by day 50.

There were large differences between the three CRF's in the proportion of their total N that was eventually released. ESN released about 98%, K3 about 78%, and KB about 65%. Nitrogen release by K3 was much greater than the 60% N release from the Kingenta product K2 that was studied in 2007 and 2008, although environmental conditions may have played a role in these differences. ESN and K3 had released nearly all the N they were going to release by 100 days after planting, whereas KB had released less than 75% of the N it eventually released. Late N release increases the potential for N leaching between the end of one growing season and the beginning of the next.

**Tuber yield:** Treatment #4 with 240 lb N/A mostly applied as urea preplant had the highest total tuber yield and it was significantly greater than 160 lb N/A mostly applied as urea after planting, both of the KB treatments, and 240 lb N/A with ESN applied at planting (Table 1). The treatment with 160 lb N/A mostly applied as urea after planting also had significantly lower total yields than 240 lb N/A with K3 applied preplant and 160 lb N/A with ESN applied preplant. There were no significant differences between 160 and 240 lb N/A for the urea, K3, and ESN treatments that had similar application timing. There were also no significant differences between the comparable preplant vs. planting/postplant applications of urea, K3, KB, and ESN at 240 lb N/A. The KB treatments generally had lower total yields than the other N fertilized treatments, probably because of delayed N release (Fig. 3). The delayed N release from K3 compared with ESN (Fig. 3) did not affect total yield, because there were no significant differences between the K3 and ESN treatments applied at comparable rates and timing.

Treatment #4 with 240 lb N/A mostly applied as urea preplant also had the highest marketable tuber yield. It was significantly greater than 160 lb N/A mostly applied as urea after planting and the K3 treatment that received 160 lb N/A. Marketable yields were consistently lower at 160 lb N/A than 240 lb N/A for the urea, K3, and ESN treatments that had similar application timing. Only the difference for urea was significant, but the three treatments receiving 160 lb N/A had lower marketable yields than all of the other N fertilized treatments. Low marketable yields at 160 lb N/A were due to greater amounts of small tubers (0-4 oz) and a lower proportion of large tubers (>6 oz and >10 oz) than all of the other treatments receiving N.

There were no significant differences between the comparable preplant vs. planting/postplant applications of urea, K3, KB, and ESN at 240 lb N/A. The KB treatments generally had lower marketable yields than the other 240 lb N/A treatments. The 240 lb N/A treatment with K3 applied preplant was similar to the two KB treatments, due to significantly greater amounts of small tubers and a significantly lower proportion of large tubers compared with K3 applied at planting. Similar tuber size differences occurred between preplant and planting applications of ESN. The 240 lb N/A treatment with ESN applied preplant had a significantly greater amount of small tubers and a significantly lower proportion of large tubers than 240 lb N/A with ESN applied at planting. These differences in tuber size distribution for preplant vs. planting applications of K3 and ESN did not result in significant differences in marketable yield, because the preplant applications had numerically greater total yields. Marketable yields and tuber size tended to be greater with ESN than K3, although there were no significant differences between them when applied at comparable rates and timing.

**Plant stand, stems per plant, tuber quality, and vine dry matter:** Plant stands were above 98% for all treatments (Table 2). There were also no significant differences among treatments in the number of stems per plant or the incidence of hollow heart. The two KB treatments had the highest specific gravities and KB at planting was significantly higher than any of the treatments except KB at planting. Specific gravities were similar for all of the non-KB treatments. KB application did not affect specific gravity in previous years and the reason for higher levels in 2009 is not clear.

Treatment #3 with 240 lb N/A mostly applied as urea after planting had the highest vine dry matter production. It was significantly higher than the all of the other treatments except 240 lb N/A mostly applied as urea before planting and the two 240 lb N/A treatments with ESN applied preplant or at planting. Vine dry matter was generally lower for K3 and KB than for ESN, probably due to delayed N release (Fig. 3). Vine dry matter production was consistently lower at 160 lb N/A than 240 lb N/A for the urea, K3, and ESN treatments that had similar application timing. The differences for urea and ESN were statistically significant and the three treatments receiving 160 lb N/A had lower vine dry matter than any of the other N fertilized treatments. There were no significant differences between the comparable preplant vs. planting/postplant applications of urea, K3, KB, and ESN at 240 lb N/A.

**Petiole nitrate-N concentrations:** On all three sampling dates, petiole nitrate-N was significantly lower with 160 lb N/A than with 240 lb N/A for the urea, K3, and ESN treatments that had similar application timing (Table 3). For the comparable preplant vs. planting applications of K3 and ESN at 240 lb N/A, nitrate-N was significantly higher for preplant on the first sampling date and significantly higher for application at planting on the second and third dates. There was no difference in nitrate-N between preplant and planting applications of KB. For urea applied preplant vs. postplanting there was no difference in nitrate-N on the first sampling date, but the postplanting applications maintained significantly higher petiole concentrations on the second and third dates. Nitrate-N tended to be slightly lower for comparable K3 vs. ESN treatments. On the first sampling date, concentrations were significantly higher for comparable KB vs. K3 and ESN treatments, but lower for KB on the second and third dates. Except for KB on the first sampling date, these trends were generally consistent with differences in N release from the three CRF's (Fig. 3). For comparable treatments, nitrate-N was significantly higher with urea than K3 and ESN on the first sampling date, but not on the second and third dates. These results are consistent with the rapid availability of urea-N compared with CRF's.

**Residual soil N:** The two KB treatments had the highest amounts of residual inorganic soil one month after harvest (Table 4). This was consistent with late-season N release from KB (Fig. 3). Nitrogen release from K3 was slower than from ESN, but residual soil N tended to be lower for K3. There were no significant differences in residual N between 160 and 240 lb N/A for the urea, K3, and ESN treatments that had similar application timing. For the comparable preplant vs. planting/postplant applications of urea, K3, and ESN at 240 lb N/A, residual N was consistently lower with preplant applications, although only the difference for K3 was statistically significant. For the 240 lb N/A treatments with most of the N applied at planting, urea had significantly lower residual soil N than K3 or ESN.

## Conclusions

Nitrogen release rate from the Kingenta product K3 was slower and less complete than from ESN, but more rapid and complete than from the Kingenta product KB. Differences in N release were reflected in the results obtained, although many of the differences were not statistically significant. Marketable yields and tuber size tended to be lower for K3 than ESN, and KB generally had lower yields than the other fertilizer sources. The treatment with 240 lb N/A mostly applied as urea preplant had the highest yield, but averaged over all treatments yields were similar for urea, K3, and ESN. Preplant application of K3 and ESN resulted in significantly greater amounts of small tubers and lower amounts of large tubers than applications at planting, although yield differences were not significant. Tuber yields were lower at 160 lb N/A than 240 lb N/A for urea, K3, and ESN, due to greater amounts of small tubers and lower amounts of large tubers. Vine dry matter was generally lower for K3 and KB than for urea and ESN, probably due to delayed N release. Petiole nitrate-N was generally lower for K3 and KB than ESN and the two KB treatments had the highest amounts of residual inorganic soil N one month after harvest. These results were also consistent with differences in N release rates.

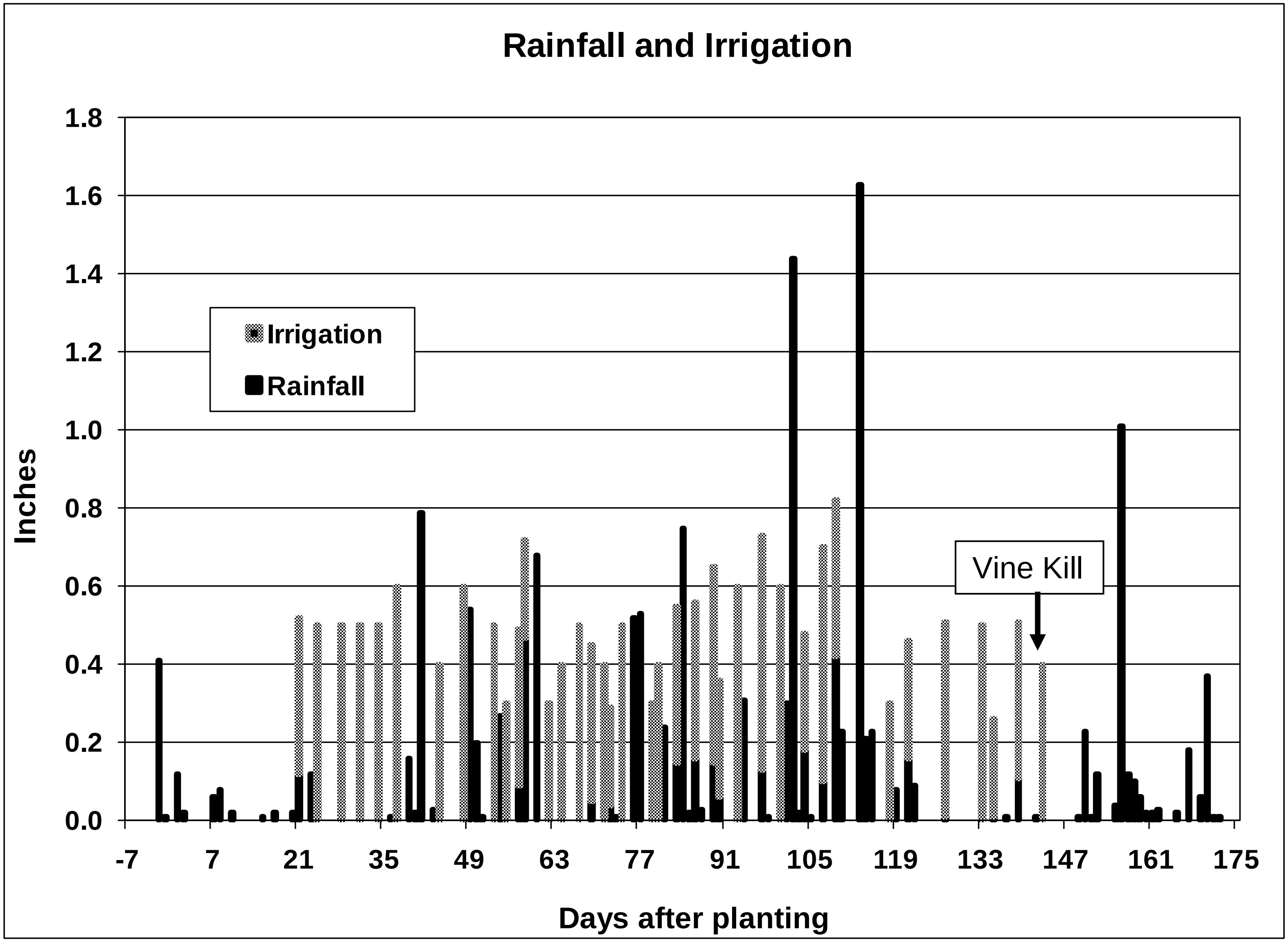

Figure 1. Rainfall and irrigation amounts during the 2009 growing season.

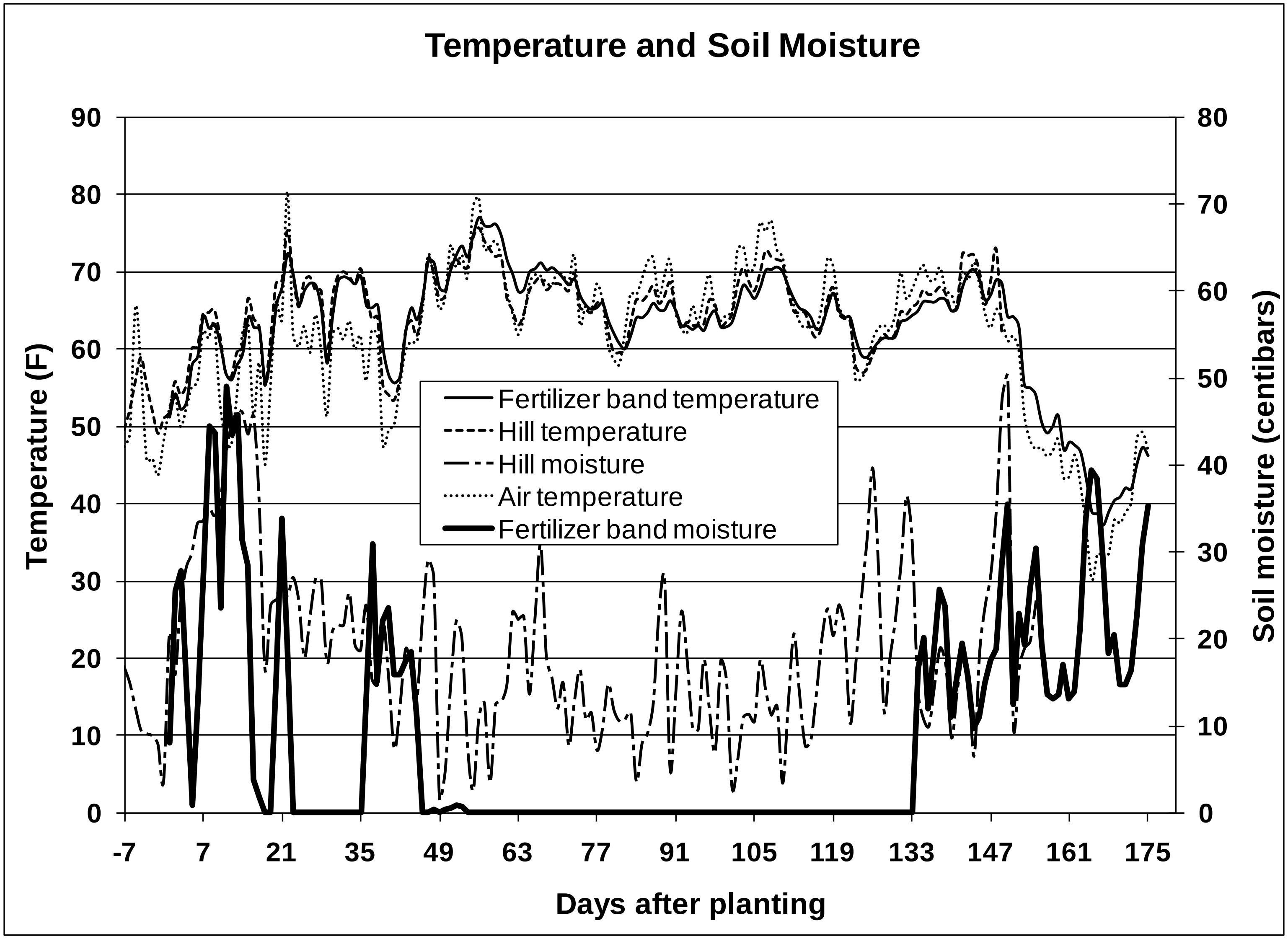

Figure 2. Soil temperature, air temperature, and soil moisture during the 2009 growing season.

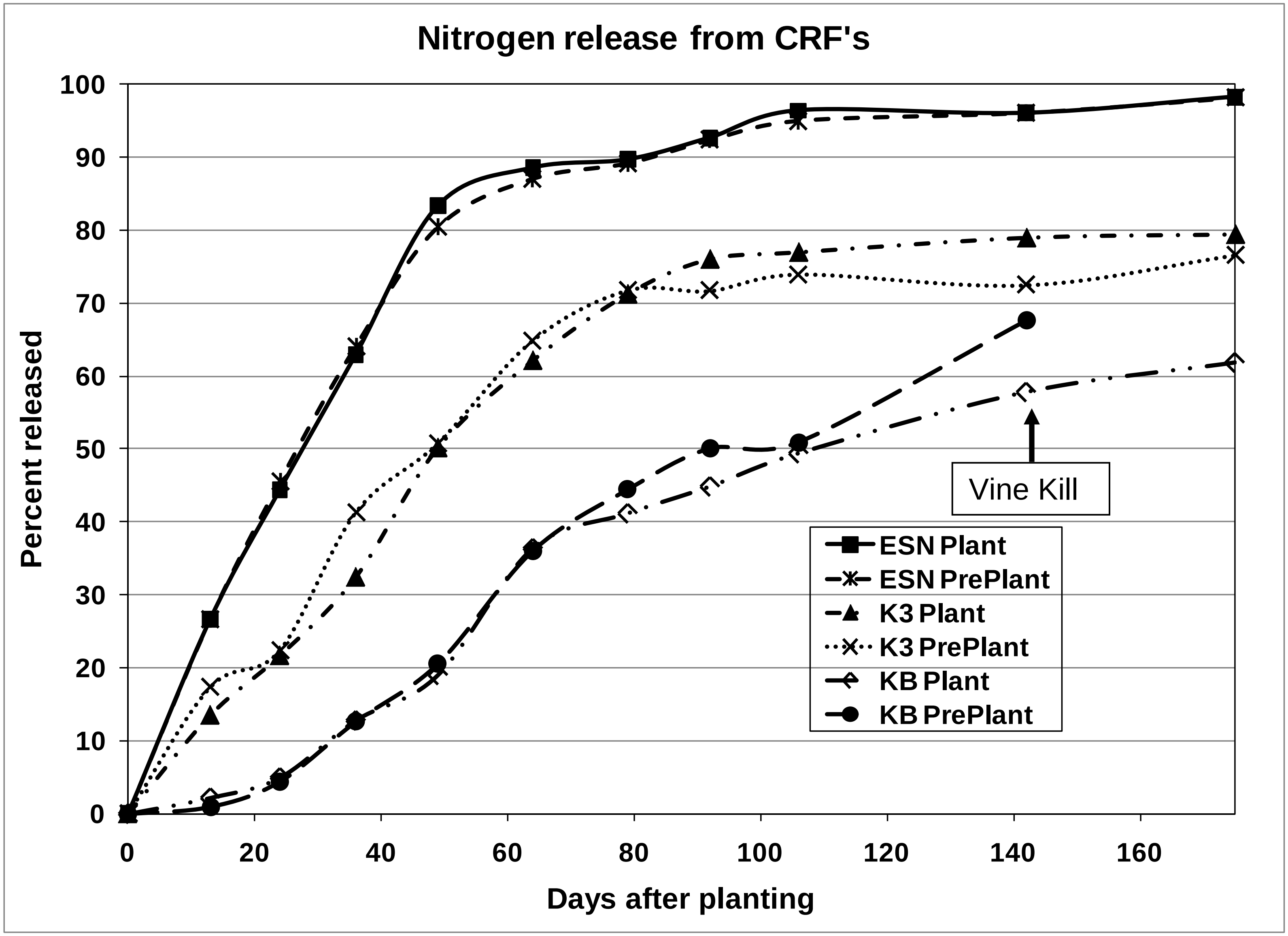

Figure 3. Nitrogen release from controlled release fertilizers during the 2009 growing season.

Table 1. Effects of N source, rate, and timing on Russet Burbank tuber yield and size distribution.

| | | | Tuber Yield | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Nitrogen** | **N Rate/Timing** | **0-4 oz** | **4-6 oz** | **6-10 oz** | **10-14 oz** | **>14 oz** | **Total** | **#1 > 4 oz** | **# 2 > 4 oz** | **Total marketable** | **> 6oz** | **> 10 oz** |
| **#** | **Source** | **lb N/A** | **------------------------------ cwt/A ------------------------------** | | | | | | | | | **%** | **%** |
| 1 | Control | 0 | 117.2 | 168.4 | 120.1 | 42.5 | 0.0 | 448.2 | 99.2 | 231.8 | 331.0 | 36.1 | 9.3 |
| 2 | Urea | 160 | 113.7 | 161.9 | 236.8 | 94.6 | 40.9 | 647.8 | 386.2 | 147.9 | 534.1 | 57.4 | 20.7 |
| 3 | Urea | 240 | 85.8 | 129.8 | 200.1 | 145.2 | 137.1 | 697.9 | 445.0 | 167.2 | 612.2 | 69.0 | 40.4 |
| 4 | Urea | 240 pre | 83.6 | 123.0 | 219.1 | 168.0 | 132.9 | 726.5 | 522.2 | 120.8 | 643.0 | 71.5 | 41.3 |
| 5 | Kingenta 43-0-0 (K3) | 160 pre | 129.8 | 185.2 | 221.7 | 106.6 | 43.8 | 687.0 | 382.2 | 175.1 | 557.3 | 53.2 | 21.4 |
| 6 | Kingenta 43-0-0 (K3) | 240 pre | 105.8 | 149.4 | 232.3 | 136.4 | 87.8 | 711.8 | 435.8 | 170.1 | 605.9 | 64.3 | 31.6 |
| 7 | Kingenta 43-0-0 (K3) | 240 plt | 50.7 | 78.8 | 187.9 | 188.2 | 162.1 | 667.5 | 499.3 | 117.6 | 616.9 | 80.6 | 52.5 |
| 8 | Kingenta 20-8-10 (KB) | 240 pre | 58.0 | 104.6 | 235.7 | 165.2 | 99.9 | 663.2 | 466.2 | 139.1 | 605.3 | 75.5 | 40.0 |
| 9 | Kingenta 20-8-10 (KB) | 240 plt | 58.2 | 108.0 | 234.3 | 167.3 | 97.9 | 665.7 | 466.6 | 140.9 | 607.5 | 75.1 | 40.0 |
| 10 | ESN 44-0-0 | 160 pre | 112.4 | 184.3 | 253.2 | 99.3 | 57.8 | 706.9 | 448.4 | 146.2 | 594.6 | 57.8 | 21.8 |
| 11 | ESN 44-0-0 | 240 pre | 79.9 | 116.7 | 227.5 | 141.0 | 136.4 | 701.3 | 499.2 | 122.2 | 621.5 | 72.1 | 39.8 |
| 12 | ESN 44-0-0 | 240 plt | 42.5 | 57.7 | 160.5 | 180.4 | 229.2 | 670.2 | 545.3 | 82.4 | 627.6 | 85.0 | 61.1 |
| | | **Significance[1]** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| | | LSD (0.1) | 20.1 | 21.6 | 41.2 | 25.5 | 37.3 | 54.8 | 57.8 | 50.5 | 59.5 | 5.4 | 6.1 |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 2. Effects of N source, rate, and timing on plant stand, number of stems per plant, tuber quality, and vine dry matter.

| Treatment # | Nitrogen Source | N Rate/Timing lb N/A | % Stand | # Stems per plant | Specific gravity | HH % | Vine DM Tons/Acre |
|---|---|---|---|---|---|---|---|
| 1 | Control | 0 | 100.0 | 2.6 | 1.0860 | 0.0 | 0.37 |
| 2 | Urea | 160 | 98.5 | 3.1 | 1.0891 | 9.0 | 0.98 |
| 3 | Urea | 240 | 100.0 | 3.0 | 1.0878 | 9.0 | 1.46 |
| 4 | Urea | 240 pre | 99.3 | 2.8 | 1.0880 | 11.0 | 1.35 |
| 5 | Kingenta 43-0-0 (K3) | 160 pre | 100.0 | 2.9 | 1.0892 | 9.0 | 0.97 |
| 6 | Kingenta 43-0-0 (K3) | 240 pre | 100.0 | 2.9 | 1.0864 | 6.0 | 1.09 |
| 7 | Kingenta 43-0-0 (K3) | 240 plt | 100.0 | 3.3 | 1.0847 | 6.0 | 1.22 |
| 8 | Kingenta 20-8-10 (KB) | 240 pre | 100.0 | 2.7 | 1.0903 | 12.0 | 1.11 |
| 9 | Kingenta 20-8-10 (KB) | 240 plt | 100.0 | 2.8 | 1.0942 | 13.0 | 0.99 |
| 10 | ESN 44-0-0 | 160 pre | 98.5 | 2.8 | 1.0888 | 10.3 | 0.87 |
| 11 | ESN 44-0-0 | 240 pre | 100.0 | 3.2 | 1.0878 | 8.0 | 1.28 |
| 12 | ESN 44-0-0 | 240 plt | 100.0 | 2.9 | 1.0890 | 4.0 | 1.39 |
|  |  | **Significance**[1] | NS | NS | ++ | NS | ** |
|  |  | LSD (0.1) | -- | -- | 0.0054 | -- | 0.21 |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 3. Effects of N source, rate, and timing on nitrate-N concentrations in petioles on three sampling dates.

| **Treatment #** | **Nitrogen Source** | **N Rate/Timing lb N/A** | **Petiole Nitrate - N** | | |
|---|---|---|---|---|---|
| | | | **24-Jun** | **7-Jul** | **21-Jul** |
| | | | **----------------- ppm ---------------** | | |
| 1 | Control | 0 | 2815 | 367 | 149 |
| 2 | Urea | 160 | 14973 | 6362 | 3780 |
| 3 | Urea | 240 | 19652 | 14724 | 12415 |
| 4 | Urea | 240 pre | 20588 | 11893 | 6426 |
| 5 | Kingenta 43-0-0 (K3) | 160 pre | 14290 | 5817 | 1770 |
| 6 | Kingenta 43-0-0 (K3) | 240 pre | 17695 | 11485 | 7115 |
| 7 | Kingenta 43-0-0 (K3) | 240 plt | 15468 | 14488 | 11484 |
| 8 | Kingenta 20-8-10 (KB) | 240 pre | 22770 | 10804 | 6292 |
| 9 | Kingenta 20-8-10 (KB) | 240 plt | 21598 | 11315 | 5063 |
| 10 | ESN 44-0-0 | 160 pre | 16024 | 7107 | 3113 |
| 11 | ESN 44-0-0 | 240 pre | 19238 | 11964 | 7216 |
| 12 | ESN 44-0-0 | 240 plt | 16306 | 16724 | 12588 |
| | | **Significance[1]** | ** | ** | ** |
| | | LSD (0.1) | 2139 | 2067 | 1736 |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 4. Effects of N source, rate, and timing on residual inorganic soil N after harvest.

| **Treatment #** | **Nitrogen Source** | **N Rate/Timing lb N/A** | **Residual Soil N** | | |
|---|---|---|---|---|---|
| | | | **Total** | **$NH_4$-N** | **$NO_3$-N** |
| | | | **---------------lbs. / A --------------** | | |
| 1 | Control | 0 | 41.2 | 25.4 | 15.9 |
| 2 | Urea | 160 | 42.8 | 25.8 | 17.0 |
| 3 | Urea | 240 | 44.6 | 23.1 | 21.5 |
| 4 | Urea | 240 pre | 37.4 | 21.1 | 16.3 |
| 5 | Kingenta 43-0-0 (K3) | 160 pre | 37.3 | 23.8 | 13.5 |
| 6 | Kingenta 43-0-0 (K3) | 240 pre | 38.5 | 21.9 | 16.6 |
| 7 | Kingenta 43-0-0 (K3) | 240 plt | 54.6 | 32.3 | 22.3 |
| 8 | Kingenta 20-8-10 (KB) | 240 pre | 61.3 | 28.2 | 33.1 |
| 9 | Kingenta 20-8-10 (KB) | 240 plt | 62.1 | 32.0 | 30.1 |
| 10 | ESN 44-0-0 | 160 pre | 48.0 | 28.6 | 19.4 |
| 11 | ESN 44-0-0 | 240 pre | 48.1 | 27.8 | 20.3 |
| 12 | ESN 44-0-0 | 240 plt | 57.9 | 33.0 | 24.8 |
| | | **Significance[1]** | ** | ++ | ** |
| | | LSD (0.1) | 11.4 | 9.4 | 7.8 |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

# Red Norland and Russet Norkotah Response to Nitrogen Source, Timing, and Rate

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**Summary:** A field experiment was conducted for the second year at the Sand Plain Research Farm in Becker, Minn. to evaluate the effects of nitrogen source, timing, and rate on yield and quality of Red Norland and Russet Norkotah potato. For each variety, nine N treatments were evaluated, which included a zero N control. Four of the nine treatments were conventional N sources with the following N rates (lb/A): 160 and 220 split applied urea, 220 preplant applied urea and 220 emergence applied urea for Red Norland and 180 and 240, 240 preplant applied urea and 240 emergence applied urea for Russet Norkotah. Four of the seven treatments were ESN: 160 and 220 lb N/A preplant and 160 and 220 lb N/A banded at planting for Red Norland and 180 and 240 lb N/A preplant and 180 and 240 lb N/A banded at planting for Russet Norkotah. A starter N rate of 40 lb N/A as diammonium phosphate was included in the total N rate applied. Release of N from ESN was similar to that recorded in 2008 and about 20-30 days faster than that recorded in years prior to 2008, suggesting that the coating was either different or perhaps subjected to more abrasion. Soil chemical properties had a major influence on potato response to ESN in application in 2009. Soil pH was 4.8 and soil P was 29 ppm prior to planting. Growth and yield of both varieties was poor when ESN was applied in a band at planting suggesting that roots were slow to reach the band. The preplant applied urea treatment resulted in higher yields for both varieties than urea applied at emergence. Yields with preplant ESN were similar to those with preplant urea and this timing resulted in the best performance for both varieties. Leaching was not a major factor in 2009 so early applied N as urea was not lost during the season.

**Background:** Previous studies with ESN have focused on late maturing processing cultivars. Preliminary ESN demonstrations have shown some promise with early and mid season maturing cultivars such as 'Red Norland' and 'Russet Norkotah' if the application is made at planting or earlier. As with late maturing cultivars, the advantage of using ESN is that multiple N fertilizer applications can be reduced or eliminated. In addition, the potential for N losses with early season rainfall may be minimized. The overall objective of this study is to evaluate the effects of ESN applications on yield and quality of Red Norland and Russet Norkotah potato. This was the second year of the study.

## Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye. Selected soil chemical properties before planting in the plot area planted to Red Norland were as follows (0-6"): water pH, 4.8; buffer pH, 6.0; organic matter, 2.2%; Bray P1, 29 ppm; ammonium acetate extractable K, Ca, and Mg, 78, 363, and 42 ppm, respectively; Ca-phosphate extractable $SO_4$-S, 4.5 ppm; and DTPA extractable Zn, Cu, Fe, and Mn, 1.4, 0.5, 122.0, and 36.4 ppm, respectively. Extractable nitrate-N and ammonium-N in the top 2 ft prior to planting were 10.0 and 15.6 lb/A, respectively.

Selected soil chemical properties before planting in the Russet Norkotah plot area were as follows (0-6"): water pH, 5.0; organic matter, 1.7%; Bray P1, 23 ppm; ammonium acetate extractable K, Ca, and Mg, 59, 301, and 36 ppm, respectively; Ca-phosphate extractable $SO_4$-S, 4.0 ppm; and DTPA extractable Zn, Cu, Fe, and Mn, 0.7, 0.3, 67.5, and 15.2 ppm, respectively.

Extractable nitrate-N and ammonium-N in the top 2 ft prior to planting were 10.3 and 12.6 lb/A, respectively.

The two cultivars were planted as separate experiments and each treatment was replicated four times for each cultivar in a randomized complete block design. Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed was used for both cultivars. Red Norland was hand planted in furrows on April, 17, 2009 and Russet Norkotah was planted on April 21. Row spacing was 12 inches within each row and 36 inches between rows. Admire Pro was applied in-furrow for beetle control. Weeds, diseases, and other insects were controlled using standard practices during the growing season. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Each cultivar was subjected to nine N treatments with different N sources, rates, and application timing as described in Tables 1 and 2. Comparisons among N sources and application timing were the same for the two cultivars, but total N rates were 0, 160, or 220 lb N/A for Red Norland and 0, 180, or 240 lb N/A for Russet Norkotah.

Table 1. Nitrogen fertilizer treatments for Red Norland.

| **Treatment** | **Preplant** | **Planting** | **Emergence** | **Posthilling** | **Total** |
|---|---|---|---|---|---|
| | --------------------------N sources* and rates (lb N/A) ---------------------- | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 40 D | 90 U | 30 UAN | 160 |
| 3 | 0 | 40 D | 120 U | 60 UAN | 220 |
| 4 | 120 E | 40 D | 0 | 0 | 160 |
| 5 | 180 E | 40 D | 0 | 0 | 220 |
| 6 | 0 | 40 D + 120 E | 0 | 0 | 160 |
| 7 | 0 | 40 D + 180 E | 0 | 0 | 220 |
| 8 | 0 | 40 D | 180 U | 0 | 220 |
| 9 | 180 U | 40 D | 0 | 0 | 220 |

*E = ESN, D = diammonium phosphate (DAP), U = urea, UAN = a combination of granular urea and ammonium nitrate.

Table 2. Nitrogen fertilizer treatments for Russet Norkotah.

| **Treatment** | **Preplant** | **Planting** | **Emergence** | **Post-hilling** | **Total** |
|---|---|---|---|---|---|
| | --------------------------N sources* and rates (lb N/A) ---------------------- | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 40 D | 90 U | 50 UAN | 180 |
| 3 | 0 | 40 D | 120 U | 80 UAN | 240 |
| 4 | 140 E | 40 D | 0 | 0 | 180 |
| 5 | 200 E | 40 D | 0 | 0 | 240 |
| 6 | 0 | 40 D + 140 E | 0 | 0 | 180 |
| 7 | 0 | 40 D + 200 E | 0 | 0 | 240 |
| 8 | 0 | 40 D | 200 U | 0 | 240 |
| 9 | 200 U | 40 D | 0 | 0 | 240 |

*E = ESN, D = diammonium phosphate (DAP), U = urea, UAN = a combination of granular urea and ammonium nitrate.

Preplant ESN fertilizer was applied for both Red Norland and Russet Norkotah on April 16 and disked in. Nitrogen applications at planting were banded 3 inches to each side and 2 inches below the seed piece using a belt type applicator. For all treatments, banded fertilizer at planting included 100 lb $P_2O_5$/A as diammonium phosphate or triple superphosphate (for the 0 N control), 200 lb $K_2O$/A as potassium chloride and potassium magnesium sulfate, 30 lb Mg/A and 55 lb S/A as potassium magnesium sulfate, 2 lb Zn/A as zinc oxide, and 0.5 lb B/A as boric acid. Emergence N applications were supplied as urea and mechanically incorporated. Post-hilling N was applied by hand as 50% granular urea and 50% ammonium nitrate, which was watered-in with overhead irrigation to simulate fertigation with a 28% UAN solution. For both cultivars, emergence fertilizer was applied on May 18 and post-hilling N was applied on June 11.

Plant stands were measured on June 3 for Red Norland and June 9 for Russet Norkotah, and the number of stems per plant was counted on June 9 for both cultivars. Petiole samples were collected from the 4th leaf from the terminal on three dates: June 16, June 30, and July 15 for Red Norland and June 16, June 30, and July 14 for Russet Norkotah. Petioles were analyzed for nitrate-N on a dry weight basis. Vines were harvested from two, 10-ft sections of row on July 30 for Red Norland (104 days after planting) and Aug. 13 for Russet Norkotah (114 days after planting), followed by mechanically beating the vines over the entire plot area. Plots were machine harvested on Aug. 24 for Red Norland and Aug. 27 for Russet Norkotah and total tuber yield and graded yield were measured. Sub-samples of vines and tubers were collected to determine moisture percentage and N concentrations, which were then used to calculate N uptake and distribution within the plant. Nitrogen uptake results were not available at the time of this report. Tuber sub-samples were also used to determine tuber specific gravity and the incidence of hollow heart and brown center.

A WatchDog weather station from Spectrum Technologies was used to monitor rainfall, air temperature, and soil temperature at the fertilizer band depth. Measured amounts of ESN fertilizer were placed in plastic mesh bags and buried at the depth of fertilizer placement when both the preplant and emergence applications were made. Bags were removed on April 28, May 11, May 22, June 3, June 16, July 1, July 22, Aug 12, Sept 9, and Oct 20 to track N release over time.

## RESULTS

### Weather

Rainfall and irrigation for the 2009 growing season for the Norland plot are provided in Figure 1. The Norkotah graphs would be similar except that they were planted 5 days later than Norland. From April 17 to September 9, approximately 13.4 inches of rainfall was supplemented with 11.0 inches of irrigation for Norland and 13.1 inches for Norkotah. There were no leaching events early in the season. Leaching events (greater than 1 inch of water) occurred at 60, 113, and 123 days after planting. Air temperature measurements and soil temperature and moisture measurements at the fertilizer band depth (10 inches below the top of the hill) are provided in Figure 2. Soil moisture was only monitored in the banded at planting 240 lb N/A ESN treatment. Of interest is that the water potential from 10 to 60 days after planting indicated almost saturated conditions with very little water uptake, suggesting that roots were very shallow for most of the season. Reasons for the shallow root system are discussed below.

## Nitrogen Release from ESN

Figures 3 and 4 show release of N from ESN applied preplant and at emergence for the Norland and Norkotah plots respectively. The shape of the curves was similar for both plots. Release of N from ESN tended to be similar to that reported in 2008, but faster than that recorded in previous years. In 2007, approximately 80% of N was released by 70 days after planting for preplant and planting applied fertilizer and by 80 days after planting for ESN applied at emergence. In 2008, 80% had been released by 40 days after planting for the preplant application and by about 50 days for the emergence application. In 2009, 80% had been released by 45 days after planting for the preplant application and by about 55 days for the emergence application. Given the apparent need for early season N for these potato varieties, the shorter release time may have been advantageous. Differences in release rate are likely due to difference in abrasion of the coating as well as temperature difference. Temperatures in 2009 were cooler than those in 2008.

## Stand Count and Stems per Plant

The stand of both Norland and Norkotah crops ranged from 95 to 100% (Table 3 and 4). For Norland, stand was not affected by treatment but for Norkotah, urea applied at emergence resulted in slightly lower stand. Reasons for this reduction are not clear. For Norland, stem number per plant ranged for 4.1 to 4.7 while for Norkotah, stem number per plant ranged from 3.6 to 4.4. The slightly higher stems per plant for Norland were likely due to the use of “B” seed as compared with cut “A” seed for Norkotah. Nitrogen treatments did not significantly affect stem number.

## Tuber Yield and Size Distribution

The effects of N application rate, source, and timing on tuber yield and size distribution for both varieties are shown in Tables 5 and 6. For Norland (Table 5), total yields increased with increasing N rate with the highest yield at 220 lb N/A in the preplant urea and preplant ESN treatments. One of the more dramatic effects that occurred in 2009 was the negative effects of planting applied ESN on Norland yield. Plants in these treatments appeared stunted most of the season with signs of nitrogen and phosphorus stress. The low pH and P in this site apparently limited growth of the roots to the fertilizer band (where all the N fertilizer was located) and resulted in poor yields. Vine dry matter at harvest was also lower for these ESN treatments. Unlike previous years ESN did not increase the yield of smaller tubers. The preplant urea treatment (treatment #9) resulted in higher yields than urea applied at emergence and numerically higher yields than urea split applied. Yields with preplant ESN (treatment #5) were similar to those with preplant urea and this timing resulted in the best performance for Norland in 2009. Leaching was not a major factor in 2009, so early applied N was not lost during the season.

Yield of Norkotah increased with N compared with the control, but effects at higher N rates depended on N source (Table 6). For split applied urea and preplant applied ESN, yield with 180 lb N/A was similar to yield with 240 lb N/A. Highest yields were with 240 lb N/A preplant applied urea, which were similar to yields with preplant applied ESN at the same N rate. Tuber size in general increased with increasing N rate regardless of source. The one exception was planting applied ESN, which resulted in the lowest yields due to limited root growth as a result of low pH and nitrogen/phosphorus deficiency. As stated above, leaching was not a major factor in 2009, so early applied N was not lost during the season.

### Tuber Quality

Tables 7 and 8 show the effects of N application source, timing, and rate on tuber quality. For Norland (Table 7), hollow heart was not detected. Scab incidence and red skin color was not affected by N treatments. For Norkotah (Table 8), specific gravity tended to be highest in the control and lowest with ESN applied at planting. It is likely that roots in the planting ESN treatments had reached the fertilizer band by the end of the growing season and delayed maturity (see petiole nitrate discussion below). Hollow heart was generally low with no differences due to N treatment. Scab incidence was variable and not consistently affected by N source or rate.

### Petiole Nitrate-N Concentrations

#### *Nitrogen rate, source, and timing comparisons*

Petiole $NO_3$-N concentrations on three dates as affected by N source, timing, and rate are presented in Table 9 for Norland and Table 10 for Norkotah. As expected, petiole $NO_3$-N increased with increasing N rate for both varieties and decreased as the season progressed, with the exception of the planting applied ESN treatments. Samples collected on the first sampling date indicated deficient levels of petiole nitrate with planting applied ESN. These results are consistent with the suggestion that root growth was poor for most of the season with banded applied nutrients in this low pH and P soil. Once roots did grow into the banded area, petiole nitrate increased. These effects were apparent in both varieties, but were more distinct for Norland than for Norkotah. Preplant urea and ESN resulted in the higher petiole $NO_3$-N levels than split applied urea early in the season and lower levels later in the season. Petiole P was also determined in selected treatments on the June 30 sampling date. For Norland, planting applied ESN resulted in lower petiole P (0.31% P) than with preplant applied ESN (0.48% P) or with split applied urea (0.44% P). For Norkotah, planting applied ESN resulted in lower petiole P (0.31% P) than with preplant applied ESN (0.32% P) or with split applied urea (0.38% P). These results suggest that N was more limiting than P as all petiole P concentrations were in a range considered to be sufficient.

## CONCLUSIONS

During this year of low leaching events in May and June, the best yields were obtained with preplant applied urea or ESN at 220 lb N/A for Norland and 240 lb N/A for Norkotah. In many years, early applied N would be subject to leaching with heavy spring rainfall; however, because leaching was not a major factor in 2009, early applied N was not lost during the season.

Banded applied ESN did not perform well this year due to the low pH and low P in this soil, which resulted in poor root growth within the hill. It took almost the whole season for the roots to reach the fertilizer band. Release of N from ESN was 20-30 days faster than that recorded in previous years, suggesting that the coating was either different or perhaps more abraded.

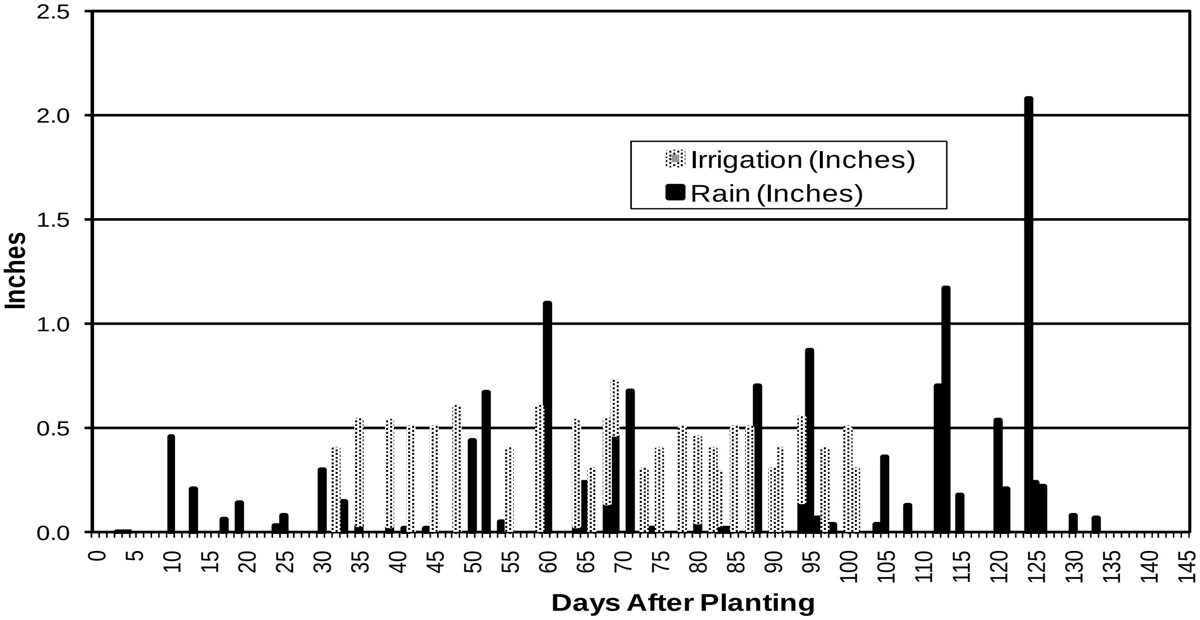

Figure 1. Rainfall and irrigation over the 2009 growing season for the Norland Plots.

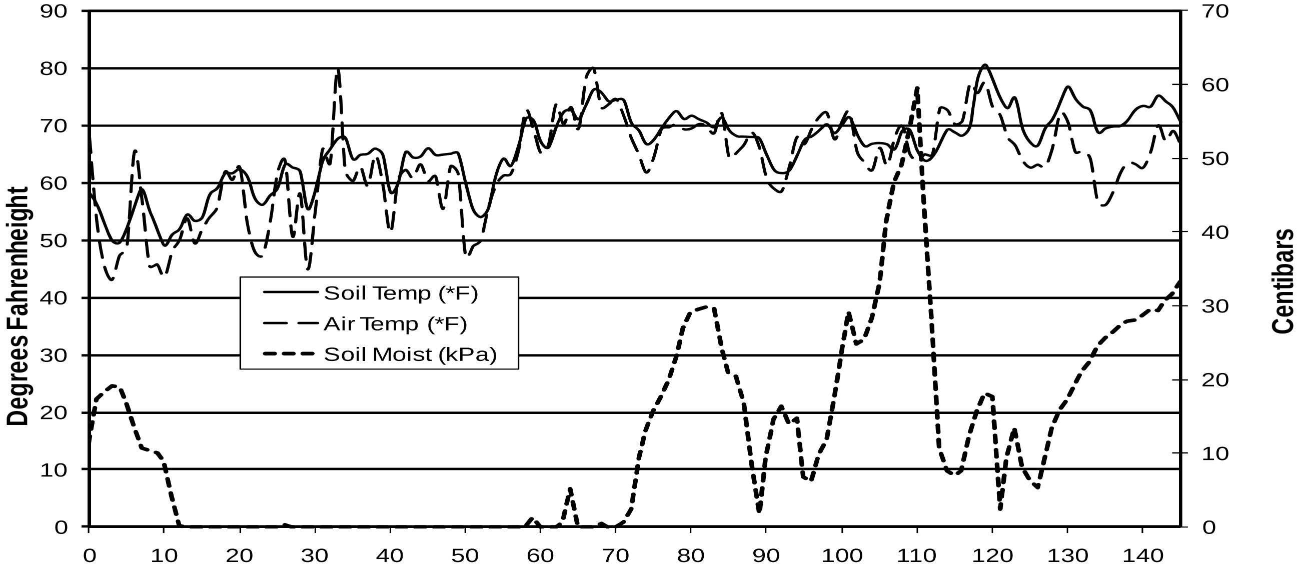

Figure 2. Average daily air and soil temperature and moisture at the 10 inch depth below the top of the hill over the growing season.

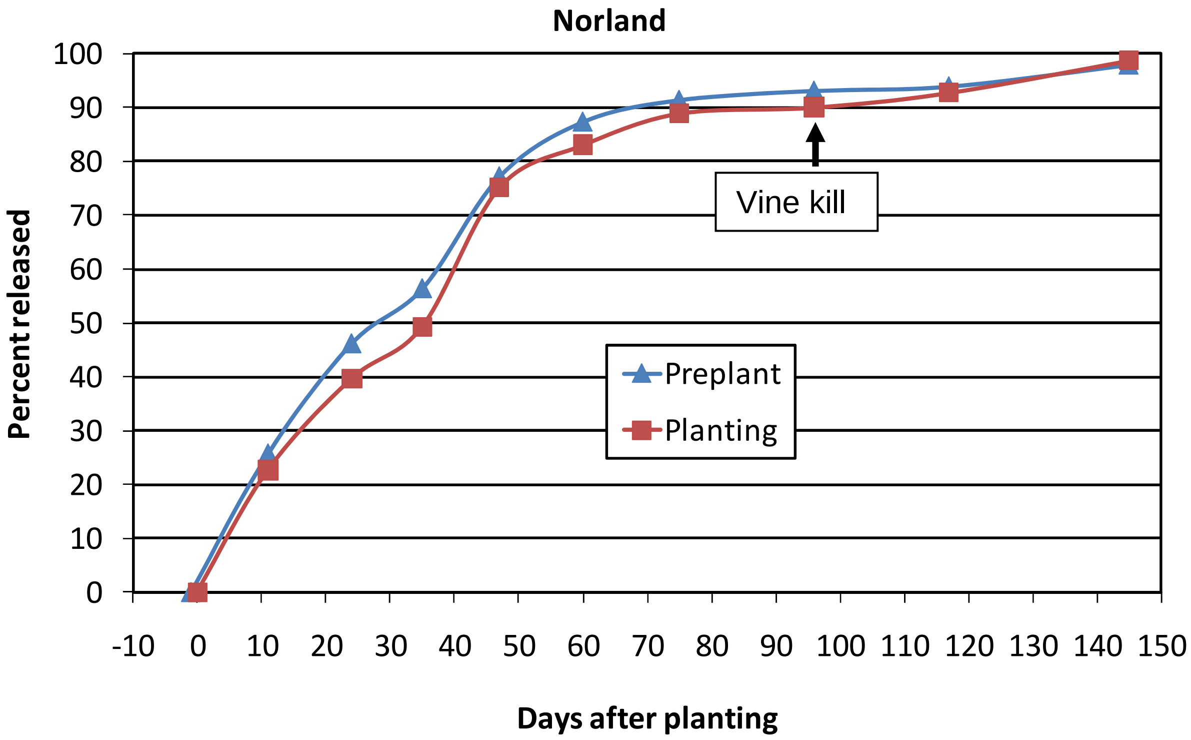

Figure 3. N released from ESN applied preplant and at planting for Norland potato in 2009.

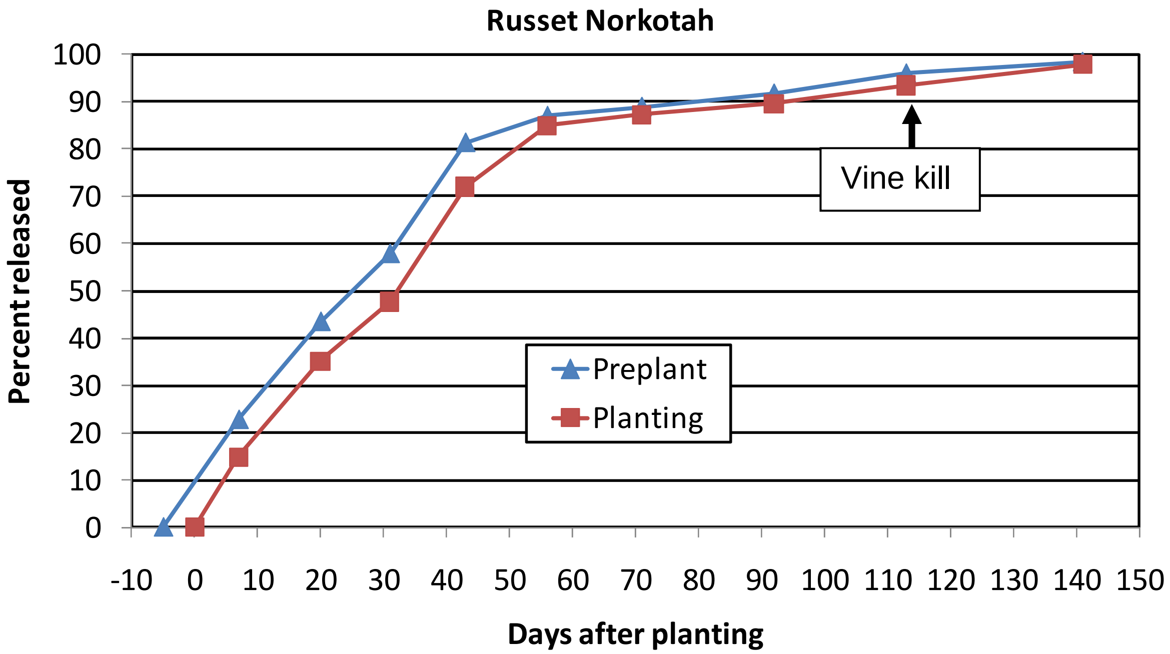

Figure 4. N released from ESN applied preplant and at planting for Norkotah potato in 2009.

