DREC Cross-Slot Plot Drill

R.O. Ashley, and J. L. Nelson

Summary

No-till production practices are utilized on nearly 50% of the spring seeded small grain acres in southwestern North Dakota. Research and extension efforts have traditionally directed resources towards currently accepted practices as well as targeted towards promising emerging technologies. Dickinson Research Extension Center (DREC) staff proposed to develop and assemble a no-till plot drill for use in planting on farm demonstration projects utilizing new technology in low disturbance seeding and fertilizing. DREC provided the initial design for this drill, which will do both small plot and field size demonstrations. This drill utilizing Cross-slot openers was assembled by a local fabricating manufacturer in Nov 2003 and demonstrated on five farms in 2004.

Introduction

The use of no-tillage practices for crop production has gained wide acceptance among farmers in southwestern North Dakota. The Conservation Technology Information Center (CTIC, 2004) Crop Residue Management Survey indicates this practice is being adopted primarily in southwest and south central North Dakota (Figure 1).

Producers are utilizing no-tillage practices because: 1) Lower labor requirements per acre. 2) Lower equipment costs. A drill, sprayer, and combine are all that is needed. 3) Saves fuel costs, 4) Improves soil quality (Hussain el al., 1999; Wander, 1999; Wright et al., 1999), 5) Fewer weeds (Anderson, 2004), 6) Increased yields. Research and producers have found wheat yields in western North Dakota from no-till fields are on the average 47% greater than from conventionally tilled fields (Carr, 2004).

In addition producers find that no-tillage methods reduce runoff, decrease movement of pesticides and fertilizers to ground and surface waters (Hall et al., 1991), reduce soil erosion, increase wildlife numbers, and has the potential to sequester more carbon than conventional tilled planting systems (Robertson, et al. 2000; Reicosky, et al., 1999; Reicosky, 2004).

Producers who fully understand and use a no-till production system view crop residue as a resource to conserve and use, not a nemesis that must be destroyed and buried with tillage. Crop residue limits evaporation from the soil surface and helps maintain humidity levels in undisturbed soils between 90 and 100%, which is ideal for germinating wheat seed (Wuest, 2002). Even with excellent soil seed contact, at least 85% of the water is imbibed by the seed in the form of vapor. In dry conditions such as often experienced in southwest North Dakota, no-till planting systems conserve moisture in the seedbed allowing uniform germination and plant establishment to occur. Residue also provides a food source for beneficial fungi and bacteria as well as insect and weed seed predators. Managed properly, the beneficial aspects of residue will outweigh any negative aspects the previous crop's residue will have on this year's crop.

The objective of this project was to 1) develop a no-till demonstration/research plot drill specifically for North Dakota conditions, 2) demonstrate the capabilities of this no-till drill under a wide range of on-farm conditions, 3) use the drill to seed trials requiring no-till methods.

Materials and Methods

The criteria that the Center used in developing the no-till plot drill was:

1) Low Soil Disturbance – studies indicate that low-disturbance seeding results in:

- Less opportunity for weed seeds to germinate and establish.
- More moisture is maintained in soils.
- Fuel and time conservation.
- Timeliness of seeding operation.
- Improvement in soil organic matter.
- Preservation of soil structure, earthworms, beneficial soil micro-fauna and micro-flora.
- Reduction of wind and water erosion.
- Moderating soil temperatures.
- Improved internal drainage.

2) Accurate placement of seed for uniform germination and emergence. Uneven germination

and emergence will create problems with weed control, crop injury, and harvest.

3) Manage large amounts of residue. The drill must handle more than just the "average" amount of residue. Yields have been trending higher. In some years, planting may occur into stubble from a 70 to 80 bushel per acre winter wheat crop, 100 bushel plus per acre barley crop, and 90 bushel per acre corn crop.

4) Ability to operate under a wide range of conditions including soil texture, moisture content, and crop residue levels.

5) Provide for separate bands of fertilizer and seed. Since seed in contact with high rates of fertilizer results in lower germination rates or damaged seedlings. If adequate amounts of fertilizer materials are going to be applied in a no-till situation at planting time then banding fertilizer separate from seed is required.

6) The drill must be adaptable to seed both small research plots as well as larger demonstration plots. The drill must have the capability to use liquid as well as dry fertilizers. Producers want to see performance of a wide range of practices over a large field in wide ranging conditions.

7) The technology incorporated into the drill must be available and ready for adaptation and use on the farm today.

