North Dakota State University * Dickinson Research Extension Center
1089 State Avenue, Dickinson, ND 58601-4642 Voice: (701) 483-2348 FAX: (701) 483-2005

Alternative Crops and Cropping Systems in Southwestern North Dakota

Patrick M. Carr, Associate Agronomist;
Glenn B. Martin, Research Specialist;
Burt A. Melchior, Research Technician;
Lee J. Tisor, Research Specialist;
W. W. "Chip" Poland, Area Livestock Specialist

Abstract

Crop production systems in southwestern North Dakota generally are dominated by cereals. Production of these crops for grain has been plagued by pests and other problems. The development of alternative production methods, and the production of other grain and seed crops, is needed to improve cereal cropping systems. The objectives of this research are to determine if (1) cereals and annual legumes can be grown successfully for forage, alone and in combination, (2) pulse crops are adapted to growing conditions in southwestern North Dakota, and (3) oilseed crops can be grown profitably in southwestern North Dakota. To do this, several experiments were conducted in 1997, each having a randomized complete block design with four replications. Results of these experiments showed a general trend for annual legumes to produce less forage than cereals in side-by-side comparisons, though differences between treatments were not always detected at the $P < 0.05$ level of significance. The crude protein (CP) concentration of legume forage was higher than that of cereal forage. Forage yield was inversely related to the CP concentration of both legume and cereal forage when cut at different growth stages. The impact of intercropping cereal with pea crops compared to cereal sole crops on forage yield and CP concentration was inconsistent. The cultivar CDC Milestone produced as much or more seed than seven other lentil cultivars in a seed production trial; gross returns were $203.99/acre. No cultivar was superior to others in a pea seed yield trial; gross returns averaged $75.72/acre for the 12 cultivars evaluated. Mustard seed yield averaged 278 lb/acre for six cultivars in an experiment damaged by hail at Beulah, ND. Average yield was 653 lb/acre for these same cultivars in the experiment at Hannover, ND. Gross returns averaged $80.40/acre for the six cultivars at Hannover; by comparison, gross returns averaged $131.92/acre in a wheat cultivar adaptation experiment also at Hannover. These data show that lentil generated gross economic returns that compared favorably to those generated by wheat in 1997, but peas and mustard did not.

Introduction

Cereals are the most widely grown, cultivated crops in the northern Great Plains. These crops are well adapted to the cool semiarid climate of the region and sometimes produce economic grain yields when other cultivated plants cannot. Exclusive reliance on cereals in crop rotations, however, has encouraged the growth and development of cereal crop pests, along with increased reliance on applications of fertilizer and pesticides to maintain economic yields. Average yields for these crops when grown for grain recently have been lower than those required to return an adequate profit margin to producers.

Expanding cropping choices has been suggested as a possible strategy for profitable crop production (Jolliff, 1989). Crop diversity also can expand market opportunities, improve pest control, and enhance soil conservation (Jolliff and Snapp, 1988).

Diversifying cropping systems is important in southwestern North Dakota, since fewer crops traditionally have been grown here than elsewhere in the state (Ball, 1987).

The objectives of this project are to:

1. Identify which cereal crops have the greatest potential when grown for forage in southwestern North Dakota, and determine what, if any, advantages cereals have when grown with lentil and peas, compared with cereal sole crops.
2. Determine if commercially available lentil and pea cultivars are adapted to growing conditions in southwestern North Dakota, and calculate economic returns when growing lentil and peas for seed.
3. Determine if oilseed crops can be grown profitably in southwestern North Dakota.

Objective 1

Many livestock producers rely on perennial forages to supply most, if not all, of their feed needs in southwestern North Dakota. Perennial forage supplies can become depleted during long dry periods, or following particularly harsh winters. When this occurs, annual forages may be relied upon to meet at least some feed needs of a livestock operation.

Corn has been one of the most dependable, annual forage crops grown in North Dakota. Conlon and Douglas (1957) reported that corn produced more forage per acre than any other annual crop grown at the Dickinson Research Extension Center (formerly Dickinson Experiment Station) between 1907-57. More recently, Nelson and Landblom (1991) reported that other silage crops like forage sorghum have been unable to match the yields produced by corn in southwestern North Dakota.

The importance of corn in the region supports adaptation trials of newly developed hybrids. These trials should reflect changes in corn production strategy, including increased planting rates, narrower row spacing, and crop rotations that include corn but not a summer fallow period.

Cereals besides corn are grown successfully for forage in the southwest. Barley and other small grain crops may be preferred to corn if row crop equipment is not available. In other instances, oat or other annual crops may be preferred to corn to break certain disease or other pest problems. For example, growing oats rather than corn in rotation with wheat may be advisable in environments where *Fusarium* head blight, or scab, is widespread since corn is susceptible to attack from this pathogen while oat generally is not.

While annual cereal crops have been evaluated at the Dickinson Research Extension Center since the early part of this century for forage yield, forage CP concentration and other data relating to quality generally have not been collected. Forage quality data may not have been recognized by researchers as important to livestock producers in the past, but with margins between costs and returns narrowing, forage quality in addition to quantity data now are recognized as important. It is essential that forage quality data be collected in any experiment evaluating alternative sources of forage.

Barley and other cool season cereal crops produce fewer total digestible nutrients than corn when grown for either grain or silage (Smith and Stoa, 1944; Wiidakas, 1967). However, it is possible to enhance the feed value of barley or oat haylage by growing these cereals together with field peas. We found that intercropping barley and oats with field peas significantly increased the CP concentration of forage compared to sole cereal forage (Carr et al., 1998a), as have others (Izaurralde et al., 1990). Forage yield generally was unaffected by intercropping compared with cereal sole cropping in our study, if the seeding rate of the cereal component remained at a sole crop or heavier rate.

It remains unclear at what growth stage the cereal-pea mixture should be harvested for forage. Previous work shows that oats should be harvested at the kernel soft dough stage (Feekes 11.2, in Large, 1954) for the best compromise between forage yield and CP concentration (Dodds et al., 1985), but it is unknown if oats and other cereals should be harvested at this same growth stage when intercropped with peas.

An alternative to growing annual cereals for forage is to grow annual legumes, particularly if the goal is to maximize forage N yield. Lentil and pea forage both contain more CP than cereal forage. If these annual legumes produce comparable amounts of forage to that produced by cereal crops, then production of annual legumes may be preferred to cereals in southwestern North Dakota. Lentil and pea cultivars have been developed for forage production, but generally have not been evaluated anywhere in North Dakota.

Objective 2

Adaptation screening trials in the early 1990s suggested that lentil and pea cultivars were adapted to growing conditions in southwestern North Dakota (Eriksmoen et al., 1992). Since then, many new lentil and pea cultivars have been developed. Markets for peas and lentil grown in North Dakota have developed over the past five years. The Freedom to Farm Act, legislated by Congress, also makes production of lentil and peas more appealing than formerly, now that federal price support programs for wheat and other selected crops are being eliminated.