Table 3. Effect of N source, timing, and rate on Norland stand and number of stems per plant.

| Treatment # | Source | Rate (lb N/A) | Stand (%) | Number of Stems per plant |
|---|---|---|---|---|
| 1 | Control | 0 | 100.0 | 4.4 |
| 2 | Urea | 160 | 100.0 | 4.5 |
| 3 | Urea | 220 | 100.0 | 4.1 |
| 4 | ESN | 160 pre | 100.0 | 4.6 |
| 5 | ESN | 220 pre | 99.3 | 4.5 |
| 6 | ESN | 160 plt | 100.0 | 4.4 |
| 7 | ESN | 220 plt | 100.0 | 4.5 |
| 8 | Urea | 220 em | 99.3 | 4.5 |
| 9 | Urea | 220 pre | 97.8 | 4.7 |
|  |  | **Significance**[2] | NS | NS |
|  |  | LSD (0.1) | -- | -- |

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 4. Effect of N source, timing, and rate on Norkotah stand and number of stems per plant.

| Treatment # | N Source | Rate (lb N/A) | Stand (%) | Number of Stems per plant |
|---|---|---|---|---|
| 1 | Control | 0 | 98.5 | 4.0 |
| 2 | Urea | 180 | 100.0 | 3.9 |
| 3 | Urea | 240 | 99.3 | 4.0 |
| 4 | ESN | 180 pre | 100.0 | 4.4 |
| 5 | ESN | 240 pre | 100.0 | 3.6 |
| 6 | ESN | 180 plt | 100.0 | 3.8 |
| 7 | ESN | 240 plt | 100.0 | 4.0 |
| 8 | Urea | 240 em | 95.5 | 3.7 |
| 9 | Urea | 240 pre | 100.0 | 4.2 |
|  |  | **Significance**[1] | ** | NS |
|  |  | LSD (0.1) | 1.5 | -- |

[1]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 5. Effect of N source, timing, and rate on Norland tuber yield and size distribution and vine weights at harvest.

| | | | Tuber Yield | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | % | Vine |
| Treatment | Source | Rate | < 1.75" | 1.75-2.25" | 2.25-2.50" | 2.50-3.00" | > 3.00" | Total | > 2.25" | DM |
| # | | lb N/A | cwt/A | | | | | | | Tons/A |
| 1 | Control | 0 | 16.6 | 114.7 | 95.2 | 22.5 | 2.0 | 251.0 | 47.3 | 0.42 |
| 2 | Urea | 160 | 11.4 | 71.2 | 142.1 | 135.0 | 47.5 | 407.3 | 78.7 | 0.82 |
| 3 | Urea | 220 | 12.1 | 81.5 | 147.3 | 143.2 | 32.5 | 416.5 | 77.2 | 0.91 |
| 4 | ESN | 160 pre | 11.6 | 77.0 | 144.1 | 144.4 | 22.1 | 404.6 | 76.8 | 0.83 |
| 5 | ESN | 220 pre | 11.0 | 73.1 | 128.3 | 169.8 | 64.1 | 446.3 | 81.0 | 0.99 |
| 6 | ESN | 160 plt | 12.2 | 87.7 | 133.9 | 112.0 | 13.2 | 358.9 | 72.1 | 0.72 |
| 7 | ESN | 220 plt | 12.2 | 89.5 | 128.6 | 57.2 | 6.5 | 294.0 | 64.9 | 0.67 |
| 8 | Urea | 220 em | 14.3 | 77.3 | 133.7 | 144.4 | 22.4 | 392.1 | 76.3 | 0.85 |
| 9 | Urea | 220 pre | 10.3 | 62.0 | 144.8 | 142.0 | 71.1 | 443.2 | 80.2 | 0.87 |
| | Significance[2] | | NS | ** | * | ** | * | ** | ** | ** |
| | LSD (0.1) | | -- | 15.9 | 27.3 | 35.9 | 37.2 | 37.9 | 6.7 | 0.11 |

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 6. Effect of N source, timing and rate on Norkotah tuber yield and size distribution and vine weights at harvest.

| | | | Tuber Yield | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | #1 | # 2 | Total | | | Vine |
| Treatment | N Source | Rate | 0-3oz | 3-6oz | 6-10 oz | 10-14oz | >14oz | Total | > 3oz | >3oz | marketable | > 6oz | > 10 oz | DM |
| # | | lb N/A | cwt/A | | | | | | | | | % | % | Tons /A |
| 1 | Control | 0 | 79.8 | 137.7 | 58.4 | 1.0 | 0.0 | 276.9 | 193.8 | 3.3 | 197.1 | 21.2 | 0.3 | 0.28 |
| 2 | Urea | 180 | 72.5 | 157.1 | 194.4 | 68.5 | 27.1 | 519.4 | 434.3 | 12.6 | 446.9 | 55.8 | 18.5 | 0.87 |
| 3 | Urea | 240 | 81.1 | 139.8 | 151.8 | 96.9 | 52.2 | 521.7 | 421.6 | 19.0 | 440.6 | 57.5 | 28.4 | 0.91 |
| 4 | ESN | 180 pre | 77.1 | 168.9 | 179.9 | 79.2 | 26.1 | 531.2 | 444.0 | 10.0 | 454.1 | 53.7 | 19.8 | 0.81 |
| 5 | ESN | 240 pre | 58.5 | 127.1 | 160.3 | 105.8 | 69.6 | 521.3 | 444.7 | 18.2 | 462.8 | 64.4 | 33.7 | 0.79 |
| 6 | ESN | 180 plt | 61.7 | 115.4 | 151.7 | 68.2 | 23.6 | 420.6 | 338.9 | 20.0 | 358.9 | 57.9 | 21.9 | 0.72 |
| 7 | ESN | 240 plt | 53.6 | 119.2 | 145.2 | 68.3 | 26.7 | 413.1 | 342.6 | 16.8 | 359.4 | 57.9 | 22.8 | 0.80 |
| 8 | Urea | 240 em | 55.8 | 111.7 | 159.8 | 115.0 | 67.7 | 510.0 | 430.8 | 23.4 | 454.2 | 67.1 | 35.7 | 0.75 |
| 9 | Urea | 240 pre | 71.8 | 153.6 | 186.6 | 89.7 | 43.9 | 545.6 | 460.5 | 13.3 | 473.8 | 58.6 | 24.4 | 0.80 |
| | Significance[2] | | ** | ** | ** | ** | ** | ** | ** | * | ** | ** | ** | ** |
| | | LSD (0.1) | 13.1 | 19.7 | 23.7 | 16.6 | 19.6 | 26.1 | 32.8 | 10.5 | 31.7 | 5.1 | 4.4 | 0.20 |

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 7. Effect of N source, timing, and rate on Norland tuber quality.

| Treatment # | Source | Rate lb N/A | Visred[2] | Scab % | HH % |
|---|---|---|---|---|---|
| 1 | Control | 0 | 2.9 | 5.1 | 0.0 |
| 2 | Urea | 160 | 3.0 | 9.0 | 0.0 |
| 3 | Urea | 220 | 3.0 | 7.0 | 0.0 |
| 4 | ESN | 160 pre | 3.0 | 4.9 | 0.0 |
| 5 | ESN | 220 pre | 3.0 | 4.0 | 0.0 |
| 6 | ESN | 160 plt | 2.9 | 4.0 | 0.0 |
| 7 | ESN | 220 plt | 3.0 | 7.0 | 0.0 |
| 8 | Urea | 220 em | 3.0 | 1.0 | 0.0 |
| 9 | Urea | 220 pre | 3.0 | 9.1 | 0.0 |
| | | **Significance[1]** | NS | NS | NS |
| | | LSD (0.1) | -- | -- | -- |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

[2] Visual red color rating: 1(pale red/pink) to 5 (dark red).

Table 8. Effect of N source, timing, and rate on Norkotah tuber quality.

| Treatment # | N Source | Rate lb N/A | Specific gravity | HH % | Scab % |
|---|---|---|---|---|---|
| 1 | Control | 0 | 1.0747 | 0.0 | 2.0 |
| 2 | Urea | 180 | 1.0718 | 1.0 | 11.4 |
| 3 | Urea | 240 | 1.0692 | 3.0 | 7.1 |
| 4 | ESN | 180 pre | 1.0704 | 0.0 | 7.0 |
| 5 | ESN | 240 pre | 1.0735 | 0.0 | 7.2 |
| 6 | ESN | 180 plt | 1.0676 | 0.0 | 11.0 |
| 7 | ESN | 240 plt | 1.0673 | 0.0 | 17.0 |
| 8 | Urea | 240 em | 1.0720 | 0.0 | 1.0 |
| 9 | Urea | 240 pre | 1.0720 | 1.0 | 12.0 |
| | | **Significance[2]** | * | NS | ++ |
| | | LSD (0.1) | 0.0041 | -- | 10.5 |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 9. Effect of N source, timing, and rate on Norland petiole nitrate-N.

| **Treatment #** | **Source** | **Rate (lb N/A)** | **Petiole Nitrate - N** | | |
|---|---|---|---|---|---|
| | | | **16-Jun** | **30-Jun** | **15-Jul** |
| | | | **------------------ppm----------------** | | |
| 1 | Control | 0 | 3064 | 342 | 319 |
| 2 | Urea | 160 | 12531 | 15159 | 9789 |
| 3 | Urea | 220 | 13708 | 19870 | 12816 |
| 4 | ESN | 160 pre | 12881 | 14160 | 7237 |
| 5 | ESN | 220 pre | 16935 | 19724 | 14911 |
| 6 | ESN | 160 plt | 8940 | 11727 | 13246 |
| 7 | ESN | 220 plt | 9774 | 10841 | 14934 |
| 8 | Urea | 220 em | 14794 | 18276 | 15594 |
| 9 | Urea | 220 pre | 16321 | 17990 | 12347 |
| | | **Significance**[2] | ** | ** | ** |
| | | LSD (0.1) | 1143 | 2507 | 2593 |

Table 10. Effect of N source, timing, and rate on Norkotah petiole nitrate-N.

| **Treatment #** | **N Source** | **Rate (lb N/A)** | **Petiole Nitrate - N** | | |
|---|---|---|---|---|---|
| | | | **16-Jun** | **30-Jun** | **14-Jul** |
| | | | **-------------------ppm------------------** | | |
| 1 | Control | 0 | 3926 | 704 | 573 |
| 2 | Urea | 180 | 17720 | 18305 | 11583 |
| 3 | Urea | 240 | 18145 | 21127 | 16682 |
| 4 | ESN | 180 pre | 18801 | 17264 | 9320 |
| 5 | ESN | 240 pre | 20204 | 19153 | 13554 |
| 6 | ESN | 180 plt | 12767 | 19474 | 17079 |
| 7 | ESN | 240 plt | 14314 | 20746 | 17981 |
| 8 | Urea | 240 em | 18051 | 21466 | 16892 |
| 9 | Urea | 240 pre | 20576 | 20469 | 12749 |
| | | **Significance**[2] | ** | ** | ** |
| | | LSD (0.1) | 1661 | 2285 | 2672 |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

# Evaluation of Specialty Phosphorus Fertilizer Sources for Potato

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**Summary:** Field experiments were conducted at the Sand Plain Research Farm in Becker, Minn. to evaluate the effects of specialty P fertilizer formulations manufactured by Mosaic Co. on yield, quality, and P nutrition of Russet Burbank potato. Treatments included a zero P control; MAP, MES10, and MESZ fertilizers applied at 60 and 120 lb $P_2O_5$/A; and ACT142, 143, 144, and 145 fertilizers applied at 120 lb $P_2O_5$/A. Some of the treatments were also adjusted to permit comparisons of treatments with and without S, Mg, and Zn. One or more of these nutrients are contained in each of the specialty P fertilizers. All of the P sources significantly increased total tuber yield compared with the zero P control. At the 120 lb $P_2O_5$/A rate, MAP+S resulted in the greatest total yield in the study, but this treatment also had the highest proportion of undersized tubers (<4 oz). The zero P control also had the lowest marketable yield, but treatment effects on marketable yield were not significant due to higher tuber set with P fertilizer. The zero P control had the lowest amounts of small tubers and the highest percentages of large tubers, which was consistent with reduced tuber set when no P was applied. Sulfur, Mg, and Zn had no significant effects on total or marketable yield, but application of Mg and the high rate of Zn did result in lower amounts of small tubers and higher percentages of large tubers. MAP+S had greater tuber set at the high P rate than the low P rate, but increasing the P rate did not increase tuber set with MES10 and MESZ. Application of P increased petiole P concentrations at tuber set and late tuber bulking, but not at early and mid tuber bulking. Application of S, Mg, and Zn had no effects on their concentrations in petioles. The zero P control had significantly lower dry matter production, tuber P concentration, and total P uptake than the treatments receiving P fertilizer. There were no significant differences among the P sources in dry matter, tuber P, and P uptake. Application of Mg significantly increased tuber Mg concentrations.

**Background:** One of the challenges associated with improving P use efficiency in plants is maintaining an available form of P following application of P fertilizer. Acid and high pH soil will tend to adsorb or precipitate soluble P. Use of elemental sulfur in the formulation has an acidifying effect and may help keep P in solution for a longer period of time, particularly on neutral to alkaline soils. Specialty P fertilizers have recently been developed by The Mosaic Company (US patent #6544313) that blend sulfur into a monoammonium phosphate (MAP)-based product. Formulations containing Zn and Mg have also been developed. This is the third year of a study with the overall objective of determining potato response to specialty P products manufactured by The Mosaic Company. Results in 2007 showed yield increases with specialty P fertilizers compared with conventional sources, but no differences were found in 2008. The reason for this may have been higher soil test P levels in 2008. The objective of this 2009 study was to follow up on previous research and determine the effects of the specialty P fertilizers MES10, MESZ, ACT142, ACT143, ACT144, and ACT145 on growth and yield of irrigated potato.

## Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye and selected soil chemical properties before planting were as follows (0-6"): water pH, 5.0; buffer pH, 6.4; organic matter, 2.3%; Bray P1, 18 ppm; ammonium acetate extractable K, Ca, and Mg, 63, 324, and 40 ppm, respectively; hot water extractable B, 0.3 ppm; Ca-phosphate extractable $SO_4$-S, 1.0 ppm; and DTPA extractable Zn, Cu, Fe, and Mn, 1.1, 0.4, 90.2, and 29.6 ppm, respectively. Extractable nitrate-N and ammonium-N in the top 2 ft prior to planting were 10.9 and 14.1 lb/A, respectively. Extractable $SO_4$-S in the top 2 ft prior to planting was 20.0 lb/A.

On April 13, 150 lb $K_2O$/A as 0-0-60 (potassium chloride) was broadcast on all plots and later incorporated by plowing. Because of the low pH and calcium levels, 1000 lbs/A pel-lime was applied and incorporated with a field cultivator on April 20. Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole “B” Russet Burbank potato seed was hand planted in furrows on April 21, 2009. Row spacing was 12 inches within each row and 36 inches between rows. Each treatment was replicated 4 times in a randomized complete block design. Admire Pro was applied in-furrow for beetle control, along with the fungicides Quadris and Ultra Flourish. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling. Rainfall and irrigation amounts were recorded and are shown in Fig. 1.

Twelve fertilizer treatments were tested and are listed below. MESZ was tested in 2007 and 2008. This was the first year of testing for MES10, ACT142, ACT143, ACT144, and ACT145.

Fertilizer treatments tested in the specialty phosphorus fertilizers study.

| Treatment number | P rate | P source* | Description | S rate | Zn rate | Mg rate |
|---|---|---|---|---|---|---|
| | lb $P_2O_5$/A | | | ------------ lb/A -------------- | | |
| 1 | 0 | Control | 46-0-0 + 0-0-50-18S | 30 | 0 | 0 |
| 2 | 60 | MAP + S | 11-52-0 + 0-0-50-18S | 30 | 0 | 0 |
| 3 | 60 | MES10 | 12-40-0-10S | 15 | 0 | 0 |
| 4 | 60 | MESZ | 12-40-0-10S-1Zn | 15 | 1.5 | 0 |
| 5 | 120 | MAP | 11-52-0 | 0 | 0 | 0 |
| 6 | 120 | MAP + S | 11-52-0 + 0-0-50-18S | 30 | 0 | 0 |
| 7 | 120 | MES10 | 12-40-0-10S | 30 | 0 | 0 |
| 8 | 120 | MESZ | 12-40-0-10S-1Zn | 30 | 3.0 | 0 |
| 9 | 120 | ACT142 | 10-49-0-2S-1Zn | 4.9 | 2.5 | 0 |
| 10 | 120 | ACT143 + Mg | 10-46-0-3S-1Zn-2Mg + $MgCl_2$ | 7.8 | 2.6 | 35 |
| 11 | 120 | ACT144 | 11-48-0-3S-1Zn | 7.5 | 2.5 | 0 |
| 12 | 120 | ACT145 | 10-44-0-3S-1Zn | 8.2 | 2.7 | 0 |

*MAP = monoammonium phosphate; MES10, MESZ, ACT 142, ACT 143, ACT 144, ACT 145 = specialty P fertilizers from The Mosaic Co.

Phosphorus fertilizer treatments were applied at planting in a band 3 inches to the side and 2 inches below the seed piece using a belt type applicator. Potassium was applied to all plots in the band at planting at a rate of 150 lbs $K_2O$/A. The K source was 0-0-60 or a combination of 0-0-60 and 0-0-50 (potassium sulfate) for treatments 1, 2, and 6 to equalize the amount of S applied with the high rates of MES10 and MESZ. Treatment 10 received 5 lbs Mg/A at planting from ACT143. For all the other treatments except treatment 11, an additional 30 lb Mg/A was sidedressed on May 14 and incorporated in the hilling operation. The additional Mg was supplied as magnesium chloride deicing salt. Total N applied was 236 lb N/A for all treatments. The rate of N applied at planting was adjusted with urea to be equivalent to the amount applied with the high rates of MES10 and MESZ (36 lb N/A). Sidedress N applications were made with urea at the rate of 100 lb N/A at emergence on May 19 and three post-hilling applications as urea-ammonium nitrate on June 11 (50 lb N/A), June 22 (25 lb N/A), and July 1 (25 lb N/A). Plots were irrigated immediately after post-hilling N application to minimize volatilization.

Plant stands were measured on June 3 and the number of stems per plant was counted on June 9. Petiole samples were collected from the 4th leaf from the terminal on June 18, June 30, July 14, and Aug 5. Petioles were analyzed for nitrate-N, P, S, Mg, and Zn on a dry weight basis. Vines were harvested on Sept 16 from two, 10-ft sections of row, followed by mechanically beating the vines over the entire plot area. Tuber numbers in treatments 1-4 and 6-8 were measured by hand-digging five plants before machine harvest on September 25 and separating them into size categories before counting. Total tuber yield, graded yield, tuber specific gravity, and internal disorders were recorded at final harvest. Subsamples of vines and tubers were collected for moisture determination. Dried tissues were weighed and then ground to pass through a 1 mm screen. Phosphorus, N, S, Mg, and Zn concentrations in plant tissue were determined by AgVise laboratories. Phosphorus uptake was calculated by multiplying vine and tuber P concentrations by the amounts of tuber and vine dry matter. Phosphorus uptake results were not available at the time of this report.

The experiment was statistically analyzed using ANOVA procedures on SAS and means were separated using a Waller-Duncan LSD test at P = 0.10. Orthogonal contrasts were also performed to compare P vs. no P, S vs. no S, Mg vs. no Mg, and Zn vs. no Zn and to evaluate linear response to P fertilizer rate.

## Results

**Tuber yield:** Total tuber yield for the zero P control was significantly lower than any of the treatments receiving P fertilizer, indicating that there was a response to P at the Bray P1 soil test level of 18 ppm and the low soil pH of 5.0 (Table 1). For MAP+S there was a strong trend for total yield to increase as the P rate increased up to 120 lb $P_2O_5$/A, but for MES10 and MESZ yields were similar for 60 and 120 lb $P_2O_5$/A. MAP+S at 120 lb $P_2O_5$/A had the highest total yield and at the 10% probability level it was significantly higher than MESZ, ACT142, and ACT145 at 120 lb $P_2O_5$/A. MAP+S was numerically higher than MAP alone, but the difference was not significant, indicating that there was no response to S on this soil. Comparable total yields for ACT143 and ACT144 indicate there was no response to Mg and similar yields for MESZ and MES10 at both P rates indicate no response to Zn.

There were no significant differences among any of the treatments in marketable yield. The zero P control had lower marketable yield than any of the treatments receiving P fertilizer, but the contrast between P and no P was not significant. The control had the lowest amounts of small tubers (0-4 and 4-6 oz) and the highest percentages of large tubers (>6 and >10 oz). Sulfur had no effect on tuber size. ACT144 (no Mg) had significantly higher amounts of small, unmarketable tubers (<4 oz) than ACT143 (with Mg). The percentages of large tubers were numerically higher with Mg added, although the differences were not significant. Zinc had no effect on tuber size at 60 lb $P_2O_5$/A, but at 120 lb $P_2O_5$/A there were significantly lower amounts of small tubers (0-4 and 4-6 oz) and significantly greater percentages of large tubers (>6 and >10 oz) for MESZ (with Zn) than MES10 (no Zn). Zinc application was 1.5 lb/A at 60 lb $P_2O_5$/A and 3.0 lb/A at 120 lb $P_2O_5$/A.

**Plant stand, stems and tubers per plant, and tuber quality:** There were no significant differences among any of the treatments in plant stand, the number of stems per plant, specific gravity, and the incidence of hollow heart (Table 2). The zero P control had significantly lower numbers of tubers per plant than MAP+S, MES10, and MESZ at either 60 or 120 lb $P_2O_5$/A. This is consistent with research in previous years showing increased tuber set with P application. These differences in tuber set are also consistent with the lower amounts of small tubers and higher percentages of large tubers for the control treatment (Table 1). MAP+S also had significantly greater tuber set at the high P rate of 120 lb $P_2O_5$/A than at 60 lb $P_2O_5$/A and tended to have greater amounts of 0-4 oz tubers at the high P rate. MES10 and MESZ did not follow the same pattern and MES10 actually had significantly greater tuber set at the low P rate.

**Petiole nutrient concentrations:** Petiole P concentrations at the time of tuber set were significantly higher for all of the treatments receiving P fertilizer than for the zero P control (Table 3). The zero P control also had significantly lower concentrations of petiole P at late tuber bulking when contrasted with the P fertilized treatments as a group (Table 6). There were no significant effects of P application on petiole P at early or mid tuber bulking (Tables 4 and 5).

There were no significant effects of S, Mg, and Zn application on petiole concentrations of these elements on any sampling date. The zero P control had significantly lower petiole Mg concentration than the P fertilized treatments at early and mid tuber bulking, but significantly higher concentrations of Zn than the P treatments at tuber set and early tuber bulking. The zero P control had significantly lower S concentration than the group of P fertilized treatments at tuber set, but significantly higher S concentration than all of the P treatments at early tuber bulking. The reasons for these differences in petiole Mg, Zn, and S concentrations are not clear, although high soil P can inhibit Zn uptake.

The zero P control had significantly higher petiole nitrate-N concentrations than the group of P fertilized treatments at tuber set and early tuber bulking. This could have been due to reduced growth from inadequate P for the control and subsequent concentration of the N that was taken up. The zero P control also had numerically higher petiole nitrate-N concentrations than most of the other treatments at mid and late tuber bulking. The zero P control had significantly higher petiole K concentrations than all of the P fertilized treatments at early tuber bulking, which could also have been a concentration effect from reduced growth. A similar trend in petiole K also occurred at mid tuber bulking. The MESZ treatment at 120 lb $P_2O_5$/A had significantly higher petiole K concentrations than a number of other treatments at early and mid tuber bulking, but the reasons for these effects are not clear.

**Tuber and vine nutrient concentrations:** The zero P control had significantly lower tuber P concentrations than the group of treatments receiving P fertilizer (Table 7). The contrast between ACT143 (with Mg) and ACT144 (no Mg) found that Mg application significantly increased tuber Mg. There were no significant differences among any of the treatments in tuber concentrations of N, S, or Zn. The zero P control had significantly higher vine concentrations of S and Zn than the group of treatments receiving P fertilizer. There were no significant differences in vine concentrations of P, N, or Mg.

**Tuber and vine dry matter accumulation and P uptake:** The zero P control had significantly lower tuber and total dry matter production and tuber and total P uptake than the group of treatments receiving P fertilizer (Table 8). There were no significant differences among any of the treatments in vine dry matter accumulation at harvest or vine P uptake.

**Conclusions:** All of the P sources significantly increased total tuber yield compared with the zero P control. MAP+S at 120 lb $P_2O_5$/A had the greatest total yield, primarily due to an increase in undersized tubers. Phosphorus fertilization increased tuber set and decreased tuber size. This is consistent with the results of previous research, although increasing the P rate from 60 to120 lb $P_2O_5$/A did not increase tuber set for MES10 and MESZ. Application of S, Mg, and Zn had no effects on yield, but Mg and the high rate of Zn resulted in lower amounts of small tubers and higher percentages of large tubers. Application of P increased petiole P concentrations on some sampling dates, but S, Mg, and Zn applications had no effects on their petiole concentrations. Phosphorus fertilization from all P sources increased dry matter production, tuber P concentration, and total P uptake. Application of Mg significantly increased tuber Mg concentration.

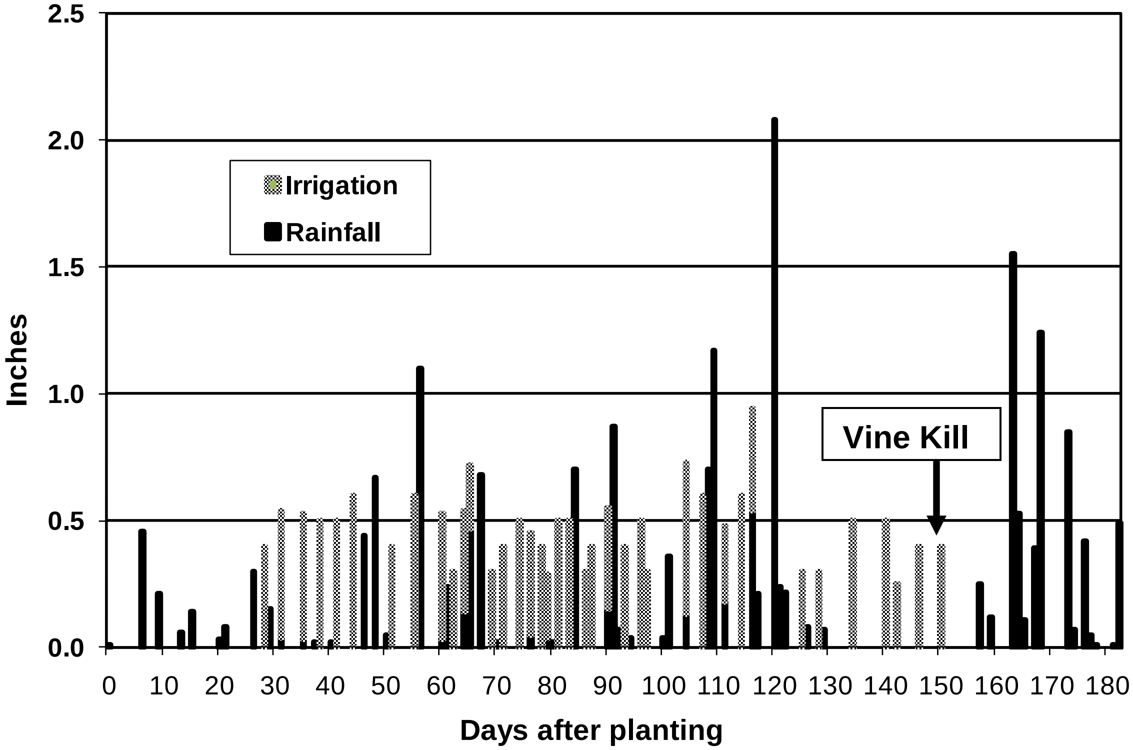

Figure 1. Rainfall and irrigation amounts during the 2009 growing season.

Table 1. Effects of specialty P fertilizers on tuber yield and size distribution of Russet Burbank potatoes.

| Treatments | | | | Tuber Yeild | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | #1 | # 2 | Total | | |
| | | | $P_2O_5$ Rate | 0-4 oz | 4-6 oz | 6-10 oz | 10-14 oz | >14 oz | Total | > 4 oz | > 4 oz | marketable | > 6oz | > 10 oz |
| Treatment # | P Source | Description | lb/A | ---------------------------------------------------------------- cwt/A ------------------------------------------------------------------ | | | | | | | | | % | % |
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 38.8 | 63.9 | 190.4 | 151.0 | 110.5 | 553.6 | 431.7 | 83.1 | 514.8 | 81.3 | 46.5 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 133.7 | 176.9 | 180.3 | 105.0 | 66.2 | 662.0 | 399.3 | 129.1 | 528.4 | 53.3 | 26.3 |
| 3 | MES10 | 12-40-0-10S | 60 | 131.5 | 164.2 | 189.7 | 112.0 | 69.9 | 667.4 | 383.0 | 152.9 | 535.8 | 55.6 | 27.2 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 133.4 | 167.0 | 198.0 | 97.7 | 87.5 | 683.5 | 404.1 | 146.0 | 550.1 | 56.0 | 27.0 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 137.5 | 163.6 | 188.3 | 114.1 | 73.8 | 677.3 | 375.2 | 164.6 | 539.8 | 55.7 | 27.9 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 151.5 | 168.3 | 209.6 | 101.6 | 87.2 | 718.2 | 408.9 | 157.8 | 566.7 | 55.4 | 26.3 |
| 7 | MES10 | 12-40-0-10S | 120 | 126.7 | 176.7 | 172.8 | 109.2 | 75.3 | 660.7 | 436.9 | 97.1 | 534.0 | 54.2 | 27.9 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 102.2 | 133.5 | 184.8 | 140.1 | 98.3 | 658.8 | 417.0 | 139.7 | 556.7 | 64.5 | 36.4 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 133.7 | 162.4 | 188.4 | 102.9 | 68.3 | 655.6 | 402.9 | 119.0 | 521.9 | 54.8 | 26.2 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 121.6 | 166.6 | 221.5 | 106.3 | 63.4 | 679.4 | 468.0 | 89.8 | 557.8 | 57.2 | 24.8 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 147.1 | 176.5 | 214.9 | 81.4 | 51.9 | 671.8 | 428.3 | 96.3 | 524.7 | 51.7 | 19.8 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 122.1 | 144.8 | 217.7 | 111.8 | 60.5 | 656.9 | 429.8 | 105.0 | 534.8 | 59.4 | 26.2 |
| Significance[1] | | | | ** | ** | NS | ** | NS | ** | NS | ** | NS | ** | ** |
| LSD (0.1) | | | | 20.0 | 33.1 | -- | 27.9 | -- | 57.7 | -- | 36.2 | -- | 5.7 | 6.6 |
| Contrasts | | | | | | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | ** | ** | NS | ** | * | ** | NS | ** | NS | ** | ** |
| linear P MAP + S (trmts 1,2,6) | | | | ** | ** | NS | ** | NS | ** | NS | ** | NS | ** | ** |
| linear P MES10 (trmts 1,3,6) | | | | ** | ** | NS | ** | ++ | ** | NS | NS | NS | ** | ** |
| linear MESZ (trmts 1,4,8) | | | | ** | ** | NS | NS | NS | ** | NS | ** | NS | ** | * |
| Mg vs No Mg (trmts 10 vs 11) | | | | * | NS | NS | ++ | NS | NS | NS | NS | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | * | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 2. Effects of specialty P fertilizers on plant stand, number of stems and tubers per plant, and tuber quality.

| Treatment # | P Source | Description | $P_2O_5$ Rate lb/A | Stand % | Number of Stems per Plant | Tubers per Plant | Specific Gravity | % Hollow Heart |
|---|---|---|---|---|---|---|---|---|
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 100.0 | 3.0 | 8.4 | 1.0877 | 12.0 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 100.0 | 3.0 | 16.4 | 1.0867 | 7.0 |
| 3 | MES10 | 12-40-0-10S | 60 | 100.0 | 3.0 | 18.5 | 1.0853 | 3.0 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 100.0 | 3.1 | 18.3 | 1.0909 | 10.3 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 98.5 | 3.1 | ND | 1.0900 | 4.0 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 100.0 | 3.2 | 20.1 | 1.0854 | 8.8 |
| 7 | MES10 | 12-40-0-10S | 120 | 100.0 | 3.0 | 16.0 | 1.0849 | 5.0 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 100.0 | 3.0 | 16.8 | 1.0852 | 8.0 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 100.0 | 3.4 | ND | 1.0884 | 10.0 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 100.0 | 2.9 | ND | 1.0906 | 7.0 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 100.0 | 2.8 | ND | 1.0892 | 6.0 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 100.0 | 3.1 | ND | 1.0856 | 8.0 |
| **Significance**[1] | | | | NS | NS | ** | NS | NS |
| LSD (0.1) | | | | -- | -- | 2.2 | -- | -- |
| **Contrasts** | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | NS | NS | ND | NS | ++ |
| linear P MAP + S (trmts 1,2,6) | | | | NS | NS | ** | NS | NS |
| linear P MES10 (trmts 1,3,6) | | | | NS | NS | ** | NS | * |
| linear MESZ (trmts 1,4,8) | | | | NS | NS | ND | NS | NS |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | ND | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | ND | NS | * |
| MAP vs MAP + S (trmts 5 vs 6) | | | | * | NS | ND | NS | NS |

[1] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

ND = not determined

Table 3. Effects of specialty P fertilizers on petiole nutrient concentrations at tuber set (June 18).

| Treatment # | Source | Description | $P_2O_5$ Rate (lb/A) | $NO_3$-N ppm | P % | K % | S % | Mg % | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 26766 | 0.19 | 10.4 | 0.23 | 0.30 | 58 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 24080 | 0.37 | 11.0 | 0.26 | 0.31 | 43 |
| 3 | MES10 | 12-40-0-10S | 60 | 22782 | 0.36 | 11.1 | 0.25 | 0.30 | 44 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 23173 | 0.37 | 11.2 | 0.25 | 0.31 | 48 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 22982 | 0.38 | 10.9 | 0.25 | 0.31 | 42 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 22340 | 0.39 | 11.3 | 0.26 | 0.32 | 47 |
| 7 | MES10 | 12-40-0-10S | 120 | 23468 | 0.38 | 10.6 | 0.25 | 0.29 | 47 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 23826 | 0.35 | 11.4 | 0.24 | 0.29 | 53 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 22198 | 0.40 | 10.1 | 0.25 | 0.30 | 45 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 23885 | 0.41 | 10.5 | 0.25 | 0.31 | 47 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 23707 | 0.40 | 10.2 | 0.24 | 0.27 | 41 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 23209 | 0.40 | 11.4 | 0.25 | 0.31 | 53 |
| **Significance[2]** | | | | NS | ** | NS | NS | NS | ++ |
| LSD (0.1) | | | | -- | 0.04 | -- | -- | -- | 12 |
| **Contrasts** | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | ** | ** | ++ | ** | NS | ** |
| linear P MAP + S (trmts 1,2,6) | | | | ** | ** | * | ** | NS | * |
| linear P MES10 (trmts 1,3,6) | | | | * | ** | NS | ++ | NS | * |
| linear MESZ (trmts 1,4,8) | | | | * | ** | * | NS | NS | NS |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | NS | NS | * | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | NS | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | NS |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 4. Effects of specialty P fertilizers on petiole nutrient concentrations at early tuber bulking (June 30).

| Treatment # | Source | Description | $P_2O_5$ Rate (lb/A) | $NO_3$-N ppm | P % | K % | S % | Mg % | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 24346 | 0.24 | 9.18 | 0.24 | 0.40 | 51 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 18200 | 0.28 | 7.33 | 0.22 | 0.46 | 36 |
| 3 | MES10 | 12-40-0-10S | 60 | 20391 | 0.23 | 8.13 | 0.21 | 0.48 | 34 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 19984 | 0.24 | 7.83 | 0.21 | 0.52 | 36 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 18127 | 0.29 | 7.53 | 0.20 | 0.46 | 33 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 21066 | 0.25 | 7.55 | 0.21 | 0.55 | 30 |
| 7 | MES10 | 12-40-0-10S | 120 | 19571 | 0.24 | 7.75 | 0.21 | 0.50 | 33 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 19642 | 0.23 | 8.43 | 0.19 | 0.44 | 37 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 19684 | 0.26 | 7.85 | 0.22 | 0.52 | 33 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 19633 | 0.29 | 7.85 | 0.21 | 0.50 | 33 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 20098 | 0.27 | 7.50 | 0.21 | 0.46 | 33 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 18926 | 0.25 | 8.23 | 0.21 | 0.53 | 34 |
| **Significance[2]** | | | | NS | NS | ** | * | NS | ** |
| LSD (0.1) | | | | -- | -- | 0.66 | 0.02 | -- | 7 |
| **Contrasts** | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | ** | NS | ** | ** | * | ** |
| linear P MAP + S (trmts 1,2,6) | | | | NS | NS | ** | ** | * | ** |
| linear P MES10 (trmts 1,3,6) | | | | * | NS | ** | ** | ++ | ** |
| linear MESZ (trmts 1,4,8) | | | | * | NS | * | ** | NS | ** |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | NS | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | NS | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | NS |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 5. Effects of specialty P fertilizers on petiole nutrient concentrations at mid tuber bulking (July 14).

| Treatment # | Source | Description | $P_2O_5$ Rate | $NO_3$-N | P | K | S | Mg | Zn |
|---|---|---|---|---|---|---|---|---|---|
| | | | (lb/A) | ppm | % | % | % | % | ppm |
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 20118 | 0.22 | 8.05 | 0.24 | 0.68 | 40 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 19116 | 0.25 | 7.54 | 0.27 | 0.95 | 36 |
| 3 | MES10 | 12-40-0-10S | 60 | 18869 | 0.23 | 7.00 | 0.24 | 0.98 | 38 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 15093 | 0.23 | 7.02 | 0.25 | 0.95 | 37 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 18541 | 0.27 | 7.56 | 0.25 | 0.99 | 31 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 16448 | 0.27 | 6.89 | 0.25 | 0.99 | 65 |
| 7 | MES10 | 12-40-0-10S | 120 | 18450 | 0.26 | 6.79 | 0.25 | 0.95 | 35 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 19796 | 0.29 | 8.41 | 0.25 | 0.83 | 36 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 21529 | 0.26 | 7.59 | 0.25 | 0.96 | 30 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 19664 | 0.26 | 7.76 | 0.24 | 0.93 | 35 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 18374 | 0.22 | 6.48 | 0.25 | 1.01 | 38 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 17674 | 0.27 | 7.92 | 0.24 | 0.95 | 43 |
| **Significance**[2] | | | | ++ | NS | ++ | NS | ++ | NS |
| LSD (0.1) | | | | 3593 | -- | 1.39 | -- | 0.2 | -- |
| **Contrasts** | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | NS | NS | NS | NS | ** | NS |
| linear P MAP + S (trmts 1,2,6) | | | | * | NS | ++ | NS | ** | ++ |
| linear P MES10 (trmts 1,3,6) | | | | NS | NS | * | NS | ** | NS |
| linear MESZ (trmts 1,4,8) | | | | NS | ++ | NS | NS | NS | NS |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | * | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | ++ | NS | NS | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | ** |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 6. Effects of specialty P fertilizers on petiole nutrient concentrations at late tuber bulking (August 5).

| Treatment # | Source | Description | $P_2O_5$ Rate | $NO_3$-N | P | K | S | Mg | Zn |
|---|---|---|---|---|---|---|---|---|---|
| | | | (lb/A) | ppm | % | % | % | % | ppm |
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 3971 | 0.11 | 4.55 | 0.16 | 1.07 | 37 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 4138 | 0.16 | 5.56 | 0.16 | 1.15 | 37 |
| 3 | MES10 | 12-40-0-10S | 60 | 2563 | 0.14 | 4.56 | 0.19 | 1.25 | 36 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 1845 | 0.13 | 4.92 | 0.16 | 1.19 | 55 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 3594 | 0.17 | 5.42 | 0.18 | 1.27 | 36 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 3701 | 0.16 | 4.92 | 0.19 | 1.31 | 45 |
| 7 | MES10 | 12-40-0-10S | 120 | 2966 | 0.16 | 4.92 | 0.19 | 1.31 | 32 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 4293 | 0.16 | 5.20 | 0.18 | 1.08 | 34 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 2890 | 0.14 | 5.36 | 0.20 | 1.03 | 27 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 3457 | 0.14 | 4.55 | 0.17 | 1.15 | 34 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 2471 | 0.13 | 4.90 | 0.15 | 1.21 | 35 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 2860 | 0.14 | 5.93 | 0.13 | 1.00 | 31 |
| **Significance**[2] | | | | ++ | NS | NS | NS | NS | ** |
| LSD (0.1) | | | | 1952 | -- | -- | -- | -- | 10 |
| **Contrasts** | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | NS | * | NS | NS | NS | NS |
| linear P MAP + S (trmts 1,2,6) | | | | NS | * | NS | NS | * | NS |
| linear P MES10 (trmts 1,3,6) | | | | NS | * | NS | NS | * | NS |
| linear MESZ (trmts 1,4,8) | | | | NS | ** | NS | NS | NS | NS |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | NS | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | ++ | ** |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | ++ |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 7. Effects of specialty P fertilizers on tuber and vine nutrient concentrations.

| | | | | Elemental concentration | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **$P_2O_5$ Rate** | % P | | % N | | % S | | % Mg | | ppm Zn | |
| **Treatment #** | **Source** | **Description** | **lb/A** | Tubers | Vines | Tubers | Vines | Tubers | Vines | Tubers | Vines | Tubers | Vines |
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 0.14 | 0.05 | 1.13 | 1.45 | 0.12 | 0.19 | 0.07 | 0.99 | 19 | 122 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 0.15 | 0.06 | 1.28 | 1.33 | 0.13 | 0.14 | 0.08 | 0.89 | 18 | 97 |
| 3 | MES10 | 12-40-0-10S | 60 | 0.15 | 0.06 | 1.18 | 1.30 | 0.12 | 0.13 | 0.07 | 0.79 | 19 | 94 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 0.15 | 0.05 | 1.10 | 1.15 | 0.12 | 0.13 | 0.08 | 0.76 | 20 | 102 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 0.16 | 0.05 | 1.23 | 1.28 | 0.13 | 0.12 | 0.08 | 0.81 | 19 | 93 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 0.16 | 0.07 | 1.13 | 1.33 | 0.12 | 0.15 | 0.07 | 0.92 | 20 | 91 |
| 7 | MES10 | 12-40-0-10S | 120 | 0.16 | 0.05 | 1.25 | 1.28 | 0.13 | 0.16 | 0.07 | 0.94 | 19 | 91 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 0.16 | 0.06 | 1.28 | 1.35 | 0.12 | 0.14 | 0.07 | 0.83 | 19 | 106 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 0.16 | 0.05 | 1.23 | 1.25 | 0.12 | 0.13 | 0.07 | 0.87 | 18 | 100 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 0.17 | 0.05 | 1.20 | 1.20 | 0.13 | 0.14 | 0.08 | 0.93 | 19 | 105 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 0.17 | 0.05 | 1.35 | 1.25 | 0.13 | 0.13 | 0.07 | 0.84 | 19 | 93 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 0.16 | 0.06 | 1.20 | 1.28 | 0.12 | 0.12 | 0.07 | 0.76 | 18 | 91 |
| **Significance**[2] | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| LSD (0.1) | | | | - | - | - | - | - | - | - | - | - | - |
| **Contrasts** | | | | | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | ** | NS | NS | NS | NS | ** | NS | * | NS | ** |
| linear P MAP + S (trmts 1,2,6) | | | | * | NS | NS | NS | NS | NS | NS | NS | NS | ** |
| linear P MES10 (trmts 1,3,6) | | | | * | NS | NS | NS | NS | NS | NS | NS | NS | ** |
| linear MESZ (trmts 1,4,8) | | | | ++ | NS | ++ | NS | NS | * | NS | ++ | NS | NS |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | ++ | NS | NS | NS | * | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

Table 8. Effects of specialty P fertilizers on tuber and vine dry matter accumulation and nutrient uptake.

| | | | **$P_2O_5$ Rate** | **Dry Matter, lbs/A** | | | **P uptake, lbs/A** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatment #** | **Source** | **Description** | **lb/A** | Tubers | Vines | Total | Tubers | Vines | Total |
| 1 | Control | 46-0-0 + 0-0-50 | 0 | 12399 | 1806 | 14205 | 17.1 | 1.0 | 18.0 |
| 2 | MAP + S | 11-52-0 + 0-0-50 | 60 | 13976 | 1489 | 15465 | 20.5 | 0.8 | 21.4 |
| 3 | MES10 | 12-40-0-10S | 60 | 14010 | 2015 | 16025 | 20.4 | 1.2 | 21.6 |
| 4 | MESZ | 12-40-0-10S-1Zn | 60 | 14882 | 1727 | 16608 | 22.3 | 0.8 | 23.1 |
| 5 | MAP | 11-52-0 +0-0-60 | 120 | 14358 | 2270 | 16629 | 23.3 | 1.2 | 24.5 |
| 6 | MAP + S | 11-52-0 + 0-0-50 | 120 | 15317 | 2506 | 17823 | 23.9 | 1.7 | 25.6 |
| 7 | MES10 | 12-40-0-10S | 120 | 13861 | 2068 | 15929 | 21.8 | 1.0 | 22.8 |
| 8 | MESZ | 12-40-0-10S-1Zn | 120 | 14013 | 2442 | 16454 | 21.6 | 1.5 | 23.1 |
| 9 | ACT142 | 10-49-0-2S-1Zn | 120 | 14421 | 2076 | 16496 | 23.1 | 1.1 | 24.2 |
| 10 | ACT143 | 10-46-0-3S-1Zn-2Mg | 120 | 14775 | 1884 | 16659 | 24.3 | 1.0 | 25.3 |
| 11 | ACT144 | 11-48-0-3S-1Zn (0 Mg) | 120 | 14272 | 2029 | 16301 | 23.4 | 1.0 | 24.4 |
| 12 | ACT145 | 10-44-0-3S-1Zn | 120 | 13909 | 2248 | 16157 | 22.5 | 1.3 | 23.8 |
| **Significance**[2] | | | | NS | NS | NS | NS | NS | NS |
| LSD (0.1) | | | | - | - | - | - | - | - |
| **Contrasts** | | | | | | | | | |
| P vs No P (trmts 1 vs rest) | | | | ** | NS | ** | ** | NS | ** |
| linear P MAP + S (trmts 1,2,6) | | | | ** | * | ** | ** | * | ** |
| linear P MES10 (trmts 1,3,6) | | | | ++ | NS | ++ | ** | NS | ** |
| linear MESZ (trmts 1,4,8) | | | | ++ | * | * | ** | ++ | ** |
| Mg vs No Mg (trmts 10 vs 11) | | | | NS | NS | NS | NS | NS | NS |
| MES10 vs MESZ (trmts 3,7 vs 4,8) | | | | NS | NS | NS | NS | NS | NS |
| MAP vs MAP + S (trmts 5 vs 6) | | | | NS | NS | NS | NS | NS | NS |

[2] NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively

**Final Project Report: 2-8-2010**

**For Minnesota Area I/II Potato Growers Council and Northern Plains Potato Growers Association**

**Project Title**:
Using Insecticides and Host Plant Resistance for Colorado Potato Beetle Control

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## Executive Summary

This is a new project. Colorado potato beetles (CPB) are insect pests that can defoliate entire potato plants, resulting in severe yield and quality loss. Chemical control is often the primary method used to manage CPB. However, this pest has developed resistance to several insecticides, and some populations have recently become resistant to imidacloprid (Admire). Growers need effective, economical, and sustainable methods for pest control. We propose to: 1) test experimental insecticide(s) for CPB control.

After we received funding from the MN Area II group, the company we agreed to work with (Nichino America) changed the target pest from CPB to green peach aphids (GPA). We also conducted insecticide trials for GPA in cooperation with Bayer CropScience. Data from both these trials is presented in this report. With regard to testing insecticides against CPB, we are presenting data from trials conducted by Janet Knodel (NDSU Extension Entomologist, co-PI on this grant) in cooperation with various chemical companies.

## 1) <u>Insecticide Trials – Green Peach Aphid (Prischmann-Voldseth)</u>

### Materials and Methods

<u>Location</u>. The experiment was conducted across the Red River from Fargo ND in Glyndon MN (3 mi N of Glyndon, NW ¼ of section 30, township 140N, range 47).

<u>Experiment establishment</u>. The experiment was established within a solid block planting of potatoes (150 x 120 ft). Red Norland seed stock was used as the potato variety. Seed pieces were hand cut and sized to 1.5 to 2 ounces. Seed pieces were treated 2-June 2009 with fungicide (6% Mancozeb dust, 25%) at a rate of 1.0 lb/100wt. Potatoes were planted 3-June using a 2-row shovel opening potato planter. Potato seed pieces were planted in 36-in rows using a within-row seed spacing of 14-in.

Each experimental plot was approximately 15 x 12 ft, and consisted of 4 rows of potatoes with 12-13 plants per row. For the Bayer trial, four replicates of five treatments (see Table 1a for details) were established in a complete random block design, including an untreated control. For the Nichino trial, four replicates of seven treatments (see Table 1b for details) were established, with one untreated control and two standard controls, Warrior® (Syngenta) and Leverage$^{TM}$ 2.7 EC (Bayer Crop Science). Two standards were used because of concerns with insecticide resistance within greenhouse-collected aphid populations used to artificially infest experimental plants.

<u>Weed and disease control</u>. Prior to planting, both herbicides and fertilizer were applied. Acumen$^{TM}$ (Tenkoz Inc.) herbicide (a generic of Prowl®, BASF Ag Products) was applied at a rate of 1 qt/acre along with 10/34/0 plus 10% zinc liquid fertilizer. Herbicides were broadcast applied using T-jet flat fan nozzles at 40 psi pressure. Fertilizers were commercially applied by the cooperating grower and then incorporated to a depth of 4-6in with a field cultivator. Herbicides and fertilizers were applied 29-May.

Potatoes were hilled (cultivated) for the first time on 21-June. At that time less than 5% of the potatoes had emerged. Post-emergent herbicides were applied after hilling (Matrix® DF, 1.0 oz /acre, DuPont; Sencor 4DF 41%, 0.33 lb/acre, Bayer Crop Science). Herbicides were broadcast and applied at a rate of 20 gal/acre total volume using T-jet flat fan nozzles at 40 psi pressure. For additional weed control, potatoes were hilled twice more (5-July and 22-July).

For disease control (predominately early and late blight) Bravo® ZN fungicide (Syngenta) was broadcast on 24-July (2 pt/acre) and 1-August (1 pt/acre). During the growing season no disease was evident.

Green peach aphid (GPA) rearing and inoculation. Early scouting of experimental plots for natural GPA infestation showed that there was not a resident aphid population. Therefore, to ensure enough GPA would be present to conduct insecticide trials, we artificially infested experimental plants using aphids from greenhouse-reared colonies.

GPA colonies were initially established by allowing aphids to naturally infest sentinel potato plants (Red Norland) placed in greenhouses where sugar beets were present. Infested plants were then transferred to mesh cages and populations allowed to build. On 15-July GPA-infested leaves were then moved from greenhouse-grown potatoes to a 6 x 6 x12 ft screen cage placed over two rows of potatoes on the edge of the field plot. GPA were allowed to reproduce and then on 5-Aug, GPA-infested leaves (25-50 aphids per leaf) were transferred to four experimental plants per plot. For each experimental plant, one infested leaf was gently nestled on top of a non-infested leaf located in the middle of the canopy. Both leaves were then covered by a 10 x 12-in mesh Delnet® bag (DelStar Technologies Inc.) in order to restrict aphid movement and prevent aphids from being eaten by predators. Bag location was marked using fluorescent marking tape and flags (Fig. 1a-b). On 10-Aug, experimental plants were reinfested with GPA by placing two infested leaves (50-100 GPA per leaf) from the field rearing cage within the canopy of each experimental plant. However, these leaves were not caged with Delnet bags, and GPA had extremely low establishment.

GPA counts and chemical application. On 13-Aug, prior to spraying, the Delnet bags were removed and aphid densities assessed. Fig. 2a shows pre-treatment GPA densities on one infested leaf with has 7 leaflets. Aphids were counted on 5 leaflets per infested leaf (from leaves initially covered with Delnets), beginning at the terminal end of the leaf (Fig. 2a-b). After pre-counts were taken, the target pesticides were applied using a $CO^2$ backpack sprayer. Silwet L-77 was used as the non-ionic surfactant. Pesticides were applied using a T-jet flat fan nozzle at 40 psi with a total application rate of 20 gal/acre. For the Bayer trial, GPA densities were assessed on 14-Aug, 16-Aug, 18-Aug, 21-Aug, 26-Aug, and 3-Sept with data presented as mean aphids per leaflet (Table 2a). For the Nichino trial, GPA densities were assessed on 21-Aug, 24-Aug, 31-Aug, and 7-Sept with data presented as mean aphids per leaflet (Table 2b). Potatoes then began senescing and GPA densities were not assessed further.

Colorado potato beetle (CPB) control and assessment. CPB were present throughout the plots, and needed to be controlled in order to prevent experimental plants from being defoliated. We decided not to use Admire Pro at planting to control CPB because we were concerned there might be non-target effects on GPA densities. Therefore, on 7-Aug, once defoliation by the beetles reached ~5%, Novodor FC® insecticide (Valent BioSciences; 3 qt/acre) was applied to all plots using a $CO^2$ backpack sprayer with T-jet flat fan nozzles at 40 psi. Novodor is a biological insecticide (*Bacillus thuringiensis*, *tenebrionis* strain) that is host specific to Coleoptera, including CPB. For the Nichino trial, percent CPB defoliation was quantitatively assessed on 18-Aug and qualitatively assessed on 24-Aug.

Potato yield. For the Bayer trial, yield data was gathered from each of the four experimental plants per plot (*i.e.* the plants that were infested with GPA).On 24 Oct, potatoes in individual hillswere hand dug using a 4-tined potato fork. Potatoes from each plant were weighed on site using a portable electronic balance. Yield data is presented in Table 3 (in ounces per plant).

Statistical analysis. Treatment averages were used if there was any missing data (*e.g.* if a leaflet was damaged / dead). Aphid count data was square root transformed and analyzed using analysis of variance (ANOVA) in Systat 12 (Systat Inc. 2007). Tukey's Honest Significant Difference was used as a posthoc test. The same statistical methods were used to analyze potato yield data, although the data did not need to be transformed. Non-transformed data are presented in Tables 2a-b and 3.

## Results and Discussion

Artificial aphid infestation of experimental plants was successful, although initial aphid densities were higher than threshold levels when chemicals were applied (in some cases over 100 aphids per leaflet).

Bayer trial. Aphid populations were not significantly different between treatments at the beginning of the experiment (Table 2a). GPA densities decreased dramatically after chemicals were applied in all treatments. The decrease in GPA densities in the untreated control was likely due to dispersal after Delnets were removed. Dispersal could have contributed to lower aphid densities in non-control plots, although dead aphids were observed on leaves, and the only chemical treatment that did not have significantly lower GPA aphid densities 1 day post-treatment (PT) was #2 (Movento-70) . In addition, 3, 5, 7, and 13 days PT GPA densities in all Movento treatments were close to zero and significantly lower than GPA densities in the untreated control. By 21 days PT, GPA densities in the control treatment had fallen and were not significantly different than those in the chemical treatments, with the exception of #2 (Movento-70), where GPA densities were still significantly lower than those in the control. Overall, it appeared that all Movento treatments were effective at reducing GPA populations.

Mean yield per experimental potato plant was lowest in treatment #3 (Movento-88; 45.88 ± 3.84 ounces per plant) and highest in treatment #4 (Movento + Provado; 55.25 ± 2.67 ounces per plant). However, there was no significant impact of chemical treatment on potato yield per experimental plant (Table 3).

Nichino trial. Aphid populations were not significantly different between treatments at the beginning of the experiment. Post-treatment (PT) aphid densities were assessed after four days instead of three due to inclement weather. GPA densities decreased dramatically after chemicals were applied in all treatments. The decrease in GPA densities in the untreated control was likely due to dispersal after Delnets were removed. Dispersal could have contributed to lower aphid densities in non-control plots, although dead aphids were observed on leaves. In addition, even though GPA densities in the untreated control declined, four and seven days PT GPA densities in all NNI-0101 treatments and the Leverage treatment were close to zero and significantly lower than GPA densities in the untreated control and Warrior treatment. Applying Warrior appeared to flare GPA densities. Seven days PT, GPA densities in the untreated control were significantly lower than the Warrior treatment. Fourteen and 21 days PT, GPA densities in all treatments were significantly lower than the Warrior treatment. Overall, it appeared that Leverage and all the NNI-0101 treatments were effective at reducing GPA populations.