8) The size of the plot drill can be no wider than 8 feet and no longer than 14 feet. Since the Dickinson Research Extension Center plants a number of on-farm demonstrations, the drill and tractor must fit on a 32-foot long trailer for legal transport.

Opener Selection

Cross-Slot™ openers manufactured by Baker Notillage Ltd, Feilding, New Zealand were selected for the application outlined by the criteria above.

The Cross-Slot™ opener developed from research conducted at Massey University, New Zealand and the Agricultural Research Service at Pullman, WA is designed specifically for no-till seeding. The Cross-Slot™ opener uses parallel linkage so the opener follows the irregularities of the soil surface found in no-till conditions. A 22-inch vertical scalloped coulter cuts through crop residue. A blade on each side of the coulter cuts a horizontal slot. Seed is placed in the horizontal slot created by the left blade and fertilizer is placed in the horizontal slot created by the right blade. A scraper behind each blade on the opener prevents sticky soil and seed from being thrown up onto the surface by the coulter. The two semi-pneumatic wheels on each opener are 3 inches wide, 16 inches in diameter and control the depth of penetration as well as pressing the soil and residue back into place thus closing the slot. The horizontal slot created by the blades plus the vertical slot created by the coulter give the opener its name. Fertilizer can be placed deeper than the seed by using a short or a medium length blade for placing the seed and a long blade for placing the fertilizer. Growers in Washington State indicated that they do this for their spring wheat plantings (Wolf, 2002). Separation can be ½ inch to the side and 1 ½ inches below the seed. Up to 300 pounds per acre of urea fertilizer has been applied through a drill equipped with the opener without injury to germinating wheat seed when the fertilizer is place horizontal to the seed (Saxton, 2004). A hydraulic cylinder on each opener raises and lowers the opener as well as providing constant down pressure to each opener when in the planting position.

Cross-Slot™ openers cost was $1,535 each. Though the cost may appear to be high relative to the John Deere™ 90 series no-till opener single disc opener would require two single disc openers to perform the same tasks as a one Cross-Slot™ opener. Since John Deere would only sell the single disc opener in parts the cost for a one single disc opener was about $1,100. In addition, this particular opener would have required the drill length to be increased by at least 50%. Flexicoil Barton™ double-shoot openers were considered but a report from Dr. Gary Peterson (2003) at Colorado State University indicated highly variable seed placement with shallow seeding depths of small seeded crops. The length of the drill to accommodate this style of opener would also be a design challenge to maintain drill length within the requested specifications. Double disc openers are known to compact soils as well as "hairpin" residue into the seed furrow (Wilkins, Bolton and Saxton, 1992).

Draft requirements for a Cross-Slot™ opener is about 25 to 50% greater than a vertical triple disc opener but the weight required to maintain the opener at the desired seeding depth is only 25% of that required by the vertical triple disc opener. In comparison with other types of openers the Cross-Slot™ requires about the same amount of weight to maintain seeding depth as a one-inch wide hoe opener but requires about twice the weight as a single disc opener (Baker et al, 2002).

The initial drill design with Cross-Slot™ openers was developed by DREC staff and submitted to Vernon Hofman and Dr. Keith Saxton for review and comment. Modifications based on their suggestions were made and the design (Figure 2) submitted to interested contractors for final design and fabrication. Steffes Corporation, Dickinson, ND was the successful bidder for the project. The frame, seed cone-timing computer, and drive components were fabricated by Steffes and assembled with parts provided by DREC. More information on the drill components and assembled drill statistics can be found in Table 1 (Figure 3).