Lentil and pea cultivars adapted to growing conditions in southwestern North Dakota need to be identified, as do cultural practices that optimize production of both crops. Economic data also are needed which indicate that lentil and peas can be profitably grown in the Missouri Slope region.

Objective 3

Mustard and other oilseed crops are being grown in southwestern North Dakota. Oilseed crop cultivars have been compared in adaptation trials at the Dickinson Research Extension Center (Eriksmoen et al., 1995; 1996). It is important that additional data are collected for these oilseed crops across different environment-years, and new cultivars evaluated, so that the range in adaptation of established cultivars can be determined.

Materials and Methods

Objective 1

Twelve corn hybrids and one open pollinated cultivar were evaluated for silage and grain yield in a dryland, recropped environment in 1997. Crops and cultivars evaluated for forage yield in other experiments included: (i) cool season, annual cereals and legumes (11 treatments); (ii) field peas (13 treatments); (iii) lentil (6 treatments); and (iv) cool and warm season, annual cereals (6 treatments). Also, (v) barley, oats, peas, and lentil were seeded alone and in several combinations (11 treatments), and harvested at four cereal growth stages, in a harvest date experiment.

Cultivars were evaluated using a randomized complete block design with four replications in each experiment. Individual plot dimensions were 28 by 6 ft for all experiments, with two exceptions. Plot dimensions in the corn hybrid experiment were 50 by 6 ft. Plots were 28 by 12 ft in the harvest date experiment.

Cultural practices including tillage and seeding, fertilization, and herbicide application followed currently acceptable agronomic procedure in implementing and maintaining each experiment. Variables measured in each plot varied, depending on the experiment.

The center three adjoining rows of each nine-row plot was harvested with a small plot forage harvester (Swift Machine & Welding Ltd., Swift Current, SK), except in the corn hybrid and harvest date experiments. Plots consisted of two rows that were three feet apart in the corn hybrid experiment, and plants were harvested from a 45-ft^2 area by hand. In the harvest date experiment, the interior 12 rows of each 18-row plot were harvested, 3 adjoining rows at a time, during one of four harvest dates.

Plots containing cool season, cereal crops were harvested at the kernel milky ripe growth stage (Feekes 11.1) (Long, 1954). In addition, plots were harvested at three other cereal growth stages in the harvest date experiment: early heading(Feekes 10.1), kernel soft dough (Feekes 11.2) and kernel hard dough (Feekes 11.3) (Long, 1954). Lentil and fababean plots were harvested at bud to 100% bloom growth stages, and pea plots were harvested during pod development stages. Warm season cereals were harvested at early heading to kernel soft dough stages of cereal plant development.

Forage yield was determined by recording a fresh weight when forage was harvested. A subsample of approximately 1 lb was randomly selected from the harvested portion of each plot and dried at 140^{o}F until a constant weight was attained. Forage yield is expressed on a dry weight basis. In all experiments except the corn hybrid trial, forage CP concentration, acid detergent fiber (ADF), and neutral detergent fiber (NDF) were determined by standard procedures (AOAC, 1990).

Data within each experiment were analyzed by ANOVA using SAS (SAS Inst., 1985). Where F tests showed significant differences ($P < 0.05$) among treatments, means were separated using Fischer's protected LSD.

Objective 2

Twelve field pea cultivars were evaluated for seed yield in a dryland, recropped experiment at Dickinson in 1997. Eight lentil cultivars were evaluated in a separate experiment. Experimental design, plot dimensions, management, and data analysis were nearly identical to those used in the cool season, annual cereals and legumes experiment described under objective 1.

The effect of placing N fertilizer with Trapper pea seed at planting on pea plant establishment and seed yield was evaluated in an experiment at Dickinson and Glen Ullin in 1996. The effect of placing both N and P fertilizer with Carneval pea seed at planting was studied at Beulah and Hannover in 1997. Both experiments were designed, implemented, and analyzed in the same way as the field pea cultivar experiment.

The impact of three contrasting seeding rates (7, 8, and 9 pure live seed (PLS)/ft^2) on pea plant stand and seed yield was studied at Glen Ullin in 1996, and at Beulah and Hannover in 1997. The experiment was designed, implemented, and analyzed as described for other experiments involving peas.

Objective 3

Six mustard cultivars were evaluated in an experiment at Beulah and Hannover in 1997. Experimental design, plot dimensions, management, and data analysis were nearly identical to those used in the cool season, annual cereals and legumes experiment described under objective 1.

Results and Discussion

Objective 1

Corn

Average silage yield was 4.2 tons of dry matter (DM)/acre for the 13 cultivars evaluated in 1997 (Table 1). Silage yield ranged from 3.6 tons DM/acre for the cultivar Proseed 180 to 5.1 tons DM/acre for the cultivar Dekalb DK-385 B, although differences were not detected between cultivars at the $P < 0.05$ level of significance.

The corn cultivar Pioneer 3893 was superior to all other cultivars for grain yield in 1997, except Dekalb DK-449 (Table 1). Average yield for the twelve cultivars evaluated for grain production under dryland conditions was 71.7 bu/acre. This yield level is higher than typical at

Dickinson, and attests to the favorable environmental conditions that existed for corn production in 1997 (Eriksmoen et al., 1997). These data suggest that corn grain production can be successful in southwestern North Dakota. Grain yield is not reported for the cultivar Proseed S107, which was developed for silage and not grain production.

Grain test weight was light (< 56 lb/bu) for most cultivars in 1997 (Table 1), as it had been in 1996 (Eriksmoen et al., 1996). It is unclear why test weights were light, although dry conditions developed late in the growing season in 1997 and may have inhibited carbohydrate translocation into kernels of developing corn plants.

Cool Season, Annual Cereals and Legumes

Forage yield among the eleven cereal and legume treatments averaged only 1.5 tons DM/acre in 1997 (Table 2). By comparison, an average of 2.8 tons DM/acre was produced by thirteen cereal and legume cultivars in 1996. Lack of precipitation from May through mid-June accounts for the low forage yield of cool season treatments tested in 1997. Differences in yield were not detected among treatments in 1997; the triticale cultivar 2700 produced more forage than other treatments included in this experiment in 1996.

Forage of Aladdin fababean and Indianhead black lentil contained more CP than that of other cereals or legumes, either alone or in combination, evaluated in 1997 (Table 2). In contrast, the CP concentration of Trapper pea forage was not higher than that of Haybet barley, Paul oat or 2700 triticale forage. Similarly, the CP concentration of sole cereal forage was comparable to that of Arvika pea forage in 1996. These data show that the forage of some pea cultivars is not higher in CP than forage of selected cereal cultivars under certain environmental conditions.