On 18-Aug, mean percent CPB defoliation was below 3% in all plots (1-N25, 2.9 ± 0.6; 2-N37.5, 2.3 ± 0.3; 3-N50, 1.7 ± 0.3; 4-N37.5 WDG, 1.9 ± 0.4; 5-Warrior, 2.4 ± 0.4; 6-Leverage, 1.9 ± 0.2; 7-untreated, 2.9 ± 0.4; refer to Table 1 for treatment details). On 24-Aug, percent CPB defoliation was uniform in all plots and ranged from 5-8%.

Table 1a.  Bayer GPA trial: details of experimental treatment applications.

| # | Product | Formulation | Rate (g ai/ha) | Product (oz/ac) | Application timing | Type of application |
|---|---|---|---|---|---|---|
| 1 | Untreated control | n/a | n/a | n/a | n/a | n/a |
| 2 | MOVENTO 240 SC + NIS | 240 + 100 | 70,<br>0.25% v/v | 4,<br>0.25% v/v | At detection | Foliar |
| 3 | MOVENTO 240 SC + NIS | 240 + 100 | 88,<br>0.25% v/v | 5,<br>0.25% v/v | At detection | Foliar |
| 4 | MOVENTO 240 SC + PROVADO + NIS | 240 + 192 + 100 | 56.2 + 53.3,<br>0.25% v/v | 3, 3.8,<br>0.25% v/v | At detection | Foliar |
| 5 | MOVENTO 240 SC + LEVERAGE + NIS | 240 + 324 + 100 | 56.2 + 90,<br>0.25% v/v | 3, 3.8,<br>0.25% v/v | At detection | Foliar |
| # = Treatment code<br>NIS = non-ionic surfactant (see methods for details) | | | | | | |

Table 1b.  Nichino GPA trial: details of experimental treatment applications.

| # | Product | Product | Product (oz/ac) | Application timing | Type of application |
|---|---|---|---|---|---|
| 1 | NNI-0101 20SC + NIS | 25 g ai / ha | 1.59 fl oz<br>0.5% v/v | At detection | Foliar |
| 2 | NNI-0101 20SC + NIS | 37.5 g ai / ha | 2.39 fl oz<br>0.5% v/v | At detection | Foliar |
| 3 | NNI-0101 20SC + NIS | 50 g ai / ha | 3.19 fl oz<br>0.5% v/v | At detection | Foliar |
| 4 | NNI-0101 20WDG + NIS | 37.5 g ai / ha | 2.68 oz<br>0.5% v/v | At detection | Foliar |
| 5 | Standard = Warrior | 22.4 g ai / ha | 2.56 fl oz / acre | At detection | Foliar |
| 6 | Standard = Leverage 2.7 EC | 90.0 g ai / ha | 3.8 fl oz / acre | At detection | Foliar |
| 7 | Untreated control | n/a | n/a | n/a | n/a |
| # = Treatment code<br>NIS = non-ionic surfactant | | | | | |

Table 2a. Bayer GPA trial: effect of experimental treatments on green peach aphid densities.

| # | Product | Green peach aphids / leaflet | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Aug 13**[1] | **Aug 14** | **Aug 16** | **Aug 18** | **Aug 21** | **Aug 26** | **Sept 3** |
| 1 | Untreated control | 49.6 ± 9.7 a | 23.4 ± 7.4 a | 5.4 ± 3.0 a | 4.5 ± 2.5 a | 3.8 ± 1.8 a | 2.1 ± 0.9 a | 0.3 ± 0.1 a |
| 2 | MOVENTO 240 SC (70) | 44.5 ± 4.9 a | 13.3 ± 2.9 ab | .04 ± .02 b | .01 ± .01 b | .02 ± .01 b | .01 ± .01 b | 0 ± 0 b |
| 3 | MOVENTO 240 SC (88) | 45.7 ± 5.8 a | 7.6 ± 2.4 bc | .14 ± .06 b | 0.5 ± 0.5 b | 0.2 ± 0.2 b | 0 ± 0 b | .05 ± .03 ab |
| 4 | MOVENTO 240 SC + PROVADO | 45.1 ± 9.7 a | 3.5 ± 2.4 c | 0.9 ± 0.8 b | 0.8 ± 0.6 b | 0.5 ± 0.4 b | .03 ± .02 b | .05 ± .03 ab |
| 5 | MOVENTO 240 SC + LEVERAGE | 60.6 ± 9.9 a | 0.9 ± 0.6 c | .09 ± .09 b | .09 ± .06 b | .09 ± .09 b | .03 ± .02 b | .08 ± .05 ab |
| | *P*-value | 0.67 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.06 |

Means (± standard error of the mean) followed by the same letter are not significantly different (*P* > 0.05), Tukey's HSD test. # = Treatment code. [1] = pre-treatment densities

Table 2b. Nichino GPA trial: effect of experimental treatments on green peach aphid densities.

| # | Product | Green peach aphids / leaflet | | | | |
|---|---|---|---|---|---|---|
| | | **Aug 17**[1] | **Aug 21** | **Aug 24** | **Aug 31** | **Sept 7** |
| 1 | NNI-0101 25 | 99.8 ± 6.7 a | 1.2 ± 0.6 a | 0 ± 0 a | 0.03 ± 0.02 a | 0.03 ± 0.02 a |
| 2 | NNI-0101 37.5 | 102.5 ± 8.6 a | 0.1 ± 0.1 a | 0.01 ± 0.01 a | 0 ± 0 a | 0 ± 0 a |
| 3 | NNI-0101 50 | 124.0 ± 8.0 a | 1.1 ± 0.4 a | 0.03 ± 0.03 a | 0 ± 0 a | 0 ± 0 a |
| 4 | NNI-0101 37.5 WDG | 108.3 ± 10.2 a | 1.0 ± 0.5 a | 0.2 ± 0.1 a | 0.01 ± 0.01 a | 0.01 ± 0.01 a |
| 5 | Warrior | 99.6 ± 7.1 a | 25.2 ± 3.3 b | 14.0 ± 1.8 b | 2.8 ± 0.4 b | 0.5 ± 0.2 b |
| 6 | Leverage | 109.5 ± 9.0 a | 0.05 ± 0.03 a | 0.01 ± 0.01 a | 0.3 ± 0.1 a | 0.01 ± 0.01 a |
| 7 | Untreated control | 119.5 ± 7.9 a | 20.3 ± 2.4 b | 9.7 ± 1.8 c | 0.3 ± 0.1 a | 0 ± 0 a |
| | *P*-value | 0.101 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

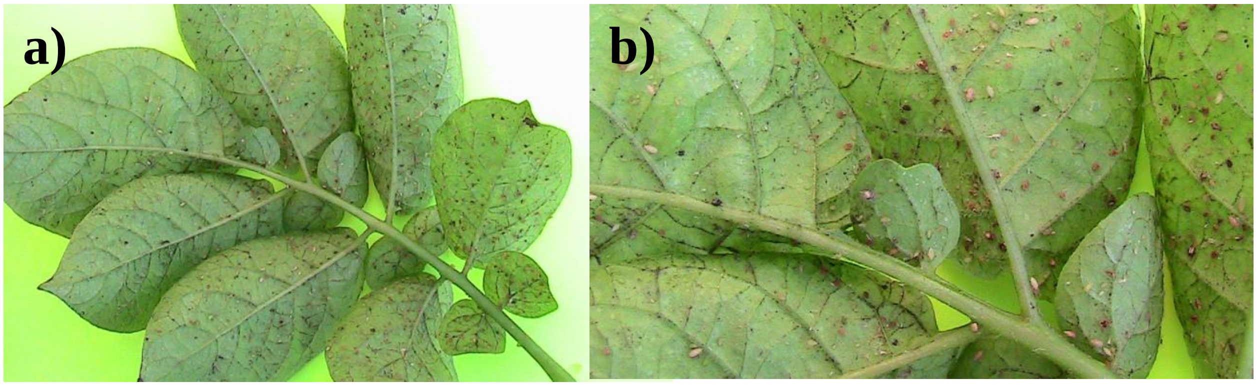
Means followed by the same letter are not significantly different (*P* > 0.05), Tukey's HSD test. # = Treatment code. [1] = pre-treatment densities

Table 3. Bayer GPA trial: effect of experimental treatments on potato yield.

| **#** | **Product** | **Yield / experimental plant (oz.)** |
|---|---|---|
| 1 | Untreated control | 53.75 ± 2.71 a |
| 2 | MOVENTO 240 SC (70) | 52.69 ± 2.58 a |
| 3 | MOVENTO 240 SC (88) | 45.88 ± 3.84 a |
| 4 | MOVENTO 240 SC + PROVADO | 55.25 ± 2.67 a |
| 5 | MOVENTO 240 SC + LEVERAGE | 46.38 ± 2.88 a |
| | *P*-value | 0.08 |
| Means (± standard error of the mean) followed by the same letter are not significantly different (*P* > 0.05), Tukey's HSD test. # = Treatment code | | |

Fig. 1a-b. Green peach aphid infestation technique.

Fig. 2a-b. Pre-treatment green peach aphid densities per leaf.



## 2) Insecticide Trials – Colorado Potato Beetles (Knodel, Beauzay, Prischmann-Voldseth)

### Materials and Methods

The experiment was conducted across the Red River from Fargo ND in Glyndon MN (3 mi N of Glyndon, NW ¼ of section 30, township 140N, range 47).

Red Norland seed stock was used as the potato variety. Seed pieces were hand cut and sized to 1.5 to 2 ounces. Seed pieces were treated 2 June 2009 with fungicide (6% Mancozeb dust, 25%) at a rate of 1.0 lb/100wt. Potatoes were planted 3 June using a 2-row shovel opening potato planter. Rows were hilled when needed and kept free of weeds by herbicides, cultivation and hand-weeding. On 29 May, PPI herbicide (Prowl at 1qt/acre) plus fertilizer (10-34-0 + 10% zinc) was applied at 5 gal/acre. On 21 June 21, Matrix was applied 10 fl oz/acre plus Sencor @ 0.33 lb/acre. On 13 and 20 Sept, Bravo Zinc fungicide was applied at 1 pt/acre, and then at 1.5 pt/acre.

Plots were 30 ft long and consisted of 4 rows per plot with two guard rows between plots. Row spacing was 36 inches and potatoes were planted 14 inches apart within the rows. Plant population was approximately 19,360 plants/acre. Blocks (replications) were separated by 10-foot alleys. Four replicates of eight treatments were established in a complete random block design:

1) Untreated check
2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a
3) Rimon at 9 fl oz/a
4) Temprano at 8 fl oz/a
5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT)
6) Coragen at 3.5 fl oz/a (low label rate)
7) Coragen at 5 fl oz/a (high label rate)
8) Admire Pro at 0.35 oz/cwt (seed treatment standard)

Rimon is a growth regulator with long residual activity. Temprano has a quick knock down and some residual activity. Coragen has a quick knockdown and good residual, but is not effective against the egg stage of CPB. All foliar insecticide treatments were mixed just prior to application. Foliar treatments were applied with a $CO_2$ sprayer and 12-foot boom with T-Jet 80015 nozzles at 40 psi and an application volume of 20 GPA. Admire Pro was applied as a seed treatment at planting.

The pre-spray CPB count was conducted on the morning of 13 July. All foliar insecticide applications were made on the afternoon of 13 July. The second application of Rimon at 2 fl oz/a was applied to Treatment 6 on 21 July. Weekly counts were conducted on 20 July (7 DAT), 27 July (14 DAT), 3 Aug (21 DAT) and 10 Aug (28 DAT). Counts were made by counting the numbers of egg masses, small larvae, large larvae and adults on 10 plants in the center two rows of each plot. Defoliation ratings were made at 7, 14, 21, and 28 DAT. Defoliation was visually estimated and recorded as the percent of leaf tissue consumed for the entire plot. Plots were harvested on 28 Oct. Analysis of variance for CPB count data, defoliation data and yield was conducted using PROC GLM in SAS statistical software. Treatment means were compared using Fisher's Protected LSD ($P \leq 0.05$).

Mating CPB adults and egg masses were first noted in the trial during the first week of July. This was about two weeks later than in previous years due to much below normal temperatures in June. CPB numbers built up rapidly throughout the trial, but feeding activity was slow. This also was likely due to unseasonably cool temperatures during July and early August. Pre-spray count data on July 13 (Table 4) suggested that CPB was fairly well distributed in the trial (with the exception of the Admire seed treatment, which had low CPB densities). The presence of all life stages within the trial indicated that the time was right to apply the foliar insecticide treatments. After this date, adult and egg mass counts were generally too low to be statistically meaningful. No phytotoxicity was observed for any treatment.

Most of the damage was caused by larvae, especially large larvae, and therefore we will focus on the larval life stages. Prior to applications of foliar chemicals (13 July), there were no significant differences in densities of large larvae (LL) between foliar chemical treatments, although densities of small larvae (SL) ranged from a mean of 3.33 to 8.00 (Figs. 1-2; Table 4). On 20 July, after foliar chemicals were applied, SL and LL densities were significantly higher in the untreated control compared to all chemical treatments, including the Admire Pro seed piece treatment (Figs. 1-2; Table 5). On 27 July, densities of LL were still significantly higher in the untreated control compared to all chemical treatments. However, on 27 July, there were no significant differences in densities of SL between the untreated control and any of the chemical treatments, with the exception of treatment 3 (Rimon), which had significantly higher densities of SL (Figs. 1-2; Table 6). By 3 Aug, virtually all of the SL in all treatments had grown into the LL group. On 3 Aug, LL densities in treatment 4 (Temprano), were significantly higher than the other treatments. All other chemical treatments, with the exception of #3 (Rimon), had significantly lower LL densities compared to the untreated control (Figs. 1-2; Table 7). By 10 Aug, LL densities had dropped in all treatments, although densities in treatment #4 (Temprano) were still significantly higher than those in all other treatments (Figs. 1-2; Table 8).

Overall, the Admire Pro seed treatment provided excellent control of CPB throughout the growing season. Foliar insecticide treatments that provided comparable control of CPB included #5 [Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT)] and #7 (Coragen at 5 fl oz/a).

For yield, a season-long moisture gradient existed in about ½ of the trial. This had a significant impact on yield for several plots. Treatment 8 was not impacted by excessive moisture, but all other treatments had at least two plots that were. This is reflected by the high CV (46%) for yield. A log transformation was performed on yield data to try and lower the variability within treatments, even though the raw data satisfied the assumption of homogeneity of variance. Significance for raw yield data and transformed yield data are presented in Table 9. The CPB life stage count data and percent defoliation data give a better indication of insecticide activity than does yield data.

Fig. 1. Mean densities of small CPB larvae per plant (Series #'s correspond to treatments).

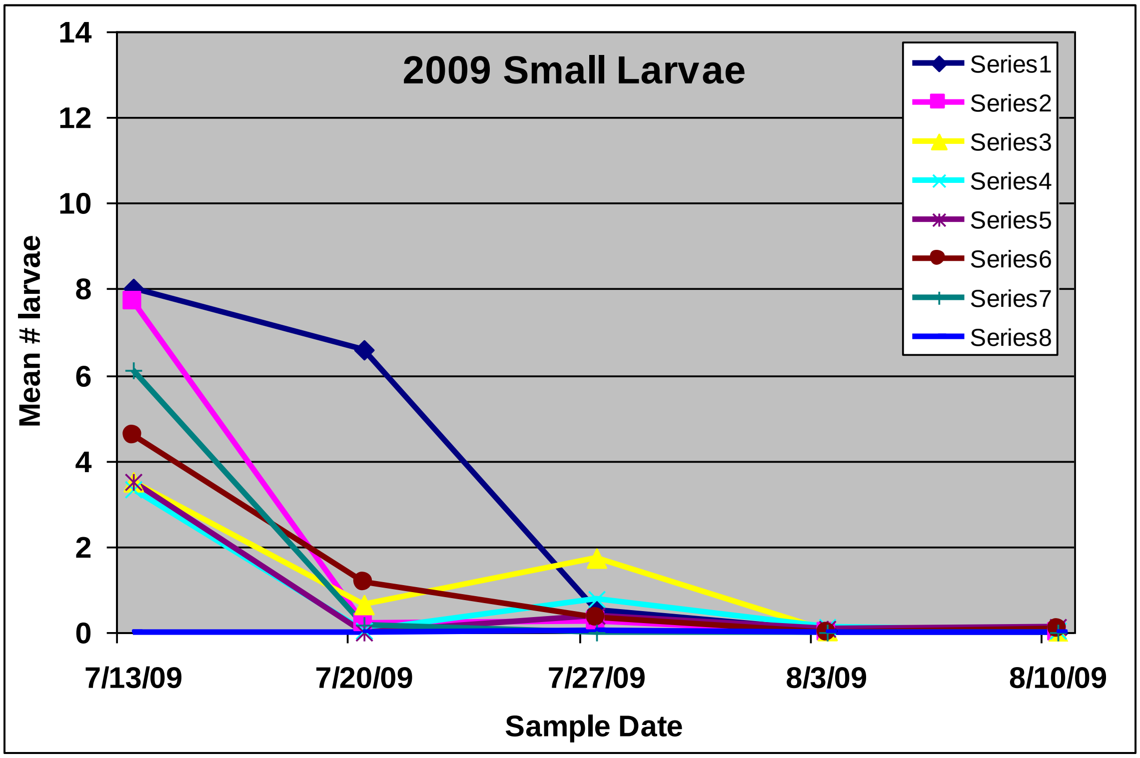


Fig. 2. Mean densities of large CPB larvae per plant (Series #'s correspond to treatments).

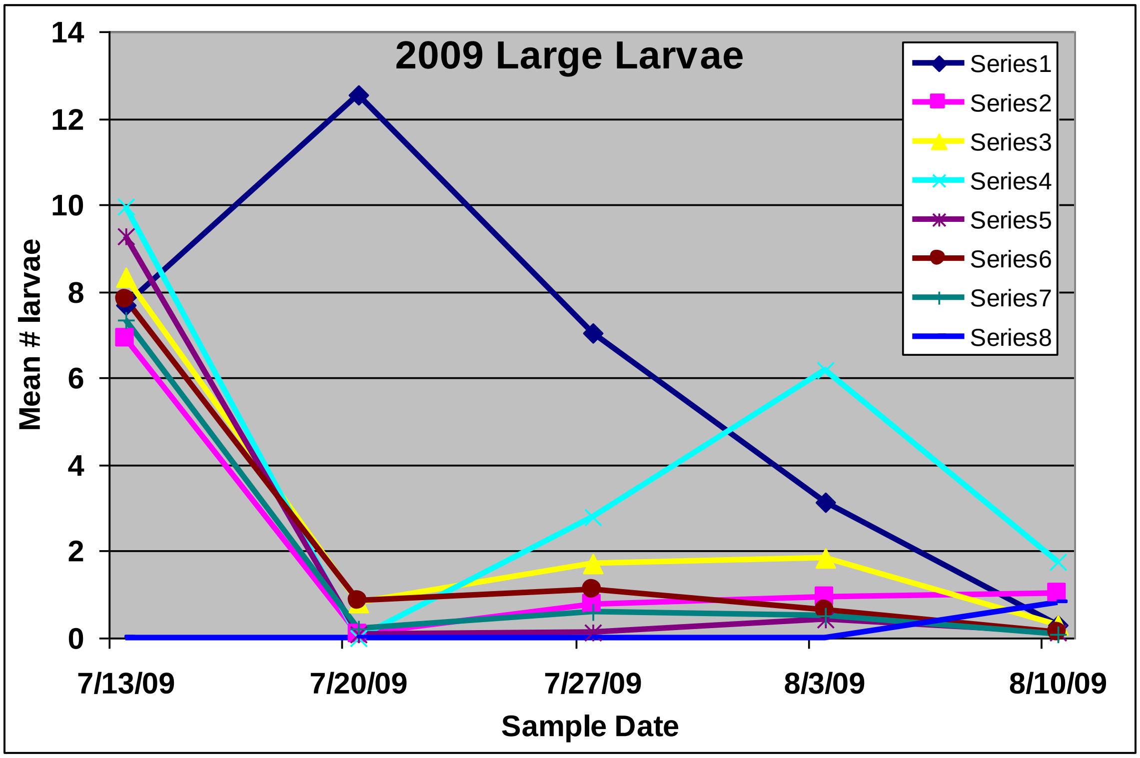


**Table 4. Mean CPB life stage counts for 13 July (pre-foliar spray count date).**

| Treatment | Egg masses/plant | Small larvae/plant | Large larvae/plant | Adults/plant | % Defoliation /plot |
|---|---|---|---|---|---|
| 1) Untreated check | 0.23 abc | 8.00 a | 7.70 a | 0.18 b | --- |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 0.15 bc | 7.73 a | 6.90 a | 0.10 b | --- |
| 3) Rimon at 9 fl oz/a | 0.40 a | 3.53 bc | 8.33 a | 0.18 b | --- |
| 4) Temprano at 8 fl oz/a | 0.28 abc | 3.33 bc | 9.98 a | 0.40 a | --- |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 0.28 abc | 3.50 bc | 9.28 a | 0.10 b | --- |
| 6) Coragen at 3.5 fl oz/a | 0.35 ab | 4.58 ab | 7.80 a | 0.05 b | --- |
| 7) Coragen at 5 fl oz/a | 0.33 ab | 6.10 ab | 7.35 a | 0.05 b | --- |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 0.05 c | 0 c | 0 b | 0.15 b | --- |
| ***P*-value** | **0.125** | **0.001** | **0.004** | **0.012** | **---** |

Means within a column with the same letter are not significantly different (Fisher’s Protected LSD, $P \leq 0.05$).

**Table 5. Mean CPB life stage counts and percent defoliation for 20 July (7 DAT).**

| **Treatment** | **Egg masses/plant** | **Small larvae/plant** | **Large larvae/plant** | **Adults/plant** | **% Defoliation /plot** |
|---|---|---|---|---|---|
| 1) Untreated check | 0 b | 6.58 a | 12.53 a | 0 b | 18 a |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 0.10 a | 0.23 b | 0.08 b | 0.10 ab | 5 b |
| 3) Rimon at 9 fl oz/a | 0.03 ab | 0.65 b | 0.80 b | 0.08 ab | 5 b |
| 4) Temprano at 8 fl oz/a | 0.05 ab | 0.05 b | 0 b | 0.08 ab | 5 b |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 0.03 ab | 0 b | 0.10 b | 0 b | 5 b |
| 6) Coragen at 3.5 fl oz/a | 0.08 ab | 1.18 b | 0.85 b | 0.08 ab | 5 b |
| 7) Coragen at 5 fl oz/a | 0.05 ab | 0.18 b | 0.23 b | 0.13 ab | 5 b |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 0 b | 0 b | 0 b | 0.23 a | 5 b |
| ***P*-value** | **0.264** | **<0.001** | **<0.001** | **0.099** | **0.003** |

Means within a column with the same letter are not significantly different (Fisher’s Protected LSD, $P \leq 0.05$).

**Table 6. Mean CPB life stage counts and percent defoliation for 27 July (14 DAT).**

| **Treatment** | **Egg masses/plant** | **Small larvae/plant** | **Large larvae/plant** | **Adults/plant** | **% Defoliation /plot** |
|---|---|---|---|---|---|
| 1) Untreated check | 0 b | 0.53 b | 7.05 a | 0.05 a | 30 a |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 0.05 ab | 0.28 b | 0.78 cd | 0.08 a | 5 b |
| 3) Rimon at 9 fl oz/a | 0 b | 1.75 a | 1.70 bc | 0 a | 5 b |
| 4) Temprano at 8 fl oz/a | 0 b | 0.78 b | 2.80 b | 0 a | 5 b |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 0.03 ab | 0.38 b | 0.13 d | 0.03 a | 5 b |
| 6) Coragen at 3.5 fl oz/a | 0.03 ab | 0.33 b | 1.13 cd | 0.08 a | 5 b |
| 7) Coragen at 5 fl oz/a | 0 b | 0 b | 0.58 cd | 0.03 a | 5 b |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 0.08 a | 0.05 b | 0 d | 0.08 a | 5 b |
| ***P*-value** | **0.323** | **0.006** | **<0.001** | **0.572** | **0.104** |

Means within a column with the same letter are not significantly different (Fisher's Protected LSD, P ≤ 0.05).

**Table 7. Mean CPB life stage counts and percent defoliation for 3 August (21 DAT).**

| **Treatment** | **Egg masses/plant** | **Small larvae/plant** | **Large larvae/plant** | **Adults/plant** | **% Defoliation /plot** |
|---|---|---|---|---|---|
| 1) Untreated check | 0 b | 0.05 a | 3.15 b | 1.08 a | 59 a |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 0.03 a | 0 a | 0.95 cd | 0.05 bc | 5 b |
| 3) Rimon at 9 fl oz/a | 0 b | 0.03 a | 1.85 bc | 0.10 bc | 5 b |
| 4) Temprano at 8 fl oz/a | 0 b | 0.15 a | 6.20 a | 0.18 bc | 5 b |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 0 b | 0.10 a | 0.43 d | 0.03 c | 5 b |
| 6) Coragen at 3.5 fl oz/a | 0 b | 0 a | 0.63 cd | 0.33 b | 5 b |
| 7) Coragen at 5 fl oz/a | 0 b | 0 a | 0.53 cd | 0.18 bc | 5 b |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 0 b | 0 a | 0 d | 0.13 bc | 5 b |
| ***P*-value** | **0.431** | **0.652** | **<0.001** | **<0.001** | **<0.001** |

Means within a column with the same letter are not significantly different (Fisher's Protected LSD, $P \leq 0.05$).

**Table 8. Mean CPB life stage counts and percent defoliation for 10 August (28 DAT).**

| **Treatment** | **Egg masses/plant** | **Small larvae/plant** | **Large larvae/plant** | **Adults/plant** | **% Defoliation /plot** |
|---|---|---|---|---|---|
| 1) Untreated check | 0 a | 0 a | 0.28 cd | 5.50 a | 54 a |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 0 a | 0 a | 1.03 b | 1.35 bc | 5 b |
| 3) Rimon at 9 fl oz/a | 0 a | 0 a | 0.28 cd | 0.48 d | 5 b |
| 4) Temprano at 8 fl oz/a | 0 a | 0.03 a | 1.78 a | 0.23 d | 5 b |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 0 a | 0.13 a | 0.15 d | 0.83 bcd | 5 b |
| 6) Coragen at 3.5 fl oz/a | 0 a | 0.10 a | 0.15 d | 1.65 b | 5 b |
| 7) Coragen at 5 fl oz/a | 0 a | 0 a | 0.10 d | 0.78 cd | 5 b |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 0 a | 0 a | 0.83 bc | 0.18 d | 5 b |
| ***P*-value** | **n/a** | **0.478** | **<0.001** | **<0.001** | **<0.001** |

Means within a column with the same letter are not significantly different (Fisher’s Protected LSD, P ≤ 0.05).

**Table 9. Mean yields.**

| **Treatment** | **Yield (cwt/acre)** |
|---|---|
| 1) Untreated check | 87.0 b |
| 2) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a | 152.1 b |
| 3) Rimon at 9 fl oz/a | 145.4 b |
| 4) Temprano at 8 fl oz/a | 185.7 ab |
| 5) Rimon at 9 fl oz/a + Temprano at 8 fl oz/a + 2nd app of Rimon at 2 fl oz/a (7-10 DAT) | 120.6 b |
| 6) Coragen at 3.5 fl oz/a | 110.4 b |
| 7) Coragen at 5 fl oz/a | 120.5 b |
| 8) Admire Pro at 0.35 oz/cwt (seed treatment standard) | 290.9 a |
| **LSD** | **110.49** |
| **CV** | **49.6%** |

Means within a column with the same letter are not significantly different (Fisher’s Protected LSD, P ≤ 0.05

# Potato Breeding and Cultivar Development for the Northern Plains
# North Dakota State University
# 2009 Summary

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## Potato Breeding, Selection, Cultivar Development, and Germplasm Enhancement

Potato continues to be the most important vegetable and horticultural crop grown in North Dakota and the Northern Plains. Traditionally, North Dakota State University (NDSU) potato cultivar releases have been widely adapted and accepted, thus significantly impacting production in North Dakota, Minnesota, the Northern Plains, and often throughout North America. The NDSU potato breeding program was established more than 75 years ago as part of the North Dakota Agricultural Experiment Station (NDAES). Since 1930, 24 cultivars have been named and released by the NDAES, in cooperation with the USDA-ARS, and others (please see attachment). Many additional collaborative releases with state Agricultural Experiment Stations, the USDA-ARS, and Agriculture Canada have also occurred. As a leader in potato breeding, selection, and cultivar development, our goal is to identify and release superior, multi-purpose cultivars that are high yielding, possess multiple resistances to diseases, insect pests, and environmental stresses, have excellent processing and/or culinary quality, and that are adapted to production in North Dakota, Minnesota, and the Northern Plains. Our program emphasizes late blight, cold-sweetening, Colorado potato beetle, pink rot and *Pythium* leak, silver scurf, sugar end, and aphid and virus resistance breeding. In 2009, we initiated an accelerated effort to develop *Verticillium* wilt resistant cultivars with Dr. Neil Gudmestad's research program in Plant Pathology. This effort is in response to producer needs to aid in production of an economically and environmentally sustainable crop. In order to develop durable and long-term resistance to pests and stresses, breeding efforts continue to include germplasm enhancement to incorporate important pest resistances and improved quality traits via exploitation of wild species and wild species hybrids, in addition to the use of released cultivars and advanced germplasm from around the globe. Breeding, evaluation, and screening efforts are successful because of the cooperative and interdisciplinary efforts amongst the NDSU potato improvement team, the North Dakota State Seed Department (NDSSD), and with potato producers, research and industry personnel in ND, the Northern Plains, and North America.

In order to meet the needs of producers and industry, we have established the following research objectives:

1) Develop potato (*Solanum tuberosum* Group Tuberosum L.) cultivars for North Dakota, the Northern Plains, and beyond, using traditional hybridization that are genetically superior for yield, market-limiting traits, and processing quality.

2) Identify and introgress into adapted potato germplasm, genetic resistance to major disease,

insect, and nematode pests causing economic losses in potato production in North Dakota and the Northern Plains.

3) Identify and develop enhanced germplasm with resistance to environmental stresses and improved quality characteristics for adoption by consumers and the potato industry.

Research activities in 2009 ranged from research trial and seed production sites from Langdon to Wyndmere in North Dakota. Procedures used by the NDSU potato breeding program in breeding, selection and cultivar development are summarized in the attached schematic. Potato cultivar development is a long process requiring 10 to 20 years from hybridizing to naming and release. It involves interdisciplinary teams which evaluate multiple characteristics required by producers and the industry. As with other crops, potato is influenced by seed quality, cultural practices, and the environment. The NDSU potato improvement team works with the North Dakota State Seed Department to certify production from greenhouse seedling crops through advanced field generations. The following narrative summarizes our 2009 research efforts.

In 2009, 604 new families were created in crossing blocks; 60%, 46%, 42%, and 32% had late blight (LB), Colorado potato beetle (CPB), cold chipping/processing, aphid/virus resistance breeding, respectively. In addition to these primary areas of concentration and efforts in developing resistance to sugar end, pink rot and *Pythium* leak, and silver scurf, new areas of emphasis in response to producer needs include *Verticillium* wilt, corky ring spot, and *Fusarium* dry rot resistance. Germplasm enhancement exploiting wild species, wild species hybrids, and cultivars and advanced selections from cooperators around the globe, is used in an effort to develop durable and long-term resistance to pests and stresses and to improve quality traits. Seedling families (522) from true botanical seed were grown in summer and fall greenhouse crops. We have completed harvest and are inventorying tubers to plant at our seedling nursery in Langdon in 2010, and to share with cooperative programs such as Maine and others. At Langdon, 79,416 ND seedlings (536 families) were evaluated; 907new individual genotypes were selected for evaluation in 2010. Unselected seedling tubers (20,500) from cooperating programs in ID, TX, and ME were grown at Inkster and Larimore. Unselected seedlings (31,668) were shared with programs in ID, ME, OR, and TX. Seed maintenance and increase lots at Absaraka and Wyndmere included 1,834 second, 184 third, and 321 fourth year and older selections; 173, 22, and 260, were retained for further evaluation and increase, respectively. Yield and evaluation trials were grown at three irrigated (Larimore, Oakes, and Inkster) and two non-irrigated locations (Hoople and Crystal). The state chip trial at Hoople included 36 entries; eight clones were evaluated in the North Central Regional (NCR) Chip Processing Trial. ND8304-2 and ND8305-1, two advancing cold-chipping selections, were entries in the regional trial. Thirty-seven entries (28 advancing ND selections) were grown in the fresh market trial at Crystal. The NCR Fresh Market Trial had 13 entries including red and yellow skinned selections with white and yellow flesh colors. NDSU entries in the regional fresh market trial included two red skinned, yellow fleshed selections, ATND98459-1RY and ND028842-1RY; this latter selection also has red marbling mixed with the yellow pigmented flesh. A new trial in 2009 was the preliminary fresh market trial evaluating 26 entries (21 advanced selections compared to five industry checks) grown at Crystal. The objective of this replicated trial is to help us narrow our focus on the best genotypes advancing through our program. The trials at Crystal and Hoople experienced the heavy June rains and flooding, thus struggled during the entire growing season;

both stand and yield were significantly impacted at the two locations. The Oakes and Larimore processing trials evaluated 20 and 25 clones, respectively. Another new trial in 2009 was the preliminary processing trial which included 10 new selections with processing potential compared to five industry standards at Larimore. The objective of this trial is to help us more quickly and efficiently identify selections with French fry processing potential; this should aid our efforts to increase seed more rapidly for large scale evaluations with producers and processors. Several progeny of Dakota TrailBlazer (AOND95249-1Russ) and ND8229-3 performed well and possessed excellent processing qualities when evaluated in these processing trials at Oakes and Larimore. An irrigated fresh market trail was also grown at Larimore in cooperation with Dr. Nick David. Thirty-two cultivars and advancing selections were evaluated in the replicated trial with clones ranging from European yellow fleshed cultivars, new cultivars from the Colorado potato breeding program to a myriad of NDSU materials including several with yellow and blue (purple) flesh and even one with red marbled flesh. The North Central Regional Processing Trial consisted of four entries. NDSU did not have a selection in this trial. At Inkster, trials ranged from the chip processing yield trial with 34 entries, irrigated NCR trials (chip, processing and fresh market), a trial evaluating clones developed to resist sweetening with Dr. Joe Sowokinos, several cultural management trials including work with AgZyme, 2,4-D, metribuzin sensitivity, and four graduate student projects. Many of the trials were in collaboration with NDSU researchers evaluating germplasm for disease/stress resistance or in support of cultivar specific management practices. Second year (413) and third year and older (52) selections from out-of-state programs were maintained/increased at Inkster. An additional set of germplasm (43 clones) primarily from Dr. Shelley Jansky with the USDA-ARS in Madison, WI was also evaluated at Inkster. We continue our efforts to identify germplasm for cultivar release that will reliably and consistently process from long term cold storage. Entrants from chip trials were sampled and stored at 42F (5.5C) and 38F (3.3C) for eight weeks; additional samples from 42F (5.5C) will be processed after seven months. Frozen processing selections and cultivars from processing trials were sampled and stored at 45F (37.2C) for eight weeks; additional samples will be processed after seven months storage. All yield trial entries were evaluated for blackspot and shatter bruise potential.

Collaborative disease resistance breeding and screening trials focused on foliar and tuber late blight, tuber blemish diseases, bacterial ring rot expression, pink rot, *Pythium* leak, and CPB resistance, sucrose rating, invertase/ugpase analysis, and serial chipping of chip and frozen processing selections. As part of our dedicated effort to develop late blight resistant cultivars, Dr. Gary Secor's program evaluated seedling families using a detach leaf assay in the greenhouse. Resistant selections were retained for field selection in 2010. Two field trials were grown at Prosper, ND to evaluate field resistance of advancing selections identified in previous years as being resistant. The replicated trial compared 29 advancing selections to Stirling and Patagonia, resistant checks and Russet Burbank, a susceptible check, for defoliation by *Phytophthora infestans*. In the unreplicated screening trial, 230 genotypes were evaluated for defoliation. In 2009 we had several selections with commercial potential (ie. appearance and processing/tablestock quality) in our trials. Nine selections were evaluated for symptom expression of bacterial ring rot in the field by Dr. Neil Gudmestad's research group. Entrants were compromised by wet conditions at planting, during the growing season and at harvest. All will be repeated in 2010. Drs. Neil Gudmestad and Ray Taylor continued evaluating clones for resistance to pink rot, *Pythium* leak, and *P. nicotianae*. These evaluations have identified several parental genotypes express resistance or moderate resistance to one or more of the disease pathogens, in addition to advancing selections with some resistance, generally to only one pathogen, as well. Dr. Secor's program is evaluating selections for resistance to tuber blemish diseases including incidence of silver scurf and blackdot; in 2009 14 selections were evaluated. Four hundred-sixty early generation selections were evaluated for defoliation in a CPB resistance screening nursery by Dr. Deirdre Prischmann Voldseth's program with assistance from Don Carey; 460 clones were Defoliation data was used in determining selection intensity of some families at Langdon. A replicated trial with 16 entries included advancing selections which previously demonstrated resistance to feeding by CPB and parental genotypes possessing leptine glycoalkaloid or glandular trichome mediated resistance. Our program has now stacked these mechanisms in several families and is actively evaluating progeny in an effort to develop durable and long-term resistance to this super pest. Additional collaborative evaluations included sucrose rating and serial chipping of chip and frozen processing selections. Additional collaboration includes sucrose rating and serial chipping of chip and frozen processing selections by Marty Glynn (USDA-ARS) and Dr. Joseph Sowokinos (UMN) at the USDA-ARS Potato Worksite in East Grand Forks, MN. Dr. Nicholas David evaluated several advancing red, chip processing and French fry processing selections in cultural management trials (seed piece spacing, nutrient management, harvest date) conducted at Hoople, Crystal, and Inkster, ND, and Becker, MN. French fry processing selections were also evaluated by Dr. David's program at Oakes, near Tappen, and at Park Rapids. A collaborative trial was conducted with Dr. Harlene Hatterman-Valenti to evaluate sensitivity to the widely used herbicide metribuzin. Thirty entries were grown with the resistant check, Russet Norkotah, and the susceptible check, Shepody. In 2009 we included many red fresh market cultivars in addition to many advancing selections in order to answer questions we have received from seed and commercial producers growing popular fresh market selections. In the replicated study, treated plots (1 lb./acre applied post-emergence when plants are 8 to 12 inches tall) were compared to untreated plots (no metribuzin) for plant damage, plant height, and total yield. NDSU had entries in cooperative trials with producers, industry, and research groups around North America (NC, MI, MN, WI amongst others).

The highlight of 2009 was the release of AOND95249-1Russ as Dakota TrailBlazer, in December. It offers producers and processors sugar end, *Verticillium* wilt, pink rot, and late blight (field) resistance, in addition to outstanding French fry/frozen processing and tablestock properties. Dakota TrailBlazer has very high specific gravity, long dormancy, and cold sweetening resistance, processing reliably from 42F storage. The most promising selections in our program include red tablestock selections, ND4659-5R and ND8555-8R. Dual-purpose russet selections, ND8229-3, AOND95292-3Russ, and ND8068-5Russ possess excellent appearance and processing qualities. ND7519-1 and ND8304-2 possess superior chip processing traits. Dakota TrailBlazer and twelve promising advancing selections are summarized at the end of this report. Many are available from the NDSSD, Valley Tissue Culture or other certified seed producers.

Goals for 2010 include continued breeding, selection, evaluation and development efforts of superior genotypes with multiple resistances, high yield potential, and important quality attributes; to continue to adopt early generation selection technologies including the use of marker-assisted selection, to continue to improve our seed increase procedures and certified seed production efforts working with the NDSSD; and, to continue the long-term storage and cultural management evaluations.

We enjoy the opportunity to conduct cooperative and interdisciplinary research projects with members of the NDSU potato improvement team, the NDSSD, the USDA-ARS programs in Fargo and East Grand Forks, and other U.S. and Canadian research programs.  These relationships permit us to evaluate new and advancing selections for adaptation, yield stability, appearance, quality attributes, and resistance to pests and environmental stresses in many locations.  We are extremely grateful for the support of potato producers and industry personnel in North Dakota and Minnesota, the Northern Plains, and around North America.  You make our work challenging, fun, and rewarding.

# Cultivar Releases

## North Dakota State University
## Potato Breeding Program

| Cultivar | Year | Type | Seed Acreage 2009[1] |
|---|---|---|---|
| Nordak | 1957 | Tablestock, round-oval white | |
| Norgleam | 1957 | Tablestock, round-oval white | |
| Norland | 1957 | Tablestock, round-oval red | 3037.66[2] |
| Snowflake | 1961 | Tablestock, round-oval white | |
| Viking | 1963 | Tablestock, oblong-round red | 100.40 |
| Norgold Russet | 1964 | Tablestock, russet | |
| Norchip | 1968 | Chip processing, round white | |
| Norchief | 1968 | Tablestock, round-oblong red | |
| Bison | 1974 | Tablestock, round-oblong red | |
| Dakchip | 1979 | Chip processing, round-oval white | |
| Crystal | 1980 | Chip processing, oval | |
| Redsen | 1983 | Tablestock, round-oval red | |
| NorKing Russet | 1985 | Tablestock, russet | |
| Russet Norkotah | 1987 | Tablestock, russet | 234.90[3] |
| Goldrush | 1992 | Tablestock, russet | 192.60 |
| Norqueen Russet | 1992 | Tablestock, russet | |
| NorDonna | 1995 | Tablestock, round-oval red | |
| NorValley | 1997 | Chip processing, round-oval white | 127.00 |
| Dakota Pearl | 1999 | Chip processing, round white | 807.20 |
| Dakota Rose | 2000 | Tablestock, round-oblong red | 22.00 |
| Dakota Jewel | 2004 | Tablestock, round-oblong red | 10.60 |
| Dakota Crisp | 2005 | Chip processing, round white | 250.13 |
| Dakota Diamond | 2005 | Chip processing, round white | 17.35 |
| Dakota TrailBlazer | 2009 | Dual-purpose[4], russet | 4.30 |

[1] North Dakota Certified Seed Potato Acreage.

[2] Includes all selections

[3] Standard Russet Norkotah, does not include lines, strains or selections from CO, TX, or NE

[4] Dual-purpose – suitable for French fry processing and tablestock  Evaluated as AOND95249-1Russ.

*January 2010*

# Potato Breeding and Cultivar Development
# Breeding, Selection and Development Schematic
# North Dakota State University

| Year | Procedure |
|---|---|
| 1 | Parental selection, crossing and true seed production in the greenhouse. Produce seedling tubers from true seed in the greenhouse. Initiate late blight screening of seedling families. |
| 2 | 100,000+ North Dakota seedlings are planted in the field (Langdon, ND) as single hills. Up to 100,000 from out-of state programs are also planted at ND and MN locations. Initial selection takes place at harvest; 1,000-1,500 genotypes are typically retained. This is the first cycle of field selection. Decisions regarding seed increase are initiated. |
| 3 | Two-four hill units are planted at Absaraka for seed maintenance. Typically 200-250 selections are retained at harvest based primarily on phenotypic selection. This is the second cycle of field selection. Colorado potato beetle (CPB) resistant (potential) selections are entered into replicated trials and evaluated for defoliation. Selections are evaluated for specific gravity and internal defects. Chipping and russet selections are evaluated for sucrose rating and are chipped from storage (5.5 and 7.2 C). Replicated late blight resistance screening field evaluations begin. Preliminary yield trials begin. |
| 4 and/or 5 | Two-four hill units are planted at Absaraka and 10 hills are planted at Wyndmere for seed maintenance. Decisions regarding increase are made at harvest and following quality evaluations during the winter. This is the third cycle of field selection. Selections are evaluated for specific gravity and internal defects. Chipping evaluations, late blight and CPB resistance screenings continue. Cleanup and micropropagation are initiated for exceptional genotypes. Selected lines are increased for trial seed. Entry into state yield trials for up to three years may occur. Sensory evaluations are initiated. Decision is made following grading, or during the winter evaluations, determining which selections to continue with. |
| 6 | Second year of state trials. Promising selections continue to be increased. Additional selections may be entered into micropropagation. Cultural management and disease/pest (field and post-harvest reaction) evaluation trials begin. Promising selections continue to be increased. To growers for evaluation and increase. |
| 7 | Third year in State Trials or exceptional selections to North Central Regional Potato Variety Trial. Cultural management and disease/pest evaluation trials continue. Processing selections are evaluated for flake production. |
| 8-11 | Enter in North Central Regional Trial for up to 3 years and Snack Food Association Trial if it is a chipper. Grower evaluation and increase continue. Cultural management and disease/pest reaction evaluations continue. |
| 10-15+ | Consider for release as a named cultivar. |

*Summer 2009*

# Dakota TrailBlazer (AOND95249-1Russ)

- A89163-3LS x A8914-4
- Medium-late maturity
- High yield potential
- Good storability and low sugar accumulation in storage.
- High specific gravity
- Resistance to late blight, *Vertillium* wilt, and sugar ends in field evaluations. Moderately resistant to pink rot. Hollow heart and blackspot bruise occasionally noted.
- Tolerant of metribuzin applications.


09/30/2009

# ND8229-3

- Marcy x AH66-4
- Medium maturity
- Medium vine size
- High yield potential
- Good storability and excellent fry color from 45F storage
- High specific gravity
- Resistance to sugar ends
- Tolerant of metribuzin applications


09/30/2009

# ND8068-5Russ

- ND2667-9Russ x ND4233-1Russ
- Medium vine size
- Early vine maturity
- Medium to high yield potential
- High specific gravity
- Good storability with low sugar accumulation
- Early in evaluation process


09/17/2009

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# AOND95292-3Russ

- A89805-7 x A9014-2
- Late maturity
- Medium yield potential
- High specific gravity
- Good storability with low sugar accumulation
- Resistance to sugar ends
- Expresses typical symptoms of bacterial ring rot
- Tolerant of metribuzin applications


09/17/2009

# AND97279-5Russ

- A92001-2 x Ranger Russet
- Medium to large vine size
- Medium to late vine maturity
- High yield potential
- High specific gravity
- Good storability with low sugar accumulation
- Early in evaluation process

# ND4659-5R

- NorDonna x ND2842-3R
- Tablestock, medium specific gravity
- Medium vine with red-purple flowers
- Medium maturity
- Medium yield potential
- Bright red, round, smooth tubers with white flesh and shallow eyes.
- No outstanding disease or pest susceptibilities
- Stores well

# ND8555-8R

- ND7188-4R x ND5256-7R
- Tablestock, medium specific gravity
- Early maturity
- Medium sized vine
- Medium yield potential
- Bright red, round, smooth tubers with white flesh and shallow eyes
- Stores well
- Early in the evaluation process for cultivar specific information

# AND00272-1R

- MN17922 x A92653-6R
- Tablestock, medium specific gravity (1.081)
- Medium vine with red-purple flowers
- Medium maturity
- Medium yield potential
- Bright red, round, smooth tubers with white flesh and shallow eyes.
- No outstanding disease or pest susceptibilities
- Stores well

# ND6002-1R

- NorDonna x Bison
- Medium sized vine
- Medium maturity
- Medium yield potential
- Round, smooth, bright red tubers with smooth eyes and bright white flesh
- Medium specific gravity
- Early in evaluation process

# ATND98459-1RY

- ATD252-5R x T4845
- Medium sized vine
- Medium early maturity
- High yield potential
- Round, smooth, bright red tubers with smooth eyes and yellow flesh
- High specific gravity (1.091)
- Need for cultivar specific management information

# ND7519-1

- ND3828-15 x W1353
- Medium sized vine
- Medium maturity
- Medium to high yield potential
- High specific gravity
- Chips from 42F storage
- Early in evaluation process for cultivar specific management information


09/17/2009

# ND8304-2

- ND860-2 x ND7083-1
- Medium early maturity
- Small to medium sized vine
- Medium yield potential
  - Nice tuber type, smaller size profile
- High specific gravity
- Chips from 42F storage
  - Excellent cold chipping selection
- Early in the evaluation process

# ND8305-1

- ND2471-8 x White Pearl
- Medium late maturity
- Medium sized vine
- Medium yield potential
  - Smaller size profile
- High specific gravity
- Chips from 42F storage
- Early in the evaluation process

## Project Title: Adapting Trap Cropping of Colorado Potato Beetle To Minnesota and North Dakota

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**Executive Summary** – This project was designed to evaluate the adaption of trap cropping as a mechanism to control Colorado Potato Beetle (CPB) in Minnesota and North Dakota. This proposal was in response to the expected continued development and spread of neonicitinoid resistant CPB. Trap cropping requires early germinating varieties, yet most of the varieties grown in ND and MN can be described as such. We will establish trap crop plots surrounding a production potato field block. We will assess several techniques designed to encourage emergence in the trap crops prior to the emergence of potatoes grown in the field block inside the perimeter of trap crop plots. Trap crop plots will then be treated with non-neonicitinoid insecticides and destroyed by discing prior to the maturation of any surviving CPB larvae. Colorado potato beetle populations will be monitored in both the trap crop plots and the production field. Defoliation and yields will be compared from the production field adjacent to the trap crop fields.

### Methods & Materials

Location & Plot Description - Plots were established at the UMN Northwest Research & Outreach Center in Crookston, MN. Trap plots were 6 rows wide and 33' long. Standard weed and disease treatments were applied pre and post planting.

Experimental Design & Data Collection - All plots and the field block were planted with an early variety (i.e. Red Norlands) planted on all sides bounding a ~3 ac field (~360' x 360'). Seed potatoes in the outer trap plots were either untreated, environmentally conditioned prior to plant by exposing them to ambient temperatures for 1 week, or treated with Giberellic Acid (GA) to encourage sprouting and early emergences by using a 5ppm GA mist and allowing treated potatoes to dry prior to planting. Trap plots were 30' long and were separated with plot-sized breaks in the trap crop perimeter to serve as an untreated check allowing beetles to enter the main field behind the trap plot rows. Four unplanted rows were left between the outer trap plots and the main field. All trap plot rows were planted as shallowly as possible (~2"-3"), while still allowing emergence and growth. The field block established inside the perimeter of the trap crop plots was planted and managed using standard production techniques, including hilling (~6"-8" deep). Previous work (Grafius 2005) indicates little movement from trap crop potatoes to adjacent potatoes occurs, consequently trap crop plants needed emerge only early enough to attract CPB immigrating into the field. Beetle emergence, oviposition and larval development were recorded in both trap crops and production field adjacent to plots. Trap crop rows were to be treated with Rimon, and/or Agri-mek and/or Spintor. After treatment, trap rows were destroyed by discing before any remaining larvae mature. Beetle colonization and numbers in production field were be monitored through the rest of the season. Yields and crop damage in areas adjacent to trap crop plots were collected and compared. Yields were assed from 10' of sampled row

**Results & Discussion** – Plots and fields were planted on May 21. Emergence was considerably delayed by unseasonable spring temperatures and precipitation, with all trap plots and the 3 ac field block emerging June 12-17. Emergence was not uniform, resulting in patchy stands for 1-2 weeks in all plots and the field block. There was no significant difference in the timing of emergence in any of the plots or the field block, the entire field emerged at roughly the same time. CPB populations per plant were not significantly different in field blocks adjacent to any trap plot treatment, nor was there any significant difference in the mean number of CPB in any plot trap and the adjacent field block at any sample date. This uniform distribution of beetles resulted in a rescue application of Spintor applied to the entire experimental area. The chemical treatments incorporating mixed and solo applications of Agri-Mek, Rimon and Spintor were consequently not attempted. There was considerable variation in yields from the field block adjacent to the trap plots and there was no significant difference associated with any trap plot treatment.

While the field block inside the perimeter of the trap plots was planted deeper and hilled, plant emergence was no later than observed in the trap plots. Seed potatoes in the trap plots were planted as shallowly as possible to encourage accumulation of heat and result in an earlier emergence than potatoes in the field block. However, we suspect the irregular temperatures experience in the spring of 2009 may have resulted in exactly the opposite situation. Any early heat may have raised temperatures in the soil and the deeper soil over the seed in the field block may have held it more efficiently than the shallow soil over the seed in the trap plots. This would result in the deeper planted seed accumulating heat in a more consistent pattern, and possibly over longer period of time than the trap plots, the seeds of which would have cooled rapidly after any temperature drop. Because all plantings in the experiment emerged at roughly the same time, it is not surprising there was no difference in the timing or rate of establishment and subsequent distribution of CPB in the experiment field. The uniform distribution of CPB would, in turn, explain the lack of yield differences between any trap plot treatment and the 3 ac field block.

**Conclusions –** While the results of the experiment were heavily influenced by the weather conditions in 2009, it should be noted that irregular spring temperatures and precipitation are not unusual in the Red River Valley. Consequently, these results are probably indicative of what can be expected in years with varying spring temperature and precipitation. It is therefore concluded that this technique does not have application as a management tool in the Red River Valley. The lack of tactics to manage the loss of neonicitinoid insecticides underscores the necessity of developing techniques to delay or prevent its onset in the Red River Valley.

Table 1. Mean Colorado potato beetle larvae populations in the field block adjacent to trap plots. Means followed by the same letter are not significantly different at the P = 0..05 level. It is important to note that there also was no difference in the population of Colorado potato beetle in any of the trap plots or the adjacent field blocks. Spintor was applied July 15.

| **Treatent** | **June 19** | **June 25** | **July 6** | **July 14** | **July 21** | **July 28** |
|---|---|---|---|---|---|---|
| Untreated | 0a | 0.2a | 3.2a | 3.3a | 0.2a | 0a |
| GA treated | 0a | 0.5a | 2.8a | 3.3a | 0.1a | 0a |
| Conditioned | 0a | 0.1a | 1.9a | 4.9a | 0.3a | 0a |
| No Trap Plot | 0a | 0a | 2.9a | 3.9a | 0.2a | 0a |

Table 2. Mean treatment yields from the field block adjacent to the trap treatment. Values represent lbs/10 foot row sample. Means followed by the same letter are not significantly different at the P = 0..05 level
.

| **Teatment** | **Yield** |
|---|---|
| Untreated | 12.25a |
| GA treated | 13.19a |
| Conditioned | 13.22a |
| No Trap Plot | 10.27a |

# University of Minnesota
# Department of Plant Pathology

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# 2009
# Potato Disease Report

## Potato Pathology and Genomics
## http://ppg.cfans.umn.edu/

**James Bradeen**

TABLE OF CONTENTS.