Demonstrations

James Bloom Farm, Taylor, ND

A field demonstration into barley (*Hordeum vulgare* L.)residue was imitated at the James Bloom Farm, Taylor, ND. The straw was baled and removed from the field with only two to three inches of lower part of the stem attached to the roots remaining in the field. Three plots, 1.5 acres each, were delineated in the field for hard red spring wheat (*Triticum aestivum* L. c.v. Reeder) and three additional plots of 1.5 acres each were delineated for field pea (*Pisum arvense* L. c.v. AC Mozart), flax (*Linum usitatissimum* L. c.v. Omega), and several varieties of soybean (*Glycine max* L.). The three different strips of hard red spring wheat were seeded with three different drills. The first strip was seeded with a Morris air drill with narrow hoe openers, the second strip was seeded with a John Deere 1895 air drill with single disc openers and the third strip was seeded with the Cross-Slot plot drill. Prior to seeding urea was applied at the rate of 150 pounds per acre to the strips that were to be seeded with the Morris air drill and the John Deere 1895 drill on 15 Apr. Fifty pounds of 11-52-0 was applied through the drill and placed with the seed for the Morris and John Deere drills. All fertilizer seeded with the Cross-Slot drill was applied through the drill in a separate band away from the seed. A blend of Simplot liquid fertilizer, 6 gal 10-34-0 (7 lbs N + 24 lbs P205) and 23 gal 28-0-0 (68 lbs N) per acre was applied which supplied the same rate of N and P per acre as the dry fertilizer applications made to the other wheat strips. The target-seeding rate was 80 pounds of seed per acre. A burn down application of 20 fl oz/A Roundup Ultra Max + 40 fl oz/A of Actamaster (ammonium sulfate) was applied to control emerged weeds and volunteer grain on 22 Apr. prior to crop emergence to all three strips. A post emergence herbicide application of Harmony GT XP at 0.5 oz/A + Everest at 0.6 oz/A + 2,4-D at 0.5 pt/A + Activator 90 a non-ionic surfactant at 0.25% volume/volume was applied on 21 May. Whole plant samples were harvested by hand and hung to dry prior to separating the grain from the straw using a stationary combine. The grain was weighed, test weight measured, and yields calculated.

Roundup Ultra Max at the rate of 20 fl oz/A + Spartan at the rate of 2.5 oz/A + 40 fl oz/A of Actamaster (AMS) per acre was applied to the strips to be seeded to flax and field pea on 22 Apr to eliminate emerged weeds and volunteer crop and to control weeds within the crop to be planted. Field peas were seeded at the rate of 350,000 pls/A on 15 May. A post emergent application of Poast at 1.5 pt/A + 1.5 pt/A Basagran + 1.5 pt/A methylated seed oil was applied 4 Jun. Whole plant samples at maturity were harvested by hand and hung up to dry prior to separating the grain from the pods. Flax was seeded at the rate of 25 pounds per acre on 15 May. A post emergent application of Poast at 1.5 pt/A + 1.5 pt/A methylated seed oil was applied 4 Jun. Whole plant samples at maturity were harvested by hand and hung up to dry prior to separating the seed from the pods. The seed was weighed, test weight measured and yields were calculated from these samples.

Rich Schmidt Farm, Center, ND

A five-acre planting demonstration into standing corn stubble was initiated on the Rick Schmidt Farm located near Center, ND. The previous corn (*Zea mays*) crop yielded 30 bu/A and residue remaining at planting time was estimated to be 1000 lbs/A. Roundup Ultra Max (glyphosate) at the rate of 20 fl oz/A and Spartan (sulfentrazone) at the rate of 3 oz/A was applied to kill emerged weeds and provide in crop weed control. Field peas were seeded 13 May at the rate of 350,000 pls/A. with the Cross-Slot plot drill. Rainfall was scattered and very limited after the initial herbicide application and planting. Rainfall during vegetative growth stimulated weed germination and emergence and required an application or Rezult, a co-pack of bentazon and sethoxydim, at the rate of 1.6 pt + 1.6 pt/A. This field was harvested on 28 Jul with a combine.

Tom Kautzman, Mott, ND

A Roundup Ready soybean variety demonstration plot was established on standing wheat stubble near Mott on the Tom Kutzman Farm using the Cross-Slot plot drill on 19 May. Roundup Ultra

Max at the rate of 20 fl oz/A + ammonium sulfate were applied to control emerged weeds and volunteer grain prior to seeding. Four varieties were seeded in unreplicated plots which were 6 feet by 50 feet in size on 19 May. Roundup was applied twice more during the season to control emerged weeds in the crop. Plots were had harvested at maturity by hand, dried in an oven, grain separated from pods and weighed. Total weight of grain and weight per 100 seed was measured. Yields and seed count per pound were then calculated.

Larry Pavlicek Farm, Dickinson, ND and Jay Elkin Farm, Taylor, ND

Seed treatment trials were planted at the Larry Pavlicek Farm, Dickinson, ND and the Jay Elkin Farm, Talyor, ND into standing wheat stubble. Details about establishment practices used in these plots can be found in the reports on seed treatments in the 2005 DREC Annual Report. Residue levels at the Elkin farm were estimated to be 1,200 pounds per acre and at the Pavlicek farm they were 2,200 pounds per acre. Details for the 2004 fall seeded winter wheat seed treatment trial were not available at the time this report was written but residue levels were estimated to be 3,300 pounds per acre at planting time (Figure 4).