Seeding peas with cereals failed to produce forage with a higher CP concentration than seeding the cereal component alone in either 1996 or 1997 (Table 2). These results contradict those of earlier research which indicated that intercropping increases CP concentration compared to cereal sole cropping (Carr et al., 1998). Soil N differences between environments may explain why results of the two experiments differ. Forage CP concentration was not increased by intercropping in environments where soil N levels were 70 lb/acre or more, but was in environments where soil N levels were less than 55 lb/acre (data not presented). We suggest that seeding pea with cereals can increase forage CP concentration in low soil N environments when fertilizer is not applied, if pea seed is inoculated. Forage CP concentration may not be increased by intercropping in environments where soil N levels are at least 70 lb N/acre, or fertilizer N is applied.

A consistent trend in forage CP concentration as affected by intercropping did not exist in either 1996 or 1997 (Table 2). For example, the average CP concentration of 2700 triticale was 10.1% when seeded alone compared with 10.9% when intercropped with peas in 1996, while it was 11.5% when seeded alone and 10.5% in 1997.

Acid detergent fiber concentration of pea forage generally was greater than cereal forage in 1996, but not in 1997 (Table 2). An exception existed in 1996, when forage of Whitestone oat and Arvika pea were comparable in ADF concentration. Intercropping cereals with peas generally failed to affect ADF concentration of forage compared to cereal sole cropping in either 1996 or 1997. Intercropping reduced NDF concentration of forage compared to sole cereal cropping in 1997, but did not affect NDF concentration of forage in 1996.

Forage Pea

Pea plants were harvested at an average moisture content of 81% (Table 3). By comparison, lentil plants were harvested at a moisture content of 66% (Table 4), and cool season, annual cereals at an average moisture content of 68% (data not provided). The lush growth and higher moisture content of peas at harvest suggest that a mower conditioner might be needed if peas are cut for hay, rather than ensiled.

Forage yield averaged 1.1 tons DM/acre among thirteen pea cultivars during 1997 (Table 3); average forage yield was similar for cool season, annual cereal crops in a similar experiment also at Dickinson (Table 2). Yield ranged from 0.7 tons DM/acre for the pea cultivar Totem to 1.4 tons DM/acre for cultivars Algera and Grande, though differences in yield were not detected at the $P < 0.05$ level.

Average height of pea plants was 25 inches at harvest (Table 3), and forage was harvested without difficulty. Plant height ranged from 18 inches for the cultivar Totem to 29 inches for the cultivar 148-24f/200-17f, though significant differences in plant height were not detected ($P < 0.05$).

Crude protein content of pea forage ranged from 16.9% for the cultivar Pro 2100/8612-2g to 20.3% for the cultivar 148-24f/200-17f (Table 3). Other cultivars with forage CP concentration similar to that of Pro 2100/8612-2g were Grande (18.8%), Highlite (18.6%), Motazz (19.8%), Precourse (18.1%), Totem (20%), and Cenex 4010 (18.6%). These data reveal considerable variation among pea cultivars in forage CP concentration, showing the importance of collecting forage CP concentration with yield data when comparing pea cultivars for forage production.

Relative feed values (RFVs) were estimated for pea forage using equations developed for other crops (Schroeder, 1996). The RFVs for forage of cultivars Grande, Highlite, Precourse, and Totem were superior to those of other cultivars in the experiment (Table 3). The RFVs for forage of these four cultivars averaged 153%, showing that peas can produce high quality forage under conditions similar to those encountered during this experiment.

Forage Lentil

Forage yield averaged 1.4 tons DM/acre for six lentil cultivars evaluated in 1997 (Table 4). More forage was produced by cultivars CDC Richlea, Indianhead, and Laird than Brewer, Pardina, or CDC Milestone. These data suggest that cultivars CDC Richlea and Laird, which were developed for seed production, can sometimes produce as much forage as the cultivar Indianhead, which was developed for forage production.

Lentil plants were harvested after pods began to develop in the experiment. Yield of the forage cultivar Indianhead was 2 tons DM/acre (Table 4), but only 0.7 tons DM/acre in a separate experiment when lentil plants were harvested prior to flower formation (Table 2). These data suggest that forage yield of lentil can be increased if harvest is delayed from flower bud to pod development growth stages.

The forage CP concentration of the cultivar Indianhead was superior to that of other lentil cultivars (Table 4). Acid detergent fiber, NDF, and RFV concentrations of Indianhead lentil forage were comparable to that of forage for other cultivars. These preliminary data support the use of Indianhead lentil for forage production in southwestern North Dakota.

Warm Season, Annual Cereals

Forage yield of warm season, annual cereal crops along with the oat cultivar Paul averaged only 1.4 tons DM/acre in 1997 (Table 5). Significant differences in yield were not detected among cultivars, which ranged from 1.2 tons DM/acre for German millet to 1.6 tons DM/acre for Siberian millet and Paul oats. Forage yield was much less than expected, based on data collected in 1995 and 1996. Dry conditions and weed infestations were encountered during this experiment and probably explain the low yields that occurred in 1997.

Crude protein concentration of forage ranged from 8.4% for Piper sudangrass to 10.8% for German millet (Table 6). These data and those for ADF, NDF, and RFV concentrations suggest that forage produced by warm season, annual cereals, along with Paul oat that was planted in late May, was inferior to that produced by cool season, annual cereals grown at Dickinson in 1997 (Table 2).

Contrasting Harvest Dates with Barley, Oat, Pea, and Lentil

Average forage yield was only 0.9 tons DM/acre across sole crop and intercrop treatments when the cereal component was cut at the early heading growth stage in 1997 (Table 7). Forage yield averaged 1.7 tons DM/acre when cut at the same cereal growth stage in 1996. Average forage yield was 1.6 tons DM/acre across all treatments when harvesting was delayed until the kernel milky ripe stage in 1997, and 2.3 tons DM/acre in 1996. Two tons of forage DM/acre was produced when harvesting was delayed until the kernel soft dough stage in 1997, and 2.5 tons DM/acre in 1996. Delaying harvesting until the kernel hard dough stage resulted in an average forage yield of 2 tons DM/acre in 1997, and 2.6 tons DM/acre in 1996.

Seeding Dumont oats at 26 kernels/ft^2 with Trapper pea at 11 seeds/ft^2 produced comparable or greater amounts of forage than other treatments at each harvest date in 1996 and 1997 (Table 7). In contrast, seeding Dumont oats at 9 kernels/ft^2 and Trapper peas at 4 seeds/ft^2 sometimes produced less forage than other treatments that included Dumont oats, including the cereal sole treatment. A similar trend existed for Horsford barley treatments. These data concur with earlier work (Carr et al., 1998a) showing that forage yield could be reduced by intercropping compared to sole cropping when the cereal was seeded at half of the sole crop rate in the mixture.

Forage yield in lentil and pea sole crop plots generally was less than plots where cereals were seeded, either alone or with peas, at each harvest date in 1996 and 1997 (Table 7). These data suggest that cool season, annual legumes should not be seeded if the goal of forage production is to maximize forage yield.