**The financial support of the Minnesota Area II Potato Research and Promotion Council is gratefully acknowledged.**

## Section I. Evaluating Potato Germplasm for Disease Resistance

SUMMARY: Disease screening plots were established at two locations (Rosemount and Becker, MN) in 2009. Entries were screened for resistance to late blight (caused by the Oomycete *Phytophthora infestans*; UMore Park, Rosemount, MN) and common scab (caused by the Actinomycete *Streptomyces scabies;* Sand Plain Research Farm, Becker, MN). In total, 492 entries were tested for late blight and 371 entries were tested for common scab. Entries for evaluation originated from the UM Potato Breeding Program, the UM Potato Pathology & Genomics Program, the USDA, the North Central breeding programs, and the National Late Blight and Scab Trials.

**Table 1. Source and number of entries screened at the late blight and common scab nurseries in 2009.**

| **Source** | **Late Blight** (UMore Park, Rosemount, MN) | **Common Scab** (Sand Plain Research Farm, Becker, MN) |
|---|---|---|
| UMN Potato Breeding | 275 | 270 |
| UMN Potato Pathology & Genomics | 12 | |
| North Central Trial | 34 | 38 |
| National Late Blight and Scab Trial | 147 | 63 |
| USDA-ARS, Madison, WI | 24 | |

## (A) Late Blight – Rosemount, MN

Late blight, caused by the fungus *Phytophthora infestans*, was responsible for the Irish Potato Famine of the mid-1800's. The disease is characterized by brown to black water-soaked lesions on potato leaves and stems. Under cool, humid conditions, late blight can destroy an entire field within 10-14 days. When sporangia or zoospores are washed into the soil, they can infect potato tubers. Tuber infection is characterized by a dry, brown, granular rot. Secondary pathogens, such as *Erwinia carotovora* (soft rot), *Phytophthora erythroseptica* (pink rot), and *Pythium* spp. (leak) frequently follow. Late blight is currently managed by intensive fungicide applications. This approach is expensive and not environmentally sustainable. Genetic resistance derived from cultivated or wild potato is a promising means to reduce pesticide dependency, risk to the environment, and costs to potato growers.

Resistance to late blight is evaluated at UMore Park (Rosemount, MN) in cooperation with James Rowe (Administrative Professional), Jim Karelis (Sr. Research Plot Technician) and Kimon Karelis (Research Plot Coordinator). The UMore Park is geographically isolated from commercial potato farms allowing intentional inoculation with the late blight pathogen. Because the spores of the pathogen are air-borne, inoculations and late blight screening is restricted to non-production areas. To further protect regional growers, the Late Blight Nursery is planted 4 to 8 weeks later than commercial production fields in Minnesota and Wisconsin.

Disease screening methods are detailed in Appendix A. Complete results for individual entries from the University of Minnesota Potato Breeding Program, University of Minnesota Potato Pathology and Genomics Program, National Late Blight, and North Central Region for 2009 are listed in Appendix B. Table 2 summarizes our findings.

**Table 2. Number of entries in each late blight resistance class based on infection 35 days after inoculation with the potato late blight pathogen at Rosemount, MN 2009**

| Sources of entries | No. (percent) of entries 35 DAI |
|---|---|
| **UM Potato Breeding** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 1 (0.4%) |
| Moderately Susceptible | 2 (0.7%) |
| Susceptible | 272 (98.9%) |
| **UM Potato Pathology & Genomics** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 2 (16.7%) |
| Moderately Susceptible | 4 (33.3%) |
| Susceptible | 6 (50.0%) |
| **National Late Blight Trial** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 24 (16.3%) |
| Moderately Susceptible | 36 (24.5%) |
| Susceptible | 87 (59.2%) |
| **North Central Trial** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 0 (0%) |
| Moderately Susceptible | 6 (17.6%) |
| Susceptible | 28 (82.4%) |
| **USDA-ARS, Madison, WI** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 7 (29.2%) |
| Moderately Susceptible | 11 (45.8%) |
| Susceptible | 6 (25.0%) |
| **All Entries** | |
| Resistant | 0 (0.0%) |
| Moderately Resistant | 34 (6.9%) |
| Moderately Susceptible | 59 (12.0%) |
| Susceptible | 399 (81.1%) |

## (B) Common Scab

Common scab, caused predominantly by the ubiquitous soil-borne bacterium *Streptomyces scabies,* is a disease of several root crops. In potato, symptoms include the development of corky lesions on the tuber that significantly reduce tuber quality and marketability, particularly for table stock varieties. In severe cases, common scab appears as deep sunken lesions ("pit scab") that invite secondary infection. Alkaline and dry soils exacerbate disease development. Genetic tolerance is sought after by potato breeders in Minnesota and throughout the US. The Sand Plain Research Farm is an ideal location for germplasm screening for resistance to common scab. As in previous years, in 2009 the Potato Pathology and Genomics program cooperated with the UM Potato Breeding Program and potato breeding programs at Michigan State University, University of Wisconsin, and North Dakota State University to screen breeding materials for tolerance to common scab. We also served as a test site for the replicated National Scab Trial.

Resistance to common scab is evaluated at the Sand Plain Research Farm located in Becker, MN in cooperation with Ronald Faber (Farm Manager) and Scott Garvin (Research Plot Technician). Detailed disease screening methods are listed in Appendix A. Severity and coverage ratings for all entries are listed in Appendix B. Table 3 summarizes our findings.

All 'Red Pontiac' plots that were planted next to test plots developed high levels of common scab, indicating disease pressure was fairly uniform throughout the plot. Coverage evaluations did not always correlate well with severity evaluations. Any tuber that received a 0 for severity also was scored with a 0 for coverage. However, scab lesions could range from superficial (severity = 1) to very deep (e.g. severity = 5) and only have 5% or less of the tuber surface covered (coverage = 2). Therefore, several entries that received a severity rating of 3 or 4 had coverage ratings of only 1 or 2. Since tubers can be rejected for sale when common scab lesions are severe, regardless of the degree of coverage, severity is a better measure of resistance in processing-type potatoes. Coverage may be the better assessment for fresh market reds.

**Table 3. Number of entries in each common scab resistance class based on Severity and Coverage Ratings at Becker, MN 2009**

| Sources of entries | Severity Rating (%) |
|---|---|
| **UM Potato Breeding** | |
| Resistant | 1 (0.0%) |
| Moderately Resistant | 34 (12.6%) |
| Moderately Susceptible | 40 (14.8%) |
| Susceptible | 195 (72.2%) |
| **National Scab Trial** | |
| Resistant | 0 (0.0%) |
| Moderately Resistant | 18 (28.6%) |
| Moderately Susceptible | 12 (19.0%) |
| Susceptible | 33 (52.4%) |
| **North Central Trial** | |
| Resistant | 0 (0%) |
| Moderately Resistant | 1 (0.3%) |
| Moderately Susceptible | 4 (10.5%) |
| Susceptible | 33 (86.8%) |
| **All Entries** | |
| Resistant | 1 (0.3%) |
| Moderately Resistant | 53 (14.3%) |
| Moderately Susceptible | 56 (15.1%) |
| Susceptible | 261 (70.4%) |

## References

Davis, J. R., and Garner, J. 1978. Common scab of potato. University of Idaho Agricultural Experiment Station current information series No. 386. University of Idaho, Moscow, Idaho.

Henfling, J. W. 1987 Late blight of potato: *Phytophthora infestans*. Technical Information Bulletin 4. International Potato Center, Lima, Peru.

King, R. R., and Lawrence, C. H., and Clark, M. C. 1991. Correlation of phytotoxin production with pathogenicity of *Streptomyces scabies* isolates from scab infected potato tubers. Am. Potato J. 68:675-680.

## Appendix A: Disease Screening Methods

### (A) Late Blight

Tubers were planted on June 12. Entries were submitted by the University of Minnesota Potato Pathology and Genomics Program, the University of Minnesota Potato Breeding Program, the National Late Blight Trial (conducted by Dr. Kathleen Haynes, USDA/ARS, Beltsville, MD), the North Central Region trials, and the USDA-ARS at Madison, WI. Admire 2F insecticide was applied in furrow at a rate of 16 fl. oz./acre to all planted potatoes. No fungicides were applied to the field at any time during the season.

All experimental were directly inoculated with a suspension of *P. infestans* (US-8 strain) zoospores and sporangia at a concentration of 260 sporangia /ml in the late evening of August 12. Inoculum was applied with a $CO_2$ sprayer at 20 psi using a single nozzle (6502 tip) wand. Plots were irrigated for 1 hour prior to inoculation. Sprinkler irrigation was applied the next morning and thereafter, 4 to 6 times per week depending upon weather conditions for 1 hour to prolong natural dew periods. All irrigation was accomplished using a low-volume, overhead mist-type sprinkler system.

Evaluations were initiated 14 days after inoculation and were made approximately every 3 to 5 days until 35 days after inoculation (4 readings total). Each entry was visually scored for disease severity using the CIP scale (Henfling, 1987). The CIP rating system is as follows:

| CIP | % Late Blight | |
|---|---|---|
| Rating | Mean | Limits |
| 1 | 0 | 0 |
| 2 | 2.5 | Trace to 5 |
| 3 | 10 | 5 to <15 |
| 4 | 25 | 15 to <35 |
| 5 | 50 | 35 to <65 |
| 6 | 75 | 65 to <85 |
| 7 | 90 | 85 to <95 |
| 8 | 97.5 | 95 to <100 |
| 9 | 100 | 100 |

After all disease ratings were made, the CIP ratings were categorized based on readings taken 35 DAI as follows:

| Resistance Class | Score |
|---|---|
| Resistant | <2.5 |
| Moderately Resistant | 2.5-4.99 |
| Moderately Susceptible | 5-7.49 |
| Susceptible | >7.5 |

## (B) Common Scab

Potato seed pieces were planted on May 8 by hand and Admire 2F insecticide was applied in furrow at a rate of 16 fl. oz./acre. Each entry consisted of 4 seed pieces spaced 12 inches apart, followed by a four-foot space, then two seed pieces of 'Red Pontiac' 12 inches apart, followed by another four-foot space. The 'Red Pontiac' was used as a susceptible check, to measure disease pressure throughout the plot.

For evaluation, all potato hills were lifted from the ground and dropped back on the ground using a one-row potato harvester. Evaluations were made on September 15, after a natural rainfall had washed much of the soil from the harvested tubers. All tubers from the four hills were rated as a group using the following scale:

| Rating | Severity | Coverage |
|---|---|---|
| 0 | No scab visible | No scab visible |
| 1 | Scab <= 1 mm deep | Trace or 1-2 lesions less than 1 $cm^2$ |
| 2 | Scab 2-3 mm deep | 1 to 5 % tuber surface covered |
| 3 | Scab 3-4 mm deep | >5 to 50% tuber surface covered |
| 4 | Scab 4-5 mm deep | Over 50% tuber surface covered |
| 5 | Scab over 5 mm deep | --- |

Entries were considered resistant if the severity and coverage ratings were 0, moderately resistant for severity and coverage ratings of 1-2, moderately susceptible for severity and coverage ratings of 3, and susceptible for severity ratings of 4-5 or a coverage rating of 4.

## Appendix B. Field Plot Data

### (A) Late Blight: Disease resistance scores for entries in 2009.

| Clone | Source | 8/26/09 Reading 1 | 9/2/09 Reading 2 | 9/8/09 Reading 3 | 9/16/09 Reading 4 | Resistance Category |
|---|---|---|---|---|---|---|
| A0008-1TE | National | 3 | 5 | 9 | 9 | S |
| A0008-1TE | National | 2 | 6 | 9 | 9 | S |
| A0008-1TE | National | 2 | 7 | 9 | 9 | S |
| A00286-3Y | National | 2 | 3 | 4 | 7 | MS |
| A00286-3Y | National | 2 | 3 | 6 | 8 | S |
| A00286-3Y | National | 2 | 5 | 7 | 9 | S |
| A00324-1 | National | 3 | 4 | 6 | 7 | MS |
| A00324-1 | National | 2 | 4 | 6 | 7 | MS |
| A00324-1 | National | 2 | 3 | 5 | 7 | MS |
| A96814-65LB | National | 2 | 3 | 5 | 5 | MR |
| A96814-65LB | National | 2 | 3 | 4 | 6 | MS |
| A96814-65LB | National | 2 | 3 | 5 | 7 | MS |
| A97066-42LB | National | 1 | 2 | 3 | 4 | MR |
| A97066-42LB | National | 2 | 3 | 4 | 6 | MS |
| A97066-42LB | National | 2 | 4 | 5 | 6 | MS |
| A98345-1 | National | 2 | 4 | 7 | 7 | MS |
| A98345-1 | National | 2 | 4 | 7 | 8 | S |
| A98345-1 | National | 2 | 5 | 7 | 8 | S |
| A99331-2RY | National | 1 | 3 | 6 | 9 | S |
| A99331-2RY | National | 2 | 3 | 7 | 9 | S |
| A99331-2RY | National | 2 | 4 | 7 | 9 | S |
| AC99375-1RU | National | 2 | 4 | 5 | 6 | MS |
| AC99375-1RU | National | 2 | 3 | 4 | 6 | MS |
| AC99375-1RU | National | 2 | 3 | 6 | 6 | MS |
| AF2376-5 | National | 2 | 2 | 6 | 6 | MS |
| AF2376-5 | National | 2 | 3 | 5 | 7 | MS |
| AF2376-5 | National | 2 | 3 | 6 | 7 | MS |
| AF2574-1 | National | 2 | 5 | 5 | 6 | MS |
| AF2574-1 | National | 2 | 3 | 6 | 6 | MS |
| AF2574-1 | National | 3 | 3 | 6 | 7 | MS |
| AF3317-15 | National | 2 | 2 | 3 | 4 | MR |
| AF3317-15 | National | 2 | 3 | 6 | 6 | MS |
| AF3317-15 | National | 2 | 4 | 6 | 6 | MS |
| AF4121-3 | National | 2 | 3 | 4 | 4 | MR |
| AF4121-3 | National | 2 | 2 | 3 | 5 | MR |

| | | | | | | |
|---|---|---|---|---|---|---|
| AF4121-3 | National | 2 | 3 | 4 | 5 | MR |
| Alpine Russet (A9305-10) | National | 2 | 6 | 8 | 9 | S |
| Alpine Russet (A9305-10) | National | 2 | 6 | 8 | 9 | S |
| Alpine Russet (A9305-10) | National | 2 | 6 | 8 | 9 | S |
| AO96141-3 | National | 3 | 6 | 8 | 9 | S |
| AO96141-3 | National | 3 | 7 | 7 | 9 | S |
| AO96141-3 | National | 2 | 5 | 7 | 9 | S |
| AO96305-3 | National | 2 | 6 | 8 | 9 | S |
| AO96305-3 | National | 2 | 5 | 8 | 9 | S |
| AO96305-3 | National | 2 | 4 | 7 | 9 | S |
| AO96365-2 | National | 3 | 5 | 7 | 9 | S |
| AO96365-2 | National | 2 | 6 | 8 | 9 | S |
| AO96365-2 | National | 2 | 6 | 8 | 9 | S |
| AOMN 03178-2 | UM-Thill | 2 | 7 | 8 | 9 | S |
| AOMN 03178-2 | UM-Thill | 3 | 6 | 8 | 9 | S |
| AOMN 041101-01 | UM-Thill | 2 | 3 | 7 | 8 | S |
| AOMN 041101-01 | UM-Thill | 2 | 4 | 6 | 9 | S |
| AOMN 06077-01 | UM-Thill | 4 | 7 | 9 | 9 | S |
| AOMN 06077-01 | UM-Thill | 3 | 6 | 8 | 9 | S |
| AOMN 06077-03 | UM-Thill | 3 | 7 | 9 | 9 | S |
| AOMN 06077-03 | UM-Thill | 4 | 7 | 9 | 9 | S |
| AOMN 06107-01 | UM-Thill | 3 | 7 | 9 | 9 | S |
| AOMN 06107-01 | UM-Thill | 3 | 6 | 9 | 9 | S |
| AOMN 06118-01 | UM-Thill | 2 | 4 | 7 | 9 | S |
| AOMN 06118-01 | UM-Thill | 2 | 6 | 7 | 9 | S |
| AOMN 06126-02 | UM-Thill | 3 | 4 | 8 | 9 | S |
| AOMN 06126-02 | UM-Thill | 2 | 7 | 9 | 9 | S |
| AOMN 06131-01 | UM-Thill | 3 | 5 | 9 | 9 | S |
| AOMN 06131-01 | UM-Thill | 2 | 7 | 9 | 9 | S |
| AOMN 06147-05 | UM-Thill | 2 | 5 | 7 | 8 | S |
| AOMN 06147-05 | UM-Thill | 2 | 4 | 8 | 9 | S |
| AOMN 06150-02 | UM-Thill | 3 | 8 | 9 | 9 | S |
| AOMN 06150-02 | UM-Thill | 3 | 7 | 9 | 9 | S |
| AOMN 06153-01 S.D. | UM-Thill | 4 | 9 | 9 | 9 | S |
| AOMN 06153-01 S.D. | UM-Thill | 3 | 9 | 9 | 9 | S |
| AOMN 06156-02 | UM-Thill | 3 | 6 | 9 | 9 | S |
| AOMN 06156-02 | UM-Thill | 2 | 6 | 8 | 9 | S |
| AOMN 06162-02 | UM-Thill | 4 | 5 | 8 | 9 | S |
| AOMN 06162-02 | UM-Thill | 2 | 6 | 8 | 9 | S |

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|---|---|---|---|---|---|---|
| AOMN 06174-01 S.D. | UM-Thill | 2 | 3 | 5 | 9 | S |
| AOMN 06174-01 S.D. | UM-Thill | 2 | 4 | 7 | 9 | S |
| Atlantic (All Red) | UM-Thill | 4 | 8 | 8 | 9 | S |
| Atlantic (All Red) | UM-Thill | 2 | 6 | 8 | 9 | S |
| ATMN 03505-3 | UM-Thill | 2 | 7 | 9 | 9 | S |
| ATMN 03505-3 | UM-Thill | 2 | 8 | 9 | 9 | S |
| ATND98459-1RY | NCR | 3 | 6 | 8 | 9 | S |
| ATND98459-1RY | NCR | 3 | 6 | 8 | 9 | S |
| AWN86514-2 | National | 2 | 2 | 3 | 3 | MR |
| AWN86514-2 | National | 2 | 3 | 3 | 3 | MR |
| AWN86514-2 | National | 1 | 2 | 3 | 4 | MR |
| B0692-4 | National | 2 | 3 | 3 | 4 | MR |
| B0692-4 | National | 2 | 3 | 3 | 5 | MR |
| B0692-4 | National | 2 | 3 | 3 | 5 | MR |
| B0718-3 | National | 2 | 2 | 3 | 3 | MR |
| B0718-3 | National | 2 | 2 | 2 | 4 | MR |
| B0718-3 | National | 2 | 2 | 3 | 4 | MR |
| B2152-17 | National | 2 | 9 | 9 | 9 | S |
| B2152-17 | National | 2 | 8 | 9 | 9 | S |
| B2152-17 | National | 3 | 8 | 9 | 9 | S |
| B2423-65 | National | 2 | 3 | 4 | 5 | MR |
| B2423-65 | National | 2 | 3 | 4 | 5 | MR |
| B2423-65 | National | 2 | 3 | 5 | 7 | MS |
| B2431-23 | National | 2 | 2 | 2 | 5 | MR |
| B2431-23 | National | 2 | 3 | 3 | 6 | MS |
| B2431-23 | National | 2 | 3 | 6 | 7 | MS |
| B2492-7 | National | 3 | 6 | 9 | 9 | S |
| B2492-7 | National | 3 | 8 | 9 | 9 | S |
| B2492-7 | National | 4 | 7 | 9 | 9 | S |
| B2501-10 | National | 3 | 7 | 9 | 9 | S |
| B2501-10 | National | 4 | 8 | 9 | 9 | S |
| B2501-10 | National | 3 | 8 | 9 | 9 | S |
| B2634-3 | National | 3 | 8 | 9 | 9 | S |
| B2634-3 | National | 3 | 9 | 9 | 9 | S |
| B2634-3 | National | 3 | 7 | 9 | 9 | S |
| BNC182-5 | National | 3 | 6 | 8 | 9 | S |
| BNC182-5 | National | 3 | 5 | 8 | 9 | S |
| BNC182-5 | National | 3 | 5 | 7 | 9 | S |
| BNC49-1 | National | 2 | 5 | 8 | 9 | S |

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|---|---|---|---|---|---|---|
| BNC49-1 | National | 2 | 6 | 8 | 9 | S |
| BNC49-1 | National | 2 | 6 | 8 | 9 | S |
| Classic Russet (A95109-1) | National | 2 | 5 | 8 | 9 | S |
| Classic Russet (A95109-1) | National | 2 | 5 | 8 | 9 | S |
| Classic Russet (A95109-1) | National | 3 | 6 | 8 | 9 | S |
| Clearwater Russet (AOA95154-1) | National | 2 | 4 | 6 | 8 | S |
| Clearwater Russet (AOA95154-1) | National | 2 | 4 | 7 | 9 | S |
| Clearwater Russet (AOA95154-1) | National | 2 | 4 | 7 | 9 | S |
| CO98012-5R | National | 3 | 6 | 9 | 9 | S |
| CO98012-5R | National | 2 | 6 | 8 | 9 | S |
| CO98012-5R | National | 2 | 6 | 8 | 9 | S |
| CO98067-7RU | National | 4 | 6 | 9 | 9 | S |
| CO98067-7RU | National | 3 | 7 | 9 | 9 | S |
| CO98067-7RU | National | 3 | 6 | 8 | 9 | S |
| CO98368-2RU | National | 3 | 8 | 9 | 9 | S |
| CO98368-2RU | National | 3 | 9 | 9 | 9 | S |
| CO98368-2RU | National | 3 | 8 | 9 | 9 | S |
| CO99053-3RU | National | 2 | 3 | 6 | 7 | MS |
| CO99053-3RU | National | 2 | 4 | 7 | 8 | S |
| CO99053-3RU | National | 2 | 5 | 7 | 8 | S |
| CO99053-4RU | National | 4 | 7 | 8 | 9 | S |
| CO99053-4RU | National | 2 | 7 | 8 | 9 | S |
| CO99053-4RU | National | 4 | 7 | 9 | 9 | S |
| CO99100-1RU | National | 4 | 8 | 9 | 9 | S |
| CO99100-1RU | National | 3 | 8 | 8 | 9 | S |
| CO99100-1RU | National | 5 | 8 | 9 | 9 | S |
| COMN 03021-1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| COMN 03021-1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 03024-6 | UM-Thill | 3 | 9 | 9 | 9 | S |
| COMN 03024-6 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 03027-1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 03027-1 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN 04674-02 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN 04674-02 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN 04692-10 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 04692-10 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 04697-02 | UM-Thill | 4 | 9 | 9 | 9 | S |
| COMN 04697-02 | UM-Thill | 5 | 9 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| COMN 04702-03 | UM-Thill | 3 | 7 | 9 | 9 | S |
| COMN 04702-03 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN 06332-01 | UM-Thill | 2 | 4 | 8 | 9 | S |
| COMN 06332-01 | UM-Thill | 2 | 6 | 7 | 9 | S |
| COMN 06344-03 | UM-Thill | 2 | 6 | 8 | 9 | S |
| COMN 06344-03 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN 06353-04 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN 06353-04 | UM-Thill | 2 | 6 | 8 | 9 | S |
| COMN 06358-02 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN 06358-02 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN 06360-01 | UM-Thill | 5 | 8 | 9 | 9 | S |
| COMN 06360-01 | UM-Thill | 3 | 7 | 8 | 9 | S |
| COMN 06363-01 | UM-Thill | 2 | 3 | 8 | 9 | S |
| COMN 06363-01 | UM-Thill | 2 | 7 | 8 | 9 | S |
| COMN 06379-02 | UM-Thill | 3 | 4 | 8 | 9 | S |
| COMN 06379-02 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 06392-01 | UM-Thill | 2 | 4 | 6 | 8 | S |
| COMN 06392-01 | UM-Thill | 3 | 4 | 7 | 9 | S |
| COMN 06393-01 | UM-Thill | 3 | 5 | 9 | 9 | S |
| COMN 06393-01 | UM-Thill | 2 | 6 | 9 | 9 | S |
| COMN 06433-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 06433-01 | UM-Thill | 2 | 7 | 8 | 9 | S |
| COMN 06438-02 | UM-Thill | 4 | 9 | 9 | 9 | S |
| COMN 06438-02 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN 06471-02 | UM-Thill | 2 | 4 | 5 | 8 | S |
| COMN 06471-02 | UM-Thill | 2 | 4 | 5 | 8 | S |
| COMN07-B001BG1 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN07-B004BG1 | UM-Thill | 3 | 9 | 9 | 9 | S |
| COMN07-B018BG1 | UM-Thill | 6 | 9 | 9 | 9 | S |
| COMN07-B023BG1 | UM-Thill | 4 | 6 | 8 | 9 | S |
| COMN07-B025BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| COMN07-B028BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B035BG1 | UM-Thill | 2 | 6 | 8 | 9 | S |
| COMN07-B041BG1 | UM-Thill | 3 | 5 | 7 | 9 | S |
| COMN07-B047BG1 | UM-Thill | 4 | 9 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| COMN07-B050BG1 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN07-B051BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B052BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| COMN07-B061BG1 | UM-Thill | 3 | 7 | 8 | 9 | S |
| COMN07-B062BG1 | UM-Thill | 2 | 6 | 8 | 9 | S |
| COMN07-B063BG1 | UM-Thill | 2 | 2 | 3 | 7 | MS |
| COMN07-B071BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| COMN07-B083BG1 | UM-Thill | 2 | 5 | 9 | 9 | S |
| COMN07-B087BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| COMN07-B089BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B095BG1 | UM-Thill | 5 | 8 | 9 | 9 | S |
| COMN07-B117BG1 | UM-Thill | 2 | 3 | 8 | 9 | S |
| COMN07-B120BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN07-B128WG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| COMN07-B132BG1 | UM-Thill | 2 | 4 | 8 | 9 | S |
| COMN07-B134BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| COMN07-B139BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN07-B141BG1 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN07-B142BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B143BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| COMN07-B144BG1 | UM-Thill | 2 | 7 | 8 | 9 | S |
| COMN07-B149BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| COMN07-B151BG1 | UM-Thill | 5 | 9 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| COMN07-B153BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B182BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| COMN07-B182WG1 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN07-B196BG1 | UM-Thill | 2 | 3 | 6 | 9 | S |
| COMN07-B198BG1 | UM-Thill | 4 | 7 | 8 | 9 | S |
| COMN07-B210BG1 | UM-Thill | 2 | 7 | 8 | 9 | S |
| COMN07-B211BG1 | UM-Thill | 4 | 7 | 9 | 9 | S |
| COMN07-B212BG1 | UM-Thill | 3 | 4 | 7 | 9 | S |
| COMN07-B214BG1 | UM-Thill | 2 | 3 | 6 | 7 | MS |
| COMN07-B216BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-B217BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN07-B218BG1 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN07-B225BG1 | UM-Thill | 2 | 5 | 9 | 9 | S |
| COMN07-B229BG1 | UM-Thill | 2 | 7 | 8 | 9 | S |
| COMN07-B229WG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| COMN07-B241BG1 | UM-Thill | 2 | 8 | 9 | 9 | S |
| COMN07-B248BG1 | UM-Thill | 2 | 3 | 6 | 8 | S |
| COMN07-GF170WG1 | UM-Thill | 2 | 3 | 7 | 8 | S |
| COMN07-GF173BG1 | UM-Thill | 3 | 5 | 9 | 9 | S |
| COMN07-GF176BG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| COMN07-GF179BG1 | UM-Thill | 2 | 4 | 7 | 9 | S |
| COMN07-GF180WG1 | UM-Thill | 2 | 5 | 7 | 9 | S |
| COMN07-GF188BG1 | UM-Thill | 2 | 6 | 8 | 9 | S |

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|---|---|---|---|---|---|---|
| COMN07-GF193BG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| COMN07-GF198BG1 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN07-GF203BG1 | UM-Thill | 3 | 9 | 9 | 9 | S |
| COMN07-GF205BG1 | UM-Thill | 5 | 8 | 9 | 9 | S |
| COMN07-GF206BG1 | UM-Thill | 2 | 3 | 6 | 8 | S |
| COMN07-GF216BG1 | UM-Thill | 5 | 9 | 9 | 9 | S |
| COMN07-GF241BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-GF271BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-GF286BG1 | UM-Thill | 1 | 3 | 8 | 9 | S |
| COMN07-GF298BG1 | UM-Thill | 3 | 7 | 8 | 9 | S |
| COMN07-GF299BG1 | UM-Thill | 2 | 5 | 8 | 9 | S |
| COMN07-GF299WG1 | UM-Thill | 2 | 6 | 8 | 9 | S |
| COMN07-GF307BG1 | UM-Thill | 3 | 5 | 9 | 9 | S |
| COMN07-GF307WG1 | UM-Thill | 4 | 9 | 9 | 9 | S |
| COMN07-GF310BG1 | UM-Thill | 3 | 9 | 9 | 9 | S |
| COMN07-GF315BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-W034WG1 | UM-Thill | 3 | 6 | 8 | 9 | S |
| COMN07-W048BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| COMN07-W067BG1 | UM-Thill | 3 | 4 | 8 | 9 | S |
| COMN07-W073BG1 | UM-Thill | 2 | 3 | 5 | 8 | S |
| COMN07-W080BG1 | UM-Thill | 2 | 9 | 9 | 9 | S |
| COMN07-W090BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| COMN07-W109BG1 | UM-Thill | 4 | 9 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| COMN07-W112BG1 | UM-Thill | 3 | 6 | 8 | 9 | S |
| COMN07-W199BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| COMN07-W201BG1 | UM-Thill | 3 | 6 | 8 | 9 | S |
| COMN07-W203BG1 | UM-Thill | 3 | 5 | 7 | 9 | S |
| Dk. Red Norland | UM-Thill | 3 | 8 | 9 | 9 | S |
| Dk. Red Norland | UM-Thill | 2 | 7 | 9 | 9 | S |
| LBR1R2R3R4 | National | 2 | 3 | 5 | 7 | MS |
| LBR1R2R3R4 | National | 2 | 3 | 6 | 8 | S |
| LBR1R2R3R4 | National | 2 | 3 | 6 | 8 | S |
| LBR5 | National | 3 | 3 | 6 | 8 | S |
| LBR5 | National | 2 | 7 | 8 | 9 | S |
| LBR5 | National | 2 | 6 | 7 | 9 | S |
| LBR7 | National | 1 | 1 | 6 | 8 | S |
| LBR7 | National | 2 | 3 | 7 | 8 | S |
| LBR7 | National | 2 | 3 | 6 | 8 | S |
| LBR9 | National | 5 | 8 | 9 | 9 | S |
| LBR9 | National | 3 | 6 | 8 | 9 | S |
| LBR9 | National | 3 | 7 | 9 | 9 | S |
| Missaukee (MSJ461-1) | NCR | 2 | 3 | 4 | 6 | MS |
| Missaukee (MSJ461-1) | NCR | 2 | 3 | 5 | 7 | MS |
| MN 00467-4 | UM-Thill | 3 | 7 | 9 | 9 | S |
| MN 02 419 | UM-Thill | 3 | 5 | 7 | 9 | S |
| MN 02 467 | NCR | 2 | 3 | 4 | 7 | MS |
| MN 02 467 | NCR | 2 | 3 | 5 | 7 | MS |
| MN 02 574 | UM-Thill | 2 | 5 | 7 | 9 | S |
| MN 02 582 | UM-Thill | 2 | 6 | 9 | 9 | S |
| MN 02 586 | UM-Thill | 2 | 6 | 9 | 9 | S |
| MN 02 588 | UM-Thill | 3 | 6 | 8 | 9 | S |
| MN 02 598 | UM-Thill | 3 | 7 | 9 | 9 | S |
| MN 02 616 | NCR | 3 | 8 | 9 | 9 | S |
| MN 02 616 | NCR | 3 | 8 | 9 | 9 | S |
| MN 02 696 | UM-Thill | 3 | 9 | 9 | 9 | S |
| MN 05001-033 | UM-Thill | 2 | 6 | 9 | 9 | S |
| MN 05001-033 | UM-Thill | 3 | 7 | 9 | 9 | S |
| MN 05001-074 | UM-Thill | 2 | 3 | 7 | 8 | S |
| MN 05001-074 | UM-Thill | 2 | 4 | 4 | 9 | S |
| MN 05001-124 | UM-Thill | 2 | 4 | 6 | 9 | S |
| MN 05001-124 | UM-Thill | 2 | 3 | 6 | 9 | S |

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|---|---|---|---|---|---|---|
| MN 061788-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| MN 061788-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| MN 15620 | UM-Thill | 2 | 6 | 9 | 9 | S |
| MN 18747 | UM-Thill | 3 | 8 | 9 | 9 | S |
| MN 19298 | NCR | 2 | 7 | 9 | 9 | S |
| MN 19298 | NCR | 2 | 6 | 9 | 9 | S |
| MN 96013-1 | NCR | 2 | 5 | 8 | 9 | S |
| MN 96013-1 | NCR | 2 | 7 | 9 | 9 | S |
| MN 96072-4 | UM-Thill | 5 | 9 | 9 | 9 | S |
| MN 99380-1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| MN 99460-14 | UM-Thill | 3 | 8 | 9 | 9 | S |
| MSL268-D | National | 3 | 5 | 7 | 8 | S |
| MSL268-D | National | 2 | 4 | 6 | 8 | S |
| MSL268-D | National | 3 | 4 | 6 | 8 | S |
| MSL268-D | NCR | 2 | 4 | 5 | 8 | S |
| MSL268-D | NCR | 2 | 3 | 6 | 8 | S |
| MSM171-A | National | 4 | 6 | 8 | 9 | S |
| MSM171-A | National | 3 | 7 | 9 | 9 | S |
| MSM171-A | National | 2 | 6 | 7 | 9 | S |
| MSM171-A | NCR | 2 | 5 | 6 | 8 | S |
| MSM171-A | NCR | 3 | 6 | 6 | 9 | S |
| MSM182-1 | National | 2 | 5 | 6 | 6 | MS |
| MSM182-1 | National | 2 | 4 | 6 | 6 | MS |
| MSM182-1 | National | 2 | 3 | 6 | 7 | MS |
| MSN170-A | NCR | 3 | 6 | 7 | 9 | S |
| MSN170-A | NCR | 2 | 6 | 8 | 9 | S |
| MSQ070-1 | National | 2 | 3 | 3 | 5 | MR |
| MSQ070-1 | National | 2 | 3 | 5 | 5 | MR |
| MSQ070-1 | National | 2 | 3 | 5 | 5 | MR |
| MSQ176-5 | National | 1 | 2 | 2 | 5 | MR |
| MSQ176-5 | National | 2 | 4 | 5 | 6 | MS |
| MSQ176-5 | National | 2 | 3 | 3 | 7 | MS |
| ND028842-1RY | NCR | 4 | 8 | 9 | 9 | S |
| ND028842-1RY | NCR | 3 | 6 | 8 | 9 | S |
| ND8304-2 | NCR | 6 | 9 | 9 | 9 | S |
| ND8304-2 | NCR | 4 | 9 | 9 | 9 | S |
| ND8305-1 | NCR | 3 | 6 | 9 | 9 | S |
| ND8305-1 | NCR | 2 | 7 | 9 | 9 | S |
| NDMN 03324-4 | UM-Thill | 2 | 7 | 8 | 9 | S |
| NDMN 03324-4 | UM-Thill | 2 | 6 | 8 | 9 | S |
| NDMN 03376-1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| NDMN 03376-1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN 03382-2 | UM-Thill | 5 | 9 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| NDMN 03382-2 | UM-Thill | 2 | 8 | 9 | 9 | S |
| NDMN 04910-01 | UM-Thill | 3 | 6 | 9 | 9 | S |
| NDMN 04910-01 | UM-Thill | 3 | 6 | 9 | 9 | S |
| NDMN 04911-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN 04911-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN 04916-01 | UM-Thill | 3 | 7 | 8 | 9 | S |
| NDMN 04916-01 | UM-Thill | 2 | 3 | 8 | 9 | S |
| NDMN 04927-01 | UM-Thill | 2 | 3 | 6 | 8 | S |
| NDMN 04927-01 | UM-Thill | 2 | 5 | 8 | 8 | S |
| NDMN 04960-01 | UM-Thill | 4 | 8 | 9 | 9 | S |
| NDMN 04960-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN07-B167BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| NDMN07-B266BG1 | UM-Thill | 3 | 6 | 7 | 9 | S |
| NDMN07-B272BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| NDMN07-B277BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| NDMN07-B289BG1 | UM-Thill | 5 | 7 | 8 | 9 | S |
| NDMN07-B299BG1 | UM-Thill | 5 | 9 | 9 | 9 | S |
| NDMN07-B302BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| NDMN07-B303BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN07-B309BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| NDMN07-B311BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| NDMN07-B312BG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| NDMN07-B316WG1 | UM-Thill | 4 | 7 | 8 | 9 | S |
| NDMN07-B319BG1 | UM-Thill | 3 | 4 | 8 | 9 | S |
| NDMN07-B322BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| NDMN07-B324BG1 | UM-Thill | 2 | 6 | 8 | 9 | S |
| NDMN07-B326BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| NDMN07-B330BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |

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|---|---|---|---|---|---|---|
| NDMN07-GF040BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| NDMN07-GF056BG1 | UM-Thill | 5 | 8 | 9 | 9 | S |
| NDMN07-GF059WG1 | UM-Thill | 2 | 3 | 7 | 9 | S |
| NDMN07-GF066BG1 | UM-Thill | 4 | 9 | 9 | 9 | S |
| NDMN07-GF071BG1 | UM-Thill | 3 | 5 | 8 | 9 | S |
| NDMN07-GF080BG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| NDMN07-GF092BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| NDMN07-GF106BG1 | UM-Thill | 2 | 4 | 6 | 9 | S |
| NDMN07-GF136BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| NDMN07-GF150BG1 | UM-Thill | 4 | 9 | 9 | 9 | S |
| NDMN07-W146BG1 | UM-Thill | 4 | 7 | 9 | 9 | S |
| NDMN07-W151BG1 | UM-Thill | 2 | 7 | 9 | 9 | S |
| NDMN07-W152BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| NDMN07-W153BG1 | UM-Thill | 2 | 3 | 3 | 5 | MR |
| NDMN07-W159BG1 | UM-Thill | 4 | 6 | 8 | 9 | S |
| NDMN07-W160BG1 | UM-Thill | 3 | 6 | 7 | 9 | S |
| NDMN07-W161BG1 | UM-Thill | 2 | 8 | 9 | 9 | S |
| NDMN07-W162BG1 | UM-Thill | 3 | 7 | 8 | 9 | S |
| NDMN07-W162WG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| NDMN07-W173BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| NDMN07-W180WG1 | UM-Thill | 2 | 5 | 7 | 8 | S |
| NDMN07-W184WG1 | UM-Thill | 3 | 5 | 8 | 9 | S |
| NDMN07-W186WG1 | UM-Thill | 2 | 8 | 9 | 9 | S |

| | | | | | | |
|---|---|---|---|---|---|---|
| NDMN07-W187BG1 | UM-Thill | 4 | 7 | 9 | 9 | S |
| NorValley | UM-Thill | 3 | 8 | 9 | 9 | S |
| NorValley | UM-Thill | 2 | 7 | 8 | 9 | S |
| OR03029-2 | National | 2 | 3 | 3 | 5 | MR |
| OR03029-2 | National | 2 | 3 | 4 | 6 | MS |
| OR03029-2 | National | 3 | 3 | 6 | 7 | MS |
| ORMN07-B257BG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| ORMN07-B258BG1 | UM-Thill | 3 | 6 | 9 | 9 | S |
| ORMN07-B260WG1 | UM-Thill | 2 | 5 | 9 | 9 | S |
| ORMN07-GF008BG1 | UM-Thill | 4 | 8 | 9 | 9 | S |
| ORMN07-GF011BG1 | UM-Thill | 2 | 6 | 9 | 9 | S |
| ORMN07-GF014BG1 | UM-Thill | 3 | 7 | 9 | 9 | S |
| ORMN07-W125BG1 | UM-Thill | 2 | 4 | 8 | 9 | S |
| ORMN07-W125WG1 | UM-Thill | 3 | 8 | 9 | 9 | S |
| ORMN07-W127WG1 | UM-Thill | 3 | 7 | 8 | 9 | S |
| ORMN07-W128BG1 | UM-Thill | 2 | 7 | 8 | 9 | S |
| Owyhee (AO96160-3) | National | 3 | 5 | 8 | 9 | S |
| Owyhee (AO96160-3) | National | 2 | 5 | 8 | 9 | S |
| Owyhee (AO96160-3) | National | 3 | 5 | 8 | 9 | S |
| Patagonia | National | 2 | 3 | 4 | 5 | MR |
| Patagonia | National | 2 | 3 | 4 | 6 | MS |
| Patagonia | National | 2 | 3 | 4 | 6 | MS |
| R. Burbank | UM-Thill | 2 | 6 | 7 | 9 | S |
| R. Burbank | UM-Thill | 2 | 5 | 8 | 9 | S |
| R. Norkotah | UM-Thill | 5 | 8 | 9 | 9 | S |
| R. Norkotah | UM-Thill | 3 | 7 | 9 | 9 | S |
| RB FILLER | UM-Thill | 2 | 3 | 8 | 9 | S |
| Red Lasoda (RB FILLER) | UM-Thill | 2 | 3 | 7 | 9 | S |
| Red Lasoda (RB FILLER) | UM-Thill | 2 | 6 | 7 | 9 | S |

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| Red Norland | UM-Thill | 4 | 8 | 9 | 9 | S |
| Red Norland | UM-Thill | 3 | 8 | 9 | 9 | S |
| Sage (AO06164-1) | National | 4 | 6 | 8 | 9 | S |
| Sage (AO06164-1) | National | 2 | 4 | 8 | 9 | S |
| Sage (AO06164-1) | National | 2 | 5 | 7 | 9 | S |
| Shepody | UM-Thill | 2 | 7 | 8 | 9 | S |
| Shepody | UM-Thill | 2 | 6 | 8 | 9 | S |
| W2978-3 | NCR | 4 | 7 | 9 | 9 | S |
| W2978-3 | NCR | 3 | 7 | 9 | 9 | S |
| W5015-12 | NCR | 2 | 3 | 6 | 7 | MS |
| W5015-12 | NCR | 2 | 4 | 6 | 7 | MS |
| W5767-1R | NCR | 3 | 5 | 8 | 9 | S |
| W5767-1R | NCR | 2 | 5 | 8 | 9 | S |
| WIMN 04844-01 | UM-Thill | 2 | 6 | 7 | 9 | S |
| WIMN 04844-01 | UM-Thill | 2 | 5 | 9 | 9 | S |
| WIMN 04844-03 | UM-Thill | 3 | 6 | 8 | 8 | S |
| WIMN 04844-03 | UM-Thill | 2 | 6 | 8 | 9 | S |
| WIMN 04844-06 | UM-Thill | 2 | 5 | 9 | 9 | S |
| WIMN 04844-06 | UM-Thill | 3 | 7 | 9 | 9 | S |
| WIMN 04844-07 | UM-Thill | 4 | 9 | 9 | 9 | S |
| WIMN 04855-02 | UM-Thill | 3 | 4 | 8 | 9 | S |
| WIMN 04855-02 | UM-Thill | 2 | 5 | 8 | 9 | S |
| WIMN 06002-02 | UM-Thill | 2 | 6 | 9 | 9 | S |
| WIMN 06002-02 | UM-Thill | 3 | 7 | 9 | 9 | S |
| WIMN 06030-01 | UM-Thill | 4 | 9 | 9 | 9 | S |
| WIMN 06030-01 | UM-Thill | 4 | 9 | 9 | 9 | S |
| WIMN 06035-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| WIMN 06035-01 | UM-Thill | 3 | 8 | 9 | 9 | S |
| WIMN 06057-03 | UM-Thill | 3 | 7 | 8 | 9 | S |
| WV4992-1/Filler | NCR | 2 | 4 | 7 | 9 | S |
| WV4992-1/Filler | NCR | 2 | 4 | 7 | 9 | S |
| WV5843-6/Filler | NCR | 3 | 5 | 8 | 9 | S |
| WV5843-6/Filler | NCR | 2 | 4 | 7 | 9 | S |
| Y. Gold | UM-Thill | 3 | 8 | 9 | 9 | S |
| Y. Gold | UM-Thill | 4 | 8 | 9 | 9 | S |
| Yukon Gem (NDA5507-3Y) | National | 2 | 4 | 6 | 7 | MS |
| Yukon Gem (NDA5507-3Y) | National | 2 | 4 | 6 | 7 | MS |
| Yukon Gem (NDA5507-3Y) | National | 2 | 5 | 7 | 8 | S |

**(B) Common Scab: Disease severity and coverage scores for entries for 2009**

| Clone | Source | Severity Score | Coverage | Resistance Category |
|---|---|---|---|---|
| A0008-1TE | National Scab Trial | 1 | L | MR |
| A0008-1TE | National Scab Trial | 1 | T | MR |
| A0008-1TE | National Scab Trial | 1 | T | MR |
| A00286-3Y | National Scab Trial | 3 | M | MS |
| A00286-3Y | National Scab Trial | 4 | H | S |
| A00286-3Y | National Scab Trial | 5 | H | S |
| AC99375-1RU | National Scab Trial | 2 | T | MR |
| AC99375-1RU | National Scab Trial | 3 | T | MS |
| AC99375-1RU | National Scab Trial | 4 | H | S |
| AF2497-2 | National Scab Trial | 3 | H | MS |
| AF2497-2 | National Scab Trial | 4 | H | S |
| AF2497-2 | National Scab Trial | 5 | M | S |
| AF2936-2 | National Scab Trial | 4 | T | S |
| AF2936-2 | National Scab Trial | 5 | H | S |
| AF2936-2 | National Scab Trial | 5 | H | S |
| AF3000-1 | National Scab Trial | 2 | L | MR |
| AF3000-1 | National Scab Trial | 4 | H | S |
| AF3000-1 | National Scab Trial | 4 | M | S |
| AOMN 03178-2 | UM Potato Breeding | 3 | L | MS |
| AOMN 03178-2 | UM Potato Breeding | 4 | H | S |
| AOMN 041101-01 | UM Potato Breeding | 3 | L | MS |
| AOMN 041101-01 | UM Potato Breeding | 4 | H | S |
| AOMN 06077-01 | UM Potato Breeding | 4 | H | S |
| AOMN 06077-01 | UM Potato Breeding | 4 | L | S |
| AOMN 06077-03 | UM Potato Breeding | 4 | H | S |
| AOMN 06077-03 | UM Potato Breeding | 4 | M | S |
| AOMN 06107-01 | UM Potato Breeding | 2 | H | MR |
| AOMN 06107-01 | UM Potato Breeding | 2 | T | MR |
| AOMN 06118-01 | UM Potato Breeding | 1 | T | MR |
| AOMN 06118-01 | UM Potato Breeding | 2 | L | MR |
| AOMN 06126-02 | UM Potato Breeding | 5 | H | S |
| AOMN 06126-02 | UM Potato Breeding | 5 | H | S |
| AOMN 06131-01 | UM Potato Breeding | 5 | H | S |
| AOMN 06131-01 | UM Potato Breeding | 5 | L | S |
| AOMN 06147-05 | UM Potato Breeding | 3 | M | MS |
| AOMN 06147-05 | UM Potato Breeding | 4 | H | S |
| AOMN 06150-02 | UM Potato Breeding | 3 | L | MS |
| AOMN 06150-02 | UM Potato Breeding | 5 | L | S |

| | | | | |
|---|---|---|---|---|
| AOMN 06153-01 S.D. | UM Potato Breeding | 5 | H | S |
| AOMN 06153-01 S.D. | UM Potato Breeding | 5 | M | S |
| AOMN 06156-02 | UM Potato Breeding | 0 | 0 | R |
| AOMN 06156-02 | UM Potato Breeding | 3 | H | MS |
| AOMN 06162-02 | UM Potato Breeding | 1 | T | MR |
| AOMN 06162-02 | UM Potato Breeding | 2 | M | MR |
| AOMN 06174-01 S.D. | UM Potato Breeding | 4 | H | S |
| AOMN 06174-01 S.D. | UM Potato Breeding | 4 | T | S |
| Atlantic | National Scab Trial | 5 | H | S |
| Atlantic | National Scab Trial | 4 | H | S |
| Atlantic | National Scab Trial | 5 | H | S |
| ATMN 03505-3 | UM Potato Breeding | 3 | M | MS |
| ATMN 03505-3 | UM Potato Breeding | 4 | L | S |
| ATND98459-1RY | North Central Region | 4 | H | S |
| ATND98459-1RY | North Central Region | 4 | M | S |
| B1992-106 | National Scab Trial | 2 | L | MR |
| B1992-106 | National Scab Trial | 2 | T | MR |
| B1992-106 | National Scab Trial | 4 | L | S |
| BNC49-1 | National Scab Trial | 1 | T | MR |
| BNC49-1 | National Scab Trial | 4 | H | S |
| BNC49-1 | National Scab Trial | 5 | H | S |
| CO98012-5R | National Scab Trial | 5 | H | S |
| CO98012-5R | National Scab Trial | 5 | L | S |
| CO98012-5R | National Scab Trial | 5 | M | S |
| CO98067-7RU | National Scab Trial | 2 | T | MR |
| CO98067-7RU | National Scab Trial | 2 | T | MR |
| CO98067-7RU | National Scab Trial | 3 | L | MS |
| CO98368-2RU | National Scab Trial | 4 | H | S |
| CO98368-2RU | National Scab Trial | 4 | H | S |
| CO98368-2RU | National Scab Trial | 4 | M | S |
| COMN 03021-1 | UM Potato Breeding | 2 | T | MR |
| COMN 03021-1 | UM Potato Breeding | 4 | H | S |
| COMN 03024-6 | UM Potato Breeding | 2 | M | MR |
| COMN 03024-6 | UM Potato Breeding | 4 | L | S |
| COMN 03027-1 | UM Potato Breeding | 5 | H | S |
| COMN 03027-1 | UM Potato Breeding | 5 | H | S |
| COMN 04674-02 | UM Potato Breeding | 4 | H | S |
| COMN 04674-02 | UM Potato Breeding | 4 | H | S |
| COMN 04692-10 | UM Potato Breeding | 2 | L | MR |

| | | | | |
|---|---|---|---|---|
| COMN 04692-10 | UM Potato Breeding | 4 | M | S |
| COMN 04697-02 | UM Potato Breeding | 4 | H | S |
| COMN 04702-03 | UM Potato Breeding | 4 | H | S |
| COMN 04702-03 | UM Potato Breeding | 4 | H | S |
| COMN 06332-01 | UM Potato Breeding | 4 | H | S |
| COMN 06332-01 | UM Potato Breeding | 5 | M | S |
| COMN 06344-03 | UM Potato Breeding | 4 | H | S |
| COMN 06344-03 | UM Potato Breeding | 5 | H | S |
| COMN 06353-04 | UM Potato Breeding | 5 | H | S |
| COMN 06353-04 | UM Potato Breeding | 5 | H | S |
| COMN 06358-02 | UM Potato Breeding | 2 | L | MR |
| COMN 06358-02 | UM Potato Breeding | 2 | L | MR |
| COMN 06360-01 | UM Potato Breeding | 3 | H | MS |
| COMN 06360-01 | UM Potato Breeding | 5 | H | S |
| COMN 06363-01 | UM Potato Breeding | 2 | L | MR |
| COMN 06363-01 | UM Potato Breeding | 3 | L | MS |
| COMN 06379-02 | UM Potato Breeding | 3 | M | MS |
| COMN 06379-02 | UM Potato Breeding | 4 | H | S |
| COMN 06392-01 | UM Potato Breeding | 3 | H | MS |
| COMN 06392-01 | UM Potato Breeding | 4 | M | S |
| COMN 06393-01 | UM Potato Breeding | 3 | H | MS |
| COMN 06393-01 | UM Potato Breeding | 4 | H | S |
| COMN 06433-01 | UM Potato Breeding | 2 | L | MR |
| COMN 06433-01 | UM Potato Breeding | 5 | H | S |
| COMN 06438-02 | UM Potato Breeding | 5 | H | S |
| COMN 06438-02 | UM Potato Breeding | 5 | M | S |
| COMN 06471-02 | UM Potato Breeding | 3 | M | MS |
| COMN 06471-02 | UM Potato Breeding | 5 | H | S |
| COMN07-B021WG1 | UM Potato Breeding | 4 | H | S |
| COMN07-B023BG1 | UM Potato Breeding | 3 | H | MS |
| COMN07-B025BG1 | UM Potato Breeding | 3 | M | MS |
| COMN07-B028BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B035BG1 | UM Potato Breeding | 4 | T | S |
| COMN07-B041BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B047BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B050BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B051BG1 | UM Potato Breeding | 3 | L | MS |
| COMN07-B052BG1 | UM Potato Breeding | 2 | L | MR |
| COMN07-B061BG1 | UM Potato Breeding | 2 | H | MR |
| COMN07-B062BG1 | UM Potato Breeding | 1 | L | MR |
| COMN07-B063BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B071BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B083BG1 | UM Potato Breeding | 4 | L | S |

|  |  |  |  |  |
|---|---|---|---|---|
| COMN07-B084BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B087BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B095BG1 | UM Potato Breeding | 3 | H | MS |
| COMN07-B117BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B123WG1 | UM Potato Breeding | 1 | L | MR |
| COMN07-B128WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B132BG1 | UM Potato Breeding | 2 | L | MR |
| COMN07-B134BG1 | UM Potato Breeding | 5 | M | S |
| COMN07-B141BG1 | UM Potato Breeding | 5 | L | S |
| COMN07-B142BG1 | UM Potato Breeding | 4 | H | S |
| COMN07-B143BG1 | UM Potato Breeding | 4 | T | S |
| COMN07-B144BG1 | UM Potato Breeding | 1 | T | MR |
| COMN07-B149BG1 | UM Potato Breeding | 3 | T | MS |
| COMN07-B151BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B153BG1 | UM Potato Breeding | 5 | L | S |
| COMN07-B182BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B182WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B183WG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B186WG1 | UM Potato Breeding | 5 | M | S |
| COMN07-B196BG1 | UM Potato Breeding | 5 | L | S |
| COMN07-B198BG1 | UM Potato Breeding | 5 | M | S |
| COMN07-B211WG1 | UM Potato Breeding | 4 | H | S |
| COMN07-B212BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B214BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B216BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B217BG1 | UM Potato Breeding | 5 | L | S |
| COMN07-B218BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-B228WG1 | UM Potato Breeding | 5 | M | S |
| COMN07-B229BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-B229WG1 | UM Potato Breeding | 3 | L | MS |
| COMN07-B248WG1 | UM Potato Breeding | 4 | H | S |
| COMN07-GF169WG1 | UM Potato Breeding | 2 | L | MR |
| COMN07-GF170WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-GF173BG1 | UM Potato Breeding | 4 | H | S |
| COMN07-GF174WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-GF176BG1 | UM Potato Breeding | 4 | H | S |
| COMN07-GF179BG1 | UM Potato Breeding | 3 | L | MS |
| COMN07-GF180WG1 | UM Potato Breeding | 4 | L | S |
| COMN07-GF188BG1 | UM Potato Breeding | 5 | H | S |