Dickinson Research Extension Center, Dickinson, ND

The purpose of this demonstration was to determine if the Cross-Slot plot drill could seed through sod into dry soil and place seed below the ground surface. The area seeded into was in sod for the past 20 years and is hayed annually. Pea seed was planted on 13 Jul and digital images taken on 23 July of emerged pea in sod.

Results and Discussion

Drill Perfomance

Steffes Corporation delivered the drill on 23 Nov, 2003 to the Dickinson Research Extension Center. A few minor modifications were made from the original design concept. Three hundred sixty-six pounds of weight were added towards the front to bring the drill weight carried by the tractor to between 65 and 70% of the total drill weight. This improved the balance of the drill for seeding. Minor changes were made to the metering and distribution systems through the season. The openers penetrated various levels of crop residues and placed seed and fertilizer accurately in soil textures from sandy silt loam to clay loam with varying moisture contents easily. Crop residue levels varied from 500 lbs/A to 3,300 lbs/A. Subsurface scrapers on the openers kept sticky soil from building up on the disc blade and flicking off on the surface. No problems were experienced with the openers. Most soils where the drill was operated required from 750 psi to 1000 psi in the hydraulic system to penetrate soil in grain fields. In a sod hay field under dry July conditions the drill required 1, 350 psi to place seed at the desired depth. Information on the amount of pressure on the press wheels was provided by a load cell on one of the openers. When the pressure on the press wheels exceeded 60 psi on dry nearly residue free sandy loam soil, the press wheels caused ridging. Pressure was reduced and the ridging problem was eliminated. Maintenance, including removing and installing disc blades, scrapers, and seeding and fertilizer blades was relatively easy and did not require special tools for servicing. The liquid fertilizer system accurately metered and distributed fertilizer to all nine openers. Disturbance of soil by the opener is slightly greater than the John Deere Series 90 no-till drill single disc opener but less than a narrow point hoe.

Demonstration Results

Dry conditions and freezing temperatures affected yields of all crops grown on the Bloom Farm, Taylor. On 18 Jun freezing temperatures destroyed the soybean planting and the remaining plants were destroyed with an application of 2, 4-D. The Dickinson Research Extension Center Field Day Farm Management Tour highlighted no-till and the demonstration plots on the Bloom Farm. Over 200 people attended the program and viewed both the seeding demonstration and plots that were seeded earlier in the season. Yields and test weights of hard red spring wheat grown in the demonstration were similar in grain yield from the Cross-Slot seeded strip at 21.7 bu/A, the John Deere 1895 drill seeded strip at 20.6 bu/A and the Morris air drill seeded strip at 21.7 bu/A. Test weight was 61.5 lb/bu for all three drill strips. Pea grain yield in the demonstration was 20.5 bu/A with a test weight of 60.3 lb/bu. Flax yield was 16.8 bu/A with a test weight of 56 bu/A. Plant stands were uniform in this low residue situation (Figure 5).

Peas at Center yielded 23 bu/A of grain with a test weight of 60 lbs/bu. Soils in one area of the field that had experience compaction from the previous year's wheel traffic established a pea crop though noticeably impacted by compaction (Figure 6). Corn that was seeded the previous year with tillage was not established in this area so little or no residue remained at the time of seeding the pea crop in 2004. The Oliver County Agriculture Improvement

Association included the field on their summer tour with 20 producers in attendance. The cooperating producer indicated that a "great number" of peas remained after the harvest but weed control was "excellent" and he was pleased with the plant stand.

The soybean variety demonstration at Mott produced an average yield of 30.1 bu/A (Table 2). The Regent Twilight Tour stopped at this location to look at soybean establishment and to discuss problems with soybean culture. Twenty-five producers reviewed the plots on this part of the tour. Dwain Barondeau, Hettinger County Agent indicated several producers stopped through the season to view the plots.

Peas emerged in the sod planting five days after the 13 July seeding. Soil conditions at seeding were dry and required more pressure in the hydraulic system to penetrate than any of the other soils planted in 2004. Since established vegetation was not control prior to or during establishment pea ran out of water (Figure 7).