The CP concentration of forage was comparable or greater when Dumont oats were seeded with Trapper peas compared to seeding Dumont oats alone, at each harvest date during 1996 and 1997 (Table 8). This trend also existed for Horsford barley plots. A distinct advantage in forage CP concentration did not exist when Horsford barley rather than Dumont oats was seeded with peas at each cutting date, unless forage was harvested at the kernel milky ripe stage in 1996. In this instance, seeding Horsford barley at 9 kernels/ft^2 with Trapper peas at 4 seeds/ft^2 produced forage with a higher CP concentration than any Dumont oats treatment.

The CP concentration of Indianhead lentil forage was higher than that of Trapper pea forage at each harvest date during 1996 and 1997 (Table 8). However, the CP concentration of forage was never superior for Indianhead lentil-Dumont oats mixtures compared with Trapper peas-Dumont oats mixtures, except when forage was harvested at the kernel hard dough stage in 1996. We observed that Indianhead lentil was less competitive than Trapper peas within mixed plots with cereals and, as a result, contributed less biomass to forage yield. The small contribution in forage provided by lentil in cereal-legume mixtures negated its superior concentration in CP compared with pea forage. These data fail to show any advantage in substituting Indianhead lentil for Trapper peas in cereal-pea mixtures, under conditions similar to those encountered in this investigation.

Objective 2

Field Pea

Mean seed yield was 27 bu/acre (1623 lb/acre) for pea cultivars, ranging from 14 bu/acre (840 lb/acre)for Radley to 38 bu/acre (2280 lb/acre) for Grande (Table 9). Grande has produced an average of 39 bu/acre (2340 lb/acre) over the past two years in a recropped environment. However, Grande is prone to lodging, as the data in Table 9 show. Among the semi-leafless pea cultivars, Carneval may be the best adapted to southwestern North Dakota. Carneval has produced an average of 36 bu/acre (2160 lb/acre) over the past three years, and has been among the most upright pea cultivars tested. Carneval peas can be straight cut with little if any modification of harvesting equipment used with small grains; however, cylinder speed and concave adjustments must be made before harvesting the peas.

Economic returns generated by pea seed production averaged only $75.73/acre across twelve cultivars in 1997 (Table 9), assuming the peas were sold for feed. This assumption probably was reasonable, except for Majoret, Radley, and Totem cultivars. The seed of these three cultivars is green and could be sold on the human food market for a higher price, if quality standards were met. Still, these data suggest that current market conditions may make peas less attractive to growers than other alternative crops, even taking into account the N soil credit for peas that is described by Franzen (1996).

Many pea cultivars seem adapted to growing conditions in southwestern North Dakota and can be incorporated into small grain production systems. The seed of most pea cultivars can be planted with equipment used to seed small grains. Peas can survive hard, early-season frosts, and should be among the first crops planted in the spring. Several herbicides are labeled for the control of broadleaf and grass weeds in peas, and peas are competitive with weeds once a stand is established. Several semi-leafless peas can be straight-cut with conventional, small grain harvesting equipment. No insect pests have been observed in peas at Dickinson, and grasshoppers seem to avoid feeding on peas (M. Weiss, 1997, personal communication). Peas also can fix atmospheric N (Franzen, 1996). Our preliminary work supports incorporation of peas into cereal production systems, particularly if more favorable markets develop.

Lentil

Mean seed yield of lentil was 21 bu/acre (1260 lb/acre) in 1997 (Table 10), and ranged from 16 bu/acre (960 lb/acre) for Laird and Pardina to 25 bu/acre (1500 lb/acre) for CDC Milestone. This was the first year that CDC Milestone was evaluated at Dickinson. CDC Richlea has produced more seed (average 25 bu/acre) than any other lentil cultivar evaluated at Dickinson over the past three years. Lodging scores indicate that cultivars CDC Richlea, CDC Milestone, Eston, and CDC Redwing were more upright than other lentil cultivars. CDC Richlea also was comparable in height or taller than other lentil cultivars. For these reasons, CDC Richlea seems to be the best adapted cultivar to growing conditions in the southwestern North Dakota.

Economic returns generated by lentil seed production compared favorably with those generated by other crops commonly grown for seed in 1997. Gross returns for lentil seed averaged $168.21/acre in 1997 (Table 10). Gross returns for wheat, barley, and oat averaged $147, $136, and $115/acre, respectively, in adaptation trials at Dickinson (Eriksmoen et al., 1997). Since production costs for lentil are not much higher and can even be less than those for small grains, these preliminary data suggest that returns from lentil can compare favorably with those from small grain crops.

Lentil is not competitive with weeds for growth resources (Carr et al., 1998b), particularly early in the growing season when lentil growth can be slow. Therefore, and because broadleaf herbicide options are limited, lentil should be planted only in fields where weed problems are not severe. Lentil also is short and the seed pods shatter as they dry down. These caveats suggest that lentil may require more careful management for successful production than wheat. If properly managed, however, the data in Table 10 suggest that lentil can be grown profitably in southwestern North Dakota.

Seeding Rate - Field Pea

More pea plants became established as the pea seeding rate increased from 7 PLS/ft^2 (300,000 PLS/acre) to 9 PLS/ft^2 (400,000 PLS/acre), in three different environments (Table 11). However, altering the seeding rate within this range did not affect pea seed yield. Likewise, pea test weight was unaffected by changes in the seeding rate (data not provided). We conclude that altering the seeding rate from 7 PLS/ft^2 to 9 PLS/ft^2 does not affect pea seed yield or test weight, under conditions similar to those encountered in this investigation.

Fertilizer - Field Pea

Applying N as urea with pea seed at planting reduced pea plant stands at Dickinson and Glen Ullin in 1996, compared to forgoing fertilizer (Table 12). Pea plant numbers were reduced by 25% to 43% with applications of only 10 lb urea/acre at Dickinson and Glen Ullin. There was no advantage in pea seed yield or test weight resulting from applications of urea.

Pea plant numbers decreased by 34% when urea was applied at 12 lb/acre with pea seed at Hannover in 1997, compared to forgoing fertilizer (Table 13). Likewise, applications of MAP (11-52-0) and TSP (0-45-0) with pea seed at planting decreased pea plant numbers. Similar trends occurred when fertilizer was applied with pea seed at Beulah, although significant differences between fertilizer treatments and an unfertilized treatment were not detected at the $P < 0.05$ level. These data show that pea plant numbers can be reduced when N, P, and N+P fertilizers are applied with pea seed at planting.

Pea yield and test weight were not increased by applications of fertilizer with pea seed at planting (Table 14). Sometimes, seed yield was decreased. For example, seed yield was reduced by 18% and 42% when MAP was applied at rates of 50 lb/acre and 75 lb/acre, respectively, with the seed during planting at Beulah. These data do not support current recommendations of applying up to 40 lb P_2O_5 as MAP/acre with pea seed at planting for seed yield enhancement (Franzen, 1998). Our preliminary results suggest that applications of any N or P containing fertilizer should be avoided since pea plant stand and seed yield may be reduced.