|  |  |  |  |  |
|---|---|---|---|---|
| COMN07-GF193BG1 | UM Potato Breeding | 4 | T | S |
| COMN07-GF198BG1 | UM Potato Breeding | 4 | L | S |
| COMN07-GF203BG1 | UM Potato Breeding | 2 | L | MR |
| COMN07-GF205BG1 | UM Potato Breeding | 5 | T | S |
| COMN07-GF206BG1 | UM Potato Breeding | 2 | L | MR |
| COMN07-GF216BG1 | UM Potato Breeding | 4 | L | S |
| COMN07-GF222WG1 | UM Potato Breeding | 3 | M | MS |
| COMN07-GF271BG1 | UM Potato Breeding | 3 | H | MS |
| COMN07-GF286BG1 | UM Potato Breeding | 5 | L | S |
| COMN07-GF299BG1 | UM Potato Breeding | 5 | M | S |
| COMN07-GF299WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-GF307BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-GF307WG1 | UM Potato Breeding | 5 | M | S |
| COMN07-GF310BG1 | UM Potato Breeding | 3 | H | MS |
| COMN07-W034WG1 | UM Potato Breeding | 3 | L | MS |
| COMN07-W048BG1 | UM Potato Breeding | 5 | M | S |
| COMN07-W065WG1 | UM Potato Breeding | 5 | L | S |
| COMN07-W067BG1 | UM Potato Breeding | 1 | T | MR |
| COMN07-W073BG1 | UM Potato Breeding | 4 | M | S |
| COMN07-W080BG1 | UM Potato Breeding | 3 | M | MS |
| COMN07-W082WG1 | UM Potato Breeding | 5 | H | S |
| COMN07-W109BG1 | UM Potato Breeding | 5 | M | S |
| COMN07-W112BG1 | UM Potato Breeding | 5 | H | S |
| COMN07-W203BG1 | UM Potato Breeding | 4 | L | S |
| CV01238-3 | North Central Region | 4 | H | S |
| CV01238-3 | North Central Region | 4 | H | S |
| CV99073-1 | North Central Region | 4 | H | S |
| CV99073-1 | North Central Region | 5 | M | S |
| Dk. red Norland | UM Potato Breeding | 3 | L | MS |
| Dk. red Norland | UM Potato Breeding | 4 | M | S |
| Missaukee (MSJ461-1) | North Central Region | 4 | H | S |
| Missaukee (MSJ461-1) | North Central Region | 5 | L | S |
| MN 00467-4 | UM Potato Breeding | 2 | M | MR |
| MN 00467-4 | UM Potato Breeding | 3 | L | MS |
| MN 02 419 | UM Potato Breeding | 4 | H | S |
| MN 02 419 | UM Potato Breeding | 5 | H | S |
| MN 02 467 | North Central Region | 1 | T | MR |
| MN 02 467 | North Central Region | 5 | H | S |
| MN 02 574 | UM Potato Breeding | 5 | H | S |

| | | | | |
|---|---|---|---|---|
| MN 02 574 | UM Potato Breeding | 5 | L | S |
| MN 02 582 | UM Potato Breeding | 4 | H | S |
| MN 02 582 | UM Potato Breeding | 5 | H | S |
| MN 02 586 | UM Potato Breeding | 4 | H | S |
| MN 02 586 | UM Potato Breeding | 5 | H | S |
| MN 02 588 | UM Potato Breeding | 3 | L | MS |
| MN 02 588 | UM Potato Breeding | 5 | H | S |
| MN 02 598 | UM Potato Breeding | 5 | H | S |
| MN 02 598 | UM Potato Breeding | 5 | M | S |
| MN 02 616 | North Central Region | 3 | T | MS |
| MN 02 616 | North Central Region | 5 | L | S |
| MN 05001-016 | UM Potato Breeding | 3 | L | MS |
| MN 05001-016 | UM Potato Breeding | 5 | L | S |
| MN 05001-033 | UM Potato Breeding | 5 | H | S |
| MN 05001-033 | UM Potato Breeding | 5 | H | S |
| MN 05001-074 | UM Potato Breeding | 5 | H | S |
| MN 05001-074 | UM Potato Breeding | 5 | M | S |
| MN 05001-124 | UM Potato Breeding | 4 | H | S |
| MN 061788-01 | UM Potato Breeding | 5 | H | S |
| MN 061788-01 | UM Potato Breeding | 5 | M | S |
| MN 061910-03 | UM Potato Breeding | 3 | T | MS |
| MN 061910-03 | UM Potato Breeding | 4 | H | S |
| MN 15620 | UM Potato Breeding | 5 | H | S |
| MN 15620 | UM Potato Breeding | 5 | H | S |
| MN 18747 | UM Potato Breeding | 5 | H | S |
| MN 18747 | UM Potato Breeding | 5 | T | S |
| MN 19298 | North Central Region | 4 | H | S |
| MN 19298 | North Central Region | 4 | H | S |
| MN 96013-1 | North Central Region | 4 | M | S |
| MN 96013-1 | North Central Region | 5 | M | S |
| MN 96072-4 | UM Potato Breeding | 1 | T | MR |
| MN 96072-4 | UM Potato Breeding | 4 | L | S |
| MN 99380-1 | UM Potato Breeding | 3 | L | MS |
| MN 99380-1 | UM Potato Breeding | 5 | L | S |
| MN 99460-14 | UM Potato Breeding | 4 | M | S |
| MN 99460-14 | UM Potato Breeding | 5 | H | S |
| MSH228-6 | National Scab Trial | 3 | H | MS |
| MSH228-6 | National Scab Trial | 3 | L | MS |
| MSH228-6 | National Scab Trial | 3 | L | MS |
| MSJ126-9Y | National Scab Trial | 2 | T | MR |
| MSJ126-9Y | National Scab Trial | 4 | L | S |
| MSJ126-9Y | National Scab Trial | 4 | M | S |
| MSL268-D | North Central Region | 3 | H | MS |

| | | | | |
|---|---|---|---|---|
| MSL268-D | North Central Region | 4 | M | S |
| MSM171-A | North Central Region | 4 | H | S |
| MSM171-A | North Central Region | 5 | H | S |
| MSN170-A | National Scab Trial | 3 | H | MS |
| MSN170-A | North Central Region | 3 | L | MS |
| MSN170-A | National Scab Trial | 4 | H | S |
| MSN170-A | North Central Region | 4 | M | S |
| MSN170-A | National Scab Trial | 4 | M | S |
| MSQ070-1 | National Scab Trial | 3 | H | MS |
| MSQ070-1 | National Scab Trial | 4 | H | S |
| MSQ070-1 | National Scab Trial | 4 | H | S |
| ND028842-1RY | North Central Region | 5 | H | S |
| ND028842-1RY | North Central Region | 5 | L | S |
| ND8304-2 | North Central Region | 5 | M | S |
| ND8304-2 | North Central Region | 5 | M | S |
| ND8305-1 | North Central Region | 5 | H | S |
| ND8305-1 | North Central Region | 5 | H | S |
| NDA7985-1R | National Scab Trial | 2 | L | MR |
| NDA7985-1R | National Scab Trial | 3 | M | MS |
| NDA7985-1R | National Scab Trial | 3 | T | MS |
| NDMN 03324-4 | UM Potato Breeding | 2 | L | MR |
| NDMN 03324-4 | UM Potato Breeding | 4 | L | S |
| NDMN 03376-1 | UM Potato Breeding | 4 | H | S |
| NDMN 03376-1 | UM Potato Breeding | 4 | L | S |
| NDMN 03382-2 | UM Potato Breeding | 1 | L | MR |
| NDMN 03382-2 | UM Potato Breeding | 4 | M | S |
| NDMN 04910-01 | UM Potato Breeding | 4 | H | S |
| NDMN 04910-01 | UM Potato Breeding | 4 | H | S |
| NDMN 04911-01 | UM Potato Breeding | 3 | L | MS |
| NDMN 04911-01 | UM Potato Breeding | 4 | H | S |
| NDMN 04916-01 | UM Potato Breeding | 3 | H | MS |
| NDMN 04916-01 | UM Potato Breeding | 4 | H | S |
| NDMN 04927-01 | UM Potato Breeding | 2 | L | MR |
| NDMN 04927-01 | UM Potato Breeding | 2 | M | MR |
| NDMN 04960-01 | UM Potato Breeding | 5 | H | S |
| NDMN 04960-01 | UM Potato Breeding | 5 | H | S |
| NDMN07-B167BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B277BG1 | UM Potato Breeding | 4 | L | S |
| NDMN07-B302BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-B303BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B309BG1 | UM Potato Breeding | 3 | M | MS |
| NDMN07-B311BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B312BG1 | UM Potato Breeding | 3 | M | MS |

| | | | | |
|---|---|---|---|---|
| NDMN07-B316WG1 | UM Potato Breeding | 2 | L | MR |
| NDMN07-B318WG1 | UM Potato Breeding | 5 | L | S |
| NDMN07-B319BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B322BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-B324BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B326BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-B330BG1 | UM Potato Breeding | 4 | H | S |
| NDMN07-GF056BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-GF056WG1 | UM Potato Breeding | 4 | T | S |
| NDMN07-GF059WG1 | UM Potato Breeding | 2 | M | MR |
| NDMN07-GF066BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-GF071BG1 | UM Potato Breeding | 4 | M | S |
| NDMN07-GF080BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-GF092BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-GF106BG1 | UM Potato Breeding | 4 | H | S |
| NDMN07-GF136BG1 | UM Potato Breeding | 5 | M | S |
| NDMN07-GF150BG1 | UM Potato Breeding | 2 | L | MR |
| NDMN07-GF168WG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-W146BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-W152BG1 | UM Potato Breeding | 4 | H | S |
| NDMN07-W153BG1 | UM Potato Breeding | 3 | H | MS |
| NDMN07-W159BG1 | UM Potato Breeding | 5 | H | S |
| NDMN07-W161BG1 | UM Potato Breeding | 5 | L | S |
| NDMN07-W162WG1 | UM Potato Breeding | 1 | L | MR |
| NDMN07-W180WG1 | UM Potato Breeding | 4 | H | S |
| NDMN07-W181WG1 | UM Potato Breeding | 4 | M | S |
| NDMN07-W184WG1 | UM Potato Breeding | 4 | H | S |
| NDMN07-W186WG1 | UM Potato Breeding | 3 | T | MS |
| NDMN07-W187BG1 | UM Potato Breeding | 5 | H | S |
| NorValley | UM Potato Breeding | 4 | H | S |
| NorValley | UM Potato Breeding | 5 | M | S |
| ORMN07-B257BG1 | UM Potato Breeding | 3 | M | MS |
| ORMN07-B258BG1 | UM Potato Breeding | 5 | M | S |

| | | | | |
|---|---|---|---|---|
| ORMN07-B260WG1 | UM Potato Breeding | 5 | M | S |
| ORMN07-GF011BG1 | UM Potato Breeding | 4 | H | S |
| ORMN07-GF014BG1 | UM Potato Breeding | 4 | M | S |
| ORMN07-W125BG1 | UM Potato Breeding | 5 | M | S |
| ORMN07-W125WG1 | UM Potato Breeding | 5 | H | S |
| ORMN07-W127WG1 | UM Potato Breeding | 5 | H | S |
| ORMN07-W128BG1 | UM Potato Breeding | 4 | L | S |
| ORMN07-W129WG1 | UM Potato Breeding | 4 | H | S |
| PA00N14-2 | National Scab Trial | 1 | T | MR |
| PA00N14-2 | National Scab Trial | 2 | M | MR |
| PA00N14-2 | National Scab Trial | 2 | T | MR |
| R. Norkotah | UM Potato Breeding | 4 | M | S |
| R. Norkotah | UM Potato Breeding | 5 | H | S |
| Ranger Russet | National Scab Trial | 4 | H | S |
| Ranger Russet | National Scab Trial | 4 | H | S |
| Ranger Russet | National Scab Trial | 5 | M | S |
| Red LaSoda | UM Potato Breeding | 5 | L | S |
| Red LaSoda | UM Potato Breeding | 5 | M | S |
| Red Norland | UM Potato Breeding | 4 | H | S |
| Red Norland | UM Potato Breeding | 4 | H | S |
| Russet Burbank | National Scab Trial | 1 | T | MR |
| Russet Burbank | National Scab Trial | 2 | T | MR |
| Russet Burbank | National Scab Trial | 2 | T | MR |
| Shepody | UM Potato Breeding | 4 | H | S |
| Shepody | UM Potato Breeding | 5 | H | S |
| Superior | National Scab Trial | 3 | L | MS |
| Superior | National Scab Trial | 4 | M | S |
| Superior | National Scab Trial | 5 | L | S |
| W2978-3 | North Central Region | 4 | H | S |
| W2978-3 | North Central Region | 5 | M | S |
| W5015-12 | North Central Region | 3 | M | MS |
| W5015-12 | North Central Region | 5 | H | S |
| W5767-1R | North Central Region | 4 | L | S |
| W5767-1R | North Central Region | 5 | H | S |
| WIMN 04844-01 | UM Potato Breeding | 4 | H | S |
| WIMN 04844-01 | UM Potato Breeding | 4 | L | S |
| WIMN 04844-03 | UM Potato Breeding | 5 | M | S |
| WIMN 04844-06 | UM Potato Breeding | 3 | H | MS |
| WIMN 04844-06 | UM Potato Breeding | 4 | H | S |
| WIMN 04855-02 | UM Potato Breeding | 1 | T | MR |
| WIMN 04855-02 | UM Potato Breeding | 3 | H | MS |
| WIMN 06002-02 | UM Potato Breeding | 3 | M | MS |
| WIMN 06002-02 | UM Potato Breeding | 4 | T | S |

| | | | | |
|---|---|---|---|---|
| WIMN 06030-01 | UM Potato Breeding | 5 | M | S |
| WIMN 06030-01 | UM Potato Breeding | 5 | M | S |
| WIMN 06035-01 | UM Potato Breeding | 5 | H | S |
| WIMN 06035-01 | UM Potato Breeding | 5 | H | S |
| WV4992-1 | North Central Region | 5 | H | S |
| WV4992-1 | North Central Region | 5 | H | S |
| WV5843-6 | North Central Region | 5 | H | S |
| WV5843-6 | North Central Region | 5 | L | S |
| Y. Gold | UM Potato Breeding | 4 | H | S |
| Y. Gold | UM Potato Breeding | 5 | H | S |

Simulated glyphosate drift to red potatoes. Harlene M. Hatterman-Valenti and Collin P. Auwarter.
This study was conducted at the Northern Plains Potato Growers Association Non-irrigated research site near Grand Forks, ND to evaluate the effect of glyphosate drift to current season growth and yield for three commonly grown red cultivars (Red Norland, Red LaSoda, and Sangre). Plots were 4 rows by 25 ft arranged in a randomized complete block design with four replicates. Seed pieces (2 oz) were planted on 36-inch rows and 12-inch spacing on June 10, 2009. Plots were 4 rows by 25 ft arranged in a split-block design with cultivar as the main factor and the combination of application timing and herbicide rate as sub-plots with 3 replicates. Glyphosate was applied with a $CO_2$ pressurized sprayer equipped with 8001XR flat fan nozzles with a spray volume of 5 GPA and a pressure of 35 psi. The first application timing (TI) occurred on July 23, 2009. Extension recommendations were used for cultural practices throughout the year. Plots were desiccated on September 19, harvested October 11 and graded into the various categories after harvest.

| Date: | 7/23/09 | 8/6/09 | 9/9/09 |
|---|---|---|---|
| Treatment: | TI | EB | LB |
| Air temperature (F): | 59 | 74 | 75 |
| Rel. hum. (%): | 92 | 47 | 45 |
| Wind (mph): | 3 | 3 | 12 |
| Soil moisture: | above normal | above normal | above normal |
| Cloud cover (%): | 50 | 90 | 0 |

Red Norland appeared to be the most sensitive cultivar to glyphosate. Plants treated with glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. In contrast, potatoes treated with glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly less 4-6 oz. tubers compared to the untreated and other treatments. This resulted in 37 to 50% decrease in marketable tubers size-wise. Unfortunately, excessive tuber cracking and russet skinning occurred with most of the tubers in these application timings, further reducing marketable yields. A slight shift to smaller tubers occurred when plants were treated with 0.063 lb ai/A glyphosate at the EB stage. No yield differences and few visible tuber defects were observed when plants were treated with glyphosate at the LB stage.

Red LaSoda was the next most sensitive cultivar to glyphosate. Plants treated with 0.25 lb ai/A glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. Other grade categories were similar regardless of the glyphosate treatments. Marketbale yields were reduced 34 to 57% when plants were treated with 0.25 lb ai/A glyphosate at the TI stage or with at least 0.125 lb ai/A glyphosate at the EB stage. Excessive tuber cracking and russet skinning was most severe in the EB stage with 70 to 100% rejection of marketable tubers due to visible tuber defects.

Sangre was the least sensitive tested cultivar to glyphosate. Plants treated with 0.25 lb ai/A glyphosate at the TI or EB stage produced significantly more cull tubers (< 4 oz) compared to the untreated control. Other grade categories were similar regardless of the glyphosate treatments. Marketbale yields were reduced 31 to 58% when plants were treated with 0.25 lb ai/A glyphosate at the TI or EB stage. Excessive tuber cracking and russet skinning was most severe in the EB stage with 30 to 100% rejection of marketable tubers due to visible tuber defects.

Potato cultivar yield and grade in response to glyphosate

| Treatment | 0-4 oz | 4-6 oz | 6-10 oz | >10 oz | TOTAL | >4 oz |
|---|---|---|---|---|---|---|
| | CWT/A | | | | | |
| Red Norland Chk | 73 c-h | 140 a-d | 52 abc | 50 def | 316 a-e | 243 a-f |
| Red Norland TI Glyphosate 0.25 | 65 c-h | 64 a-f | 30 abc | 26 ef | 184 cde | 120 d-g |
| Red Norland TI Glyphosate 0.13 | 75 c-h | 51 c-f | 25 abc | 16 ef | 167 de | 92 efg |
| Red Norland TI Glyphosate 0.06 | 153 a | 60 b-f | 12 bc | 4 f | 229 a-e | 76 fg |
| Red Norland EB Glyphosate 0.25 | 105 a-f | 39 f | 11 c | 1 f | 157 e | 52 g |
| Red Norland EB Glyphosate 0.13 | 131 ab | 45 def | 9 c | 8 f | 193 b-e | 62 g |
| Red Norland EB Glyphosate 0.06 | 104 a-f | 139 a-d | 32 abc | 16 ef | 291 a-e | 187 a-g |
| Red Norland LB Glyphosate 0.25 | 76 c-h | 152 ab | 66 a | 35 ef | 329 a-e | 253 a-e |
| Red Norland LB Glyphosate 0.13 | 75 c-h | 132 a-f | 54 abc | 33 ef | 295 a-e | 220 a-g |
| Red Norland LB Glyphosate 0.06 | 58 d-h | 147 ab | 63 a | 47 def | 315 a-e | 257 a-e |
| Red LaSoda Chk | 40 h | 124 a-f | 62 a | 161 ab | 387 a | 347 a |
| Red LaSoda TI Glyphosate 0.25 | 107 a-e | 77 a-f | 26 abc | 66 c-f | 276 a-e | 169 a-g |
| Red LaSoda TI Glyphosate 0.13 | 46 fgh | 122 a-f | 69 a | 136 abc | 373 abc | 327 ab |
| Red LaSoda TI Glyphosate 0.06 | 50 e-h | 113 a-f | 55 abc | 123 a-d | 342 a-e | 292 a-d |
| Red LaSoda EB Glyphosate 0.25 | 112 a-d | 115 a-f | 31 abc | 4 f | 261 a-e | 149 b-g |
| Red LaSoda EB Glyphosate 0.13 | 102 b-g | 83 a-f | 31 abc | 21 ef | 237 a-e | 135 c-g |
| Red LaSoda EB Glyphosate 0.06 | 60 c-h | 146 abc | 69 a | 60 c-f | 336 a-e | 275 a-d |
| Red LaSoda LB Glyphosate 0.25 | 45 gh | 110 a-f | 66 a | 152 ab | 374 abc | 329 ab |
| Red LaSoda LB Glyphosate 0.13 | 47 fgh | 121 a-f | 65 a | 146 ab | 379 ab | 332 ab |
| Red LaSoda LB Glyphosate 0.06 | 43 gh | 113 a-f | 64 a | 150 ab | 369 abc | 327 ab |
| Sangre Chk | 36 h | 104 a-f | 57 ab | 151 ab | 348 a-d | 312 abc |
| Sangre TI Glyphosate 0.25 | 117 abc | 43 ef | 10 c | 8 f | 178 de | 61 g |
| Sangre TI Glyphosate 0.13 | 33 h | 111 a-f | 67 a | 170 a | 381 ab | 348 a |
| Sangre TI Glyphosate 0.06 | 71 c-h | 157 a | 69 a | 85 b-f | 383 ab | 312 abc |
| Sangre EB Glyphosate 0.25 | 86 b-h | 75 a-f | 26 abc | 27 ef | 214 a-e | 128 c-g |
| Sangre EB Glyphosate 0.13 | 71 c-h | 138 a-e | 66 a | 63 c-f | 338 a-e | 267 a-e |
| Sangre EB Glyphosate 0.06 | 47 fgh | 123 a-f | 67 a | 97 a-e | 334 a-e | 287 a-d |
| Sangre LB Glyphosate 0.25 | 52 e-h | 128 a-f | 67 a | 84 b-f | 331 a-e | 279 a-d |
| Sangre LB Glyphosate 0.13 | 42 gh | 109 a-f | 61 a | 135 abc | 347 a-e | 305 a-d |
| Sangre LB Glyphosate 0.06 | 49 e-h | 114 a-f | 58 a | 118 a-d | 339 a-e | 290 a-d |
| LSD (P=.05) | 32 | 52 | 26 | 48 | 102 | 103 |

Potato cultivar tuber set in response to glyphosate

| Treatment | 0-4 oz | | 4-6 oz | | 6-10 oz | | >10 oz | | TOTAL | | >4 oz | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Tuber no. | | | | | |
| Red Norland Chk | 93 | d-h | 67 | abc | 19 | abc | 11 | d-g | 191 | bc | 97 | abc |
| Red Norland TI Glyphosate 0.25 | 132 | c-g | 29 | a-e | 11 | abc | 6 | fg | 178 | bc | 46 | b-e |
| Red Norland TI Glyphosate 0.13 | 118 | c-h | 24 | b-e | 9 | abc | 4 | fg | 156 | bc | 38 | cde |
| Red Norland TI Glyphosate 0.06 | 273 | a | 31 | a-e | 4 | bc | 1 | g | 309 | a | 37 | cde |
| Red Norland EB Glyphosate 0.25 | 177 | bc | 20 | e | 4 | bc | 0 | g | 201 | bc | 24 | e |
| Red Norland EB Glyphosate 0.13 | 182 | bc | 24 | cde | 4 | c | 2 | g | 211 | bc | 29 | de |
| Red Norland EB Glyphosate 0.06 | 138 | c-f | 71 | a | 12 | abc | 3 | fg | 225 | bc | 87 | a-d |
| Red Norland LB Glyphosate 0.25 | 95 | d-h | 70 | a | 25 | a | 8 | fg | 198 | bc | 103 | abc |
| Red Norland LB Glyphosate 0.13 | 90 | d-h | 63 | a-e | 20 | abc | 8 | fg | 181 | bc | 91 | abc |
| Red Norland LB Glyphosate 0.06 | 74 | e-h | 68 | ab | 22 | a | 10 | efg | 175 | bc | 101 | abc |
| Red LaSoda Chk | 52 | fgh | 55 | a-e | 21 | a | 33 | a | 161 | bc | 109 | ab |
| Red LaSoda TI Glyphosate 0.25 | 162 | bcd | 37 | a-e | 9 | abc | 14 | c-g | 222 | bc | 60 | a-e |
| Red LaSoda TI Glyphosate 0.13 | 58 | fgh | 54 | a-e | 23 | a | 27 | a-d | 162 | bc | 104 | abc |
| Red LaSoda TI Glyphosate 0.06 | 67 | e-h | 50 | a-e | 20 | abc | 25 | a-e | 163 | bc | 96 | abc |
| Red LaSoda EB Glyphosate 0.25 | 145 | cde | 59 | a-e | 11 | abc | 1 | g | 217 | bc | 71 | a-e |
| Red LaSoda EB Glyphosate 0.13 | 129 | c-g | 40 | a-e | 12 | abc | 5 | fg | 186 | bc | 57 | a-e |
| Red LaSoda EB Glyphosate 0.06 | 70 | e-h | 66 | a-d | 24 | a | 13 | c-g | 173 | bc | 103 | abc |
| Red LaSoda LB Glyphosate 0.25 | 52 | fgh | 47 | a-e | 23 | a | 32 | a | 154 | c | 102 | abc |
| Red LaSoda LB Glyphosate 0.13 | 56 | fgh | 53 | a-e | 23 | a | 29 | abc | 161 | bc | 105 | abc |
| Red LaSoda LB Glyphosate 0.06 | 56 | fgh | 48 | a-e | 22 | a | 30 | ab | 157 | bc | 101 | abc |
| Sangre Chk | 41 | h | 46 | a-e | 20 | abc | 31 | a | 139 | c | 97 | abc |
| Sangre TI Glyphosate 0.25 | 220 | b | 22 | de | 4 | c | 2 | g | 247 | b | 28 | de |
| Sangre TI Glyphosate 0.13 | 40 | h | 47 | a-e | 23 | a | 32 | a | 142 | c | 102 | abc |
| Sangre TI Glyphosate 0.06 | 78 | e-h | 74 | a | 24 | a | 18 | a-g | 194 | bc | 116 | a |
| Sangre EB Glyphosate 0.25 | 118 | c-h | 37 | a-e | 10 | abc | 6 | fg | 171 | bc | 53 | a-e |
| Sangre EB Glyphosate 0.13 | 88 | d-h | 64 | a-e | 23 | a | 15 | b-g | 190 | bc | 102 | abc |
| Sangre EB Glyphosate 0.06 | 55 | fgh | 55 | a-e | 23 | a | 20 | a-f | 154 | c | 98 | abc |
| Sangre LB Glyphosate 0.25 | 58 | fgh | 58 | a-e | 23 | a | 18 | a-g | 157 | bc | 99 | abc |
| Sangre LB Glyphosate 0.13 | 48 | gh | 48 | a-e | 21 | a | 26 | a-e | 143 | c | 95 | abc |
| Sangre LB Glyphosate 0.06 | 53 | fgh | 50 | a-e | 21 | ab | 26 | a-e | 150 | c | 97 | abc |
| LSD (P=.05) | 47 | | 24 | | 9 | | 10 | | 49 | | 37 | |

Use of Metribuzin for weed control in irrigated potato. Harlene Hatterman-Valenti and Collin Auwarter.

Field research was conducted at the Northern Plains Potato Growers Association Irrigation Research site near Inkster, ND to compare the efficacy and selectivity of metribuzin when applied pre and post to Russet Burbank potatoes. Seed pieces (2oz) were planted on 36 inch rows and 12 inch spacing on May 23, 2009. Plots were 4 rows by 25 ft arranged in a randomized complete block design with 4 replicates. Extension recommendations were used for cultural practices throughout the year. The herbicide treatments were applied to the middle 2 of 4 rows using a $CO_2$ pressurized backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 gpa and a pressure of 40 psi on June 16 (‘A’) and on June 25 (‘B’). Weed control evaluations were done on June 22 (6 DAA ‘A’), July 1 (15 DAA ‘A’, 6 DAA ‘B’), July 16 (30 DAA ‘A’, 21 DAA ‘B’), and August 13 (58 DAA ‘A’, 49 DAA ‘B’). We harvested both treated rows on September 26.

| Application Date: | 6/16/09 | 6/25/09 |
|---|---|---|
| Air Temperature (F): | 67 | 76 |
| Rel. Humidity (%): | 76 | 36 |
| Wind (mph): | 8 | 5 |
| Soil Moisture: | Below Normal | Adequate |
| Cloud Cover (%): | 100 | 0 |

Effect of herbicide on weed control and yield.

| | | | | | Rrpw | Colq | Grft | Rrpw | Colq | Grft | Rrpw | Colq | Grft | Rrpw | Colq | Grft | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rate | | --------6/22/09-------- | | | --------7/1/09-------- | | | --------7/16/09------- | | | -------8/13/09-------- | | | Yield |
| No. | Name | Rate | Unit | Code | ------% Control------- | | | -----% Control------ | | | -----% Control------ | | | -----% Control------ | | | CWT/A |
| 1 | Untreated | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 285 |
| 2 | Metribuzin | 10.7 | oz/a | A | 100 | 94 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 418 |
| 3 | Metribuzin | 21.3 | oz/a | A | 100 | 100 | 99 | 100 | 100 | 100 | 99 | 99 | 99 | 100 | 100 | 100 | 389 |
| 4 | Sencor | 10.7 | oz/a | A | 100 | 95 | 100 | 96 | 99 | 100 | 100 | 98 | 100 | 100 | 100 | 100 | 401 |
| 5 | Metribuzin | 5.33 | oz/a | B | 0 | 0 | 0 | 90 | 90 | 93 | 98 | 89 | 98 | 95 | 93 | 100 | 418 |
| 6 | Metribuzin | 10.7 | oz/a | B | 0 | 0 | 0 | 90 | 90 | 98 | 100 | 91 | 98 | 100 | 100 | 100 | 407 |
| 7 | Sencor | 5.33 | oz/a | B | 0 | 0 | 0 | 93 | 90 | 100 | 100 | 92 | 100 | 98 | 98 | 100 | 412 |

Rrpw = redroot pigweed, Colq = common lambsquarters, Grft = green foxtail

Ratings on June 22 showed excellent control on redroot pigweed and green foxtail. Common lambsquarters, which was the most populated weed in the field, was completely controlled (100%) with metribuzin @ 21.3 oz/a (treatment 3), while metribuzin @ 10.7 oz/a (treatment 2) and Sencor @ 10.7 oz/a (treatment 4) had 94 and 95% control, respectively. July 1 ratings showed 100% control for the 3 weeds with both metribuzin pre-emergence treatments (2 and 3), while the post-emergence treatments showed between 90 and 93% control for redroot pigweed and common lambsquarters. By trials end, all pre-emergence treatments (2-4) and metribuzin @ 10.7 oz/a post-emergence treatment (6) had 100% control of all 3 weeds, while the lower rate of metribuzin post-emergence (treatment 5) showed 95% control of redroot pigweed and 93% control of common lambsquarters. The post-emergence Sencor treatment (7) had 98% control of both redroot pigweed and common lambsquarters. The untreated control yielded 284 cwt/A, while all other treatments (2-7) yielded between 391 and 421 cwt/A.

Use of Eptam for weed control in irrigated potato. Harlene Hatterman-Valenti and Collin Auwarter.
A study was conducted west of Inkster, ND at the Northern Plains Potato Growers Association Irrigation Research site to evaluate several Eptam based programs with Dual II Magnum + Sencor for weed control in irrigated 'Russet Burbank' potatoes. Plots were 4 rows by 25 ft arranged in a randomized complete block design with 4 replicates. Seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on May 23, 2009. Treatments were applied prior to planting ('A') and after hilling ('B'), but prior to emergence. Extension recommendations were used for cultural practices throughout the year. The herbicide treatments were applied to the middle two rows using a $CO_2$ backpack sprayer equipped with 8002 flat-fan nozzles with an output of 20 gpa and a pressure of 40 psi. Weed control was evaluated on June 22, July 14, and August 13. Treated rows were harvested on September 26 and graded at Fargo.

| Application Date: | 5/23/09 | 6/16/09 |
|---|---|---|
| Air Temperature (F): | 65 | 67 |
| Rel. Humidity (%): | 60 | 76 |
| Wind (mph): | 2 | 8 |
| Soil Moisture: | Adequate | Below normal |
| Cloud Cover (%): | 0 | 100 |

Table 1. Effect of herbicide treatments on weed control.

| | | | | Colq | Rrpw | Grft | Colq | Rrpw | Grft | Colq | Rrpw | Grft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rate | | -------6/22/09------ | | | ---------7/14/09--------- | | | ---------8/13/09--------- | | |
| Name | Rate | Unit | Code | -----% Control----- | | | ---------Control--------- | | | ------% Control-------- | | |
| Untreated | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eptam | 5.5 | pt/a | A | 96 | 100 | 99 | 94 | 100 | 100 | 98 | 98 | 100 |
| Eptam + | 4.5 | pt/a | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Sencor | 0.33 | lb/a | B | | | | | | | | | |
| Eptam + | 4.5 | pt/a | A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Matrix | 1.5 | oz/a | B | | | | | | | | | |
| Dual II | 2 | pt/a | B | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Magnum+ | | | | | | | | | | | | |
| Sencor | 0.33 | lb/a | B | | | | | | | | | |

Rrpw = redroot pigweed, Colq = common lambsquarters, Grft = green foxtail

Table 2. Effect of herbicide treatments on potato yield and grade.

| | | Rate | | <4oz | 4-6oz | 6-8oz | 8-10oz | 10-12oz | >12oz | Total | >4oz |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | Rate | Unit | Code | --------------------------------CWT/A----------------------------------- | | | | | | | |
| Untreated | | | | 144 | 133 | 81 | 42 | 13 | 11 | 424 | 279 |
| Eptam | 5.5 | pt/a | A | 149 | 119 | 70 | 25 | 19 | 17 | 400 | 251 |
| Eptam + | 4.5 | pt/a | A | 126 | 118 | 77 | 45 | 16 | 17 | 399 | 273 |
| Sencor | 0.33 | lb/a | B | | | | | | | | |
| Eptam + | 4.5 | pt/a | A | 135 | 103 | 82 | 47 | 19 | 26 | 413 | 278 |
| Matrix | 1.5 | oz/a | B | | | | | | | | |
| Dual II | 2 | pt/a | B | 141 | 132 | 78 | 51 | 16 | 20 | 438 | 297 |
| Magnum + | | | | | | | | | | | |
| Sencor | 0.33 | lb/a | B | | | | | | | | |

Weed control evaluations showed all treatments performed well. The new location did not have the weed pressure previously reported. Total yields showed no differences and that the untreated performed as well as any other treatment. This was attributed to the limited weed pressure. There was no significant difference in grade. All treatments had between 63 and 68% of their tubers greater than the 4 oz size. Results indicate that Eptam and Eptam combinations provide similar weed control as the combination of Dual II Magnum + Sencor and that plants treated with these herbicides had similar yields and grades.

Effect of glyphosate droplet concentration on drift injury to irrigated potato. Harlene Hatterman-Valenti and Collin Auwarter.

A study was conducted at the Northern Plains Potato Grower's Association Irrigation Research site near Inkster, ND to determine if increasing the glyphosate droplet concentration by reducing the water volume would increase injury to potato and whether this increase in injury would be similar at all growth stages. This was accomplished by comparing plant and tuber injury from glyphosate applied at 20, 5, or 1 GPA to 'Russet Burbank' plants at the tuber initiation (TI), early bulking (EB), and late bulking stages (LB). The potato variety 'Russet Burbank' was planted on May 24 using a Harrison double-row planter with 12-inch spacing between seed pieces and 36 inches between rows. Glyphosate was applied at one-sixth, and one-twelfth the standard use rate (0.125 and 0.0625 lb ai/A) with a $CO_2$-pressurized ATV sprayer equipped with HB/HC #2 and #5 nozzles with a spray volume of 20 GPA (70 psi and 1.8 mph), 5 GPA (25 psi and 3.6 mph), or 1 GPA (25 psi and 7.2 mph). AMS was included to the spray solution and reduced accordingly. The field design was a randomized complete block, factorial arrangement, with four replicates. Maintenance programs were conducted throughout the growing season to apply fungicides and insecticides. Plants were harvested September 25 with a single-row Hasia harvester and then graded at Fargo. Application, environmental, crop, and yield data are listed below:

| Date: | 7/23/09 | 8/6/09 | 9/9/09 |
|---|---|---|---|
| Treatment: | TI | EB | LB |
| Air temperature (F): | 68 | 70 | 73 |
| Rel. hum. (%): | 62 | 61 | 57 |
| Wind (mph): | 7 | 6 | 8 |
| Wind direction: | SE | SE | SW |

Visual injury symptoms from glyphosate applications were subtle (chlorosis at growing points) regardless of glyphosate rate or application timing. Plants treated with glyphosate recovered quicker and showed less injury symptoms than previous years due to better environmental conditions in 2009. Plants treated with 0.13 lb/A glyphosate at the TI stage when applied at 20 GPA or at the EB stage when applied at 5 GPA had significant marketable and total yield loss from the reduction in tuber size. Plants treated with glyphosate produced similar number of tubers in comparison to the untreated except when plants were treated with 0.06 lb/A glyphosate applied at 20 GPA at the TI stage, which had significantly more tubers. Additional tuber loss would have occurred if tubers were to be sold for fresh market due to growth cracks and elephant hide skin in many of the tubers when plants were treated with glyphosate at the TI or EB stage.

Potato tuber set in response to glyphosate droplet concentration.

| Treatment | < 4 oz | 4-6 oz | 6-8 oz | 8-10 oz | 10-12 oz | >12 oz | Total | >4 oz |
|---|---|---|---|---|---|---|---|---|
| | tuber no. | | | | | | | |
| Untreated | 97 | 45 | 28 | 20 | 7 | 8 | 205 | 108 |
| RU 0.125 TI 20 GPA | 159 | 20 | 7 | 4 | 2 | 1 | 192 | 33 |
| RU 0.0625 TI 20 GPA | 217 | 51 | 22 | 9 | 6 | 3 | 307 | 91 |
| RU 0.125 TI 1 GPA | 103 | 47.8 | 34 | 20 | 9 | 8 | 221 | 118 |
| RU 0.0625 TI 1 GPA | 140 | 42 | 27 | 11 | 6 | 5 | 230 | 90 |
| RU 0.125 EB 20 GPA | 130 | 56 | 43 | 18 | 6 | 4 | 257 | 127 |
| RU 0.0625 EB 20 GPA | 105 | 59 | 43 | 24 | 10 | 9 | 249 | 145 |
| RU 0.125 EB 5 GPA | 151 | 45 | 19 | 4 | 3 | 2 | 224 | 73 |
| RU 0.0625 EB 5 GPA | 129 | 58 | 33 | 14 | 5 | 5 | 243 | 115 |
| RU 0.125 EB 1 GPA | 141 | 54 | 34 | 12 | 5 | 5 | 250 | 109 |
| RU 0.0625 EB 1 GPA | 120 | 54 | 37 | 16 | 5 | 7 | 239 | 119 |
| RU 0.125 LB 20 GPA | 108 | 51 | 33 | 17 | 6 | 7 | 222 | 114 |
| RU 0.0625 LB 20 GPA | 114 | 56 | 33 | 19 | 8 | 10 | 239 | 125 |
| RU 0.125 LB 5 GPA | 113 | 57 | 33 | 20 | 8 | 7 | 237 | 124 |
| RU 0.0625 LB 5 GPA | 126 | 60 | 35 | 20 | 10 | 10 | 260 | 134 |
| RU 0.125 LB 1 GPA | 129 | 61 | 32 | 14 | 8 | 4 | 247 | 118 |
| RU 0.0625 LB 1 GPA | 124 | 60 | 31 | 19 | 7 | 2 | 243 | 119 |
| LSD (P=0.05) | 47 | 20 | 13 | 9 | 4 | NS | 76 | 40 |

Potato yield and grade in response to glyphosate droplet concentration.

| Treatment | < 4 oz | 4-6 oz | 6-8 oz | 8-10 oz | 10-12 oz | >12 oz | Total | >4 oz |
|---|---|---|---|---|---|---|---|---|
| | | | | Cwt/A | | | | |
| Untreated | 93 | 102 | 82 | 71 | 33 | 46 | 426 | 334 |
| RU 0.125 TI 20 GPA | 119 | 49 | 21 | 16 | 9 | 6 | 220 | 101 |
| RU 0.0625 TI 20 GPA | 156 | 91 | 54 | 29 | 24 | 18 | 371 | 215 |
| RU 0.125 TI 1 GPA | 83 | 87 | 86 | 65 | 34 | 42 | 397 | 315 |
| RU 0.0625 TI 1 GPA | 123 | 97 | 90 | 48 | 34 | 36 | 428 | 305 |
| RU 0.125 EB 20 GPA | 104 | 102 | 107 | 58 | 23 | 19 | 413 | 309 |
| RU 0.0625 EB 20 GPA | 82 | 106 | 107 | 77 | 38 | 51 | 460 | 379 |
| RU 0.125 EB 5 GPA | 120 | 81 | 48 | 13 | 10 | 9 | 280 | 160 |
| RU 0.0625 EB 5 GPA | 102 | 105 | 84 | 44 | 19 | 24 | 377 | 275 |
| RU 0.125 EB 1 GPA | 120 | 97 | 83 | 39 | 20 | 24 | 382 | 262 |
| RU 0.0625 EB 1 GPA | 98 | 98 | 91 | 51 | 20 | 35 | 393 | 295 |
| RU 0.125 LB 20 GPA | 92 | 93 | 84 | 55 | 23 | 35 | 381 | 289 |
| RU 0.0625 LB 20 GPA | 85 | 99 | 82 | 63 | 31 | 52 | 412 | 327 |
| RU 0.125 LB 5 GPA | 93 | 104 | 82 | 64 | 32 | 35 | 409 | 316 |
| RU 0.0625 LB 5 GPA | 100 | 109 | 88 | 64 | 38 | 53 | 451 | 351 |
| RU 0.125 LB 1 GPA | 100 | 111 | 81 | 46 | 30 | 18 | 386 | 286 |
| RU 0.0625 LB 1 GPA | 102 | 108 | 76 | 61 | 28 | 11 | 386 | 284 |
| LSD (P=0.05) | 32 | 33 | 29 | 28 | 15 | 26 | 101 | 85 |

Pyraflufen (Vida) and Aceto-diquat as a desiccant on dryland potatoes. Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted at the Northern Plains Potato Growers Association Non-irrigated research site near Grand Forks, ND to compare desiccation with Vida at different rates and timings compared with diquat. Red Norland seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on June 11, 2009. Plots were 4 rows by 25 ft arranged in a randomized complete block design with 4 replicates. Extension recommendations were used for cultural practices throughout the year. The desiccant treatments were applied to the middle 2 of 4 rows using a $CO_2$ backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 gpa and a pressure of 40 psi on September 3 (‘A’) and September 10 (‘B’). The pH of water before adding Vida to the bottles was 5.85. We added Tri-Fol @ 1 pt/100 gal to lower the pH. Potatoes were harvested on October 13.

| Application Date: | 9/3/09 | 9/10/09 |
|---|---|---|
| Air Temperature (F): | 74 | 77 |
| Rel. Humidity (%): | 68 | 73 |
| Wind (mph): | 2 | 7 |
| Soil Moisture: | Adequate | Above Normal |
| Cloud Cover (%): | 5 | 10 |

Anything with diquat faired better than the Vida treatments throughout the trial on both the leaves and stems. By 4 DAA ‘A’ the Vida treatments had between 21 and 29% leaf necrosis, while the treatments with diquat (including ones tank mixed with Vida) had between 36 and 41% leaf necrosis, with the highest being Vida @ 4.125 floz/a + Reglone @ 1 pt/a + Preference @ 0.25% v/v (treatment 4). All stems at this point showed between 10 and 20% necrosis. By 14 DAA ‘A’ and 7 DAA ‘B’ the best treatment was Vida @ 4.125 floz/a + Reglone @ 1 pt/a + Preference @ 0.25% v/v (treatment 4) with 96% leaf necrosis and 86% stem necrosis. The next best treatment was Vida @ 2.75 floz/a + Reglone @ 1 pt/a + Preference @ 0.25% v/v (treatment 6) applied 2X with 95% desiccated leaves and 84% desiccated stems. During the last ratings (18 DAA ‘A’ and 11 DAA ‘B’) all treatments had 100% desiccation of leaves, except the treatments where Vida was not tank mixed with any other herbicide (treatments 2 and 3). All stems at this point were at least 96% desiccated. All treatments had a yield between 335 and 441 cwt/A with no statistical difference between treatments. The highest yielding treatments were Vida @ 5.5 floz/a + Persist Ultra @ 1% v/v (treatment 2) with 441 cwt/A, and Reglone @ 1 pt/a + Preference fb Vida @ 2.75 floz/a + Persist Ultra @ 1% v/v (treatment 10) with 425 cwt/A. The lowest yielding was a Aceto-diquat @ 2 pt/a + Preference @ 0.25% v/v (treatment 13) with 335 cwt/a. The untreated (treatment 1) yielded 397 cwt/a.

Potato desiccation with pyraflufen and Aceto-diquat.

|  |  |  |  |  | -----9/7/09------ |  | -----9/10/09----- |  | -------9/17/09------- |  | --------9/21/09--------- |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Rate |  | 4 DAA'A' |  | 7 DAA'A' |  | 14 DAA'A', 7 DAA'B' |  | 18 DAA'A', 11 DAA'B' |  | Yield |
| No. | Name | Rate | Unit | Code | Leaves | Stems | Leaves | Stems | Leaves | Stems | Leaves | Stems | cwt/a |
| 1 | Untreated |  |  |  | 0c | 0d | 0e | 0e | 0d | 0d | 0c | 0c | 397a |
| 2 | *Vida | 5.5 | floz/a | A | 23b | 10c | 53cd | 23d | 86bc | 73c | 99b | 96b | 441a |
|  | Persist Ultra | 1 | %v/v | A |  |  |  |  |  |  |  |  |  |
| 3 | *Vida | 5.5 | floz/a | A | 29b | 13bc | 55cd | 25cd | 85c | 75bc | 99b | 97ab | 354a |
|  | Syl-Tac | 4 | floz/a | A |  |  |  |  |  |  |  |  |  |
| 4 | *Vida | 4.125 | floz/a | A | 41a | 19a | 69a | 35a | 96a | 86a | 100a | 100a | 392a |
|  | Reglone | 1 | pt/a | A |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
| 5 | *Vida | 2.75 | floz/a | A | 38a | 18a | 66ab | 33ab | 91abc | 79abc | 100a | 100a | 356a |
|  | Reglone | 1 | pt/a | A |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
| 6 | *Vida | 2.75 | floz/a | AB | 39a | 20a | 70a | 35a | 95a | 84ab | 100a | 100a | 403a |
|  | Reglone | 1 | pt/a | AB |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | AB |  |  |  |  |  |  |  |  |  |
| 7 | *Vida | 2.75 | floz/a | AB | 23b | 13bc | 55cd | 25cd | 86bc | 74bc | 100a | 97ab | 373a |
|  | Persist Ultra | 1 | %v/v | AB |  |  |  |  |  |  |  |  |  |
| 8 | *Vida | 2.75 | floz/a | A | 25b | 13bc | 53cd | 26bcd | 86bc | 73c | 100a | 98ab | 357a |
|  | Persist Ultra | 1 | %v/v | A |  |  |  |  |  |  |  |  |  |
|  | *Vida | 5.5 | floz/a | B |  |  |  |  |  |  |  |  |  |
|  | Persist Ultra | 1 | %v/v | B |  |  |  |  |  |  |  |  |  |
| 9 | *Vida | 2.75 | floz/a | A | 21b | 10c | 48d | 21d | 90abc | 80abc | 100a | 99a | 395a |
|  | Persist Ultra | 1 | %v/v | A |  |  |  |  |  |  |  |  |  |
|  | Reglone | 1 | pt/a | B |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | B |  |  |  |  |  |  |  |  |  |
| 10 | Reglone | 1 | pt/a | A | 36a | 19a | 66ab | 31abc | 93abc | 80abc | 100a | 99a | 425a |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
|  | *Vida | 2.75 | floz/a | B |  |  |  |  |  |  |  |  |  |
|  | Persist Ultra | 1 | %v/v | B |  |  |  |  |  |  |  |  |  |
| 11 | Reglone | 1 | pt/a | A | 35a | 16ab | 68ab | 35a | 94ab | 83abc | 100a | 100a | 356a |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
|  | Reglone | 1 | pt/a | B |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | B |  |  |  |  |  |  |  |  |  |
| 12 | Aceto-diquat | 1 | pt/a | A | 38a | 19a | 65ab | 33ab | 89abc | 79abc | 100a | 98ab | 342a |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
| 13 | Aceto-diquat | 2 | pt/a | A | 39a | 19a | 70a | 38a | 93abc | 83abc | 100a | 100a | 335a |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
| 14 | Aceto-diquat | 1 | pt/a | A | 36a | 19a | 59bc | 30abc | 91abc | 83abc | 100a | 99a | 386a |
|  | Preference | 0.25 | %v/v | A |  |  |  |  |  |  |  |  |  |
|  | Aceto-diquat | 1 | pt/a | B |  |  |  |  |  |  |  |  |  |
|  | Preference | 0.25 | %v/v | B |  |  |  |  |  |  |  |  |  |

*pH was brought down to 5.85 by adding Tri-Fol @ 1 pt/100 gal before adding Vida.

Weed control using CHA-023 on irrigated potato. Harlene Hatterman-Valenti and Collin Auwarter.

A study was conducted at the Northern Plains Potato Growers Association Irrigation Research site near Inkster, ND to determine the efficacy and selectivity of CHA-023 applied pre and early post to Russet Burbank potatoes. Seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on May 28, 2009. Plots were 4 rows by 25 ft arranged in a randomized complete block design with 4 replicates. Extension recommendations were used for cultural practices throughout the year. The herbicide treatments were applied to the middle 2 of 4 rows using a $CO_2$ backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 gpa and a pressure of 40 psi on June 16 (‘A’) and June 25 (‘B’). Weed control evaluations were done on June 22 (6 DAA ‘A’), July 1 (15 DAA ‘A’, 6 DAA ‘B’), July 16 (30 DAA ‘A’, 21 DAA ‘B’), and August 13 (58 DAA ‘A’, 49 DAA ‘B’). Potatoes were harvested on September 26. Plants in this trial emerged rather quickly as this land was first tilled the day before planting and deep ripping was not available, hence the seed pieces were not planted as deeply as planned ( 4 inches versus 6 inches below the soil surface) and were in slightly warmer soil. At hilling, plants were beginning to emerge (5%) and the disk cultivator was unable to get enough soil to throw on top of the hill to properly cover emerged potato plants and weeds. When application ‘A’ was applied, common lambsquarters were at 2-3 leaves and about half inch tall.

| Application Date: | 6/16/09 | 6/25/09 |
|---|---|---|
| Air Temperature (F): | 67 | 76 |
| Rel. Humidity (%): | 76 | 36 |
| Wind (mph): | 8 | 5 |
| Soil Moisture: | Below Normal | Adequate |
| Cloud Cover (%): | 100 | 0 |

Weed control evaluations.

| No. | Name | Rate | Rate Unit | Code | 6/22/09 % Control | 7/1/09 % Control | | | 7/16/09 % Control | | | 8/13/09 % Control | | | Yield cwt/a |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Colq | Colq | Rrpw | Grft | Colq | Rrpw | Grft | Colq | RRpw | Grft | |
| 1 | Untreated | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 239 |
| 2 | CHA-023 | 0.75 | oz/a | A | 50 | 61 | 63 | 71 | 64 | 73 | 78 | 73 | 80 | 88 | 340 |
| 3 | CHA-023 | 1.5 | oz/a | A | 68 | 65 | 65 | 73 | 65 | 73 | 88 | 69 | 69 | 100 | 310 |
| 4 | CHA-023 | 3 | oz/a | A | 63 | 61 | 61 | 63 | 81 | 83 | 78 | 65 | 76 | 88 | 295 |
| 5 | Matrix | 1.5 | oz/a | A | 75 | 68 | 68 | 76 | 68 | 69 | 68 | 65 | 75 | 75 | 358 |
| 6 | CHA-023 | 0.75 | oz/a | B | 0 | 90 | 90 | 91 | 91 | 94 | 100 | 100 | 100 | 100 | 356 |
| | Preference | 0.25 | %v/v | B | | | | | | | | | | | |
| 7 | CHA-023 | 1.5 | oz/a | B | 0 | 90 | 90 | 91 | 95 | 99 | 74 | 100 | 100 | 100 | 341 |
| | Preference | 0.25 | %v/v | B | | | | | | | | | | | |
| 8 | CHA-023 | 3 | oz/a | B | 0 | 91 | 91 | 90 | 98 | 99 | 100 | 100 | 100 | 100 | 369 |
| | Preference | 0.25 | %v/v | B | | | | | | | | | | | |
| 9 | Matrix | 1.5 | oz/a | B | 0 | 90 | 90 | 93 | 94 | 94 | 100 | 100 | 100 | 100 | 354 |
| | Preference | 0.25 | %v/v | B | | | | | | | | | | | |

Rrpw = redroot pigweed, Colq = common lambsquarters, Grft = green foxtail

Common lambsquarters was the only weed rated on June 22, and Matrix @ 1.5 oz/a (treatment 5) showed the best results with 75% control. If there would have been a surfactant tank mixed with application timing “A” treatments, the results may have improved. The pre-emergence treatments (2-5) struggled throughout the year, but did show better results as the season went on. CHA-023 @ 0.75 oz/a pre-emergence (treatment 2) had the best results of the pre treatments by the end of the year with 73% control of common lambsquarters and 80% of redroot pigweed. The post-emergence treatments, with the surfactant (Preference @ 0.25% v/v), provided the best season-long weed control. All had 100% control of common lambsquarters, redroot pigweed, and yellow foxtail. The highest yielding treatment was CHA-023 @ 3 oz/a + Preference @ 0.25% v/v (treatment 8) with 369 cwt/a, followed by Matrix @ 1.5 oz/a (treatment 5) with 358 cwt/a. The untreated control yielded 239 cwt/a.