Implications of Demonstration

The plot drill designed with Cross-Slot™ openers is adapted to seeding in highly variable conditions found in western North Dakota in 2004. The drill is capable of seeding in high as well as low residue situations as seen at other locations in the USA.

Though very high residue conditions were not experienced this year due to drought conditions the previous year, additional testing of the drill under high residue field conditions will provide a better understanding of how this drill will perform as well as how crop culture will be affected by very high residue levels.

Cooperating Producers

The Dickinson Research Extension Center extends their appreciation and thanks to the following organizations for their financial support in building this Cross-Slot plot drill.

North Dakota Barley Council
North Dakota Dry Pea and Lentil Association
North Dakota Western Malt Barley Initiative
CDS John Blue Company
Pattison Liquid Systems Inc.
Gustafson LLC
Syngenta Crop Protection

Final Design and Manufacturing by
Steffes Corporation
Dickinson, ND

Engineers:	**Fabricators:**
Todd Mayer	Larry Kostelecky
Dean Kovash	Lyle Mayer

Literature Cited

Anderson, R. Impact of subsurface tillage on weed dynamics in the Central Great Plains. Weed Technology 18:186-192.

Baker, C.J., K.E. Saxton and W.R. Ritchie. 2002. No-Tillage Seeding, Science and Practice. CAB International, New York, NY.

Carr, P.M. 2004. Personal communication.

CTIC. 2004. National crop residue management survey. Conservation Technology Information Center, West Lafayette, IN.

Hall, J.K., R.O. Mumma, and D.W. Watts. 1991. Leaching and runoff losses of herbicides in a tilled and untilled field. Agric. Ecosystems and Environ. 37:303-304.

Hussain, I., K.R. Olson, and S.A. Ebelhar. 1999. Long-term tillage effects on soil chemical properties and organic matter fractions. Soil Sci Soc Am J 63:1335-1341.

Peterson, G.A. 2003. Personal communication.

Reicosky, D.C., D.W. Reeves, S.A. Prior, G.B. Runion, H.H. Rogers, R.L. Raper. 1999. Effects of residue management and controlled traffic on carbon dioxide and water loss. Soil & Tillage Research 52:153-165.

Reicosky, D.C. 2004. Conservation agriculture, CO_2 mitigation, and environmental benefits: Policies and perspectives. 26th Annual Zero Tillage Workshop, 4-5 Feb 2004, Manitoba-North Dakota Zero Tillage Farmers Association, Ramkota Hotel, Bismarck, ND.

Robertson, G.P., E.A. Paul, and R.R. Harwood. 2000. Greenhouse gases in intensive agriculture: contributions of individual gases to the radiative forcing of the atmosphere. Science. 289:1922-1925.

Saxton, K.E. 2004. Five criteria of direct seeding drills and planters. DREC Field Day, July 7.

Veseth R. and R. Karow. 1999. Conservation tillage systems and equipment. In Pacific Northwest Conservation Tillage Handbook, Series No 23.

Wander M.M. and G.A. Bollero. 1999. Soil quality assessment of tillage impacts in Illinois. Soil Sci Soc Am J 63:961-971.

Wilkins, D.E., F. Bolton, and K. Saxton. 1992. Evaluating seeders for conservation tillage production of peas. Appl Eng Agri 8(2):165-170.

Wright, S.F., J.L. Starr, and I.C. Patineanu. 1999. Changes in aggregate stability and concentration of glomalin during tillage management transition. Soil Sci Soc Am J 63:1825-1829.

Table 1. Dickinson Research Extension Center Cross-Slot™ plot drill statistics.

Total length of drill = 14 feet
Frame width = 8 feet
Total weight empty = 7,760 pounds
Openers = 9 Cross-Slot

Opener Spec	Cross-Slot™ Mark V
Weight	Approximately 260 pounds/opener
Minimum mounting area on frame required	10 inches x 38 inches
Scalloped Disc	22 inch diameter
Depth Control	Two three-inch wide pneumatic tires per opener
Hydraulics	
Rams	Each opener has a hydraulic ram capable of 1,500 pounds of force
Accumulators	2 x 4 liters with memory valve, sensor system
Linkage	Parallel
Planting depth	3/8 to 3 inches
Blades and Scrapers	Case harden steel
Fertilizer placement in relation to seed placement	Med blade – ½ horizontal or long blade ½ inch horizontal and one inch deep

Width between openers on tool bar = 16 inches
Openers occupy two tool bars.
In field between rows = 8 inches
Finished planting width = 72 inches
Small plot seed metering = Hege belted 5 inch diameter cone system.