Objective 3

Mustard

Mustard yield averaged only 278 lb/acre for six cultivars evaluated at Beulah in 1997 (Table 14). Hail damage at this location account for the low seed yield; by comparison, hard red spring wheat averaged 17 bu/acre (1020 lb/acre) at this location. Seed yield averaged 653 lb/acre at Hannover in 1997 (Table 15), even though some seedpods shattered before plants were harvested. Economic returns averaged $80.40/acre for mustard at Hannover, and only $33.59/acre at Beulah. Hard red spring wheat generated higher returns at both sites (Eriksmoen et al., 1997). These data show that the mustard cultivars seeded at Beulah and Hannover were not economically competitive with hard red spring wheat at either location in 1997.

Conclusions/Implications of Research

Objective 1

Cool season and warm season, annual forages can be grown successfully for forage in southwestern North Dakota. Preliminary data show that triticale may be comparable or superior to barley and oats for forage yield, and comparable in CP concentration. We suggest that triticale is being underutilized as a cool season, annual forage in southwestern North Dakota, as has been suggested by forage seedsmen (D. Roland, per. comm, 1998). Additional data are needed, however, before we can conclude with certainty that more forage can be produced by substituting triticale for barley or oats, and that the CP concentration of triticale, barley, and oat forage is comparable.

Preliminary data suggest that forage CP concentration of cool season, annual legumes is superior to that of barley, oat, and triticale, but legumes produce less forage. Results of other experiments (Carr et al., 1998a) support these preliminary observations, although more data are needed. Forage yield and CP concentration are inversely related in cool season, annual cereals, cereal-pea mixtures, and annual legumes.

Average forage yield of the corn hybrid trial compared favorably to average yields of other experiments involving cereal crops. Statistical comparisons between experiments for yield are not possible, but we suspect that corn is comparable or superior to other cereal crops for forage yield. We will compare corn with other warm season, annual cereals and oats for forage production in 1998.

Lentil and pea cultivars vary for forage yield and CP concentration. No pea cultivar was identified as superior to others for yield or CP concentration in 1997. Indianhead lentil compared favorably to other lentil cultivars for forage yield and CP concentration. Lentil and pea cultivars will be evaluated in 1998.

Objective 2

Pea cultivars varied for seed yield at Dickinson in 1997. Among those tested, the cultivar Carneval is among the best adapted for seed production. It produces yellow seed which primarily is sold for livestock feed. Preliminary data suggest that it may be difficult for peas to generate comparable or higher economic returns than wheat, unless market conditions change. However, much uncertainty exists on the best management practices for growing peas, and as more is learned, the economics of growing peas should improve.

The economics of lentil production suggest that returns generated from lentil compared favorably to those of wheat and pea in 1997. Lentil cultivars will be compared in 1998, and beyond, to identify those which are best adapted to environmental conditions in southwestern North Dakota. Preliminary data suggest that lentils may be an alternative to cereals that is economically viable, although production problems associated with lentil must be solved (Carr et al., 1998b).

Objective 3

Preliminary data suggest that mustard was not economically competitive with wheat in 1997. However, hail damage and seedpod shattering problems were encountered and damaged data that were collected. Results of past experiments indicate that mustard can be economically competitive with wheat in southwestern North Dakota (Eriksmoen et al., 1996). Mustard cultivars will be evaluated in 1998 so the economics of mustard production can be better quantified.

Literature Cited

AOAC. 1990. Official methods of analysis. 15th ed. Vol. 1. Assoc. of Offic. Anal. Chem., Arlington, VA.

Ball, W.S. 1987. Crop rotations for North Dakota. NDSU Ext. Serv. Circ. EB-48. North Dakota State Univ., Fargo. 20 p.

Carr, P.M., G.B. Martin, J.S. Caton, and W.W. Poland. 1998a. Forage and N yield of barley-pea and oat-pea intercrops. Agron. J. 90:79-84.

Carr, P.M., G.B. Martin, and J.D. Harris. 1998b. Postplant tillage provides limited weed control in flax, lentil, and spring wheat. *North Dakota Agric. Res.* [Online], 13 pages. Available: http://www.ag.ndsu.nodak.edu/ndagres/fall97/ar11197a.htm

Conlon, T.J., and R.J. Douglas. 1957. Corn for silage. North Dak. Farm Res. 19(4): 107-114.

Dodds, D.L., L Johnson, and G. Fisher. 1985. Silage production and management. NDSU Ext. Serv. Circ. 14 AGR 9 (R-846). North Dakota State Univ., Fargo. 8 p.

Eriksmoen, E., P. Carr, and G. Martin. 1992. Ninth annual west Dakota crops day research report. Hettinger, Research Extension

Center, Hettinger. ND.

Eriksmoen, E., P. Carr, G. Martin, R. Olson and L. Tisor. 1995. Twelfth annual west Dakota crops day research report. Hettinger, Research Extension Center, Hettinger. ND.

Eriksmoen, E., P. Carr, G. Martin, R. Olson and L. Tisor. 1996. Thirteenth annual west Dakota crops day research report. Hettinger, Research Extension Center, Hettinger. ND.

Eriksmoen, E., P. Carr, G. Martin, R. Olson, and L. Tisor. 1997. Fourteenth annual west Dakota crops day research report. Hettinger, Research Extension Center, Hettinger. ND.

Franzen, D.W. 1996. North Dakota fertilizer handbook. NDSU Ext. Serv. Circ. EB-65, North Dakota State Univ., Fargo. 47 p.

Franzen, D.W. 1998. Fertilizing field pea and lentil. NDSU Ext. Serv. Circ. SF-725 (Rev.). North Dakota State Univ., Fargo.

Izaurralde, R.C., N.G. Juma, and W.B. McGill. 1990. Plant and nitrogen yield of barley-field pea intercrop in cryoboreal-subhumid central Alberta. Agron. J. 82:295-301.

Jolliff, G.D. 1989. Strategic planning for new-crop development. J. Prod. Agric. 2:6-13.

Jolliff, G.D., and S.S. Snapp. 1988. New crop development: opportunity and challenges. J. Prod. Agric. 1:83-89.

Large, E.C. 1954. Growth stages in cereals. Plant Pathol. 3:128-129.

Nelson, J.L. and D.G.Landblom. 1991. Contributions of the Dickinson Research Center to western North Dakota. North Dak. Farm Res. 49(1):3-9.

SAS Inst. 1985. SAS procedures guide for personal computers. Version 6 ed. SAS Inst., Cary, NC.

Smith, R.W., and T.E. Stoa. 1944. A comparison of different grains for feed production in North Dakota. North Dak. Agric. Exp. Stat. Bimon. Bul. 6(4): 13-17.