Use of fomesafen (Reflex) in Irrigated Potato. Harlene Hatterman-Valenti and Collin Auwarter.

Field research was conducted at the Northern Plains Potato Growers Association Irrigation Research site near Inkster, ND to evaluate potato tolerance and weed control of fomesafen +/- s-metolachlor or +/- prepackaged mix of s-metolachor and metribuzin to standards using four popular varieties grown under irrigation in North Dakota (Blazer, Russet Norkotah, Shepody, and Dakota Pearl). Seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on May 24, 2009. Plots were 4 rows by 20 ft arranged in a randomized complete block design with 4 replicates. Herbicide treatments were applied 24 DAP with a $CO_2$ pressurized sprayer equipped with 8002 flat fan nozzles with a spray volume of 20 gpa and a pressure of 40 psi. Extension recommendations were used for cultural practices throughout the year. At time of application Blazer was 80% emerged, Russet Norkotah was 75%, Shepody was 60%, and Dakota Pearl was 95%. Plants emerged at application ranged from barely poking through soil up to 1 inch in height. Injury was expected since the application timing was pre-emergence to crop and weeds.

| Application Date: | 6/17/09 |
|---|---|
| Air Temperature (F): | 67 |
| Rel. Humidity (%): | 62 |
| Wind (mph): | 4 |
| Soil Moisture: | Below Normal |
| Cloud Cover (%): | 100 |

Dakota Pearl, with the most emerged plants, showed the greatest tolerance with 5 to 16% injury 5 DAA from applications with fomesafen. Other varieties had 6 to 28% visual injury with chlorosis as the main symptom. Potatoes treated with fomesafen and the premix of s-metolachlor plus metribuzin (Reflex @ 2 pt/a + Boundary @ 4 pt/a) had the greatest injury 5 DAA; Blazer-26%, Russet Norkotah and Shepody-28%, and Dakota Pearl-16%. This treatment also provided 100% control of common lambsquarters throughout the trial. By 14 DAA, all treatments where fomesafen was applied still showed signs of injury ranging between 1 to 9%, and by 26 DAA, only slight chlorosis was observed (0 to 2%). Treatments with fomesafen alone had less control of common lambsquarters than treatments tank mixed with either a prepackaged mix of s-metolachor and metribuzin, metribuzin, s-metolachlor, of rimsulfuron throughout the trial. Russet Norkotah had the greatest yields, while Blazer was the lowest yielding variety. The marketable yields (>4 oz) were similar to total yields. Dakota Pearl had the greatest tuber counts with the untreated having the most tubers in 20 ft of row (259 tubers). However, this variety also had the most unmarketable tubers, having between 53 and 69% of the tubers considered culls. Shepody had the lowest tuber number with all treatments having less than 141 tubers in 20 ft of row. Herbicide treatments had only slight effect on potato yield and grade due to low weed density/ competitive pressure. The trial location reportedly had high weed pressure, but due to the delay in being able to work the field and plant, most weeds were controlled with the hilling procedure just prior to herbicide applications.

Effect of herbicide treatments on common lambsquarters control, Blazer injury, and yield.

|  |  |  | Rate | Colq ---6/22/09-- |  | Colq ---7/1/09---- |  | Colq --7/13/09--- |  | Colq ---8/13/09-- |  | <4oz | 4-6oz | 6-8oz | 8-10oz | 10-12oz | >12oz | Total | >4oz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Name | Rate | Unit | % Con. | % Inj. | % Con. | % Inj. | % Con. | % Inj. | % Con. | % Inj. | ---CWT/A--- |  |  |  |  |  |  |  |
| 1 | Untreated |  |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 69 | 84 | 60 | 49 | 16 | 19 | 298 | 228 |
| 2 | Reflex | 1 | pt/a | 81 | 9 | 86 | 2 | 86 | 0 | 76 | 0 | 51 | 72 | 82 | 60 | 42 | 57 | 364 | 313 |
| 3 | Reflex | 2 | pt/a | 89 | 16 | 91 | 5 | 90 | 0 | 86 | 0 | 59 | 75 | 59 | 55 | 36 | 23 | 308 | 249 |
| 4 | Dual Magnum | 1.33 | pt/a | 90 | 5 | 95 | 1 | 88 | 0 | 91 | 0 | 46 | 83 | 77 | 51 | 28 | 28 | 312 | 266 |
| 5 | Reflex | 1 | pt/a | 100 | 21 | 98 | 6 | 96 | 1 | 96 | 0 | 42 | 56 | 69 | 71 | 38 | 54 | 331 | 288 |
|  | Dual Magnum | 1.33 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 | Boundary | 2 | pt/a | 99 | 4 | 100 | 1 | 99 | 0 | 100 | 0 | 58 | 74 | 84 | 51 | 36 | 60 | 363 | 305 |
| 7 | Reflex | 0.5 | pt/a | 100 | 18 | 100 | 4 | 100 | 0 | 100 | 0 | 57 | 68 | 77 | 51 | 30 | 31 | 314 | 256 |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 8 | Reflex | 1 | pt/a | 100 | 21 | 100 | 4 | 100 | 0 | 100 | 0 | 46 | 63 | 75 | 77 | 53 | 50 | 364 | 318 |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 9 | Reflex | 2 | pt/a | 100 | 26 | 100 | 9 | 100 | 1 | 100 | 0 | 52 | 55 | 55 | 45 | 27 | 39 | 274 | 222 |
|  | Boundary | 4 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 10 | Sencor | 0.25 | lb/a | 100 | 3 | 100 | 0 | 100 | 0 | 100 | 0 | 53 | 72 | 70 | 68 | 32 | 27 | 323 | 270 |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11 | Matrix | 1.5 | oz/a | 100 | 4 | 100 | 1 | 99 | 0 | 100 | 0 | 50 | 68 | 70 | 64 | 45 | 62 | 360 | 309 |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12 | Sencor | 0.25 | lb/a | 100 | 25 | 100 | 6 | 100 | 0 | 100 | 0 | 51 | 78 | 95 | 60 | 48 | 45 | 376 | 325 |
|  | Reflex | 1 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 13 | Matrix | 1.5 | oz/a | 100 | 20 | 100 | 7 | 100 | 0 | 100 | 0 | 46 | 62 | 67 | 73 | 43 | 42 | 332 | 286 |
|  | Reflex | 1 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Boundary | 2 | pt/a |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| LSD | (P=0.05) |  |  | 3 | 4 | 3 | 2 | 3 | NS | 7 | NS | 21 | 20 | 27 | 28 | 22 | 27 | 65 | 64 |

Effect of herbicide treatments on common lambsquarters control, Russet Norkotah injury, and yield.

| No. | Name | Rate | Rate Unit | Colq ---6/22/09-- | | Colq ---7/1/09---- | | Colq --7/13/09--- | | Colq ---8/13/09-- | | <4oz | 4-6oz | 6-8oz | 8-10oz | 10-12oz | >12oz | Total | >4oz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % Con. | % Inj. | % Con. | % Inj. | % Con. | % Inj. | % Con. | % Inj. | ----------------------------------CWT/A---------------------------------- | | | | | | | |
| 1 | Untreated | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 59 | 76 | 109 | 94 | 61 | 88 | 487 | 428 |
| 2 | Reflex | 1 | pt/a | 84 | 10 | 91 | 5 | 91 | 1 | 85 | 0 | 62 | 87 | 99 | 88 | 54 | 100 | 489 | 427 |
| 3 | Reflex | 2 | pt/a | 90 | 14 | 95 | 6 | 97 | 1 | 99 | 0 | 51 | 64 | 80 | 111 | 80 | 157 | 542 | 491 |
| 4 | Dual Magnum | 1.33 | pt/a | 91 | 5 | 93 | 3 | 90 | 1 | 93 | 0 | 71 | 95 | 92 | 91 | 61 | 91 | 502 | 430 |
| 5 | Reflex<br>Dual Magnum | 1<br>1.33 | pt/a<br>pt/a | 99 | 24 | 99 | 9 | 96 | 0 | 99 | 0 | 54 | 74 | 87 | 89 | 57 | 107 | 469 | 414 |
| 6 | Boundary | 2 | pt/a | 100 | 7 | 100 | 3 | 100 | 0 | 98 | 0 | 59 | 71 | 96 | 87 | 91 | 123 | 526 | 467 |
| 7 | Reflex<br>Boundary | 0.5<br>2 | pt/a<br>pt/a | 100 | 19 | 100 | 8 | 100 | 0 | 100 | 0 | 45 | 84 | 101 | 86 | 62 | 121 | 499 | 453 |
| 8 | Reflex<br>Boundary | 1<br>2 | pt/a<br>pt/a | 100 | 23 | 100 | 5 | 100 | 0 | 100 | 0 | 52 | 62 | 88 | 83 | 74 | 128 | 487 | 435 |
| 9 | Reflex<br>Boundary | 2<br>4 | pt/a<br>pt/a | 100 | 28 | 100 | 9 | 100 | 1 | 100 | 0 | 49 | 67 | 96 | 85 | 59 | 104 | 460 | 410 |
| 10 | Sencor<br>Boundary | 0.25<br>2 | lb/a<br>pt/a | 100 | 4 | 100 | 1 | 100 | 0 | 100 | 0 | 57 | 83 | 89 | 90 | 62 | 144 | 524 | 467 |
| 11 | Matrix<br>Boundary | 1.5<br>2 | oz/a<br>pt/a | 100 | 2 | 100 | 0 | 100 | 0 | 100 | 0 | 70 | 84 | 94 | 109 | 82 | 84 | 524 | 454 |
| 12 | Sencor<br>Reflex<br>Boundary | 0.25<br>1<br>2 | lb/a<br>pt/a<br>pt/a | 100 | 21 | 100 | 6 | 100 | 0 | 100 | 0 | 54 | 67 | 83 | 84 | 67 | 98 | 454 | 399 |
| 13 | Matrix<br>Reflex<br>Boundary | 1.5<br>1<br>2 | oz/a<br>pt/a<br>pt/a | 100 | 23 | 100 | 6 | 100 | 0 | 100 | 0 | 63 | 73 | 95 | 92 | 58 | 132 | 513 | 449 |
| LSD | (P=0.05) | | | 4 | 6 | 2 | 3 | 2 | NS | 6 | NS | NS | 24 | 26 | 24 | 26 | 27 | 65 | 64 |

Effect of herbicide treatments on common lambsquarters control, Shepody injury, and yield.

| | | | | Colq | | Colq | | Colq | | Colq | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rate | ---6/22/09-- | | ---7/1/09---- | | --7/13/09--- | | ---8/13/09-- | | <4oz | 4-6oz | 6-8oz | 8-10oz | 10-12oz | >12oz | Total | >4oz |
| No. | Name | Rate | Unit | % | % | % | % | % | % | % | % | --------------------------------CWT/A-------------------------------- | | | | | | | |
| | | | | Con. | Inj. | Con. | Inj. | Con. | Inj. | Con. | Inj. | | | | | | | | |
| 1 | Untreated | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 63 | 66 | 63 | 64 | 118 | 407 | 374 |
| 2 | Reflex | 1 | pt/a | 86 | 6 | 95 | 2 | 93 | 2 | 96 | 0 | 41 | 55 | 89 | 67 | 63 | 122 | 437 | 396 |
| 3 | Reflex | 2 | pt/a | 93 | 9 | 97 | 6 | 97 | 2 | 94 | 0 | 46 | 62 | 84 | 70 | 65 | 115 | 443 | 397 |
| 4 | Dual Magnum | 1.33 | pt/a | 98 | 11 | 95 | 1 | 89 | 1 | 96 | 0 | 41 | 69 | 83 | 68 | 61 | 102 | 424 | 383 |
| 5 | Reflex | 1 | pt/a | 100 | 23 | 100 | 2 | 96 | 0 | 99 | 0 | 35 | 63 | 66 | 79 | 69 | 166 | 478 | 443 |
| | Dual Magnum | 1.33 | pt/a | | | | | | | | | | | | | | | | |
| 6 | Boundary | 2 | pt/a | 100 | 15 | 100 | 2 | 100 | 0 | 100 | 0 | 29 | 56 | 71 | 79 | 57 | 144 | 435 | 406 |
| 7 | Reflex | 0.5 | pt/a | 99 | 20 | 98 | 1 | 99 | 0 | 100 | 0 | 40 | 70 | 88 | 81 | 69 | 99 | 447 | 408 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| 8 | Reflex | 1 | pt/a | 100 | 23 | 100 | 3 | 100 | 0 | 100 | 0 | 38 | 47 | 63 | 71 | 62 | 147 | 427 | 389 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| 9 | Reflex | 2 | pt/a | 100 | 28 | 100 | 6 | 100 | 1 | 100 | 0 | 29 | 41 | 59 | 87 | 72 | 146 | 434 | 405 |
| | Boundary | 4 | pt/a | | | | | | | | | | | | | | | | |
| 10 | Sencor | 0.25 | lb/a | 100 | 11 | 100 | 2 | 100 | 0 | 100 | 0 | 34 | 63 | 79 | 82 | 66 | 133 | 457 | 423 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| 11 | Matrix | 1.5 | oz/a | 100 | 3 | 100 | 2 | 100 | 1 | 100 | 0 | 37 | 63 | 70 | 80 | 74 | 156 | 481 | 443 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| 12 | Sencor | 0.25 | lb/a | 100 | 24 | 100 | 4 | 100 | 1 | 100 | 0 | 31 | 56 | 75 | 64 | 76 | 137 | 440 | 409 |
| | Reflex | 1 | pt/a | | | | | | | | | | | | | | | | |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| 13 | Matrix | 1.5 | oz/a | 100 | 24 | 100 | 6 | 100 | 2 | 100 | 0 | 36 | 47 | 83 | 68 | 58 | 142 | 432 | 396 |
| | Reflex | 1 | pt/a | | | | | | | | | | | | | | | | |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | | | |
| LSD | (P=0.05) | | | 3 | 5 | 3 | 4 | 2 | 1 | 4 | NS | NS | 19 | 28 | NS | NS | NS | 65 | 68 |

Effect of herbicide treatments on common lambsquarters control, Dakota Pearl injury, and yield.

| No. | Name | Rate | Rate Unit | Colq ---6/22/09-- % Con. | % Inj. | Colq ---7/1/09--- % Con. | % Inj. | Colq --7/13/09--- % Con. | % Inj. | Colq ---8/13/09-- % Con. | % Inj. | <4oz | 4-6oz | 6-12oz | >12oz | Total | >4oz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | ------CWT/A------ | | | | | |
| 1 | Untreated | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 190 | 138 | 98 | 12 | 438 | 248 |
| 2 | Reflex | 1 | pt/a | 84 | 5 | 88 | 1 | 93 | 0 | 84 | 0 | 142 | 133 | 87 | 9 | 371 | 229 |
| 3 | Reflex | 2 | pt/a | 86 | 5 | 95 | 2 | 96 | 0 | 86 | 0 | 156 | 140 | 95 | 15 | 406 | 251 |
| 4 | Dual Magnum | 1.33 | pt/a | 86 | 1 | 91 | 0 | 89 | 0 | 85 | 0 | 165 | 135 | 96 | 19 | 415 | 250 |
| 5 | Reflex | 1 | pt/a | 98 | 5 | 100 | 2 | 98 | 0 | 99 | 0 | 139 | 151 | 124 | 27 | 441 | 302 |
| | Dual Magnum | 1.33 | pt/a | | | | | | | | | | | | | | |
| 6 | Boundary | 2 | pt/a | 100 | 0 | 100 | 0 | 99 | 0 | 100 | 0 | 181 | 135 | 93 | 16 | 426 | 244 |
| 7 | Reflex | 0.5 | pt/a | 100 | 5 | 100 | 1 | 99 | 0 | 99 | 0 | 159 | 138 | 98 | 20 | 415 | 257 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| 8 | Reflex | 1 | pt/a | 100 | 8 | 100 | 2 | 100 | 0 | 99 | 0 | 179 | 112 | 67 | 6 | 365 | 186 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| 9 | Reflex | 2 | pt/a | 100 | 16 | 100 | 4 | 99 | 0 | 100 | 0 | 138 | 125 | 118 | 25 | 407 | 269 |
| | Boundary | 4 | pt/a | | | | | | | | | | | | | | |
| 10 | Sencor | 0.25 | lb/a | 100 | 1 | 100 | 0 | 100 | 0 | 100 | 0 | 163 | 134 | 78 | 17 | 392 | 229 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| 11 | Matrix | 1.5 | oz/a | 99 | 1 | 100 | 0 | 100 | 0 | 100 | 0 | 169 | 123 | 75 | 12 | 380 | 211 |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| 12 | Sencor | 0.25 | lb/a | 100 | 9 | 100 | 3 | 100 | 0 | 100 | 0 | 153 | 125 | 105 | 10 | 393 | 240 |
| | Reflex | 1 | pt/a | | | | | | | | | | | | | | |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| 13 | Matrix | 1.5 | oz/a | 100 | 14 | 100 | 3 | 100 | 0 | 99 | 0 | 133 | 129 | 107 | 17 | 386 | 253 |
| | Reflex | 1 | pt/a | | | | | | | | | | | | | | |
| | Boundary | 2 | pt/a | | | | | | | | | | | | | | |
| LSD (P=0.05) | | | | 5 | 3 | 3 | 1 | 3 | NS | 6 | NS | 38 | NS | NS | NS | NS | 95 |

Use of saflufencil with multiple adjuvants as a desiccant on dryland potatoes. Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted at the Northern Plains Potato Growers Association non-irrigated research site near Grand Forks, ND to compare desiccation with saflufencil (BAS 800) when applied with different adjuvants. Red Norland seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on June 11, 2009. Plots were 4 rows by 25 ft arranged in a randomized complete block design with 4 replicates. Extension recommendations were used for cultural practices throughout the year. The desiccant treatments were applied to the middle 2 of 4 rows using a $CO_2$ backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 gpa and a pressure of 40 psi on August 31. Potatoes were harvested on October 13.

| Application Date: | 9/3/09 |
|---|---|
| Air Temperature (F): | 74 |
| Rel. Humidity (%): | 68 |
| Wind (mph): | 2 |
| Soil Moisture: | Adequate |
| Cloud Cover (%): | 5 |

Potato desiccation with saflufencil alone and tank mixed with adjuvants.

|  |  |  |  |  | -----9/8/09----- |  | ----9/10/09---- |  | ----9/14/09---- |  | ----9/17/09---- |  | Yield | Yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Rate |  | ----8 DAA---- |  | ---10 DAA--- |  | ---14 DAA--- |  | ---17 DAA--- |  | Row A | Row B |
| No. | Name | Rate | Unit | Code | Lvs | Stem | Lvs | Stem | Lvs | Stem | Lvs | Stem | cwt/A | cwt/A |
| 1 | BAS 800 | 2 | floz/a | A | 50c | 18b | 88b | 38b | 98a | 88b | 100a | 99a | 360a | 362a |
| 2 | BAS 800 | 2 | floz/a | A | 63b | 23a | 94a | 39b | 100a | 93ab | 100a | 100a | 417a | 389a |
|  | Class Act NG | 2.5 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
|  | InterLock | 2 | floz/a | A |  |  |  |  |  |  |  |  |  |  |
| 3 | BAS 800 | 2 | floz/a | A | 73ab | 28a | 96a | 51ab | 100a | 97a | 100a | 100a | 357a | 348a |
|  | Class Act NG | 2.5 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
|  | InterLock | 2 | floz/a | A |  |  |  |  |  |  |  |  |  |  |
|  | Destiny HC | 1 | pt/a | A |  |  |  |  |  |  |  |  |  |  |
| 4 | BAS 800 | 2 | floz/a | A | 70ab | 25a | 95a | 49ab | 100a | 94ab | 100a | 100a | 383a | 381a |
|  | Class Act NG | 2.5 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
|  | InterLock | 2 | floz/a | A |  |  |  |  |  |  |  |  |  |  |
|  | Superb HC | 1 | pt/a | A |  |  |  |  |  |  |  |  |  |  |
| 5 | BAS 800 | 2 | floz/a | A | 80a | 36a | 96a | 65a | 100a | 97a | 100a | 100a | 394a | 387a |
|  | NPAK AMS Liquid | 2.5 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
|  | Destiny (MSO) | 1 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
| 6 | BAS 800 | 2 | floz/a | A | 71ab | 28a | 96a | 55ab | 100a | 95ab | 100a | 100a | 409a | 371a |
|  | Class Act NG | 2.5 | %v/v | A |  |  |  |  |  |  |  |  |  |  |
|  | AG 07010 | 1 | pt/a | A |  |  |  |  |  |  |  |  |  |  |

Treatments were applied when plants were beginning to senescence. At 8 DAA the treatment with saflufencil alone (1) showed slower desiccation on both leaves and stems than treatments tank mixed with adjuvants. Saflufencil + NPAK AMS Liquid + Destiny (MSO) (treatment 5) had the highest percentage of desiccation during each rating. By trials end (17 DAA) leaves on all treatments had 100% desiccation and all stems had 100% desiccation except saflufencil alone, which had 99%. Total yield was not significantly different.

Use of saflufencil with multiple adjuvants as a desiccant on dryland potatoes - Glyndon. Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted north of Glyndon, MN to compare desiccation with saflufencil (BAS 800) when applied with different adjuvants. Red Norland seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on June 10, 2009. Plots were 4 rows by 30 feet arranged in a randomized complete block design with 3 replicates. The treatments were applied to the middle 2 of 4 rows using a CO2 backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 gpa and a pressure of 40 psi on September 2.

| Application Date: | 9/2/09 | | |
|---|---|---|---|
| Air Temperature (F): | 79 | Wind (mph): | 7 |
| Rel. Humidity (%): | 49 | Soil Moisture: | Adequate |
| Cloud Cover (%): | 50 | | |

Treatments were applied when plants were beginning to senescence. At 3 DAA the treatment with saflufencil alone (1) was significantly slower desiccating than the other treatments showing only 5% leaf necrosis while the treatment with Reglone (12) showed 60%. Saflufencil + Class Act NG + InterLock (treatment 2) and the addition of Superb HC (treatment 5) had slower desiccation than replacing Superb HC with AG 08047 (treatment 10) at 3 DAA. At 9 DAA, the Reglone treatment had 95% leaf necrosis, but this was not significant against any of the other treatments except for treatment 1 where saflufencil was applied alone. By the end of the trial, all treatments had at least 98% leaf necrosis and at least 97% stem necrosis, except for the saflufencil alone treatment with only 88%.

Potato desiccation with saflufencil alone and tank mixed with adjuvants.

| | | | | -----9/5/09----- | | ----9/11/09---- | | ----9/16/09---- | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Rate | ----3 DAA---- | | ----9 DAA---- | | ----14 DAA---- | |
| No. | Name | Rate | Unit | Leaves | Stems | Leaves | Stems | Leaves | Stems |
| 1 | BAS 800 | 2 | floz/a | 5cd | 0b | 33b | 10de | 99a | 88b |
| 2 | BAS 800 | 2 | floz/a | 18bc | 8b | 77a | 23bcd | 100a | 98a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | InterLock | 2 | floz/a | | | | | | |
| 3 | BAS 800 | 2 | floz/a | 23b | 7b | 82a | 18cd | 98a | 98a |
| | NPAK AMS Liquid | 2.5 | %v/v | | | | | | |
| | AG 06011 | 6 | floz/a | | | | | | |
| 4 | BAS 800 | 2 | floz/a | 28b | 15b | 87a | 33bc | 100a | 100a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | InterLock | 2 | floz/a | | | | | | |
| | Destiny HC | 1 | pt/a | | | | | | |
| 5 | BAS 800 | 2 | pt/a | 17bc | 6b | 75a | 18cd | 100a | 97a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | InterLock | 2 | floz/a | | | | | | |
| | Superb HC | 1 | pt/a | | | | | | |
| 6 | BAS 800 | 2 | floz/a | 28b | 13b | 87a | 27bcd | 100a | 98a |
| | NPAK AMS Liquid | 2.5 | %v/v | | | | | | |
| | Destiny (MSO) | 1 | %v/v | | | | | | |
| 7 | BAS 800 | 2 | floz/a | 25b | 13b | 80a | 33bc | 100a | 98a |
| | AG 07043 | 1 | %v/v | | | | | | |
| 8 | BAS 800 | 2 | floz/a | 33b | 15b | 87a | 42b | 100a | 100a |
| | NPAK AMS Liquid | 2.5 | %v/v | | | | | | |
| | Prime Oil | 1 | %v/v | | | | | | |
| 9 | BAS 800 | 2 | floz/a | 30b | 12b | 82a | 28bcd | 100a | 100a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | AG 07010 | 1 | pt/a | | | | | | |
| 10 | BAS 800 | 2 | floz/a | 35b | 15b | 87a | 35bc | 100a | 100a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | InterLock | 2 | floz/a | | | | | | |
| | AG 08047 | 1 | pt/a | | | | | | |
| 11 | BAS 800 | 2 | floz/a | 32b | 17b | 87a | 43b | 100a | 98a |
| | Class Act NG | 2.5 | %v/v | | | | | | |
| | AG 08050 | 0.5 | %v/v | | | | | | |
| 12 | Reglone | 2 | pt/a | 60a | 37a | 95a | 65a | 100a | 100a |
| | AdWet | 1 | pt/100gal | | | | | | |
| 13 | Unterated | | | 0d | 0b | 0c | 0e | 0b | 0c |

# Cultivar specific management profiles for red and yellow potato varieties grown in North Dakota and Minnesota

## Irrigated Variety Trial
## Becker, MN 2009

**Dr. Nick David**
**Potato Agronomist**
**NDSU/UM**

# Cultivar specific management profiles for red and yellow potato varieties grown in North Dakota and Minnesota – Irrigated Site

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## Summary

Forty-eight red and yellow potato varieties were grown at the Sand Plains Research Center near Becker, MN to determine their potential to provide high-quality fresh market potatoes following an early and a late harvest date. Total yields were 274 – 634 and 347 – 834 cwt/acre for the early and late harvest dates, respectively. The highest yielding red-skin, white-flesh entry was Red LaSoda, which produced 634 and 704 cwt/acre when harvested early and late, respectively. The highest yielding red-skin, yellow-flesh entry was AC9751-1RY, which produced 581 and 849 cwt/acre when harvested early and late, respectively. Finally, the highest yielding yellow-skin, yellow-flesh entry was VC1009-1WY, which produced 552 and 834 cwt/acre when harvested early and late, respectively. Summaries and tuber pictures for each market class can be found at the end of the report.

## *Introduction:*

One of the goals of the extension potato agronomy program at North Dakota State University and the University of Minnesota is to provide growers with research-based information that can be used to make well informed production decisions. The objective of this project was to evaluate advanced breeding clones and recently-released fresh-market potato varieties grown in the irrigated sands of central Minnesota. Entries were evaluated for stand emergence, early season vigor, total yield, tuber size profile, specific gravity, tuber length: width ratio, hollow-heart, skin color, and flesh color. The following report describes how the trial was performed and the results gathered.

## *General Materials and Methods:*

This study was conducted at the Sand Plain Research Farm in Becker, MN on a Hubbard loamy sand soil.

**Fertility and Irrigation** - A pre-plant, broadcast application of 54N- 138P- 205K was applied on 13 and 14 of April and then incorporated using a plow on 14 and 15 of April. Gypsum was applied at a rate of 950 lb/acre and incorporated during the first hilling operation on 4 May. Additional nitrogen applications of 97 and 194 lb/acre were applied to the early and late harvest blocks, respectively. Total nitrogen applied during 2009 was 151 and 248 lb/acre on the early and late harvest blocks, respectively. Solid-set irrigation applied 11 and 14” of water to the early and late harvest blocks, respectively.

**Pest management** - Pink rot (*Phytopthora erythroseptica*) was controlled by applying 12.0 oz/acre of Ultra-Flourish in-furrow at planting. Silver scurf (*Helminthisporium solani)* and *Rhizoctonia* solani were controlled by applying Maxim MZ to the cut seed and an in-furrow application of 8 oz/acre of Quadris. inear ft row Ridomil Gold EC (mefenoxam). Early season Colorado potato beetle and aphid control was achieved with an in-furrow application of 8 oz/acre of Admire Pro (imidacloprid). Following the initial cultivation on 4 May, weeds were controlled with 1.75 pt/acre Dual II Magnum (metolachlor), and 0.50 lb/acre Sencor DF. Early and Late blight were controlled with alternating applications of Dithane (mancozeb) and Bravo (chlorothalonil) on a weekly schedule.

## *Treatment Materials and Methods*

**Plot design, planting, and harvest** – Treatments (potato variety) were assigned in a randomized complete block design with four replications. Individual plots were 1 potato rows (3') wide x 20 pieces (15') long. Certified potato seed of all varieties tested (Figures 1 – 12) were hand cut into 2-2.5 ounce pieces on 22 April, treated with Maxim MZ, and suberized for 7 days at 50°F and 95% relative humidity. Plots were planted on 29 April with a 2-row, assist-feed Harriston planter. Vines were dessicated with 1 quart/acre applications of Reglone on 29 July & 5 August and 29 August & 2 September on the early and late blocks, respectively. Vines were mechanically flailed on 13 August and 11 September on the early and late blocks, respectively, and harvested with a single-row Grimme harvester on 18 August and 14 September.

**Stand and Vigor Evaluations –** Emerged plants were counted 28 and 41 DAP to determine how rapidly each variety emerged. Additionally, each plot was rated on a scale of 1 – 3 41 DAP to determine early season vigor. Plants less than six, six – twelve, and greater than twelve inches tall were given scores of 1, 2, and 3, respectively.

**Yield and size class Evaluations** – Following harvest, all potatoes were transported to the USDA Potato Worksite in East Grand Forks, MN and sized using a Kerrian sizer into the following size classes (C = < 1 7/8", B – 1 7/8 – 2 1/4 , A = 2 1/4 - 3 1/2, Premium = 3 1/2 -4, and Jumbo = > 4inches). Weights of individual plots were recorded and converted to yield (hundred-weight/acre).

**Specific Gravity evaluations** –The specific gravity is the amount of solids in tubers. As specific gravity values become higher, the percent solids increase and the percent water decrease. When prepared by baking, boiling, or microwaving, tubers with lower gravities are often referred to as "moist" or "waxy", while tubers with higher gravities are "dry" or "mealy". Following sizing, a subsample of ten tubers from each replicate was evaluated for specific gravity using the weight in air/weight in water method [Weight in air/(Weight in air - Weight in water)].

**Length: Width ratio –** The length: width (L:W) ratio is a way of describing the overall shape of potato tubers. Tubers with a L:W ratio of 1.0 are round, while those greater than 2.0 are long. As the ratio increases abovee 1.0, tubers are described as round, blocky, oblong, and finally long. Following sizing, a subsample of ten tubers from each replicate was measured parallel and perpendicular to the bud/stem axis to determine the L:W ratio.

**Hollow Heart Evaluations** – Following sizing, a subsample of ten tubers from all size classes was cut and the incidence of any hollow heart was recorded.

**Skin and Flesh Color Evaluations –** Following sizing, a subsample of ten tubers from each replicate was evaluated for skin lightness/darkness, skin color, flesh lightness/darkness, and flesh color. While color is often evaluated on a visual scale from 1 – 5, this method is subjective and results may be influenced by the evaluator. Skin and flesh color was evaluated objectively using a Konica/Minolta colorimeter, which measures how light/dark (L*), red/green (a*), and yellow/blue (b*) a sample is. Two areas free from blemish from each tuber were used to evaluate skin color, while two readings (stem and bud end) were used to evaluate flesh color. The results can be interpreted in the following manner: A higher L* value indicates a lighter (more white) sample, while a lower L* value indicates a darker (more black) sample. Furthermore, a higher a* value is the result of a more red sample, and a lower a* value is less red. Finally, a higher b* value indicates a more yellow sample, and a lower b* indicates a less yellow sample. The greater the L*, the lighter the sample; the greater the a* value, the more red the sample is, and the greater the b* value, the more yellow the sample is.

**Statistical analysis** – Analysis of variance was performed using PROC GLM in SAS v.9.3 and when significant, means were separated using least significant differences.

## *Results of Early harvest trial (108 days after planting)*

### Red-Skin, White-Flesh Varieites

Twenty-four varieties and advanced breeding selections with red-skin and white-flesh were evaluated during 2009. Analysis of variance indicates that significant differences existed between varieties in total yield and size profile (Table 1), specific gravity and length: width ratio (Table 2), and skin and flesh color (Table 3). Depending upon variety, total yield potential varied from 274 – 634 cwt/acre in 2009.

- Red LaSoda had a significantly higher yield than Red Norland (463 cwt/a), while CO99076-6R, ND5002-3R, Sangre, and Sangre 11 had lower yields than Red Norland.
- Red LaSoda was the only variety to produce a higher percentage of A size tubers than Red Norland (87%), while A.C. Peregrine, CO98012-5R, CO99256-2R, Colorado Rose, Modoc, ND2225-1R, ND5002-3R, ND8555-8R, and Rio Colorado produced a lower percentage of A size.
- The specific gravity of Colorado Rose, CO99076-6R, ND8555-8R, and Dakota Jewel was higher than that of Red Norland (1.074).
- Rio Colorado, Dakota Rose, ND2225-1R, AND00272-1R, and Viking were more oblong than Red Norland (L:W = 1.23), while Dark Red Norland, ND5002-3R, CO98012-5R, CO99076-6R, Dakota Jewel, Red LaSoda, Red LaSoda(NY), ND8555-8R, NDTX4271-5R, and ND4659-5R were more round than Red Norland.
- Dakota Jewel, ND5002-3R, AND00272-1R, Dakota Rose, Rio Colorado, ND8555-8R, CO98012-5R, CO99256-2R, NDTX4271-5R, and CO99076-6R all had darker skin than Red Norland (L*=40.04).
- The skin color of ND8555-8R was more red than Red Norland (a* = 12.98), while that of Colorado Rose, NDTX4271-5R, Sangre 11, Dark Red Norland, Viking, A.C. Peregrine, ND5002-3R, and ND2225-1R was less red than Red Norland.

**Red/Yellow-Skin, Yellow Flesh Varieties**

Twenty four varieties and advanced breeding selections with red-skin or yellow-skin and yellow-flesh were evaluated during 2009. Analysis of variance indicated that significant differences existed between varieties in total yield and size profile (Table 4), specific gravity and L:W ratio (Table 5) and skin and flesh color (Table 6). Total yield varied from 361 – 581 cwt/a. and from 266 – 552 cwt/a. for red-skin, yellow-flesh, and yellow-skin, yellow-flesh varieties, respectively.

- AC97521-1RY had the highest yield potential, while MN96013-1RY had the lowest yield potential of the red-skin,yellow-flesh entries.
- VC1009-1W/Y, Yukon Gem, MN99380, Elfe, Molli, MIlva, Zebra, and MN02589 had significantly higher yield potential than Yukon Gold (381 cwt/a.), while Zeus and Satina had lower yield potential.

- MN19298 produced the highest percentage of A size tubers in the red-skin, yellow-flesh category, while AC97521-1RY produced the lowest.
- All yellow-skin, yellow -flesh entries produced a fewer percentage of A size tubers compared to Yukon Gold (81%) with the exception of MN99380 and Satina, which were both equal to Yukon Gold.

- AC9751-1RY produced the highest percentage of B size tubers in the red-skin, yellow-flesh category, while MN19298 produced the lowest.
- All yellow-skin, yellow-flesh entries produced a higher percentage of B size tubers compared to Yukon Gold (13%)except Satina, MN99380, and Marilyn.

- MN02616 was the most oblong, while MN19298 was the most round red-skin, yellow-flesh entry.
- All yellow-skin, yellow-flesh entries were more oblong than Yukon Gold (L:W = 1.10) except Satina, Yellow Finn, MN02589, Zeus, MN99380-1WY, and MN02588.

- MN96013-1RY and MN02616 had the darkest skin color of the red-skin, yellow-flesh entries.
- MN19298 had the reddest skin color of the red-skin, yellow-flesh entries.

- CO97232-2RY had the darkest flesh of the red-skin, yellow-flesh entries.
- All yellow-skin, yellow flesh entries had a darker flesh color than Yukon Gold (L* = 62.76).

- The flesh color of MN96013-1RY, MN02616RY, and AC97521-1RY was the most yellow of the red-skin, yellow flesh entries.
- The flesh color of Satina and Elfe was more yellow than Yukon Gold (b* = 19.76), while the flesh color of MN02589, Ambra, Yukon Gem, Marilyn, Zeus, Tara, Zebra, and MN02588 was less yellow than Yukon Gold.

## *Results of Late harvest trial (135 days after planting)*

### Red-Skin, White-Flesh Varieties

Twenty-four varieties and advanced breeding selections with red-skin and white-flesh were evaluated during 2009. Analysis of variance indicates that significant differences existed between varieties in total yield and size profile (Table 7) and specific gravity and length: width ratio (Table 8). Depending upon variety, total yield potential varied from 441–704 cwt/acre in 2009.

- Red LaSoda, Colorado Rose, Viking, and Red LaSoda(NY) all had a significantly higher yield potential than Red Norland(493 cwt/a).
- No variety produced a higher percentage of A size than Red Norland (59%), but CO98012-5R and ND2225-1R produced a lower percentage.
- CO98012-5R, ND8555-8R, ND2225-1R, and A.C. Peregrine produced a higher percentage of B size than Red Norland (27%), while Dark Red Norland, ND4659-5R, ND5002-3R, Dakota Rose, NDTX4271-5R, Dakota Jewel, Sangre, Winema, Red LaSoda, Sangre 11, Red LaSoda(NY), and Viking produced a lower percentage of B size than Red Norland.
- Dakota Rose was more oblong than Red Norland (L:W = 1.35), while Colorado Rose, Dark Red Norland, Sangre, Modoc, Winema, CO9956-2R, A.C. Peregrine, AO93487-2R, ND5002-3R, Red LaSoda, CO98012-5R, CO99076-6R, Red LaSoda(NY), ND8555-8R, Dakota Jewel, NDTX4271-5R, and ND4659-5R were more round than Red Norland.
- All varieties exept AND00272-1R, Dark Red Norland, Modoc, Dakota Rose, AO93487-2R, ND2225-1R, and Winema had a higher specific gravity than Red Norland (1.063).

### Red/Yellow-Skin, Yellow Flesh Varieties

Twenty four varieties and advanced breeding selections with red-skin or yellow-skin and yellow-flesh were evaluated during 2009. Analysis of variance indicated that significant differences existed between varieties in total yield and size profile (Table 9) and specific gravity and L:W ratio (Table 10). Total yield ranged from 371 – 849 cwt/a. and from 347 – 834 cwt/a. for red-skin, yellow-flesh, and yellow-skin, yellow-flesh varieties, respectively.

- AC97521-1RY had the highest yield potential, while MN96013-1RY had the lowest yield potential of the red-skin,yellow-flesh entries.
- VC1009-1W/Y, Yukon Gem, Milva, Tara, Molli, Sylvana, Elfe, MN99380-1, and Zebra had a higher yield potential than Yukon Gold (484 cwt/a.), while Satina had a lower yield potential.

- AC97521-1RY and CO97232-2RY produced the lowest percentage of A size tubers in the red-skin, yellow-flesh category.
- Yukon Gem and MN99380-1 produced a higher percentage of A size tubers compared to Yukon Gold (53%), while Tara, VC1009-1W/Y, German Butterball, Zeus, Yellow Finn, Zebra, and Marilyn produced a lower percentage of A size tubers.

- CO97232-2RY and AC9751-1RY produced the highest percentage of B size tubers in the red-skin, yellow-flesh category, while MN96013-1 produced the lowest.

- All yellow-skin, yellow-flesh entries produced a higher percentage of B size tubers compared to Yukon Gold (14%) except MN99380-1, and Marilyn.

- AC97521-1RY and MN02616 were the most oblong, while MN19298 was the most round red-skin, yellow-flesh entry.
- Marilyn, Milva, Ambra, German Butterball, Elfe, Tara, VC1009-1W/Y, and Zeus were more oblong than Yukon Gold (L:W = 1.21), while MN99380-1WY and MN02588 were more round.

Table 1. Total Yield and Tuber Size Profile of 24 Red-Skin, White-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| | | | **Yield** | | |
|---|---|---|---|---|---|
| **Variety** | **Total** *(cwt/a)* | **Premium**[1] *(%)* | **A size**[2] *(%)* | **B size**[3] *(%)* | **C size**[4] *(%)* |
| A.C. Peregrine | 429 | 0 | 58 | 35 | 7 |
| AND00272-1R | 465 | 0 | 67 | 25 | 7 |
| AO93487-2R | 467 | 0 | 74 | 21 | 5 |
| CO98012-5R | 480 | 0 | 40 | 41 | 18 |
| CO99076-6R | 378 | 0 | 73 | 21 | 7 |
| CO99256-2R | 395 | 0 | 26 | 50 | 24 |
| Colorado Rose | 540 | 0 | 65 | 26 | 9 |
| Dakota Jewel | 431 | 0 | 73 | 20 | 7 |
| Dakota Rose | 446 | 1 | 78 | 18 | 3 |
| Dark Red Norland | 460 | 0 | 82 | 14 | 4 |
| Modoc | 441 | 0 | 61 | 30 | 8 |
| ND 2225-1R | 448 | 0 | 28 | 47 | 25 |
| ND4659-5R | 390 | 3 | 82 | 12 | 4 |
| ND5002-3R | 293 | 1 | 53 | 36 | 10 |
| ND8555-8R | 425 | 0 | 43 | 43 | 14 |
| NDTX4271-5R | 388 | 2 | 82 | 11 | 5 |
| Red LaSoda | 634 | 2 | 84 | 13 | 1 |
| Red LaSoda(NY) | 505 | 5 | 87 | 6 | 1 |
| Red Norland | 463 | 0 | 76 | 19 | 5 |
| Rio Colorado | 417 | 0 | 42 | 44 | 14 |
| Sangre | 383 | 1 | 82 | 14 | 3 |
| Sangre 11 | 274 | 3 | 78 | 14 | 4 |
| Viking | 453 | 6 | 86 | 6 | 2 |
| Winema | 461 | 6 | 79 | 11 | 4 |
| *LSD α =0.10* | *78*[5] | *3* | *11* | *9* | *8* |

Plots were planted on 29 April and harvested on 18 August, 2009.

[1]Premium = >3 ½", [2]A size = 2 ¼ - 3 ½", [3]B size = 1 7/8 - 2 ¼", [4]C size = < 1 7/8"

[5]Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 2. Early-season vigor, Specific gravity, Length:width ratio, and Hollow heart of 24 Red-Skin, White-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| Variety | Early Season Vigor[1] | Specific Gravity[2] | L:W Ratio[3] | Hollow Heart[4] |
|---|---|---|---|---|
| A.C. Peregrine | 2.0 | 1.076 | 1.21 | 0 |
| AND00272-1R | 1.9 | 1.070 | 1.31 | 0 |
| AO93487-2R | 1.4 | 1.063 | 1.26 | 0 |
| CO98012-5R | 2.3 | 1.076 | 1.14 | 0 |
| CO99076-6R | 1.9 | 1.083 | 1.09 | 0 |
| CO99256-2R | 1.9 | 1.071 | 1.27 | 0 |
| Colorado Rose | 1.9 | 1.084 | 1.22 | 0 |
| Dakota Jewel | 1.9 | 1.082 | 1.06 | 0 |
| Dakota Rose | 1.8 | 1.071 | 1.38 | 0 |
| Dark Red Norland | 2.6 | 1.071 | 1.17 | 0 |
| Modoc | 1.6 | 1.072 | 1.25 | 0 |
| ND 2225-1R | 2.0 | 1.073 | 1.35 | 0 |
| ND4659-5R | 2.0 | 1.075 | 0.98 | 0 |
| ND5002-3R | 1.9 | 1.072 | 1.17 | 0 |
| ND8555-8R | 1.3 | 1.083 | 1.05 | 0 |
| NDTX4271-5R | 1.6 | 1.069 | 1.04 | 0 |
| Red LaSoda | 1.9 | 1.080 | 1.05 | 0 |
| Red LaSoda(NY) | 1.8 | 1.074 | 1.05 | 0 |
| Red Norland | 2.5 | 1.074 | 1.23 | 0 |
| Rio Colorado | 1.9 | 1.076 | 1.39 | 0 |
| Sangre | 1.0 | 1.070 | 1.22 | 0 |
| Sangre 11 | 1.0 | 1.063 | 1.22 | 0 |
| Viking | 1.9 | 1.080 | 1.29 | 0 |
| Winema | 1.8 | 1.074 | 1.18 | 0 |
| *LSD α = 0.10* | | *0.007*[5] | *0.06* | *ns*[6] |

Plots were planted on 29 April and harvested on 18 August, 2009.

[1] Early Season Vigor (1 = <6", 2 = 6-12", 3 = >12"); [2] Specific gravity = [Weight in air/(Weight in air - Weight in water)]

[3] L:W ratio = Length/Width of tuber (1.0 = round); [4] 40 tubers were cut to evaluate for hollow heart

[5] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

[6] Values within a column with a LSD value of ns are not significantly different.

Table 3. Skin and Flesh Color Readings of 24 Red-Skin, White-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| | Skin Color[1] | | | Flesh Color[1] | | |
|---|---|---|---|---|---|---|
| **Variety** | **L*** | **a*** | **b*** | **L*** | **a*** | **b*** |
| A.C. Peregrine | 38.13 | 10.41 | 6.15 | 60.18 | -0.86 | 10.46 |
| AND00272-1R | 37.23 | 14.28 | 5.71 | 63.72 | -0.97 | 11.72 |
| AO93487-2R | 38.22 | 13.64 | 6.46 | 61.13 | -1.47 | 12.13 |
| CO98012-5R | 36.41 | 12.12 | 4.83 | 60.34 | -0.74 | 10.29 |
| CO99076-6R | 35.16 | 13.48 | 4.82 | 61.09 | -0.78 | 11.24 |
| CO99256-2R | 36.04 | 12.45 | 5.21 | 57.94 | -0.70 | 10.54 |
| Colorado Rose | 38.52 | 11.42 | 6.39 | 63.66 | -0.94 | 11.79 |
| Dakota Jewel | 37.60 | 11.72 | 5.86 | 61.14 | -0.75 | 11.57 |
| Dakota Rose | 37.02 | 13.27 | 5.80 | 62.24 | -0.89 | 10.27 |
| Dark Red Norland | 37.87 | 11.04 | 6.23 | 62.70 | -1.15 | 12.14 |
| Modoc | 38.20 | 11.81 | 6.06 | 59.07 | -0.95 | 10.27 |
| ND 2225-1R | 38.57 | 9.13 | 6.44 | 57.09 | -0.82 | 10.31 |
| ND4659-5R | 38.64 | 11.72 | 5.92 | 63.64 | -0.87 | 10.61 |
| ND5002-3R | 37.54 | 10.32 | 6.40 | 60.61 | -0.99 | 11.09 |
| ND8555-8R | 36.42 | 14.53 | 5.24 | 64.00 | -1.06 | 11.78 |
| NDTX4271-5R | 35.83 | 11.27 | 5.30 | 62.63 | -0.74 | 11.21 |
| Red LaSoda | 40.57 | 11.86 | 7.83 | 63.25 | -1.00 | 12.35 |
| Red LaSoda(NY) | 40.24 | 11.64 | 7.68 | 63.01 | -1.07 | 11.67 |
| Red Norland | 40.04 | 12.98 | 6.36 | 63.26 | -1.21 | 11.58 |
| Rio Colorado | 36.50 | 13.59 | 5.31 | 61.51 | -0.65 | 11.25 |
| Sangre | 38.17 | 11.86 | 6.16 | 62.04 | -0.52 | 10.80 |
| Sangre 11 | 38.41 | 11.05 | 6.29 | 62.59 | -0.73 | 10.75 |
| Viking | 40.67 | 10.68 | 7.18 | 62.27 | -0.70 | 10.30 |
| Winema | 38.12 | 13.00 | 5.97 | 59.64 | -0.93 | 10.45 |
| *LSD α = X* | *1.26*[2] | *1.46* | *0.32* | *1.73* | *0.21* | *0.66* |

Plots were planted on 29 April and harvested on 18 August, 2009.

[1] Quantitative skin and flesh color evaluations. L* 0 = black and L* 100 = white; a* is the postion between red and green; b* is the position between yellow and blue. The greater the L*, the lighter the sample; the greater the a* value, the more red the sample is, and the greater the b* value, the more yellow the sample is.

[2] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 4. Total Yield and Tuber Size Profile of 24 Red/Yellow-Skin, Yellow-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| | | | **Yield** | | |
|---|---|---|---|---|---|
| **Variety** | **Total** *(cwt/a)* | **Premium**[1] *(%)* | **A size**[2] *(%)* | **B size**[3] *(%)* | **C size**[4] *(%)* |
| AC97521-1R/Y | 581 | 0 | 30 | 47 | 23 |
| ATND98459-1RY | 507 | 0 | 52 | 33 | 15 |
| CO97232-2R/Y | 480 | 0 | 47 | 43 | 11 |
| MN 02 616 R/Y | 461 | 0 | 51 | 37 | 12 |
| MN 19298 R/Y | 486 | 0 | 67 | 26 | 7 |
| MN 96013-1 R/Y | 361 | 0 | 66 | 27 | 8 |
| MN 02 589 W/Y | 463 | 0 | 44 | 40 | 17 |
| VC1009-1W/Y | 552 | 0 | 34 | 46 | 20 |
| MN 02 588 W/W | 392 | 0 | 55 | 33 | 12 |
| Ambra | 400 | 0 | 55 | 33 | 12 |
| Elfe | 504 | 0 | 51 | 40 | 9 |
| German Butterball | 378 | 0 | 2 | 33 | 65 |
| Marilyn | 445 | 0 | 0 | 14 | 86 |
| Milva | 493 | 0 | 52 | 36 | 12 |
| MN 99380-1 W/Y | 513 | 1 | 71 | 22 | 6 |
| Molli | 499 | 0 | 48 | 37 | 15 |
| Satina | 266 | 0 | 67 | 22 | 10 |
| Sylvana | 444 | 0 | 42 | 43 | 16 |
| Tara | 432 | 0 | 49 | 38 | 13 |
| Yellow Finn | 379 | 0 | 49 | 34 | 17 |
| Yukon Gem | 515 | 0 | 63 | 30 | 7 |
| Yukon Gold | 381 | 1 | 81 | 13 | 5 |
| Zebra | 479 | 0 | 22 | 39 | 39 |
| Zeus | 291 | 0 | 9 | 52 | 39 |
| *LSD α = 0.10* | *72*[5] | *ns*[6] | *16* | *10* | *7* |

Plots were planted on 29 April and harvested on 18 August, 2009.

[1]Premium = >3 ½”, [2]A size = 2 ¼ - 3 ½”, [3]B size = 1 7/8 - 2 ¼”, [4]C size = < 1 7/8”

[5]Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

[6] Values within a column with a LSD value of ns are not significantly different.

Table 5. Early-season vigor, Specific gravity, Length:width ratio, and Hollow heart of 24 Red/Yellow Skin, Yellow-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| Variety | Early Season Vigor[1] | Specific Gravity[2] | L:W Ratio[3] | Hollow Heart[4] |
|---|---|---|---|---|
| AC97521-1R/Y | 3 | 1.084 | 1.30 | 0 |
| ATND98459-1RY | 2 | 1.077 | 1.09 | 0 |
| CO97232-2R/Y | 3 | 1.068 | 1.20 | 0 |
| MN 02 616 R/Y | 3 | 1.083 | 1.35 | 0 |
| MN 19298 R/Y | 3 | 1.077 | 1.01 | 0 |
| MN 96013-1 R/Y | 2 | 1.077 | 1.21 | 0 |
| MN 02 589 W/Y | 3 | 1.088 | 1.09 | 0 |
| VC1009-1W/Y | 3 | 1.078 | 1.28 | 0 |
| MN 02 588 W/W | 3 | 1.078 | 0.98 | 0 |
| Ambra | 2 | 1.067 | 1.47 | 0 |
| Elfe | 2 | 1.073 | 1.48 | 0 |
| German Butterball | 2 | 1.073 | 1.39 | 0 |
| Marilyn | 2 | 1.065 | 2.04 | 0 |
| Milva | 2 | 1.067 | 1.48 | 0 |
| MN 99380-1 W/Y | 3 | 1.083 | 1.09 | 0 |
| Molli | 2 | 1.069 | 1.86 | 0 |
| Satina | 2 | 1.062 | 1.13 | 0 |
| Sylvana | 2 | 1.067 | 1.29 | 0 |
| Tara | 2 | 1.075 | 1.20 | 0 |
| Yellow Finn | 3 | 1.078 | 1.11 | 0 |
| Yukon Gem | 3 | 1.080 | 1.27 | 0 |
| Yukon Gold | 2 | 1.079 | 1.10 | 0 |
| Zebra | 2 | 1.082 | 1.20 | 0 |
| Zeus | 2 | 1.074 | 1.09 | 0 |
| *LSD α = 0.10* |  | *0.010*[5] | *0.09* | *ns*[6] |

Plots were planted on 29 April and harvested on 18 August, 2009.
[1] Early Season Vigor (1 = <6”, 2 = 6-12”, 3 = >12”); [2] Specific gravity = [Weight in air/(Weight in air - Weight in water)]
[3] L:W ratio = Length/Width of tuber (1.0 = round); [4] 40 tubers were cut to evaluate for hollow heart
[5] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.
[6] Values within a column with a LSD value of ns are not significantly different.