- 9 cones on two frames (5 cones on front frame and 4 cones on back mounted frame)
- Electric solenoid activated.
- Rotoseedverteiler II

Cone timing = design by Todd Mayer, Steffes Corporation, Dickinson, ND
Small plot dry fertilizer metering = Single 12 inch diameter cone system.

Liquid Fertilizer System
Two – 60 gallon cone tanks
One – CDS John Blue Company LM-1255 single piston metering pump
Liquid Fertilizer Manifold = Pattison Even-Flo, 9 outlet manifold system

Bulk Dry Fertilizer and Seed Metering System
Salvage from a Melroe 202 drill

Drive wheel
Modified CDS John Blue Company drive wheel system by Dean Kovash, Steffes Corporation, Dickinson, ND

Caster wheels
4,400 pounds per wheel
Tires = 12 ply 14L x 16.1

Table 2. Soybean yield and seed weight for four soybean varieties grown at two plant populations, Mott, ND, 2004.

Variety	Population	Yield	Seed count
	plants/acre	bu/acre	per pound
00-69	95,000	38	3787
00-69	180,000	34	3739
20-50	95,000	16	6789
20-50	180,000	22	6422
30-05	95,000	35	4631
30-05	180,000	38	4483
30-07	95,000	31	7628
30-07	180,000	27	6491
Mean		30.1	5496

Figure 1. The percent of total acres seeded using no-till practices to small grains in North Dakota, 2004 (Source Conservation Technology Information Center, Residue Management Survey, 2004).

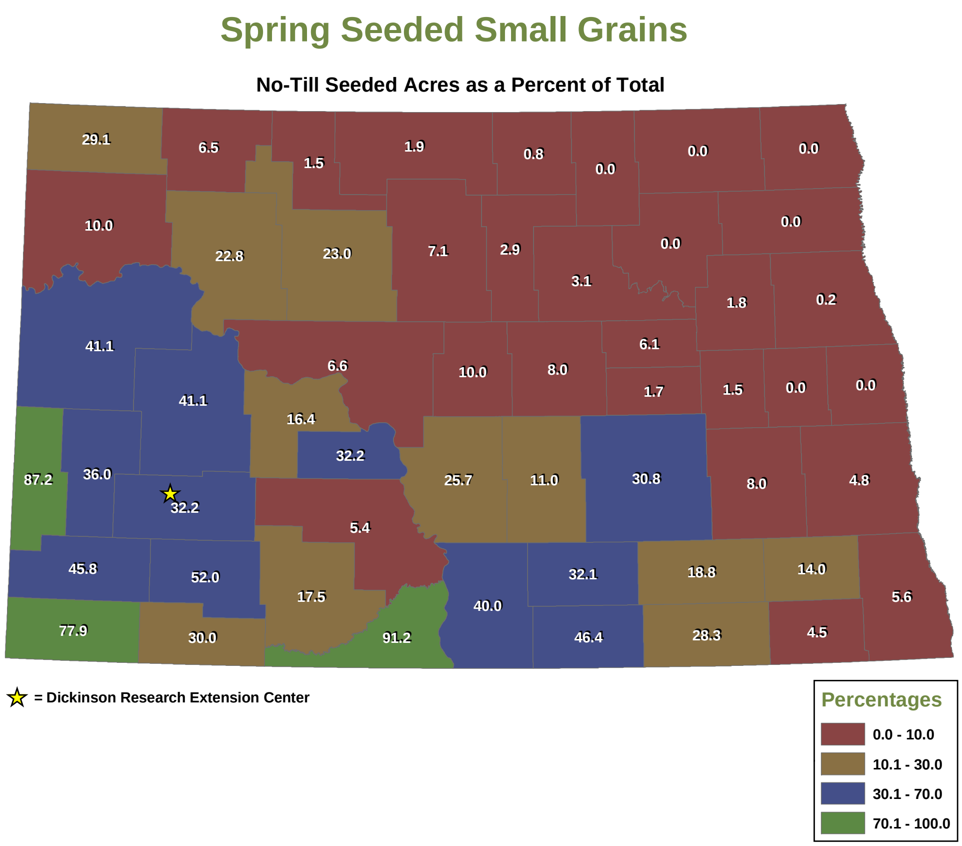

Figure 2. Top view and side view of DREC design for plot drill with Cross-Slot™ openers.