Schroeder, J.W. Quality forages for maximum production and return. 1996 NDSU Ext. Serv. Circ. AS-1117, North Dakota State Univ., Fargo. 11 p.

Wiidakas, W. 1967. Adapted corn hybrids are more dependable. North Dak. Agric. Exp. Stat. Bimonthly Bull. Farm Res. 25(1): 13-15.

Table 1. Forage and grain yield of twelve corn hybrid cultivars and one open pollinated, corn cultivar during 1996 and 1997 at Dickinson, ND.

Brand	Cultivar	RM[1]	Grain		Harvest moisture	Silage yield			
						70% Moisture	DM Basis		
			Yield	TW[2]			1996	1997	2 yr avg
		days	bu/acre	lb/bu	%	tons/ac			
Dekalb	DK-345	84	67.8	55.4	52	13.4	--	4.0	--
Dekalb	DK-365	86	69.1	53.5	54	13.0	--	3.9	--
Dekalb	DK-385 B	88	76.6	55.8	53	17.1	--	5.1	--
Dekalb	DK-449	94	80.2	54.6	63	16.0	--	4.8	--
Kaystar	KX-285	81	68.0	54.2	52	12.7	--	3.8	--
Kaystar	KX-288	82	69.3	51.5	55	13.6	--	4.1	--
Pioneer	3878	89	74.2	55.8	56	14.1	5.9	4.2	5.0
Pioneer	3893	89	87.4	54.4	48	15.8	6.1	4.7	5.4
Pioneer	3941	82	75.3	56.0	49	12.8	--	3.8	--
Pioneer	3970	77	58.1	56.8	42	12.8	5.0	3.8	4.4
Proseed	180	80	71.4	55.6	50	12.1	--	3.6	--
Proseed	185	85	63.3	51.1	54	14.4	--	4.3	--
Proseed	S 107	--	--	--	68	15.6	--	4.7	--
Mean			71.7	54.6	53.5	14.1	--	4.2	--
C.V. %			10.4	1.9	11.6	17.0	--	17.0	--

LSD .05			9.7	1.3	12.0	NS[3]	--	NS	--

[1]RM=relative maturity.
[2]TW = test weight.
[3]NS = not significant at the $P < 0.05$ level.

Table 2. Forage yield and forage crude protein (CP), acid detergent fiber (ADF),and neutral detergent fiber (NDF) content, of cool season, annual cereals and legumes during 1996 and 1997 at Dickinson, ND.

Forage treatment	Dry matter basis							
	Yield		Crude protein		ADF		NDF	
	tons/ac		%					
	1996	1997	1996	1997	1996	1997	1996	1997
Arvika pea	2.4	--	11.2	--	47.1	--	39.3	--
Trapper pea	--	1.4	--	13.4	--	46.1	--	51.1
Aladdin Fababean	--	0.6	--	18.3	--	49.0	--	51.2
Indianhead Black lentil	--	0.7	--	16.2	--	34.9	--	40.5
Azure barley	2.8	--	13.6	--	27.9	--	41.0	--
Haybet barley	--	1.8	--	11.3	--	32.7	--	52.4
Robert oat + Trapper pea	2.5	1.5	13.0	12.3	35.6	42.4	51.6	55.8
Bay oat + Trapper pea	2.5	--	14.5	--	33.6	--	49.0	--
Frank triticale	3.5	--	11.5	--	25.8	--	44.1	--

Frank triticale + Trapper pea	3.1	--	10.5	--	31.9	--	46.2	--
Paul oat	2.3	1.2	12.4	11.8	38.4	43.5	54.4	60.3
Paul oat + Trapper pea	2.2	1.5	12.1	12.6	35.3	45.1	52.7	53.0
Triticale 2700	4.2	1.9	10.1	11.5	26.6	40.8	48.2	63.2
Triticale 2700 + Trapper pea	3.5	2.2	10.9	10.5	27.1	43.0	45.6	58.5
Whitestone oat	2.7	1.6	10.7	10.1	45.1	43.8	58.0	64.5
Whitestone oat + Carneval pea	2.7	--	11.0	--	37.5	--	52.3	--
Whitestone oat + Trapper pea	2.6	2.0	12.3	11.8	36.1	43.5	56.3	57.6
Mean	2.8	1.5	11.8	12.7	34.5	42.3	49.0	55.3
CV(%)	9.2	17.0	10.4	13.0	11.1	6.7	13.7	5.3
LSD (.05)	0.4	NS[1]	NS	2.4	8.4	4.1	NS	4.2

[1]NS = not significant at the $P < 0.05$ level.

Table 3. Forage yield and forage crude protein (CP), acid detergent fiber (ADF),neutral detergent fiber (NDF), and relative feed value (RFV) content, of thirteen pea cultivars during 1997 at Dickinson, ND.

	Plant	Harvest	Dry matter basis				

Cultivar	height	moisture	Yield	CP	ADF	NDF	RFV
	in	%	tons/acre	%			
Algera	27	79	1.4	17.5	38	43	131
Carneval	24	80	1.2	17.0	33	44	134
Grande	28	82	1.4	18.8	33	41	147
Highlite	22	81	1.0	18.6	31	41	149
Motazz	26	81	0.9	19.8	34	43	137
Precourse	27	80	1.2	18.1	34	40	146
Pro 2100/8612-2g	26	79	1.2	16.9	33	42	141
Quayessa	22	82	1.2	17.2	36	42	137
Quintessa	24	79	1.0	17.3	35	41	141
Totem	18	82	0.7	20.0	29	37	169
Yorkton	24	80	1.2	17.7	35	43	133
Cenex 4010	28	82	1.3	18.6	35	44	131
148-24f/200-17f	29	84	1.2	20.3	36	43	133
Mean	25	81	1.1	18.3	34	42	141
C.V. %	18.2	1.8	15.7	9.0	11.9	7.8	11.7
LSD .05	NS[1]	2.0	NS	2.4	5.8	4.6	23.6

[1]NS = not significant at the $P < 0.05$ level.

Table 4. Forage yield and forage crude protein (CP), acid detergent fiber (ADF),and neutral detergent fiber (NDF) content, of six lentil cultivars during 1996 and 1997 at Dickinson, ND.

Cultivar	Harvest moisture	Dry matter basis				
		Yield	CP	ADF	NDF	RFV
	%	tons/acre	%			
Brewer	63	1.0	15.7	35.6	39.8	143.3
CDC Richlea	66	1.8	16.3	34.3	40.4	143.8
Indianhead	70	2.0	18.2	35.9	42.4	135.8
Laird	69	2.0	16.1	33.6	40.3	145.7
Pardina	65	0.6	16.2	34.6	42.6	135.6
CDC Milestone	64	1.2	16.0	33.2	38.9	151.6
Mean	66	1.4	16.4	34.5	40.7	142.6
C.V. %	3.4	13.9	7.5	10.9	7.6	10.9
LSD .05	3.4	0.3	1.9	NS	NS	NS

Table 5. Forage yield of cool and warm season, annual cereals and legumes during 1995, 1996, and 1997 at Dickinson, ND.