## Table 6. Skin and Flesh Color Readings of 24 Red/Yellow Skin, Yellow-Flesh Varieties harvested 108 Days after Planting grown near Becker, MN during 2009.

| | Skin Color[1] | | | Flesh Color[1] | | |
|---|---|---|---|---|---|---|
| **Variety** | **L*** | **a*** | **b*** | **L*** | **a*** | **b*** |
| AC97521-1R/Y | 40.20 | 10.81 | 8.09 | 58.99 | -3.14 | 19.96 |
| ATND98459-1RY | 41.45 | 10.85 | 7.76 | 58.73 | -2.84 | 18.18 |
| CO97232-2R/Y | 42.39 | 9.84 | 8.27 | 53.97 | -2.00 | 15.90 |
| MN 02 616 R/Y | 36.92 | 10.80 | 6.71 | 59.68 | -3.15 | 20.04 |
| MN 19298 R/Y | 41.19 | 11.89 | 7.72 | 62.35 | -3.48 | 18.87 |
| MN 96013-1 R/Y | 37.92 | 10.79 | 6.69 | 61.65 | -2.62 | 20.70 |
| MN 02 589 W/Y | 51.41 | 3.66 | 15.83 | 58.96 | -1.81 | 11.90 |
| VC1009-1W/Y | 50.16 | 3.75 | 15.49 | 59.71 | -2.48 | 18.53 |
| MN 02 588 W/W | 54.29 | 3.51 | 15.83 | 61.12 | -0.93 | 19.95 |
| Ambra | 53.68 | 2.36 | 16.00 | 57.74 | -2.73 | 20.42 |
| Elfe | 52.49 | 3.22 | 16.14 | 59.17 | -3.01 | 18.52 |
| German Butterball | 49.01 | 3.78 | 14.78 | 59.65 | -3.08 | 21.25 |
| Marilyn | 49.26 | 3.04 | 14.28 | 57.87 | -2.30 | 20.45 |
| Milva | 52.64 | 2.78 | 15.57 | 56.71 | -3.11 | 17.45 |
| MN 99380-1 W/Y | 53.00 | 3.30 | 17.19 | 60.21 | -2.88 | 19.09 |
| Molli | 51.98 | 3.31 | 15.60 | 59.74 | -3.57 | 19.41 |
| Satina | 52.05 | 3.48 | 16.26 | 60.93 | -2.92 | 20.75 |
| Sylvana | 56.33 | 2.39 | 17.50 | 60.94 | -2.80 | 19.45 |
| Tara | 49.28 | 3.46 | 14.40 | 58.93 | -2.46 | 16.75 |
| Yellow Finn | 50.00 | 3.48 | 15.06 | 59.70 | -2.71 | 20.31 |
| Yukon Gem | 50.21 | 4.06 | 14.81 | 59.09 | -2.43 | 17.51 |
| Yukon Gold | 51.36 | 4.12 | 15.83 | 62.76 | -3.06 | 19.76 |
| Zebra | 50.43 | 3.38 | 15.76 | 60.05 | -2.44 | 15.71 |
| Zeus | 49.23 | 3.51 | 14.47 | 58.16 | -2.31 | 17.25 |
| *LSD α = 0.10* | *2.68*[2] | *0.37* | *1.24* | *1.61* | *0.24* | *0.86* |

Plots were planted on 29 April and harvested on 18 August, 2009.

[1] Quantitative skin and flesh color evaluations. L* 0 = black and L* 100 = white; a* is the postion between red and green; b* is the position between yellow and blue. The greater the L*, the lighter the sample; the greater the a* value, the more red the sample is, and the greater the b* value, the more yellow the sample is.

[2] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 7. Total Yield and Tuber Size Profile of 24 Red-Skin, White-Flesh Varieties harvested 135 Days after Planting grown near Becker, MN during 2009.

| | | | Yield | | |
|---|---|---|---|---|---|
| **Variety** | **Total** ***(cwt/a)*** | **Premium[1]** ***(%)*** | **A size[2]** ***(%)*** | **B size[3]** ***(%)*** | **C size[4]** ***(%)*** |
| A.C. Peregrine | 521 | 1 | 49 | 36 | 13 |
| AND00272-1R | 530 | 1 | 60 | 28 | 11 |
| AO93487-2R | 549 | 6 | 63 | 25 | 6 |
| CO98012-5R | 541 | 1 | 32 | 44 | 23 |
| CO99076-6R | 441 | 5 | 49 | 22 | 21 |
| CO99256-2R | 593 | 2 | 53 | 33 | 13 |
| Colorado Rose | 658 | 10 | 59 | 21 | 8 |
| Dakota Jewel | 520 | 15 | 65 | 15 | 4 |
| Dakota Rose | 539 | 18 | 59 | 17 | 6 |
| Dark Red Norland | 450 | 5 | 68 | 20 | 5 |
| Modoc | 501 | 9 | 58 | 22 | 10 |
| ND 2225-1R | 539 | 1 | 31 | 38 | 31 |
| ND4659-5R | 450 | 17 | 57 | 20 | 6 |
| ND5002-3R | 479 | 10 | 58 | 17 | 13 |
| ND8555-8R | 578 | 3 | 47 | 38 | 13 |
| NDTX4271-5R | 577 | 14 | 62 | 16 | 8 |
| Red LaSoda | 704 | 21 | 65 | 8 | 4 |
| Red LaSoda(NY) | 615 | 37 | 50 | 7 | 3 |
| Red Norland | 493 | 5 | 59 | 27 | 8 |
| Rio Colorado | 539 | 3 | 48 | 33 | 16 |
| Sangre | 475 | 21 | 62 | 13 | 4 |
| Sangre 11 | 514 | 37 | 51 | 8 | 3 |
| Viking | 637 | 33 | 60 | 5 | 2 |
| Winema | 570 | 34 | 47 | 11 | 6 |
| *LSD α = 0.10* | *102*[5] | *7* | *13* | *9* | *6* |

Plots were planted on 29 April and harvested on 14 September, 2009.

[1]Premium = >3 ½”, [2]A size = 2 ¼ - 3 ½”, [3]B size = 1 $^{7/8}$ - 2 ¼”, [4]C size = < 1 $^{7/8”}$

[5]Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 8. Early-season Vigor, Specific gravity, and Length:width ratio of 24 Red-Skin, White-Flesh Varieties harvested 135 Days after Planting grown near Becker, MN during 2009.

| **Variety** | **Early Season Vigor[1]** | **Specific Gravity[2]** | **L:W Ratio[3]** |
|---|---|---|---|
| A.C. Peregrine | 2 | 1.070 | 1.23 |
| AND00272-1R | 2 | 1.067 | 1.30 |
| AO93487-2R | 2 | 1.062 | 1.21 |
| CO98012-5R | 2 | 1.068 | 1.15 |
| CO99076-6R | 2 | 1.081 | 1.14 |
| CO99256-2R | 2 | 1.082 | 1.23 |
| Colorado Rose | 2 | 1.078 | 1.27 |
| Dakota Jewel | 2 | 1.073 | 1.14 |
| Dakota Rose | 2 | 1.062 | 1.50 |
| Dark Red Norland | 2 | 1.063 | 1.27 |
| Modoc | 2 | 1.063 | 1.26 |
| ND 2225-1R | 2 | 1.061 | 1.33 |
| ND4659-5R | 2 | 1.069 | 1.03 |
| ND5002-3R | 2 | 1.074 | 1.20 |
| ND8555-8R | 2 | 1.078 | 1.14 |
| NDTX4271-5R | 2 | 1.068 | 1.06 |
| Red LaSoda | 2 | 1.075 | 1.19 |
| Red LaSoda(NY) | 2 | 1.068 | 1.14 |
| Red Norland | 2 | 1.063 | 1.35 |
| Rio Colorado | 2 | 1.076 | 1.31 |
| Sangre | 1 | 1.068 | 1.27 |
| Sangre 11 | 1 | 1.072 | 1.39 |
| Viking | 2 | 1.074 | 1.28 |
| Winema | 2 | 1.059 | 1.24 |
| *LSD α = 0.10* |  | *0.005*[4] | *0.07* |

Plots were planted on 29 April and harvested on 14 September 2009.

[1] Early Season Vigor (1 = <6", 2 = 6-12", 3 = >12"); [2] Specific gravity = [Weight in air/(Weight in air - Weight in water)]

[3] L:W ratio = Length/Width of tuber (1.0 = round)

[4] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 9. Total Yield and Tuber Size Profile of 24 Red/Yellow-Skin, Yellow-Flesh Varieties harvested 135 Days after Planting grown near Becker, MN during 2009.

| | | | **Yield** | | |
|---|---|---|---|---|---|
| **Variety** | **Total** *(cwt/a)* | **Premium[1]** *(%)* | **A size[2]** *(%)* | **B size[3]** *(%)* | **C size[4]** *(%)* |
| AC97521-1R/Y | 849 | 0 | 35 | 41 | 24 |
| ATND98459-1RY | 725 | 4 | 52 | 33 | 10 |
| CO97232-2R/Y | 521 | 1 | 34 | 43 | 22 |
| MN 02 616 R/Y | 594 | 2 | 55 | 33 | 9 |
| MN 19298 R/Y | 673 | 7 | 52 | 29 | 6 |
| MN 96013-1 R/Y | 371 | 9 | 52 | 26 | 12 |
| MN 02 589 W/Y | 582 | 1 | 52 | 35 | 12 |
| VC1009-1W/Y | 834 | 3 | 39 | 44 | 14 |
| MN 02 588 W/W | 497 | 2 | 44 | 37 | 17 |
| Ambra | 490 | 7 | 54 | 27 | 13 |
| Elfe | 619 | 4 | 56 | 29 | 11 |
| German Butterball | 501 | 0 | 23 | 39 | 37 |
| Marilyn | 470 | 0 | 7 | 5 | 87 |
| Milva | 677 | 4 | 62 | 24 | 9 |
| MN 99380-1 W/Y | 618 | 14 | 64 | 16 | 6 |
| Molli | 643 | 4 | 48 | 29 | 18 |
| Satina | 347 | 11 | 55 | 20 | 11 |
| Sylvana | 637 | 2 | 50 | 35 | 12 |
| Tara | 664 | 1 | 43 | 37 | 11 |
| Yellow Finn | 445 | 0 | 18 | 52 | 28 |
| Yukon Gem | 789 | 3 | 71 | 22 | 4 |
| Yukon Gold | 484 | 26 | 53 | 14 | 6 |
| Zebra | 591 | 0 | 13 | 50 | 36 |
| Zeus | 410 | 1 | 19 | 36 | 42 |
| *LSD α = 0.10* | *101*[5] | *4* | *10* | *6* | *8* |

Plots were planted on 29 April and harvested on 14 September, 2009.

[1]Premium = >3 ½”, [2]A size = 2 ¼ - 3 ½”, [3]B size = 1 $^{7/8}$ - 2 ¼”, [4]C size = < 1 $^{7/8”}$

[5]Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

Table 10. Early-season Vigor, Specific gravity, Length:width ratio, and Hollow heart of 24 Red/Yellow Skin, Yellow-Flesh Varieties harvested 135 Days after Planting grown near Becker, MN during 2009.

| Variety | Early Season Vigor[1] | Specific Gravity[2] | L:W Ratio[3] |
|---|---|---|---|
| AC97521-1R/Y | 3 | 1.082 | 1.37 |
| ATND98459-1RY | 2 | 1.080 | 1.13 |
| CO97232-2R/Y | 3 | 1.070 | 1.23 |
| MN 02 616 R/Y | 3 | 1.078 | 1.37 |
| MN 19298 R/Y | 3 | 1.077 | 1.03 |
| MN 96013-1 R/Y | 2 | 1.074 | 1.24 |
| MN 02 589 W/Y | 2 | 1.089 | 1.09 |
| VC1009-1W/Y | 3 | 1.078 | 1.48 |
| MN 02 588 W/W | 3 | 1.084 | 0.97 |
| Ambra | 2 | 1.059 | 1.52 |
| Elfe | 2 | 1.068 | 1.49 |
| German Butterball | 2 | 1.084 | 1.51 |
| Marilyn | 2 | 1.061 | 2.37 |
| Milva | 2 | 1.071 | 1.58 |
| MN 99380-1 W/Y | 2 | 1.088 | 1.06 |
| Molli | 3 | 1.068 | 1.34 |
| Satina | 2 | 1.055 | 1.32 |
| Sylvana | 2 | 1.067 | 1.32 |
| Tara | 2 | 1.088 | 1.48 |
| Yellow Finn | 2 | 1.089 | 1.21 |
| Yukon Gem | 3 | 1.082 | 1.33 |
| Yukon Gold | 2 | 1.085 | 1.21 |
| Zebra | 2 | 1.080 | 1.24 |
| Zeus | 2 | 1.082 | 1.36 |
| *LSD $\alpha = 0.10$* |  | *0.011*[4] | *0.14* |

Plots were planted on 29 April and harvested on 14 September 2009.

[1] Early Season Vigor (1 = <6", 2 = 6-12", 3 = >12"); [2] Specific gravity = [Weight in air/(Weight in air - Weight in water)]

[3] L:W ratio = Length/Width of tuber (1.0 = round)

[4] Values within a column are significantly different if difference is equal-to or greater-than the LSD value within the column.

# Market-Class Summaries

## Red-Skin, White-Flesh Variety

*Highest Total Yield(Early Harvest):* Red LaSoda (634), Colorado Rose (540), Red LaSoda-NY (505)
*Highest Total Yield(Late Harvest):* Red LaSoda (704), Colorado Rose (658), Viking (637), Red LaSoda-NY (615)
*Lowest Total Yield(Early Harvest):* ND5002-3R (293), Sangre-11 (274)
*Lowest Total Yield(Late Harvest):* CO99076-6R (441), ND4659-5R (450), Dark Red Norland (450)

*Highest Percent A size(Early Harvest):* Red LaSoda-NY (92), Viking (92), Red LaSoda (86)
*Highest Percent A size(Late Harvest):* Dark Red Norland (68), Dakota Jewel (65), Red LaSoda (65)
*Lowest Percent A size(Early Harvest):* CO99256-2R (26), ND2225-1R (28)
*Lowest Percent A size(Late Harvest):* CO98012-5R (32), ND2225-1R (31)

*Highest Percent B size(Early Harvest):* CO99256-2R (50), ND2225-1R (47), Rio Colorado (44)
*Highest Percent B size(Late Harvest):* CO98012-5R (44), ND8555-8R (38), ND2225-1R (38), A.C. Peregrine (36)
*Lowest Percent B size(Early Harvest):* Viking (6), Red LaSoda (6)
*Lowest Percent B size(Late Harvest):* Viking (5), Red LaSoda-NY (7), Sangre-11 (8), Red LaSoda (8)

*Highest Percent C size(Early Harvest):* ND2225-1R(25), CO99256-2R (24), CO98012-5R (18)
*Highest Percent C size(Late Harvest):* ND2225-1R(31), CO98012-5R (23), CO99076 (21)
*Lowest Percent C size(Early Harvest):* Viking (2), Red LaSoda-NY (1), Red LaSoda (1)
*Lowest Percent C size(Late Harvest):* Viking (2), Sangre-11 (3), Red LaSoda-NY (3)

*Highest Specific Gravity(Early Harvest):* Colorado Rose (1.084), CO99076-6R (1.083), ND8555-8R (1.083), Dakota Jewel (1.082)
*Highest Specific Gravity(Late Harvest):* CO99256-2R (1.082), C099076-6R (1.081), Colorado Rose (1.078), ND8555-8R (1.078)
*Lowest Specific Gravity(Early Harvest):* Sangre-11 (1.063), AO93487-2R (1.063)
*Lowest Specific Gravity(Late Harvest):* Winema (1.059), ND2225-1R (1.061), AO93487-2R (1.062), Dakota Rose (1.062)

*Highest L:W Ratio (Early Harvest):* Rio Colorado (1.39), Dakota Rose (1.38), ND2225-1R (1.35)
*Highest L:W Ratio (Late Harvest):* Dakota Rose (1.50), Sangre-11 (1.39), Red Norland (1.35)
*Lowest L:W Ratio (Early Harvest):* ND4659-5R (0.98), NDTX4271-5R (1.04), ND8555-8R (1.05), Red LaSoda-NY (1.05), Red LaSoda (1.05)
*Lowest L:W Ratio (Late Harvest):* ND4659-5R (1.03), NDTX4271-5R (1.06)

*Lightest Skin Color(Early Harvest):* Viking (40.67), Red LaSoda (40.57), Red LaSoda-NY (40.24), Red Norland (40.04)
*Lightest Skin Color(Late Harvest):* Viking (44.86), Red LaSoda (43.70), Red Norland (43.39), Sangre (43.13)
*Darkest Skin Color(Early Harvest):* CO99076-6R (35.16), NDTX4271-5R (35.83)
*Darkest Skin Color(Late Harvest):* NDTX4271-5R (38.80), CO99076-6R (38.92), CO99256-2R (38.95)

*Most Red Skin Color(Early Harvest):* ND8555-8R (14.53), AND00272-1R (14.28)
*Most Red Skin Color(Late Harvest):* AND00272-1R (12.17), Dakota Rose (12.08), ND8555-8R (11.87)
*Least Red Skin Color(Early Harvest):* ND2225-1R (9.13), ND5002-3R (10.32), A.C. Peregrine (10.41), Viking (10.68)
*Least Red Skin Color(Late Harvest):* ND2225-1R (8.13), NDTX4271-5R (9.14), CO99256-2R (9.87), CO99076-6R (9.92)

## Market-Class Summaries

**Red-Skin, Yellow-Flesh Varieties**

*Highest Total Yield(Early Harvest):* AC97521-1R/Y (581), ATND98459-1R/Y (507),
*Highest Total Yield(Late Harvest):* AC97521-1R/Y (849), ATND98459-1R/Y (725),
*Lowest Total Yield(Early Harvest):* MN96013-1R/Y (361)
*Lowest Total Yield(Late Harvest):* MN96013-1R/Y (371), CO97232-2R/Y (521)

*Highest Percent A size(Early Harvest):* MN19298 R/Y (67), MN96013-1R/Y (65)
*Highest Percent A size(Late Harvest):* MN02616 R/Y (55)
*Lowest Percent A size(Early Harvest):* AC97521-1R/Y (30)
*Lowest Percent A size(Late Harvest):* CO97232-2R/Y (34), AC97521-1R/Y (35)

*Highest Percent B size(Early Harvest):* AC97521-1R/Y (47), CO97232-2R/Y (43)
*Highest Percent B size(Late Harvest):* CO97232-2R/Y (43), AC97521-1R/Y (41)
*Lowest Percent B size(Early Harvest):* MN19298 R/Y (26), MN96013-1R/Y (27)
*Lowest Percent B size(Late Harvest):* MN96013-1R/Y (26), MN19298 R/Y (29)

*Highest Percent C size(Early Harvest):* AC97521-1R/Y (23)
*Highest Percent C size(Late Harvest):* AC97521-1RY (24), CO97232-2R/Y (22)
*Lowest Percent C size(Early Harvest):* MN19298 R/Y (7), MN96013-1R/Y (8)
*Lowest Percent C size(Late Harvest):* MN02616 R/Y (9), MN19298 R/Y (9)

*Highest Specific Gravity(Early Harvest):* AC97521-1R/Y (1.084), MN02616 R/Y (1.083)
*Highest Specific Gravity(Late Harvest):* AC97521-1R/Y (1.082), ATND98459-1R/Y (1.080)
*Lowest Specific Gravity(Early Harvest):* CO97232-2R/Y (1.068)
*Lowest Specific Gravity(Late Harvest):* CO97232-2R/Y (1.070), MN96013-1R/Y (1.074)

*Highest L:W Ratio(Early Harvest):* MN02616 R/Y (1.35), AC97521-1R/Y (1.30)
*Highest L:W Ratio(Late Harvest):* AC97521-1R/Y (1.37), MN02616 R/Y (1.37)
*Lowest L:W Ratio(Early Harvest):* MN19298 R/Y (1.01)
*Lowest L:W Ratio(Late Harvest):* MN19298 R/Y (1.03), ATND98459-1R/Y (1.13)

*Lightest Skin Color(Early Harvest):* CO97232-2R/Y (42.39)
*Lightest Skin Color(Late Harvest):* CO97232-2R/Y (46.18)
*Darkest Skin Color(Early Harvest):* MN02616 R/Y (36.92), MN96013-1R/Y (37.92)
*Darkest Skin Color(Late Harvest):* MN96013-1R/Y (40.28), MN02616 R/Y (41.19)

*Most Red Skin Color(Early Harvest):* MN19298 R/Y (11.89)
*Most Red Skin Color(Late Harvest):* ATND98459-1R/Y (10.71), MN02616 R/Y (9.94)
*Least Red Skin Color(Early Harvest):* CO97232-2R/Y (9.84)
*Least Red Skin Color(Late Harvest):* CO97232-2R/Y (8.80)

*Lightest Yellow Flesh(Early Harvest):* MN96013-1R/Y (20.07), MN02616 R/Y (20.04)
*Lightest Yellow Flesh(Late Harvest):* MN19298 R/Y (54.60), MN96013-1R/Y (54.30)
*Darkest Yellow Flesh(Early Harvest):* CO97232-2R/Y (15.90)
*Darkest Yellow Flesh(Late Harvest):* CO97232-2R/Y (48.36), AC97521-1R/Y (49.65)

*Most Yellow Flesh(Early Harvest):* MN19298 R/Y (62.35), MN96013-1R/Y (61.65)
*Most Yellow Flesh(Late Harvest):* MN96013-1R/Y (18.64), MN02616 R/Y (18.32)
*Least Yellow Flesh(Early Harvest):* CO97232-2R/Y (53.97)
*Least Yellow Flesh(Late Harvest):* MN19298 R/Y (16.36), CO97232-2R/Y (14.82)

## Market-Class Summaries

**Yellow-Skin, Yellow-Flesh Varieties**

*Highest Total Yield(Early Harvest):* VC1009-1W/Y (581), Yukon Gem (515), MN99380-1W/Y (513)
*Highest Total Yield(Late Harvest):* VC1009-1W/W (834), ATND98459-1R/Y (725)
*Lowest Total Yield(Early Harvest):* Satina (266), Zeus (291)
*Lowest Total Yield(Late Harvest):* Satina (347), Zeus (410)

*Highest Percent A size(Early Harvest):* Yukon Gold (81), MN99380-1W/Y (72), Satina (68)
*Highest Percent A size(Late Harvest):* Yukon Gem (71), MN99380-1W/Y (64), Milva (62)
*Lowest Percent A size(Early Harvest):* Marilyn (0), German Butterball (2), Zeus (9)
*Lowest Percent A size(Late Harvest):* Marilyn (7), Zebra (13)

*Highest Percent B size(Early Harvest):* Zeus (52), VC1009-1W/Y (46), Sylvana (43)
*Highest Percent B size(Late Harvest):* Yellow Finn (52), Zebra (50)
*Lowest Percent B size(Early Harvest):* Yukon Gold (13), Marilyn (14)
*Lowest Percent B size(Late Harvest):* Marilyn (5), Yukon Gold (14), MN99380-1W/Y (16)

*Highest Percent C size(Early Harvest):* Marilyn (86), German Butterball (65)
*Highest Percent C size(Late Harvest):* Marilyn (87), Zeus (42)
*Lowest Percent C size(Early Harvest):* Yukon Gold (5), MN99380-1W/Y (6)
*Lowest Percent C size(Late Harvest):* Yukon Gem (4), Yukon Gold (6), MN99380-1W/Y (6)

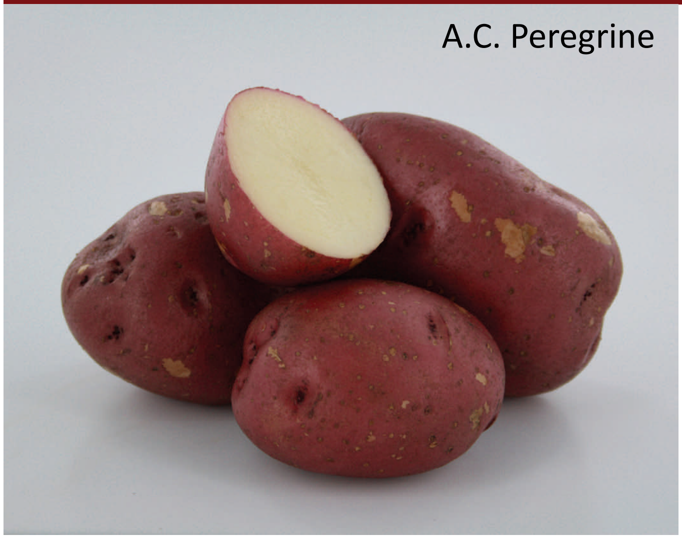
*Highest Specific Gravity(Early Harvest):* MN02589 W/Y (1.088), MN99380-1W/Y (1.083), Zebra (1.082)
*Highest Specific Gravity(Late Harvest):* MN02589 W/Y (1.089), Yellow Finn (1.089), MN99380-1W/Y (1.088), Tara (1.088)
*Lowest Specific Gravity(Early Harvest):* Satina (1.062), Marilyn (1.065)
*Lowest Specific Gravity(Late Harvest):* Satina (1.055), Ambra (1.059)

*Highest L:W Ratio(Early Harvest):* Marilyn (2.04), Molli (1.86)
*Highest L:W Ratio(Late Harvest):* Marilyn (2.37), Milva (1.58), Ambra (1.52), German Butterball (1.51)
*Lowest L:W Ratio(Early Harvest):* MN02588 W/W (0.98), MN02589 W/Y (1.09), MN99380-1W/Y (1.09), Zeus (1.09)
*Lowest L:W Ratio(Late Harvest):* MN02588 W/W (0.97), MN99380-1W/Y (1.06), MN02589 W/Y (1.09)

*Lightest Yellow Flesh(Early Harvest):* Yukon Gold (62.76), MN02588 W/W (61.12)
*Lightest Yellow Flesh(Late Harvest):* MN02588 W/W (56.74), Satina (54.30), Zeus (55.10)
*Darkest Yellow Flesh(Early Harvest):* Milva (56.71), Ambra (57.74), Marilyn (57.78)
*Darkest Yellow Flesh(Late Harvest):* Milva (49.40), Elfe (49.52), Ambra (49.75)

*Most Yellow Flesh(Early Harvest):* Elfe (21.25), Satina (20.75), German Butterball (20.45), VC1009-1W/W (20.42)
*Most Yellow Flesh(Late Harvest):* VC1009-1W/Y (19.75), Satina (19.39), Yellow Finn (19.33)
*Least Yellow Flesh(Early Harvest):* MN02588 W/W (11.90), Zebra (15.71)
*Least Yellow Flesh(Late Harvest):* MN02588 W/W (11.21), Ambra (15.12)

# 2009 Becker, MN Variety Trial


A.C. Peregrine


AC97521-1RY


AND00272-1R


AO93847-2R


ATND98549-1RY


CO97232-2RY

# 2009 Becker, MN Variety Trial


C098012-5R


CO99076-6R


CO99256-2R


Colorado Rose


Dark Red Norland


Dakota Jewel

# 2009 Becker, MN Variety Trial


Dakota Rose


MN02616 R/Y


MN19298 R/Y


MN96013-1R/Y


Modoc


ND2225-1R

# 2009 Becker, MN Variety Trial


ND4659-5R


ND5002-3R


ND8555-8R


NDTX4271-5R


Red LaSoda


Red LaSoda (NY)

# 2009 Becker, MN Variety Trial


Red Norland


Rio Colorado


Sangre


Sangre-11


Viking


Winema

# 2009 Becker, MN Variety Trial

# 2009 Becker, MN Variety Trial

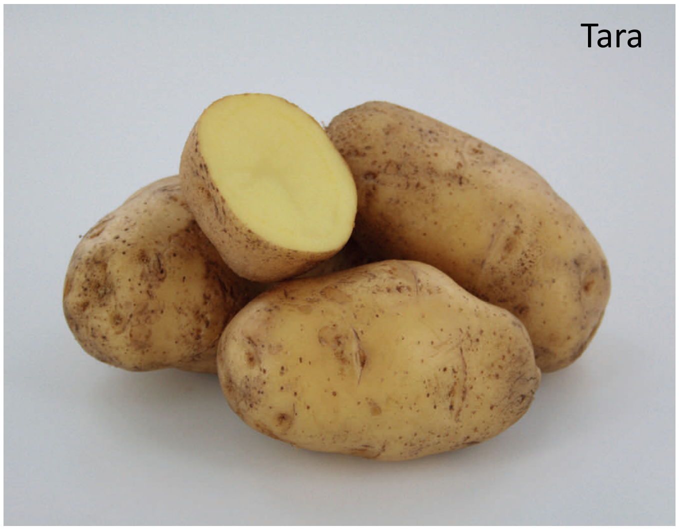

MN02589 W/Y


MN99380-1 W/Y


Molli


Satina


Sylvana


Tara

# 2009 Becker, MN Variety Trial


VC1009-1WY


Yellow Finn


Yukon Gem


Yukon Gold


Zebra


Zeus

# Management of Corky Ringspot Disease in Potato Using Vydate C-LV

## Irrigated Trial
## Rice, MN 2009

**Dr. Nick David – Potato Agronomist, NDSU/UM**
**Dr. Neil Gudmestad – Plant Pathologist, NDSU**

# Management of Corky Ringspot Disease Using Oxamyl (Vydate C-LV)

**Principal Investigators**
Nick David – Extension Potato Agronomist, North Dakota State University/University of Minnesota
Neil Gudmestad – Plant Pathologist, North Dakota State University
Marty Glynn – Food Technologist and Potato Worksite Manager, USDA-ARS

## Summary

Five oxamyl (Vydate C-LV) programs were evaluated on six different potato varieties near Rice, MN during 2009 to determine if combinations of oxamyl applied in-furrow at planting, at crop emergence, three weeks after crop emergence, and six weeks after crop emergence could effectively reduce incidence and severity of Corky Ringspot (CRS). All oxamyl programs reduced the incidence and severity of CRS in all varieties tested compared to the non-treated control, but only those programs with an in-furrow at-planting treatment resulted in commercially acceptable levels of CRS. During 2009, non-treated plots had 33% severe damage from CRS. Waiting until crop emergence (44 days after planting) to begin oxamyl treatments reduced the percentage of severe damage to 19%, but was still unacceptable. However, when treatments began at planting, severe damage was reduced to commercially acceptable levels of 1% or less. There was no difference in incidence or severity of CRS between any of the oxamyl programs that included an in-furrow application. In-furrow applications of oxamyl did not reduce the final crop emergence in any of the varieties tested, but further work to evaluate the effect of oxamyl on tubers per hill, total yield, and process quality are warranted.

## *Introduction:*

Corky Ringspot (CRS) is a disease of potato caused by Tobacco Rattle Virus (TRV) and is vectored by stubby-root nematodes. CRS symptoms can vary between varieties, but necrotic rings or spots in the tuber tissue are common (Figure 1). Damage by CRS is scored as an internal defect and can significantly reduce usable yield or lead to crop rejection if not managed properly. While this disease has been known to occur in many areas of the United States, it has only recently been reported in Minnesota (Gudmestad et al., 2008) and North Dakota (David et al., 2009). Previous work in Oregon, Washington, and Colorado has shown that the fumigant 1,3-dichloropropene (Telone II) can effectively control CRS, but may be cost prohibitive in Minnesota and North Dakota. Recent studies in Oregon (Charlton et al., 2010) report that the nematicide, oxamyl (Vydate C-LV), can reduce the incidence of CRS in potato when chemigated through the irrigation system. The current study was initiated to determine if low-volume (10 gpa or less) applications of oxamyl (Table 1) could reduce CRS symptoms in Russet Burbank, Russet Norkotah, Umatilla Russet, Dakota Pearl, Red Norland, and Yukon Gold at harvest and following four months storage.

Figure 1. Corky Ringspot Symptoms on Russet Burbank

Figure 2. Corky Ringspot Symptoms on Dakota Pearl

**Table 1. Timing and rate (lb/acre) of oxamyl treatments evaluated in 2009.**

| Treatment[1] | In-furrow at planting | Banded at crop emergence | 3 weeks after crop emergence | 6 weeks after crop emergence |
|---|---|---|---|---|
| Non-treated | -- | -- | -- | -- |
| 0, 44, 65, 86 | 1 lb | 1 lb | 1 lb | 1 lb |
| 44, 65, 86 | -- | 1 lb | 1 lb | 1 lb |
| 0, 44, 65 | 1 lb | 1 lb | 1 lb | |
| 0(2X), 65, 86 | 2 lb | | 1 lb | 1 lb |
| 0(2X), 44(2X) | 2 lb | 2lb | | |

[1] Application dates in days after planting (DAP): 0 DAP indicates in-furrow application; 44 DAP occurred at crop emergence; remaining DAP dates occurred at three-week intervals thereafter; (2X) indicates a doubled rate of 2.0 lb a.i./acre.

## *General Materials and Methods:*

This study was conducted in a commercial corn field near Rice, MN, which has a history of CRS. The area was previously cropped to field corn in 2008 and potato in 2007.

**Fertility** – During row marking, 40N- 50P- 160K- 25S- 1.5B- .75Zn 0.1B was applied as a dry band 2" below where the seed piece was planted. An additional 60 and 115 lbs nitrogen/acre was applied on 19 May and 10 June, respectively, as 46-0-0.

**Pest management** - Pink rot (*Phytopthora erythroseptica*) was controlled by applying 0.42 oz/ 1000 linear ft row Ridomil Gold EC (mefenoxam). Early and Late blight were controlled with mancozeb and chlorothalonil fungicides. Early season Colorado potato beetle and aphid control was achieved with an in-furrow application of 12 oz/acre of Belay (chlothianidin).

## *Treatment Materials and Methods*

**Plot design, planting, and harvest** – A two-factor split-plot design was utilized and treatments were assigned in a randomized complete block design with four replications. Main plots were oxamyl treatment and were 4 potato rows wide and 55 feet long. The split plot was potato variety and was 1 potato row wide and 15 feet long. Certified potato seed of all varieties evaluated were hand cut into 2-2.5 ounce pieces on 27 April, treated with Maxim MZ, and suberized for 9 days at 50°F and 95% relative humidity. Plots were planted on 6 May with a 2-row, assist-feed Harriston planter and harvested on 20 October using a single-row Grimme harvester.

**Oxamyl treatments** – The in-furrow application of oxamyl was applied in a 6-inch band at the bottom of the furrow using 7 gpa water at planting. The crop emergence application was applied on 9 June (44 days after planting, DAP) in 10gpa water using a backpack $CO_2$ sprayer (Figure 3). The three and six week post-emergence applications were applied on 30 June (65 DAP) and 21 July (86DAP), respectively, in 10 gpa water using a backpack $CO_2$ sprayer.

**Figure 3. Application of oxamyl in 10 gpa water at crop emergence**

**CRS evaluations** – Following harvest, all potatoes were transported to the USDA Potato Worksite in East Grand Forks, MN, and tubers from individual plots were equally split into two samples. The first sample was evaluated immediately following harvest and the second sample will be evaluated after 4 months storage. Twenty-five randomly selected tubers from each plot were cut into ½” transverse sections (Figure 4) and the number of spots over 1/8” in diameter were counted. Incidence, damage, and severe damage were defined as tubers having more than one, three – six, and more than six spots, respectively (USDA, 2008).

**Figure 4. Tubers cut into transverse sections to evaluate for Corky Ringspot symptoms**

**Statistical analysis** – Analysis of variance was performed using PROC GLM in SAS v.9.3 and when significant, means were separated using least significant differences.

## *Results:*

### Effect of oxamyl treatment on crop emergence

Analysis of variance indicated there was no interaction between oxamyl treatment and potato variety on crop emergence. As a result, the main effect is reported here. Crop emergence ranged from 91 – 96% of seed pieces planted and was not influenced by oxamyl treatmenty (Table 1). This indicates that neither 1 or 2 lb ai/a oxamyl applied in-furrow at planting reduced the number of plants emerged compared to treatments without oxamyl.

### *Effect of oxamyl treatment on incidence and severity of Corky Ringspot*

Analysis of variance indicated that the effect of oxamyl treatment on the incidence and severity of CRS damage was not dependent upon potato variety. As a result the main effects of oxamyl treatment across all varieties tested are reported (Table 2).

***Incidence:*** Corky ringspot disease was observed in 56% of tubers when not treated with oxamyl in 2009. While none of the oxamyl treatments eliminated CRS symptoms, they all significantly reduced the CRS incidence compared to the non-treated control. Initiating oxamyl treatment at emergence resulted in 33% incidence, and was further reduced to below 4% when treatment began at planting. There was no difference between the four treatments that included an in-furrow application of oxamyl.

***Damage:*** The percentage of tubers with damage as defined by the USDA was 42% when no oxamyl was applied. All oxamyl treatments significantly reduced damaged tubers compared to the non-treated control. When the oxamyl treatment began at crop emergence, the percentage of tubers scored with damage was 25%, and was further reduced below 3% when treatments began at planting. There was no difference between the four treatments that included an in-furrow application of oxamyl.

***Severe Damage:*** The percentage of tubers with severe damage as defined by the USDA was 33% when not treated. All oxamyl treatments significantly reduced severely damaged tubers compared to the non-treated control, but only those treatments with an in-furrow application resulted in commercially acceptable levels of CRS.

**Table 2. Effect of Oxamyl treatment on crop emergence, incidence, damage, and severe damage caused by Corky Ringspot**

| Treatment[1] | Emergence (%) | Incidence[2] (%) | Damage[3] (%) | Severe Damage[4] (%) |
|---|---|---|---|---|
| Non-treated | 94 | 56 | 42 | 33 |
| 0, 44, 65, 86 | 94 | 1 | 1 | 0 |
| 44, 65, 86 | 94 | 33 | 25 | 19 |
| 0, 44, 65 | 91 | 2 | 1 | 1 |
| 0(2X), 65, 86 | 96 | 2 | 1 | 0 |
| 0(2X), 44(2X) | 93 | 3 | 2 | 1 |
| *LSD (α= 0.10)* | *ns*[5] | *6.5*[6] | *6.5* | *6* |

[1] Application dates in days after planting (DAP): 0 DAP indicates in-furrow application; 44 DAP occurred at crop emergence; remaining DAP dates occurred at three-week intervals thereafter; (2X) indicates a doubled rate of 2.0 lb a.i./acre.

[2] Percent tubers with 1 or more spots, [3] Percent tubers with 3 – 6 spots, [4] Percent tubers with 6 or more spots.

[5] ns = values within this column are not significantly different. [6] Values in columns with a numerical LSD value are significantly different if the difference between the two values is equal-to or greater-than the LSD value.

## *Conclusion:*

The results from this trial indicate that low-volume applications of oxamyl can effectively reduce the incidence and severity of CRS symptoms in Russet Burbank, Russet Norkotah, Umatilla Russet, Dakota Pearl, Red Norland, and Yukon Gold when evaluated at harvest. Initiating applications 44 days after planting at crop emergence appears to miss early season TRV infection, resulting in unacceptable levels of CRS. All oxamyl programs that included an in-furrow treatment resulted in commercially acceptable levels of CRS. Preliminary results from this trial indicate that if in-furrow and crop emergence treatments oxamyl rates are increased to 2 lb ai/a., subsequent foliar applications may be unnecessary. However, further work is required to confirm or reject this hypothesis.

# Cultivar Specific Nitrogen Management Profiles For Irrigated Process Varieties

# Inkster, ND 2009

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Extension Potato Agronomist

North Dakota State University/University of Minnesota

# Cultivar Specific Nitrogen Management Profiles for Irrigated Process Varieties

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## Summary

Twelve russet-skin (Alpine Russet, Bannock Russet, Blazer Russet, Dakota Trailblazer, Russet Burbank, Gemstar Russet, MN02419, ND8229-3, Premier Russet, Prospect, Ranger Russet, Umatilla Russet), five white-skin (Dakota Crisp, Dakota Diamond, Dakota Pearl, MN18747, and Shepody), and one red-skin (MN15620) varieties with potential to be grown as raw product for the chip and frozen process industries were evaluated under four nitrogen treatments (120 lb/a, 180 lb/a, 240 lb/a early, and 240 lb/a late). Total yield, size profile distribution, and the hollow-heart defect were determined for each variety at each nitrogen level. The results indicate that the effect of nitrogen were not dependent upon variety. None of the varieties tested had a higher total yield potential than Russet Burbank, but all but four had a higher percentage of total yield greater than six ounces. Total yield was maximized at 240 lb/a nitrogen applied either early or late in the season. Interestingly, nitrogen treatment had no effect on the total percentage of hollow heart observed during 2009.

## *Introduction:*

Russet Burbank continues to be the most important frozen process variety grown in North Dakota and Minnesota, but it requires high rates of nitrogen and metam sodium in order to provide anacceptable raw product to processors and an economic return to the grower. The goal of this project is to provide growers and industry representatives with nitrogen management guidelines for recently released varieties that have potential to be produced in North Dakota and Minnesota with lower inputs than Russet Burbank. Four nitrogen treatments (Table 1) were evaluated for all eighteen varieties listed in the summary.

Table 1. Nitrogen amount (lb/a) and date of application for the nitrogen treatments evaluated in 2009.

| | Dates of nitrogen application | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | 5/18 | 6/10 | 6/25 | 7/1 | 7/7 | 7/14 | 7/21 | 7/28 | 8/4 | Total |
| 120N | 30 | 30 | 0 | 30 | 10 | 10 | 10 | 0 | 0 | 120 |
| 180 | 30 | 50 | 10 | 30 | 20 | 20 | 20 | 0 | 0 | 180 |
| 240 Early | 30 | 100 | 40 | 30 | 20 | 10 | 10 | 0 | 0 | 240 |
| 240 Late | 30 | 50 | 30 | 30 | 40 | 20 | 20 | 10 | 10 | 240 |

## *General Materials and Methods:*

This study was conducted at the Northern Plains Potato Growers Association's Irrigated Research Site located near Inkster, ND.

**Soil characteristics and Fertility** – The soil was classified as a sandy loam (75.2% sand, 15.4% silt, and 9.4% clay) with 2.1% organic matter and a pH of 6.0. Soil analysis indicated 14 lb/a nitrogen was present in the top 6 inches prior to planting. Furthermore, soil levels of Phosphorus (10ppm), Potassium (275ppm), Sulfur (72lb/a), Zinc (1.89ppm), Iron (52ppm), Manganese (47ppm), and Copper (.41 ppm) were present. During planting, 29 lb/a N, 100 lb/a P, and 1 lb/a Zn was applied in a split band beneath the seed piece. Following planting, additional nitrogen applications were made on 10 June, 25 June, 1 July, 7 July, 14 July, 28 July, and 4 August (Table 1), depending upon nitrogen treatment.

**Pest management** - Pink rot (*Phytopthora erythroseptica*) was controlled by applying 0.42 oz/ 1000 linear ft row Ridomil Gold EC (mefenoxam) at planting. Early blight, late blight, black dot, and white mold were controlled with applications of Bravo (8 July), Headline+Manzate (17 July), Bravo (22 July), Endura+Manzate (29 July), Bravo Zn (5 August), Scala+Manzate (10 August), Bravo Zn (18 August), and Gavel (25 August and 2,10 September). Early season Colorado potato beetle and aphid control was achieved with an in-furrow application of 12 oz/acre of Belay (chlothianidin).

## *Treatment Materials and Methods*

**Plot design, planting, and harvest** – A two-factor split-plot design was utilized and treatments were assigned in a randomized complete block design with four replications. Main plots were nitrogen treatment (Table 1) and were 8 potato rows wide and 150 feet long. The split plot was potato variety and was 1 potato row wide and 15 feet long. Seed of all varieties evaluated were hand cut into 2-2.5 ounce pieces on 5 May, treated with Maxim MZ, and suberized for 13 days at 50°F and 95% relative humidity. Plot were planted on 18 and 19 May with a 2-row, assist-feed Harriston planter and harvested on 25 and 26 October using a single-row Grimme harvester.

**Nitrogen treatments** – During planting, 29 lb/a N, 100 lb/a P, and 1 lb/a Zn was applied in a split band beneath the seed piece to all plots. Varying amounts of nitrogen were applied on 10 June, 25 June, 1 July, 7 July, 14 July, 28 July, and 4 August (Table 1), to main plots depending upon nitrogen treatment. All nitrogen applications after 25 June were hand applied to individual plots as urea (46-0-0).

**Yield and quality evaluations** – Following harvest, all potatoes were transported to the USDA Potato Worksite in East Grand Forks, MN, and tubers from individual plots were sized according to weight to determine total yield and tuber size profile. Ten tubers each from the 4-6, 6-8, 8-10, and over 10 oz size classes were cut and evaluated for the hollow-heart defect.

**Statistical analysis** – Analysis of variance was performed using PROC GLM in SAS v.9.3 and when significant, means were separated using least significant differences.

## *Results:*

## Effect of variety and nitrogen treatment on yield

Analysis of variance indicated the interaction between variety and nitrogen treatment was not significant. This means that the effect of nitrogen treatment on yield was not dependent upon the variety tested. As a result, the main effects of variety (Table 2) and nitrogen treatment (Table 4) on total yield and size class distribution are reported.

***Effect of variety on Total Yield*** – Blazer Russet, Dakota Pearl, Gemstar Russet, MN02419, MN15620, MN18747, ND8229-3, Shepody, and Dakota Trailblazer had a significantly lower total yield than Russet Burbank (503 cwt/a) during 2009. All other varieties tested were equal.
***Effect of nitrogen treatment on Total Yield*** – Total yield significantly increased as nitrogen treatment was increased from 120 lb/a nitrogen (409 cwt/a) to 180 lb/a (445 cwt/a). 240 lb/a nitrogen early (474 cwt/a) and late (487 cwt/a) were both significantly higher than 180 lb/a nitrogen, but were not different from each other.

***Effect of variety on yield of < 3 oz tubers*** – All varieties except Dakota Crisp (equal), Dakota Diamond (equal), Dakota Pearl (greater), MN02419 (equal) Ranger Russet (equal), and Umatilla Russet (greater), produced fewer tubers < 3 ounces.
***Effect of nitrogen treatment on yield of < 3 oz tubers*** – The yield of tubers < 3 oz was greatest under the 120 lb/a nitrogen treatment (41 cwt/a), while it was least when 240 lb/a nitrogen was applied late (27 cwt/a).

***Effect of variety on yield of 3 – 4 oz tubers*** – Dakota Diamond, Dakota Pearl, and Umatilla Russet produced more 3 – 4 ounce tubers than Russet Burbank (53 cwt/a), while all other varieties produced fewer.
***Effect of nitrogen treatment on yield of 3 – 4 oz tubers*** – The yield of tubers between 3 – 4 oz was the greatest under the 120 lb/a nitrogen (41 cwt/a), and was significantly decreased under 180 and 240 lb/a nitrogen.

***Effect of variety on yield of 4 – 6 oz tubers*** – All varieties except Dakota Diamond (more) and Umatilla Russet (equal) produced fewer 4 – 6 ounce tubers than Russet Burbank (143 cwt/a).
***Effect of nitrogen treatment on yield of 4 – 6 oz tubers*** – 240 lb/a nitrogen applied late had produced fewer 4 – 6 oz tubers (87 cwt/a) than all other treatments.

***Effect of variety on yield of 6 – 8 oz tubers*** – Alpine Russet, Blazer Russet, Dakota Crisp, Dakota Diamond, ND8229-3, Premier Russet, and Ranger Russet produced the same amount of 6 – 8 oz tuber as Russet Burbank (116 cwt/a), and all other varieties tested produced fewer.
***Effect of nitrogen treatment on yield of 6 – 8 oz tubers*** – Nitrogen treatment had no effect on the yield of 6 – 8 oz tubers.

***Effect of variety on yield of 8 – 10 oz tubers*** – Dakota Pearl and Umatilla Russet produced fewer, and Dakota Diamond, MN02419, MN18747, and Shepody produced the same amount of 8 – 10 oz tubers as Russet Burbank (69 cwt/a). All other varieties tested produced more 8 – 10 oz tubers than Russet Burbank.
***Effect of nitrogen treatment on yield of 8 – 10 oz tubers*** – 120 lb/a nitrogen produced fewer 8 – 10 oz tubers (62 cwt/a) than 180 lb/a nitrogen (79 cwt/a), 240 lb/a nitrogen applied early (82 cwt/a), and 240 lb/a nitrogen applied late (85 cwt/a).

***Effect of variety on yield of > 10 oz tubers*** – All varieties except Dakota Pearl (less), Blazer Russet (equal), Dakota Diamond (equal), MN02419 (equal), MN15620 (equal), and Umatilla Russet (equal) produced more > 10 oz tubers than Russet Burbank (71 cwt/a).
***Effect of nitrogen treatment on yield of > 10 oz tubers*** – 120 lb/a nitrogen produced the fewest amount of tubers > 10 oz (66 cwt/a). Increasing nitrogen to 180 lb/a nitrogen (111 cwt/a) and 240 lb/a nitrogen applied early (123 cwt/a) significantly increased the yield of tubers > 10 oz. 240 lb/a nitrogen applied late produced the greatest amount of tubers > 10 oz (163 cwt/a).

***Effect of variety on percent of total yield > 3 oz*** – All varieties tested had a higher percentage of tubers > 3 oz compared to Russet Burbank (89%), except Dakota Crisp (equal), Dakota Diamond (equal) Dakota Pearl (less), MN02419 (equal), and Umatilla Russet (less).
***Effect of nitrogen treatment on total yield > 3 oz*** – The percentage of tubers > 3 oz significantly increased as nitrogen applied increased from 120 to 240 lb/a nitrogen.

***Effect of variety on percent of total yield > 6 oz*** – All varieties tested had a higher percentage of tubers > 6 oz compared to Russet Burbank (50%), except Dakota Diamond (equal), Dakota Pearl (less), MN02419 (equal) and Umatilla Russet (less).
***Effect of nitrogen treatment on total yield > 6 oz*** – The percentage of tubers > 6 oz significantly increased as nitrogen applied increased from 120 to 240 lb/a nitrogen. There was no difference between 180 lb/a and 240 lb/a nitrogen applied early, while 240 lb/a nitrogen applied late produced the greatest percentage of tubers > 6 oz.

## Effect of nitrogen treatment and variety on hollow heart incidence

Analysis of variance indicated there was no interaction between nitrogen treatment and variety on the incidence of the hollow heart defect. As a result, the main effects of variety (Table 3) and nitrogen treatment (Table 5) on the incidence of hollow heart are reported.

***Effect of variety on the hollow-heart defect*** – During 2009, Russet Burbank had a total of 14% hollow heart. Bannock Russet (11%) had an equal percentage of hollow heart, while Blazer Russet (20%) and Premier Russet (31%) had significantly higher percentages. All other varieties tested had lower hollow heart than Russet Burbank.
***Effect of nitrogen treatment on the hollow-heart defect*** – Nitrogen treatment had no effect on the percentage of hollow heart, except in the 6 – 8 oz size class, where the 120 lb/a nitrogen treatment was the highest.

Table 2. Main effect of variety on percent stand, total yield, and tuber size profile of 18 varieties evaluated in the irrigated nitrogen trial near Inkster, ND during 2009.

| | | **Yield (cwt/acre)** | | | | | | | **Percent Yield** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | Percent Stand | *Total* | *<3oz* | *3-4oz* | *4-6oz* | *6-8oz* | *8-10oz* | *>10oz* | *>3 oz* | *>6 oz* |
| Alpine | 97 | 508 | 28 | 29 | 109 | 126 | 83 | 132 | 94 | 66 |
| Bannock | 97 | 469 | 27 | 27 | 82 | 95 | 81 | 157 | 94 | 70 |
| Blazer | 99 | 463 | 33 | 38 | 113 | 110 | 77 | 91 | 93 | 59 |
| Burbank | 98 | 503 | 51 | 53 | 143 | 116 | 69 | 71 | 89 | 50 |
| Dakota Crisp | 98 | 498 | 43 | 32 | 113 | 105 | 96 | 109 | 91 | 62 |
| Dakota Diamond | 98 | 530 | 52 | 67 | 162 | 123 | 64 | 62 | 89 | 45 |
| Dakota Pearl | 100 | 361 | 80 | 68 | 121 | 62 | 23 | 8 | 77 | 25 |
| Gemstar | 97 | 420 | 13 | 14 | 49 | 76 | 82 | 186 | 97 | 81 |
| MN02419 | 97 | 455 | 42 | 44 | 110 | 96 | 74 | 96 | 90 | 55 |
| MN15620 | 97 | 422 | 33 | 32 | 104 | 93 | 77 | 82 | 92 | 59 |
| MN18747 | 93 | 363 | 23 | 23 | 64 | 76 | 61 | 117 | 94 | 69 |
| ND8229-3 | 96 | 422 | 18 | 18 | 84 | 107 | 85 | 110 | 96 | 71 |
| Premier | 99 | 496 | 24 | 25 | 88 | 120 | 112 | 127 | 95 | 72 |
| Prospect | 97 | 476 | 10 | 11 | 47 | 86 | 97 | 227 | 98 | 84 |
| Ranger | 100 | 494 | 31 | 32 | 102 | 119 | 95 | 116 | 94 | 66 |
| Shepody | 98 | 397 | 14 | 17 | 56 | 67 | 66 | 177 | 96 | 76 |
| TrailBlazer | 95 | 430 | 9 | 13 | 55 | 89 | 98 | 167 | 98 | 82 |
| Umatilla | 97 | 467 | 70 | 69 | 143 | 80 | 48 | 57 | 84 | 38 |
| ***LSD α = 0.10*** | *3* | *39* | *10* | *8* | *17* | *16* | *16* | *37* | *3* | *7* |

Table 3. Main effect of variety on total percent hollow heart and percent hollow heart in four different size classes in 18 varieties evaluated in the irrigated nitrogen trial near Inkster, ND during 2009.

| | **Hollow Heart (Percent)** | | | | |
|---|---|---|---|---|---|
| **Variety** | *Total* | *4-6oz* | *6-8oz* | *8-10oz* | *>10oz* |
| Alpine | <1 | 0 | 0 | 0 | 1 |
| Bannock | 11 | 0 | 4 | 4 | 36 |
| Blazer | 20 | 6 | 16 | 26 | 33 |
| Burbank | 14 | 0 | 9 | 20 | 31 |
| Dakota Crisp | <1 | 0 | 0 | 1 | 0 |
| Dakota Diamond | 5 | 0 | 1 | 5 | 15 |
| Dakota Pearl | 4 | 1 | 10 | 6 | 3 |
| Gemstar | 5 | 0 | 1 | 3 | 15 |
| MN02419 | 6 | 0 | 1 | 5 | 18 |
| MN15620 | <1 | 0 | 0 | 0 | 1 |
| MN18747 | <1 | 0 | 0 | 1 | 1 |
| ND8229-3 | 1 | 0 | 0 | 0 | 3 |
| Premier | 31 | 4 | 11 | 38 | 76 |
| Prospect | <1 | 0 | 0 | 0 | 1 |
| Ranger | <1 | 0 | 0 | 0 | 1 |
| Shepody | 2 | 1 | 1 | 0 | 8 |
| TrailBlazer | 1 | 0 | 1 | 1 | 3 |
| Umatilla | 2 | 0 | 1 | 3 | 6 |
| ***LSD α = 0.10*** | *4* | *2* | *5* | *7* | *9* |

Table 4. Main effect of nitrogen treatment on percent stand, total yield, and tuber size profile on irrigated potatoes grown near Inkster, ND during 2009.

| | | **Yield (cwt/acre)** | | | | | | | **Percent Yield** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nitrogen Trt** | Percent Stand | *Total* | *<3oz* | *3-4oz* | *4-6oz* | *6-8oz* | *8-10oz* | *>10oz* | *>3 oz* | *>6 oz* |
| 120 | 97 | 409 | 41 | 41 | 104 | 94 | 62 | 66 | 90 | 53 |
| 180 | 97 | 445 | 32 | 31 | 98 | 96 | 79 | 111 | 92 | 63 |
| 240 Early | 97 | 474 | 35 | 33 | 100 | 102 | 82 | 123 | 93 | 65 |
| 240 Late | 97 | 487 | 27 | 30 | 87 | 95 | 85 | 163 | 94 | 70 |
| ***LSD α = 0.10*** | *ns* | *18* | *5* | *4* | *8* | *ns* | *8* | *17* | *1* | *3* |

Table 5. Main effect of nitrogen treatment on the hollow-heart defect observed on irrigated potatoes grown near Inkster, ND during 2009.

| | **Hollow Heart (Percent)** | | | | |
|---|---|---|---|---|---|
| **Nitrogen Trt** | *Total* | *4-6oz* | *6-8oz* | *8-10oz* | *>10oz* |
| 120 | 6 | 1 | 5 | 8 | 16 |
| 180 | 6 | 0 | 3 | 7 | 16 |
| 240 Early | 6 | 0 | 2 | 4 | 12 |
| 240 Late | 5 | 1 | 2 | 6 | 15 |
| ***LSD α = 0.10*** | *ns* | *ns* | *2* | *ns* | *ns* |

# Evaluation of advanced potato breeding clones for storage and processing performance.

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East Grand Forks, MN. – The concentration of reducing sugars that are found in a potato cultivar during storage determines its processing potential for chips, fries, or fresh markets (Sowokinos and Glynn, 2000). The darkening effect that undesirable reducing sugars have on the color of chip and fry products is well known. Potatoes that resist sweetening when cold-stressed generally have a greater ability to resist sweetening when subjected to field stress such as temperature, moisture, infertility and early dying (Sowokinos et al., 2000).