Crop	Cultivar	Harvest moisture	Dry matter basis			
			Yield			
			1995	1996	1997	3 yr avg
		%	tons/acre			
millet	German	77	4.3	4.8	1.2	3.4
millet	Siberian	72	2.9	3.6	1.3	2.6
millet	Red Proso	75	--	--	1.6	--
sudangrass	Piper	78	2.9	2.8	1.5	2.4
forage sorghum	---	81	--	--	1.3	--
oat	Paul	74	--	--	1.6	--
Mean		76	--	--	1.4	--
C.V. %		1.7	--	--	18.6	--
LSD .05		2.0	--	--	NS[1]	--

[1]NS = not significant at the $P < 0.05$ level.

Table 6. Forage crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber

(NDF) concentration of warm season, annual cereals and Paul oats during 1997 at Dickinson, ND.

Crop	Variety	DM Basis			
		CP	ADF	NDF	RFV
		%			
millet	German	10.8	41	64	83
millet	Siberian	9.0	44	66	78
millet	Red Proso	8.9	43	67	78
sudangrass	Piper	8.4	46	68	73
forage sorghum	---	8.7	44	68	76
oat	Paul	9.6	42	65	82
Mean		9.2	43	66	78
C.V. %		12.8	4.2	5.7	6.7
LSD .05		1.8	2.8	5.6	7.9

Table 7. Forage yield of barley, oat, lentil and pea seeded alone and in combination when harvested at heading (HD), kernel milky ripe (MR), kernel soft dough (SD), and kernel hard dough (HD)cereal growth stages during 1996 (96) and 1997 (97) at Dickinson, ND.

			Dry matter basis

Crop	Cultivar	Seeding rate		Yield							
		Cereal	Legume	HD		MR		SD		HD	
				96	97	96	97	96	97	96	97
		kernels or seed/ft^2		tons/acre							
barley/pea	Horsford/Trapper	26	11	1.8	1.0	2.6	1.8	2.9	1.9	1.9	2.0
barley/pea	Horsford/Trapper	17	7	1.5	1.0	2.4	1.6	2.8	1.9	2.5	2.1
barley/pea	Horsford/Trapper	9	4	1.4	1.0	2.2	1.7	2.5	1.8	2.4	1.9
barley	Horsford	17	--	1.6	0.9	2.7	1.6	2.9	1.7	2.6	1.8
oat/pea	Dumont/Trapper	26	11	2.2	1.0	2.6	1.8	2.8	2.2	2.9	2.1
oat/pea	Dumont/Trapper	17	7	2.1	0.8	2.4	1.6	2.8	2.2	2.6	2.1
oat/pea	Dumont/Trapper	9	4	1.9	0.8	2.2	1.4	2.3	2.3	2.7	2.0
oat	Dumont	17	--	2.0	1.0	2.4	1.9	2.6	2.4	2.9	2.3
oat/lentil	Dumont/Indianhead	17	6	2.0	1.0	2.4	1.9	2.6	2.2	2.9	2.0
lentil	Indianhead	--	6	0.4	0.3	0.9	0.9	1.2	1.5	2.1	1.7
pea	Trapper	--	7	--	0.6	--	1.3	--	1.8	--	2.0
Mean				1.7	0.9	2.3	1.6	2.5	2.0	2.6	2.0
CV(%)				11	18	7	17	11	12	15	10

LSD .05				0.3	NS[1]	0.2	NS	0.4	0.4	0.6	0.3

[1]NS = not significant at the $P < 0.05$ level.

Table 8. Forage crude protein concentration of barley, oat, lentil and pea seeded alone and in combination when harvested at heading (HD), kernel milky ripe (MR), kernel soft dough (SD), and kernel hard dough (HD) cereal growth stages during 1996 (96) and 1997 (97) at Dickinson, ND.

Crop	Cultivar	Seeding rate		Dry matter basis Crude protein							
		Cereal	Legume	EH		MR		SD		HR	
				96	97	96	97	96	97	96	97
		kernels or seed/ft^2		%							
barley/pea	Horsford/Trapper	26	11	17	17	12	16	11	15	10	12
barley/pea	Horsford/Trapper	17	7	16	16	13	15	10	15	9	12
barley/pea	Horsford/Trapper	9	4	18	15	16	15	11	14	10	11
barley	Horsford	17	--	15	16	12	14	11	13	10	9
oat/pea	Dumont/Trapper	26	11	14	15	11	14	11	11	7	9
oat/pea	Dumont/Trapper	17	7	15	16	12	15	11	13	10	9
oat/pea	Dumont/Trapper	9	4	15	17	14	15	12	13	10	8

oat	Dumont	17	--	13	15	10	12	12	9	10	8
oat/lentil	Dumont/Indianhead	17	6	14	16	12	13	11	10	10	8
lentil	Indianhead	--	6	22	24	20	22	18	18	15	15
pea	Trapper	--	7	--	18	--	20	--	17	--	10
Mean				16	17	13	16	12	13	10	10
CV(%)				7	8	8	7	9	9	10	15
LSD .05				2	2	2	2	2	2	2	NS[1]

[1]NS = not significant at the *P < 0.05* level.

Table 9. Plant height, lodging, seed yield, seed weight, and gross economic returns of twelve pea cultivars evaluated in a dryland environment during 1997 at Dickinson, ND.

Cultivar	Type[1]	Days to flower	Seeds	Plant height	Lodging score	Test weight	Seed yield 1995	Seed yield 1996	Seed yield 1997	Returns[2]	3-year average yield
			seeds/lb	in	0-9	lb/bu	bu/acre	bu/acre	bu/acre	$/acre	bu/acre
Aladin	Y	45	1,535	20	1.0	64.9	--	--	24	66.45	--
Carneval	Y	48	2,071	23	0.5	64.5	47	29	33	93.43	36
Grande	Y	53	1,672	18	5.5	65.3	--	40	38	107.75	--

Highlight	Y	47	2,155	20	0.3	65.9	--	--	29	82.09	--
Integra	Y	46	1,578	17	1.3	64.0	--	--	22	61.69	--
Maja	Y	46	1,553	19	0.3	65.3	--	--	24	68.55	--
Majoret	G	48	1,661	20	1.3	65.4	44	29	33	91.33	35
Mustang	Y	44	2,162	17	1.5	65.4	--	--	20	56.33	--
Profi	Y	46	1,731	23	1.0	64.8	44	29	26	72.52	33
Radley	G	45	2,094	19	7.5	65.5	27	24	14	40.23	22
Totem	G	47	1,739	18	4.3	64.0	--	--	32	89.32	--
Trapper	Y	51	3,207	24	8.0	64.5	37	31	28	78.91	32
Mean		47	1,930	20	2.7	64.9	--	--	27	75.72	--
C.V. %		1.6	6.8	21.9	51.2	0.5	--	--	13.8	--	--
LSD .05		1	188	NS[3]	NS	0.5	--	--	5	--	--

[1]Y=Yellow seed, G=Green seed
[2]Calculated using market value of $2.80/bu
[3]NS = not significant at the $P < 0.05$ level.