Potato breeding is an expensive and labor-intensive process. Tens of thousands of potato clones are grown annually by breeders in an effort to find a “single clone” that may meet all of the horticultural requirements necessary to make a successful cultivar (i, e., yield, solids content, disease resistance, etc.). Once a new clone has undergone several years of field trials, it often fails because of storage and marketing-related problems. This study reports on the storage potential of advanced clones provided by state and federal breeders and is funded, in part, by the Northern Plains Potato Growers Association.

**Material and Methods**:
Eighty-four advanced clones from Maine, Michigan, Minnesota, New York, Idaho, Wisconsin, Oregon, Texas and Alberta, Canada were grown under irrigation south of Avilla, ND. All potatoes were harvested mid-September, suberized two weeks at room temperature and then placed into 45$^{o}$ F, 42$^{o}$ F and 38$^{o}$ F storage. Tubers were evaluated for sugar content, Agtron color values, and chip appearance at four intervals (i.e. harvest, 3, 6 and 7 month’s storage. Potatoes were also reconditioned at 55$^{o}$ F for one month following 6 months of storage at 42$^{o}$ F and 38$^{o}$ F. All storage and processing evaluations were conducted at the USDA/ARS Potato Research Worksite, East Grand Forks, MN, following 7-months of storage.

**Results**
The individual clones demonstrated a wide range of ability to accumulate sugars from starch when subjected to cold stress. Following seven months of storage at 42$^{o}$ F , the concentration of glucose ranged from 0.038 mg/g in W 4013-1 (Table 1) to 6.97 in Stampede Russet (Table 3). **This shows greater than a 180-fold difference in a potato clone’s ability to accumulate sugars when placed into cold storage**. Based on sugar content and chip appearance, the clones were categorized into three classes.

Class A: Clones that have the ability to process following 42° F storage (Table 1).

Class B: Clones that have the ability to process following 45° F storage, but not from 42° F (Table 2).

Class C: Clones that do not chip acceptably from either 45° F or 42° F storage (Table 3).

Table 1 shows the 'Class A' clones that process successfully from 42° F without reconditioning. Reconditioning, however, did have a positive effect by improving most of the Agtron scores. Nine of the top 32 performers were from North Dakota (ND 7519-1, ND 5255-59, ND 7799c-1, ND 8304-2, ND 8305-1, NDA 5507-3Y, Sport 860 is ND 860-2-8, Dakota Pearl, and N8-14 (a selected clone of NorValley)). Michigan had six clones (MSJ 147-1, MSN 191-2Y, MSK 409-1, MSJ 126-9Y, MSK 061-4 and MSL 007-13). Wisconsin, six (W –4013-1, W 2133-1, W 2438-34, W 2324-1, W 2978-3 and W 2310-3). Others in the top ten were from USDA ( B 2490-7, B 1992-106 and B 2489-4, Minnesota (MN 02 586, MN 02 588), New York (NY 139, NY 138). Idaho and Maine each had one (A 91814-5 and AF 2211-4), respectively.

Table 2 shows the 'Class B' clones that process from 45° F but not from 42° F. Snowden is a well known cultivar in this class. Other Class B clones were from Minnesota, North Dakota, Maine, USDA, Canada, and Michigan. Although these clones do not have the sweetening-resistance potential of those clones listed in Table 1 (class A), their level of performance is still acceptable when chipped out of storage temperatures of 45 ° F or above. Consequently, the clones in Table 2, can and do play an important role in meeting industry's needs.

Table 3 lists 'Class C' clones that do not chip successfully from either 42° F or 45° F storage. Cultivars such as Red Pontiac, Russet Burbank and Russet Norkotah are in this class. Their higher inherent 'basal level' of sugars serves to direct their end use more towards fry and/or fresh markets.

## Summary

The thirty-two 'Class A' clones listed in Table 1 provide the quality advantages listed below**.**

- Decreased microbial spoilage.
- Retention of dry matter
- Reduced shrinkage
- Decreased need for sprout inhibition
- Decreased physiological aging
- Increased marketing window.

For a new potato cultivar to be successful, however, it must also demonstrate a variety of other horticultural and marketing qualities that are required by the processor and the consumer. Contact the respective potato breeder (listed below) if you are interested in any particular quality traits demonstrated by the potato clone of interest.

## References

Sowokinos, J. R. and M. Glynn 2000 Marketing potential of advanced potato breeding clones. *Valley Potato Grower*. 65(110):6-8

Sowokinos, J. R., S. K. Gupta and M. Glynn. 2000. Potato clones with a new anti-sweetening gene (*Asgene) Valley Potato Grower* 65(115):4-6.

| State | Breeder | Phone | E-Mail |
|---|---|---|---|
| MN | Dr. Christian Thill | 612-624-9737 | thill005@umn.edu |
| ND | Dr. Susie Thompson | 701-231-8160 | Asunta.Thompson@ndsu.nodak.edu |
| USDA/ID | Dr. Richard Novy | 208-397-4181 | novy@uidaho.edu |
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| | Dr. Felix Navarro | | fmnavarro@wisc.edu |
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| | | | |
|---|---|---|---|
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**Table 1. 2007-08 Class A Cones**: Potato clones that process successfully following 7 months storage at 42$^o$ F Clones are aligned in order of increasing glucose values from 42$^o$ F storage.

| CLONE | SOURCE | CC[1] | AGTRON | GLUCOSE mg/g |
|---|---|---|---|---|
| W 4013-1 | WI | 1 | 71 | 0.03 |
| MSJ 147-1 | MI | 1 | 69 | 0.05 |
| W 2133-1 | WI | 1 | 68 | 0.05 |
| SPORT 860 | ND | 1 | 67 | 0.06 |
| DAKOTA PEARL | ND | 1 | 68 | 0.06 |
| W 2438-34 | WI | 1 | 68 | 0.07 |
| MSN 191-2Y | MI | 1 | 66 | 0.09 |

| | | | | |
|---|---|---|---|---|
| ND 7519-1 | ND | 1 | 68 | 0.10 |
| CO 95051-7W | CO/OR | 1 | 65 | 0.15 |
| MSK 409-1 | MI | 1 | 65 | 0.15 |
| MSJ 126-9Y | MI | 1 | 66 | 0.16 |
| N 8-14 | ND | 1 | 65 | 0.19 |
| B 2490-7 | USDA | 1 | 65 | 0.21 |
| B 1992-106 | USDA | 1 | 65 | 0.29 |
| NY 139 | NY | 1 | 65 | 0.38 |
| A 91814-5 | ID | 2 | 64 | 0.40 |
| B 2489-4 | USDA | 2 | 63 | 0.46 |
| ND 5255-59 | ND | 2 | 62 | 0.51 |
| W 2310-3 | WI | 2 | 62 | 0.52 |
| MSK 061-4 | MI | 2 | 63 | 0.53 |
| ND 7799c-1 | ND | 2 | 59 | 0.63 |
| NY 138 | NY | 2 | 59 | 0.68 |
| MN 02 586 | MN | 2 | 59 | 0.74 |
| ND 8304-2 | ND | 2 | 58 | 0.78 |
| W 2324-1 | WI | 2 | 58 | 0.79 |
| ND 8305-1 | ND | 2 | 57 | 0.80 |
| MSL 007-13 | MI | 2 | 57 | 0.81 |
| AF 2211-4 | ME | 2 | 56 | 0.83 |
| MN 02 588 | MN | 2 | 56 | 0.85 |
| W 2978-3 | WI | 2 | 56 | 0.91 |
| NDA 5507-3Y | ND/ID | 2 | 56 | 0.91 |
| PREMIER RUSSET | ID | 2 | 56 | 0.95 |
| | | | | |

[1] CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable color, 3 is marginal, 4 and 5 are unacceptable color.

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**Table 2. 2007-08 Class B Cones**: Potato clones that process successfully following 7 months at 45° F. Clones are aligned in order of increasing glucose values from 42° F storage.

| CLONE | SOURCE | CC[1] | AGTRON | GLUCOSE mg/g |
|---|---|---|---|---|
| ND 5775-3 | ND | 3 | 54 | 1.03 |
| BNC 49-2 | USDA | 3 | 54 | 1.12 |
| W 2683-2 | WI | 3 | 54 | 1.15 |
| CO 97043-14W | CO/OR | 3 | 53 | 1.20 |
| MSJ 036-A | MI | 3 | 52 | 1.21 |
| WV 4298-1 | CAN/ALB | 3 | 52 | 1.31 |
| B 2477-8 | USDA | 3 | 51 | 1.32 |
| CO 96052-1RU | CO/OR | 3 | 49 | 1.32 |
| ND 7192-1 | ND | 3 | 49 | 1.35 |
| AF 2291-10 | ME | 3 | 47 | 1.35 |
| BNC 48-1 | CAN/ALB | 3 | 47 | 1.37 |
| VHB 0950-2 | CAN/ALB | 3 | 47 | 1.56 |
| SNOWDEN | WI | 3 | 46 | 1.58 |

[1] CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable color, 3 is marginal, 4 and 5 are unacceptable color.

**Table 3. 2007-08 Class C Cones**: Potato clones that do not chip successfully following 7 months storage at either 45° F or 42° F storage. Clones are aligned in order of increasing glucose values from 42° F storage.

| CLONE | SOURCE | CC[1] | AGTRON | GLUCOSE mg/g |
|---|---|---|---|---|
| CO 96141-4W | CO/OR | 3 | 45 | 1.66 |
| MN 15620 | MN | 3 | 45 | 1.77 |
| ATLANTIC | USDA | 3 | 45 | 1.84 |
| CvV97065-1 | CAN/ALB | 3 | 44 | 1.87 |
| AOA 95154-1 | ID/OR/ID | 4 | 45 | 1.93 |
| CV 98112-3 | CAN/ALB | 3 | 45 | 2.08 |
| AF 2426-1 | ME | 4 | 27 | 2.10 |
| ND 8201-2 | ND | 4 | 30 | 2.15 |
| CO 97065-7W | CO/OR | 3 | 24 | 2.19 |
| AOTX 95265-2ARU | ID/OR/TX | 3 | 36 | 2.33 |
| AOTX 95265-4RU | ID/OR/TX | 3 | 22 | 2.57 |
| VC 1009-1W/Y | CAN/ALB | 3 | 25 | 2.60 |
| RUSSET BURBANK | CO/OR | 3 | 30 | 2.62 |
| SHEPODY | CAN/NB | 5 | 27 | 2.77 |

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|  |  |  |  |  |
|---|---|---|---|---|
| ATTX 98500-2P/Y | ID/TX/TX | 5 | 27 | 2.86 |
| B 2452-3 | USDA | 5 | 23 | 3.08 |
| B 2451-6 | USDA | 5 | 35 | 3.13 |
| AF 2413-4 | ME | 5 | 29 | 3.27 |
| ATTX 961014-1R/Y | ID/TX/TX | 5 | 27 | 3.27 |
| RIO ROJO |  | 4 | 22 | 3.32 |
| RUSSET NORKOTAH | ND | 4 | 30 | 3.35 |
| AF 2290-8 | ME | 4 | 27 | 3.41 |
| IRISH COBBLER |  | 4 | 31 | 3.43 |
| CO 95172-3 RU | CO/OR | 4 | 30 | 3.47 |
| MN 02 419 | MN | 5 | 27 | 3.56 |
| A 95109-1 | ID | 5 | 23 | 3.77 |
| D.R NORLAND | ND | 5 | 26 | 3.85 |
| AF 2199-6 | ME | 5 | 33 | 3.87 |
| A 96510-4Y | ID | 5 | 22 | 3.91 |
| YUKON GOLD |  | 4 | 37 | 4.04 |
| W 2564-2 | WI | 5 | 31 | 4.14 |
| AF 2431-2 | ME | 5 | 23 | 4.35 |
| A 95409-1 | ID | 5 | 24 | 4.73 |
| RED PONTIAC | USDA/MI/FL | 5 | 20 | 4.98 |
| HIGHLAND RUSSET | ID | 5 | 20 | 6.04 |
| NDTX 4271-5R | ND/TX | 5 | 20 | 6.17 |
| NDTX 4784-7R | ND/TX | 5 | 17 | 6.82 |
| STAMPEDE RUSSET | ID | 5 | 26 | 6.97 |

[1] CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable color, 3 is marginal, 4 and 5 are unacceptable color.

Title: Quantification of Potato Stem Colonization by *Verticillium dahliae* using real-time PCR

*Submitted to NPPGA and the Grower/Processor Consortium*

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## Research Objectives:

1) Develop a real-time duplex PCR assay to enable rapid quantification of *V. dahliae* in potato stem tissue necessary to enhance large scale resistance breeding efforts.
2) Assess colonization by *V. dahliae* of russet potato cultivars with purported resistance to Verticillium wilt.

## Research Plan:

Eight potato cultivars with russet skin types were selected for evaluation of *V. dahliae* colonization. Among these were known resistant (R), cv. Ranger Russet, and very susceptible (VS), cv. Russet Norkotah, which were included as controls (Hane et al., 2003; Mosley et al., 2001; Jansky, 2009). The remaining six cultivars had been previously reported as moderately resistant (MR) to very resistant (VR), but in most instances stem colonization had not been evaluated; designations were based solely on the presence or absence of wilt symptoms in the field. These cultivars include, Russet Burbank (S/MS/MR/R) (Hane et al., 2003; Lynch et al., 2004; Mosley et al., 1999; Mosley et al., 2001), Umatilla Russet (MS/MR) (Mosley et al., 1999), Dakota Trailblazer (AOND95249-1Russ) (VR) (Jansky 2009), Bannock Russet (VR) (Novy et al., 2002), Alturas (VR) (Novy et al., 2003) and Premier Russet (MR) (Novy, et al., 2008). These cultivars were evaluated in the field and also will be evaluated under greenhouse conditions. Each cultivar was planted into naturally infested ground as well has ground amended with additional inoculum, resulting in low (4 ppg) and high (11 ppg) infestation levels.

Visual assessments for symptoms of Verticillium Wilt (VW) were performed six times in July and August from approximately 45 to 90 days after planting (DAP). General wilting as well as symptoms of unilateral wilting which are characteristic of VW were scored on a percent wilt incidence and severity basis for each treatment/replicate combination.

Sections from the basal region of true stems of five plants in each cultivar/treatment/replicate were collected three times during the growing season. Stems collected at the first two sampling dates were surface sterilized, an approximately one gram disk was excised from each stem, placed into a plastic zip-close bag and sterile distilled water was added at a 1:1 weight to volume ratio. Stem segments then were crushed and 50 µl was spread onto solid NP media. At harvest, when plants were senescent or nearly so, stem samples of the same length again were collected from main stems of an additional five plants. Stem sections were dried, ground and plated onto solid NP media. Plates from both crushed fresh and dried stem sections were incubated in the dark for 14 to 21 days before examination under 60× magnification using a stereomicroscope.

Real-time PCR primers and probe developed from the trypsin protease gene of *V. dahliae* (Dobinson et al., 2004) and internal control actin gene of *Solanum tuberosum* (Atallah and Stevenson, 2006) were compared to traditional plating methods for pathogen quantification in potato stem tissue. Total genomic DNA was extracted from stem sections as well as dried stem tissue using the FastDNA Spin Kit (MPBio, Inc.) following manufacturer's instructions. The specificity and sensitivity of the assay was determined using fungal cultures and serial dilutions of infected stem tissue, respectively.

## Results:

Wilt increased in all cultivars as the growing season progressed and was generally higher in inoculated treatments when compared to non-inoculated, although not always significantly so (Table 2; Figure 1). Wilt severity in susceptible control cv. Russet Norkotah was higher than in any other cultivar. Resistant control cv. Ranger Russet did not display lower wilt severity than all other cultivars. Wilt severity in MS/MR cvs. Russet Burbank and Umatilla Russet was between the two control cultivars, however, wilt in MR cv. Premier Russet was lower than that displayed by R cv. Ranger Russet, sometimes significantly so. Among those cultivars rated VR, Dakota Trailblazer (AOND95249-1Russ), Bannock Russet and Alturas, wilt severity tended to be less than or equal to that observed in R control cv. Ranger Russet.

Stem colonization by *V. dahliae* at the first sampling date was highly correlated with wilt severity observed on August 26 ($r = 0.92$; $P < 0.0001$) (Figure 2). Colonization increased in most cultivars from the first to the second sampling date (Figure 3). S control cv. Russet Norkotah had significantly higher colonization levels at both sampling dates than all other cultivars, while colonization in R cv. Ranger Russet was not significantly different than colonization levels of any of the other cultivars at both sampling dates, excluding cv. Russet Burbank at the first sampling date only. MS/MR cv. Russet Burbank and cv. Umatilla Russet again were colonized at a level between the S and R control cultivars. No *V. dahliae* was detected in MR cv. Premier Russet at the first sampling date, and very low levels were observed at the second sampling date. VR cv. Dakota Trailblazer was colonized at low levels at both sampling dates and cv. Bannock Russet and cv. Alturas were colonized at very low levels at the first sampling date and more moderate levels at the second sampling date.

Real-time PCR efficiencies for amplification of the potato actin gene (97.6%) and the trypsin protease gene of *V. dahliae* (94.9%) were very high using this duplex assay. Real-time PCR successfully amplified the *V. dahliae* in all eight cultivars evaluated, including numerous plants where no *V. dahliae* colonies formed on plates (data not shown). The correlation between real-time PCR Ct values and percent wilt evaluated two weeks after stem sampling ($r = -0.72$; $P = 0.0016$) wilt on August 26 ($r = -0.72$; $P = 0.0016$) were strong.

These results indicate that this PCR assay may be utilized to detect *V. dahliae* in potato stems grown under field conditions, but will also enable quantification of the pathogen in potato plants, providing breeders with the ability to rapidly screen germplasm and distinguish between genetic resistance and tolerance to the pathogen, thereby decreasing the time needed to make cultivar selections and reducing the labor required to determine the host:pathogen interaction.

**Literature Cited:**

Atallah, ZK and Stevenson, WR. 2006. A methodology to detect and quantify five pathogens causing potato tuber decay using real-time quantitative polymerase chain reaction. Phytopathology 96:1037-1045.

Dobinson, KF, Grant, SJ and Kang, S. 2004. Cloning and targeted disruption, via *Agrobacterium tumefaciens*-mediated transformation, of a trypsin protease gene from the vascular wilt fungus *Verticillium dahliae.* Current Genetics. 45:104-110.

Hane, DC, Mosley, AR, James, SR, Rykbost, KA, Shock, CC, Love, SL, Corsini, DL, Pavek, JJ, Thornton, RE, Charlton, BA, Eldredge, EP, and Yilma, S. 2003. Wallowa Russet: a full season long russet for processing and fresh market. Amer. J. of Potato Res. 80:289-294.

Jansky, SH. 2009. Identification of Verticillium wilt resistance in U.S. potato breeding programs. Am. J. Potato Res. 86:504-512.

Lynch, DR, Kawchuk, LM, Chen, Q, Konschuh, M, Holley, J, Fujimoto, DK, Dreidger, D, Wolfe, H, Dunbar, L, Waterer, D, Bains, P, Wahab, J, and McAllister, P. 2004. Alta Russet: an early-maturing, high quality russet cultivar for wedge-cut french fry production. Amer. J. of Potato Res. 81:195-201.

Mosley, AR, James, SR, Hane, DC, Rykbost, KA, Shock, CC, Charlton, BA, Pavek, JJ, Love, SL, Corsini, DL and Thornton, RE. 1999. Umatilla Russet: a full season long russet for processing and fresh market use. Amer. J. of Potato Res. 77:83-87.

Mosley, AR, Rykbost, KA, James, SR, Hane, DC, Shock, CC, Charlton, BA, Pavek, JJ, Love, SL, Corsini, DL and Thornton, RE. 2001. Klamath Russet: a full season, fresh market, long russet. Amer. J. of Potato Res. 78:377-381.

Novy, RG, Corsini, DL, Love, SL, Pavek, JJ, Mosley, AR, James, SR, Hane, DC, Shock, CC, Rykbost, KA, Brown, CR and Thornton, RE. 2002. Bannock Russet: a dual-purpose, russet potato cultivar with high U.S. No. 1 yield and multiple disease resistances. Amer. J. of Potato Res. 79:147-153.

Novy, RG, Corsini, DL, Love, SL, Pavek, JJ, Mosley, AR, James, SR, Hane, DC, Shock, CC, Rykbost, KA, Brown, CR and Thornton, RE. 2003. Alturas: a multi-purpose, russet potato cultivar with high yield and tuber specific gravity. Amer. J. of Potato Res. 80:295-301.

Novy, RG, Whitworth, JL, Stark, JC, Love, SL, Corsini, DL, Pavek, JJ, Vales, MI, James, SR, Hane, DC, Shock, CC, Charlton, BA, Brown, CR, Knowles, NR, Pavek, MJ, Brandt, TL, and Olsen, N. 2008. Premier Russet: a dual purpose, potato cultivar with significant resistance to low temperature sweetening during long-term storage. Amer. J. of Potato Res. 85:198-209.

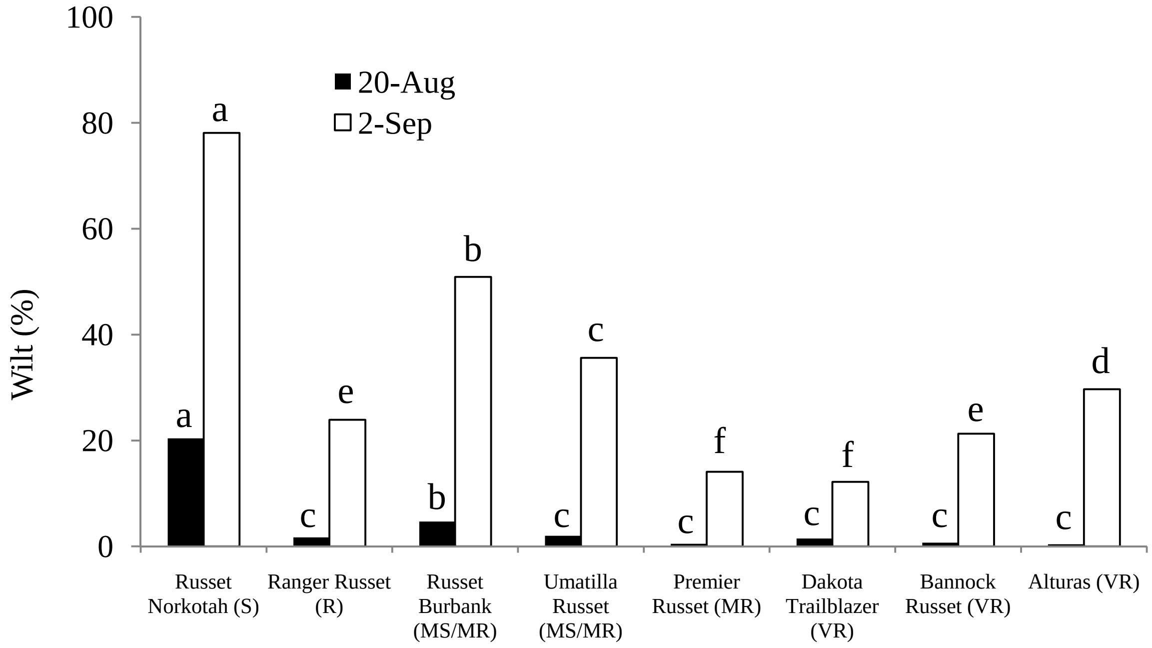

Figure 1. Severity of wilt among eight Russet cultivars with varying reported resistance to Verticillium wilt grown in soil infested with *Verticillium dahliae*.

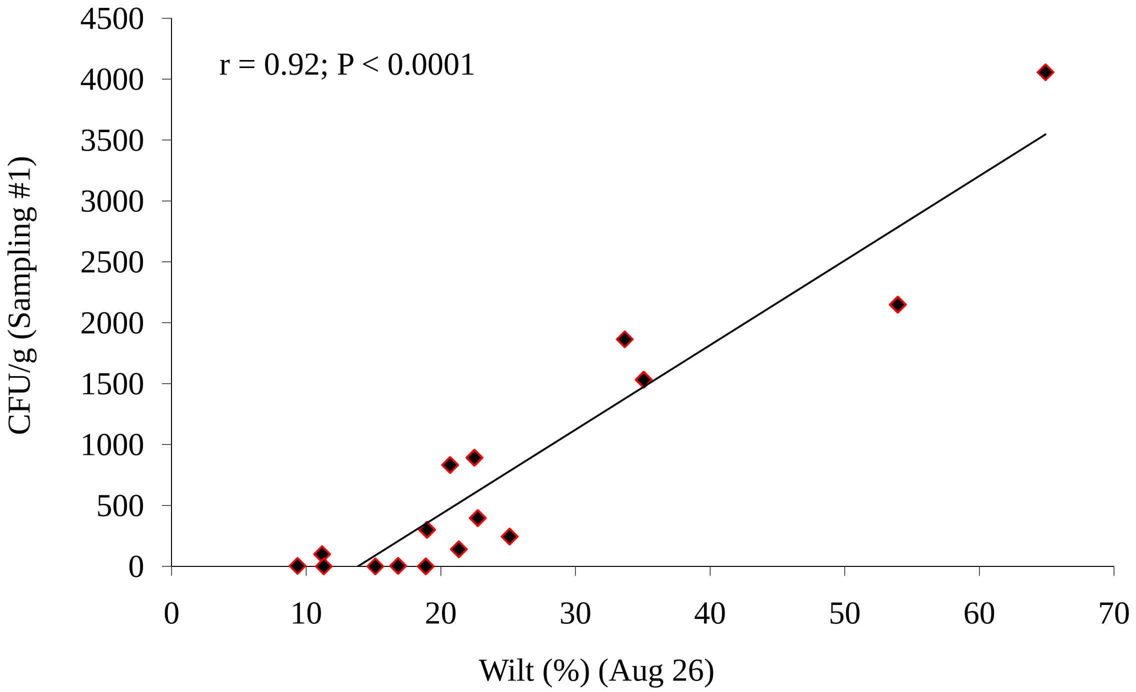

Figure 2. Relationship between colony forming units per gram stem obtained via traditional plating assays on stems sampled at 82 days after planting and wilt severity at 97 days after plating.

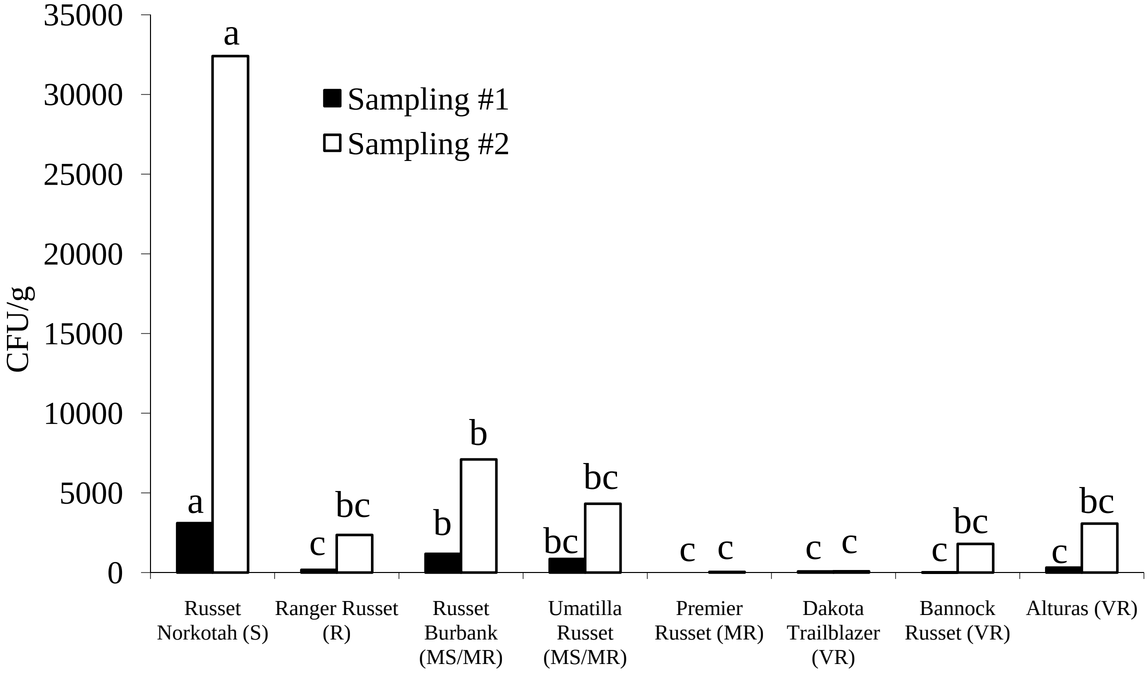

Figure 3. Colony forming units of *Verticillium dahliae* per gram stem obtained from traditional plating assays for eight Russet cultivars with varying reported resistance to Verticillium wilt.

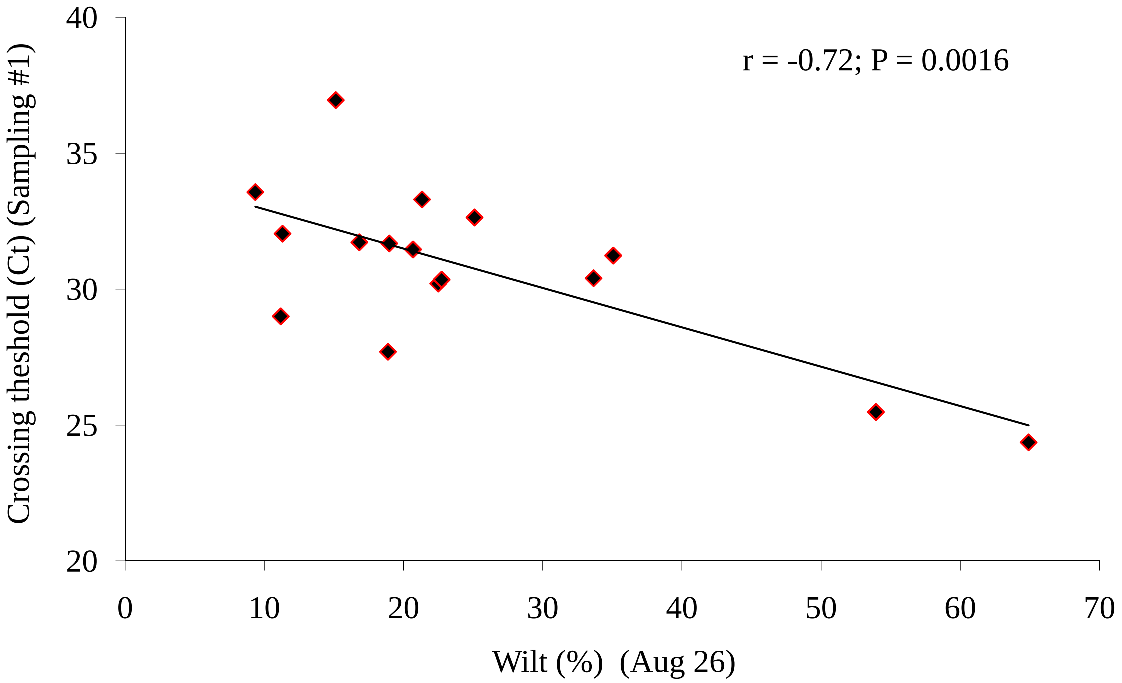

Figure 4. Relationship between crossing threshold values obtained via real-time quantitative PCR assays using primers VTP1-2F/VTP1-2R and Taqman probe VTP1-2P on stems sampled at 82 days after planting and wilt severity at 97 days after plating.

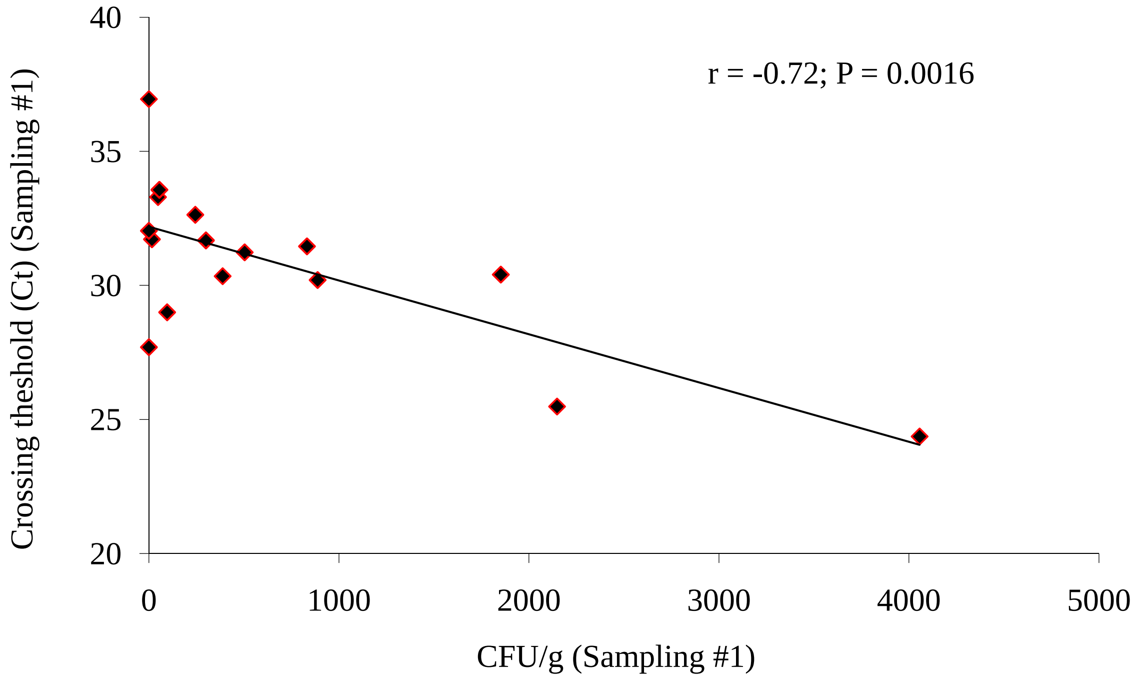

Figure 5. Relationship between crossing threshold values obtained via real-time quantitative PCR assays using primers VTP1-2F/VTP1-2R and Taqman probe VTP1-2P and colony forming units per gram stem obtained via traditional plating assays on stems sampled at 82 days after planting.

Table 1. Percentage of stems wilted among eight Russet cultivars inoculated and not inoculated in-furrow and at side-dress with *Verticillium dahliae*.

| Trt | Cultivar | Reported Susceptibility | Infestation Level | Vigor (7-7) | Percent wilted stems | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 7/30 | 8/4 | 8/11 | 8/20 | 8/26 | 9/2 | 9/9 |
| 401 | Russet Norkotah | Susceptible check | Low | 3.3 | 3.4 | 11.8 | 59.8 | 62.1 | 97.6 | 100.0 | 100.0 |
| 402 | Russet Norkotah | Susceptible check | High | 3.0 | 5.0 | 23.8 | 65.8 | 69.8 | 99.2 | 100.0 | 100.0 |
| 403 | Ranger Russet | Resistant Check | Low | 3.5 | 0.0 | 0.0 | 3.0 | 11.3 | 90.9 | 98.7 | 100.0 |
| 404 | Ranger Russet | Resistant Check | High | 3.3 | 0.0 | 0.0 | 3.4 | 22.8 | 94.0 | 100.0 | 100.0 |
| 405 | Russet Burbank | Moderately Susceptible-Moderately Resistant | Low | 3.5 | 0.0 | 1.4 | 2.6 | 25.4 | 89.1 | 100.0 | 100.0 |
| 406 | Russet Burbank | Moderately Susceptible-Moderately Resistant | High | 2.8 | 0.0 | 1.2 | 9.1 | 19.7 | 97.2 | 100.0 | 100.0 |
| 407 | Umatilla | Moderately Susceptible-Moderately Resistant | Low | 3.0 | 0.0 | 0.3 | 3.1 | 20.2 | 89.7 | 99.3 | 100.0 |
| 408 | Umatilla | Moderately Susceptible-Moderately Resistant | High | 3.0 | 0.0 | 1.0 | 6.0 | 16.0 | 87.0 | 100.0 | 100.0 |
| 409 | Dakota Trailblazer | Very Resistant | Low | 1.8 | 0.0 | 0.0 | 0.0 | 10.9 | 74.8 | 94.2 | 100.0 |
| 410 | Dakota Trailblazer | Very Resistant | High | 1.8 | 0.0 | 0.0 | 0.8 | 22.2 | 79.7 | 100.0 | 100.0 |
| 411 | Bannock | Very Resistant | Low | 1.8 | 0.0 | 0.0 | 3.2 | 7.2 | 58.7 | 94.4 | 99.3 |
| 412 | Bannock | Very Resistant | High | 1.3 | 0.0 | 0.0 | 7.0 | 2.6 | 70.1 | 97.7 | 100.0 |
| 413 | Alturas | Very Resistant | Low | 2.0 | 0.0 | 0.0 | 0.0 | 2.6 | 87.7 | 98.0 | 100.0 |
| 414 | Alturas | Very Resistant | High | 2.5 | 0.0 | 0.0 | 0.0 | 2.3 | 74.8 | 99.0 | 100.0 |
| 415 | Premier Russet | Moderately Resistant | Low | 2.3 | 0.0 | 0.0 | 3.3 | 1.4 | 49.7 | 90.8 | 98.8 |
| 416 | Premier Russet | Moderately Resistant | High | 1.8 | 0.0 | 0.0 | 9.7 | 5.8 | 77.2 | 95.8 | 100.0 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.8 | 1.3 | 2.4 | 7.3 | 19.4 | 24.1 | NS | NS |
| | Russet Norkotah | Susceptible check | | 3.1 | 4.2 | 17.8 | 62.8 | 66.0 | 98.4 | 100.0 | 100.0 |
| | Ranger Russet | Resistant Check | | 3.4 | 0.0 | 0.0 | 3.2 | 17.1 | 92.4 | 99.3 | 100.0 |
| | Russet Burbank | Moderately Susceptible-Moderately Resistant | | 3.1 | 0.0 | 1.3 | 5.8 | 22.6 | 93.2 | 100.0 | 100.0 |
| | Umatilla | Moderately Susceptible-Moderately Resistant | | 3.0 | 0.0 | 0.7 | 4.6 | 18.1 | 88.4 | 99.7 | 100.0 |
| | Dakota Trailblazer | Very Resistant | | 1.8 | 0.0 | 0.0 | 0.4 | 16.5 | 77.3 | 97.1 | 100.0 |
| | Bannock | Very Resistant | | 1.5 | 0.0 | 0.0 | 5.1 | 4.9 | 64.4 | 96.1 | 99.6 |
| | Alturas | Very Resistant | | 2.3 | 0.0 | 0.0 | 0.0 | 2.5 | 81.3 | 98.5 | 100.0 |
| | Premier Russet | Moderately Resistant | | 2.0 | 0.0 | 0.0 | 6.5 | 3.6 | 63.5 | 93.3 | 99.4 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.6 | 0.9 | 1.7 | 5.2 | 13.7 | 17.0 | NS | NS |
| | | | Low | 2.6 | 0.4 | 1.7 | 9.4 | 17.7 | 79.8 | 96.9 | 99.8 |
| | | | High | 2.4 | 0.6 | 3.3 | 12.7 | 20.2 | 84.9 | 99.1 | 100.0 |
| LSD$_{P\ =\ 0.05}$ | | | | NS | NS | 0.9 | 2.6 | NS | NS | NS | NS |

Table 1. (con't).

| Trt | Cultivar | Reported Susceptibility | Infestation Level | Vigor (7-7) | Percent wilted stems | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 7/30 | 8/4 | 8/11 | 8/20 | 8/26 | 9/2 | 9/9 |
| 401 | Russet Norkotah | Susceptible check | Low | 3.3 | 3.4 | 11.8 | 59.8 | 62.1 | 97.6 | 100.0 | 100.0 |
| 402 | Russet Norkotah | Susceptible check | High | 3.0 | 5.0 | 23.8 | 65.8 | 69.8 | 99.2 | 100.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | NS | 11.7 | NS | NS | NS | . | . |
| 403 | Ranger Russet | Resistant Check | Low | 3.5 | 0.0 | 0.0 | 3.0 | 11.3 | 90.9 | 98.7 | 100.0 |
| 404 | Ranger Russet | Resistant Check | High | 3.3 | 0.0 | 0.0 | 3.4 | 22.8 | 94.0 | 100.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | . | NS | NS | NS | NS | . |
| 405 | Russet Burbank | Moderately Susceptible-Moderately Resistant | Low | 3.5 | 0.0 | 1.4 | 2.6 | 25.4 | 89.1 | 100.0 | 100.0 |
| 406 | Russet Burbank | Moderately Susceptible-Moderately Resistant | High | 2.8 | 0.0 | 1.2 | 9.1 | 19.7 | 97.2 | 100.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | NS | NS | NS | NS | . | . |
| 407 | Umatilla | Moderately Susceptible-Moderately Resistant | Low | 3.0 | 0.0 | 0.3 | 3.1 | 20.2 | 89.7 | 99.3 | 100.0 |
| 408 | Umatilla | Moderately Susceptible-Moderately Resistant | High | 3.0 | 0.0 | 1.0 | 6.0 | 16.0 | 87.0 | 100.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | NS | NS | NS | NS | NS | . |
| 409 | Dakota Trailblazer | Very Resistant | Low | 1.8 | 0.0 | 0.0 | 0.0 | 10.9 | 74.8 | 94.2 | 100.0 |
| 410 | Dakota Trailblazer | Very Resistant | High | 1.8 | 0.0 | 0.0 | 0.8 | 22.2 | 79.7 | 100.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | . | NS | NS | NS | NS | . |
| 411 | Bannock | Very Resistant | Low | 1.8 | 0.0 | 0.0 | 3.2 | 7.2 | 58.7 | 94.4 | 99.3 |
| 412 | Bannock | Very Resistant | High | 1.3 | 0.0 | 0.0 | 7.0 | 2.6 | 70.1 | 97.7 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | . | NS | NS | NS | NS | NS |
| 413 | Alturas | Very Resistant | Low | 2.0 | 0.0 | 0.0 | 0.0 | 2.6 | 87.7 | 98.0 | 100.0 |
| 414 | Alturas | Very Resistant | High | 2.5 | 0.0 | 0.0 | 0.0 | 2.3 | 74.8 | 99.0 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | . | . | NS | NS | NS | . |
| 415 | Premier Russet | Moderately Resistant | Low | 2.3 | 0.0 | 0.0 | 3.3 | 1.4 | 49.7 | 90.8 | 98.8 |
| 416 | Premier Russet | Moderately Resistant | High | 1.8 | 0.0 | 0.0 | 9.7 | 5.8 | 77.2 | 95.8 | 100.0 |
| LSD$_{P\ = 0.05}$ | | | | NS | . | . | NS | NS | NS | NS | NS |

A significant interaction was observed between the main effects of cultivar and inoculation was observed in percent wilted stems on 8/4 ($P$ = 0.05).

Table 2. Percentage wilt per stem and total yield among eight Russet cultivars inoculated and not inoculated in-furrow and at side-dress with *Verticillium dahliae*.

| Trt | Cultivar | Reported Susceptibility | Infestation Level | Percent wilt/stem | | | | | | | Total Yield (cwt/a) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7/30 | 8/4 | 8/11 | 8/20 | 8/26 | 9/2 | 9/9 | |
| 401 | Russet Norkotah | Susceptible check | Low | 0.3 | 1.3 | 5.5 | 17.5 | 53.4 | 75.0 | 91.3 | 523.5 |
| 402 | Russet Norkotah | Susceptible check | High | 1.0 | 3.0 | 7.8 | 22.9 | 64.2 | 81.2 | 96.6 | 511.5 |
| 403 | Ranger Russet | Resistant Check | Low | 0.0 | 0.0 | 0.1 | 1.5 | 19.7 | 26.4 | 48.8 | 546.4 |
| 404 | Ranger Russet | Resistant Check | High | 0.0 | 0.0 | 0.1 | 2.0 | 17.7 | 21.0 | 42.4 | 574.4 |
| 405 | Russet Burbank | Moderately Susceptible-Moderately Resistant | Low | 0.0 | 0.2 | 0.1 | 5.2 | 32.9 | 48.7 | 73.6 | 506.5 |
| 406 | Russet Burbank | Moderately Susceptible-Moderately Resistant | High | 0.0 | 0.2 | 0.3 | 4.2 | 34.2 | 53.3 | 76.3 | 485.4 |
| 407 | Umatilla | Moderately Susceptible-Moderately Resistant | Low | 0.0 | 0.0 | 0.1 | 2.2 | 18.6 | 36.8 | 62.8 | 583.8 |
| 408 | Umatilla | Moderately Susceptible-Moderately Resistant | High | 0.0 | 0.0 | 0.4 | 1.8 | 20.0 | 34.2 | 65.9 | 562.7 |
| 409 | Dakota Trailblazer | Very Resistant | Low | 0.0 | 0.0 | 0.0 | 1.1 | 7.3 | 12.0 | 21.6 | 510.5 |
| 410 | Dakota Trailblazer | Very Resistant | High | 0.0 | 0.0 | 0.0 | 2.0 | 8.9 | 12.5 | 21.1 | 491.2 |
| 411 | Bannock | Very Resistant | Low | 0.0 | 0.0 | 0.1 | 1.2 | 11.1 | 18.5 | 35.0 | 449.1 |
| 412 | Bannock | Very Resistant | High | 0.0 | 0.0 | 0.1 | 0.2 | 13.4 | 24.1 | 37.8 | 495.9 |
| 413 | Alturas | Very Resistant | Low | 0.0 | 0.0 | 0.0 | 0.4 | 19.3 | 24.2 | 37.7 | 578.3 |
| 414 | Alturas | Very Resistant | High | 0.0 | 0.0 | 0.0 | 0.3 | 19.1 | 35.0 | 46.7 | 501.4 |
| 415 | Premier Russet | Moderately Resistant | Low | 0.0 | 0.0 | 0.1 | 0.1 | 5.0 | 10.3 | 25.7 | 487.9 |
| 416 | Premier Russet | Moderately Resistant | High | 0.0 | 0.0 | 0.2 | 1.1 | 11.6 | 19.1 | 34.1 | 424.4 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.3 | 0.5 | 0.7 | 2.2 | 3.9 | 6.0 | 6.0 | 78.8 |
| | Russet Norkotah | Susceptible check | | 0.7 | 2.2 | 6.7 | 20.4 | 59.2 | 78.1 | 94.1 | 517.5 |
| | Ranger Russet | Resistant Check | | 0.0 | 0.0 | 0.1 | 1.7 | 18.8 | 23.9 | 45.9 | 560.4 |
| | Russet Burbank | Moderately Susceptible-Moderately Resistant | | 0.0 | 0.2 | 0.2 | 4.7 | 33.4 | 50.9 | 74.7 | 495.9 |
| | Umatilla | Moderately Susceptible-Moderately Resistant | | 0.0 | 0.0 | 0.2 | 2.0 | 19.2 | 35.6 | 64.2 | 573.3 |
| | Dakota Trailblazer | Very Resistant | | 0.0 | 0.0 | 0.0 | 1.5 | 8.1 | 12.2 | 21.4 | 500.8 |
| | Bannock | Very Resistant | | 0.0 | 0.0 | 0.1 | 0.7 | 12.2 | 21.3 | 36.2 | 472.5 |
| | Alturas | Very Resistant | | 0.0 | 0.0 | 0.0 | 0.4 | 19.2 | 29.7 | 42.6 | 539.9 |
| | Premier Russet | Moderately Resistant | | 0.0 | 0.0 | 0.1 | 0.5 | 7.9 | 14.1 | 29.2 | 456.2 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.2 | 0.4 | 0.5 | 1.5 | 2.7 | 4.2 | 4.2 | 55.7 |
| | | | Low | 0.0 | 0.2 | 0.8 | 4.1 | 22.6 | 34.7 | 53.7 | 523.3 |
| | | | High | 0.2 | 0.5 | 13.6 | 5.4 | 26.7 | 39.3 | 57.6 | 505.9 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.1 | 0.2 | 0.3 | 0.7 | 1.3 | 2.0 | 2.0 | NS |

Table 2. (con't).

| Trt | Cultivar | Reported Susceptibility | Infestation Level | Percent wilt/stem | | | | | | | Total Yield (cwt/a) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7/30 | 8/4 | 8/11 | 8/20 | 8/26 | 9/2 | 9/9 | |
| 401 | Russet Norkotah | Susceptible check | Low | 0.3 | 1.3 | 5.5 | 17.5 | 53.4 | 75.0 | 91.3 | 523.5 |
| 402 | Russet Norkotah | Susceptible check | High | 1.0 | 3.0 | 7.8 | 22.9 | 64.2 | 81.2 | 96.6 | 511.5 |
| LSD$_{P\ =\ 0.05}$ | | | | 0.7 | 1.1 | 1.7 | 4.0 | 4.9 | 5.6 | 3.1 | NS |
| 403 | Ranger Russet | Resistant Check | Low | 0.0 | 0.0 | 0.1 | 1.5 | 19.7 | 26.4 | 48.8 | 546.4 |
| 404 | Ranger Russet | Resistant Check | High | 0.0 | 0.0 | 0.1 | 2.0 | 17.7 | 21.0 | 42.5 | 574.4 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | NS | NS | NS | 4.5 | 5.4 | NS |
| 405 | Russet Burbank | Moderately Susceptible-Moderately Resistant | Low | 0.0 | 0.2 | 0.1 | 5.2 | 32.9 | 48.7 | 73.7 | 506.5 |
| 406 | Russet Burbank | Moderately Susceptible-Moderately Resistant | High | 0.0 | 0.2 | 0.3 | 4.2 | 34.2 | 53.3 | 76.3 | 485.4 |
| LSD$_{P\ =\ 0.05}$ | | | | . | NS | 0.2 | NS | NS | NS | NS | NS |
| 407 | Umatilla | Moderately Susceptible-Moderately Resistant | Low | 0.0 | 0.0 | 0.1 | 2.2 | 18.6 | 36.8 | 62.8 | 583.8 |
| 408 | Umatilla | Moderately Susceptible-Moderately Resistant | High | 0.0 | 0.0 | 0.4 | 1.8 | 20.0 | 34.2 | 65.9 | 562.7 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | NS | NS | NS | NS | NS | NS |
| 409 | Dakota Trailblazer | Very Resistant | Low | 0.0 | 0.0 | 0.0 | 1.1 | 7.3 | 12.0 | 21.6 | 510.5 |
| 410 | Dakota Trailblazer | Very Resistant | High | 0.0 | 0.0 | 0.0 | 2.0 | 8.9 | 12.5 | 21.1 | 491.2 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | NS | NS | NS | NS | NS | NS |
| 411 | Bannock | Very Resistant | Low | 0.0 | 0.0 | 0.1 | 1.2 | 11.1 | 18.5 | 35.0 | 449.1 |
| 412 | Bannock | Very Resistant | High | 0.0 | 0.0 | 0.1 | 0.2 | 13.4 | 24.1 | 37.8 | 495.9 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | NS | 0.8 | NS | 4.5 | NS | NS |
| 413 | Alturas | Very Resistant | Low | 0.0 | 0.0 | 0.0 | 0.4 | 19.3 | 24.2 | 37.7 | 578.3 |
| 414 | Alturas | Very Resistant | High | 0.0 | 0.0 | 0.0 | 0.3 | 19.1 | 35.0 | 46.7 | 501.4 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | . | NS | NS | 8.7 | NS | NS |
| 415 | Premier Russet | Moderately Resistant | Low | 0.0 | 0.0 | 0.1 | 0.1 | 5.0 | 10.3 | 25.7 | 487.9 |
| 416 | Premier Russet | Moderately Resistant | High | 0.0 | 0.0 | 0.2 | 1.1 | 11.6 | 19.1 | 34.1 | 424.4 |
| LSD$_{P\ =\ 0.05}$ | | | | . | . | NS | 1.0 | 2.0 | 4.9 | 6.4 | NS |

A significant interaction was observed between the main effects of cultivar and inoculation in wilt per stems on 8/11, 8-20, 8-26, 9-2 and 9-9 ($P = 0.05$).

A significant interaction was not observed between the main effects of cultivar and inoculation in total yield (cwt/a) ($P = 0.05$).