Table 10. Plant height, lodging, seed yield, seed weight, and gross economic returns of eight lentil cultivars evaluated in a dryland environment during 1997 at Dickinson, ND.

					Seed yield		Average

Cultivar	Type[1]	Height	Lodging[2]	Test weight	Seed yield			Returns[3]	yield	
					1995	1996	1997		2-year	3-year
		in	0-9	lb/bu	bu/acre			$/acre	bu/acre	
CDC Milestone	C	11	1.5	63.1	--	--	25	203.99	--	--
Brewer	C	12	3.0	60.6	24	14	21	166.32	17	19
CDC Richlea	C	13	2.0	61.5	35	21	20	161.60	21	26
Crimson	R	10	3.5	62.9	34	14	20	160.25	17	22
Eston	P	12	2.0	62.6	30	17	22	177.66	20	23
Laird	C	14	3.5	58.5	28	16	16	127.85	16	20
Pardina	SB	9	5.3	63.3	--	11	20	163.62	16	--
Redwing	R	12	2.3	62.8	--	19	23	184.41	21	--
Mean	--	12	2.9	61.9	--	--	21	168.21	--	--
C.V. %	--	8.8	27.6	2.2	--	--	14	--	--	--
LSD .05	--	2	1.2	2.0	--	--	4	--	--	--

[1]C=Chilean, R=Red, P=Persian, SB=Spanish Brown

[2]0=standing upright 9=laying flat

[3]calculated using market value of $13.50/cwt

Table 11. Pea plant population and grain yield at three seeding rates in 1996 at Glen Ullin, ND, and in 1997 at Beulah and Hannover, ND.						
Seeding rate	Glen Ullin	Beulah	Hannover	Glen Ullin	Beulah	Hannover
	Plant Population			Grain yield		
PLS/ft^2	plants/ft^2			bu/acre		
7	4	4	5	48	30	46
8	4	6	5	50	31	43
9	5	6	7	49	32	49
Mean	5	5	6	49	31	46
CV (%)	11.1	7.7	13.6	2.5	5.4	6.4
LSD 0.05	1	1.0	NS[1]	NS	NS	NS

[1]NS = not significant at the *P* < 0.05 level.

Table 12. Trapper pea plant population, seed yield and test weight at two rates of urea and without fertilizer in 1996 at Glen Ullin, ND, and in 1997 at Dickinson, ND.							
Fertilizer	Rate	Plant stand		Test weight		Seed yield	
		Dickinson	Glen Ullin	Dickinson	Glen Ullin	Dickinson	Glen Ullin

	lbs/acre	plants/ft^2		lb/bu		bu/acre	
CHECK	0	7	4	61	63	28	46
urea	5	6	4	62	63	27	46
urea	10	4	3	61	63	26	44
	Mean	6	4	61	63	27	46
	CV (%)	9.8	14.0	1.1	1.2	7.9	8.8
	LSD 0.05	1	1	NS[1]	NS	NS	NS

[1]NS = not significant at the $P < 0.05$ level.

Table 13. Carneval pea plant population, seed yield and test weight at nine fertilizer rates and without fertilizer at Beulah and Glen Ullin, ND, in 1997.

Fertilizer	Rate	Plant stand		Test weight		Seed yield	
		Beulah	Hannover	Beulah	Hannover	Beulah	Hannover
	lb/acre	plants/ft^2		lb/bu		bu/acre	
CHECK	0	6	6	64	64	29	46
urea	6	5	5	64	63	27	36
	12	5	4	64	63	27	39
	18	4	5	64	63	26	39

MAP[1]	25	5	4	64	63	26	36
	50	3	4	63	64	24	38
	75	2	3	64	64	17	37
TSP	30	4	4	64	64	30	37
	60	5	4	64	63	29	42
	90	4	3	64	64	31	39
	Mean	4	4	64	63	27	NS
	CV (%)	16.6	14.1	1.4	2.5	11.8	11.6
	LSD 0.05	NS[2]	1	1	NS	5	NS

[1]MAP = 11-52-0; TSP = 0-45-0.
[2]NS = not significant at the $P < 0.05$ level.

Table 14. Seed yield, test weight, seed weight, and gross economic returns of six mustard cultivars evaluated in a dryland environment damaged by hail during 1997 at Beulah, ND.

Cultivar	Type	Seeds	Test weight	Seed yield	Returns
		seeds/lb	lb/bu	lb/acre	$/acre
AC Pennant	Y	126,733	55.3	291	37.77
AC Vulcan	O	157,810	50.3	518	56.98
Forge	O	173,610	51.5	248	27.26

Gisilba	Y	120,002	54.8	227	29.56
Tilney	Y	119,740	52.5	209	27.23
Viscount	Y	137,500	52.5	175	22.74
Mean	--	139,233	52.8	278	33.59
C.V. %	--	11.9	2.4	28.1	--
LSD .05	--	24,977	1.9	NS[3]	--

[1]Y=yellow, O=oriental.
[2]Y=$13.00/cwt, O=$11.00/cwt.
[3]NS = not significant at the $P < 0.05$ level.

Table 15. Seed yield, test weight, seed weight, and gross economic returns of six mustard cultivars evaluated in a dryland environment during 1997 at Hannover, ND.

Cultivar	Type[1]	Height	Lodgingscore	Seeds	Test weight	Seed yield	Returns[2]
		in	0-9	seeds/lb	lb/bu	lbs/acre	$/acre
AC Pennant	Y	28	0.8	106,859	54.6	712	92.59
AC Vulcan	O	32	1.3	187,274	51.9	794	87.35
Forge	O	39	2.0	199,859	51.0	574	63.13
Gisilba	Y	29	1.3	108,090	54.5	574	74.62

Tilney	Y	30	1.3	112,744	53.9	647	84.05
Viscount	Y	32	0.8	123,204	53.8	618	80.39
Mean	--	31	1.2	139,672	53.3	653	80.40
C.V. %	--	5.0	50.7	5.6	2.2	11.3	--
LSD .05	--	2	NS[3]	11,749	1.7	111	--

[1]Y=yellow, O=oriental.
[2]Y=$13.00/cwt, O=$11.00/cwt.
[3]NS = not significant at the $P < 0.05$ level.

Back to 1997 Research Reports Table of Contents
Back to Research Reports
Back to Dickinson Research Extension Center (http://www.ag.ndsu.nodak.edu/dickinso/)
Email: drec@ndsuext.nodak.edu