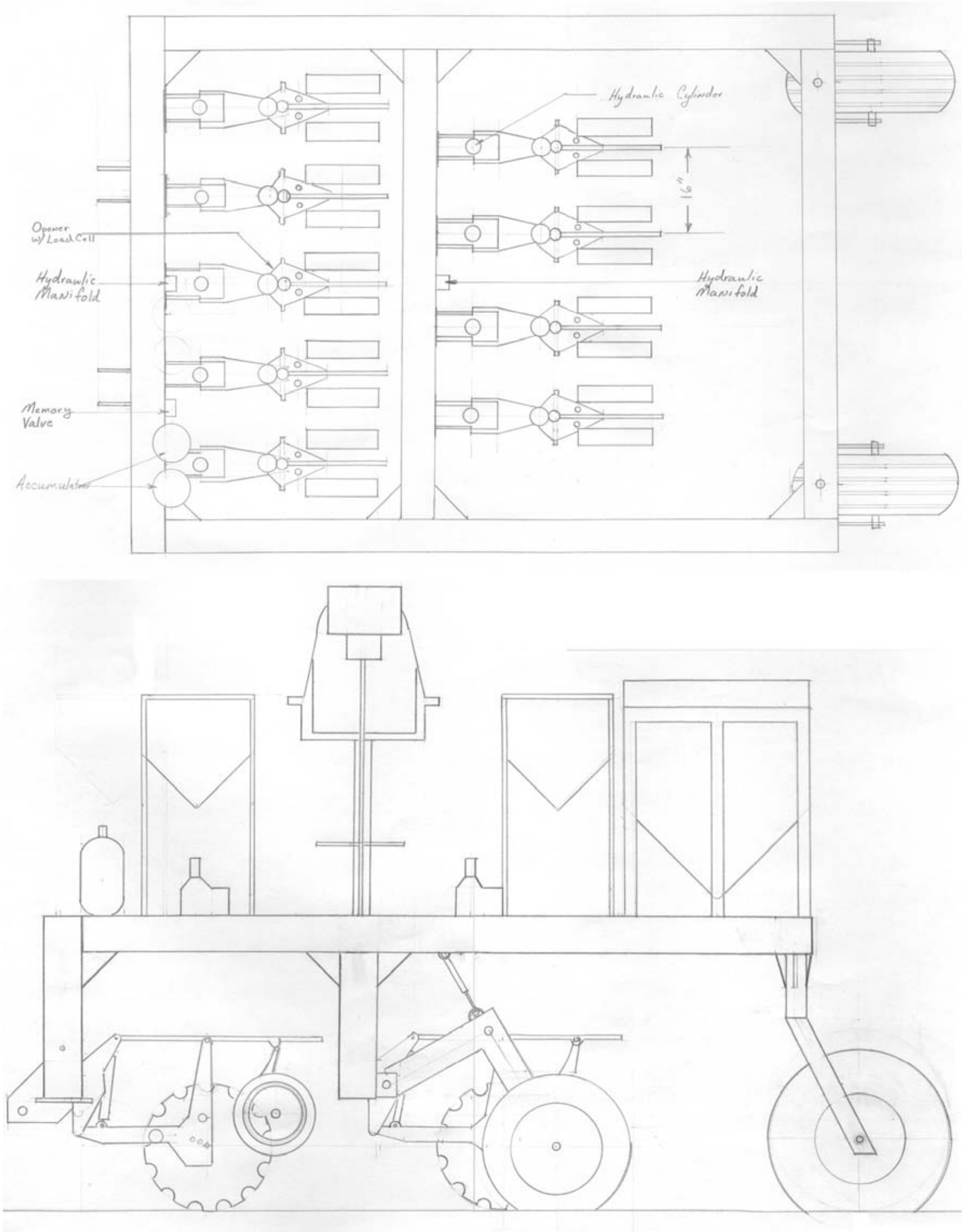

Figure 3. The DREC Cross-Slot™ opener no-till plot drill seeding field pea in corn residue at Center, ND, 2004. This drill can seed both small replicated plots and large demonstration strips.

Figure 4. Residue remaining after seeding with the Cross-Slot™ drill on the Jay Elkin Farm, Taylor, ND. The previous wheat crop produced a 55 bu/acre yield and the residue remaining was estimated to be 3,300 pounds. The photo below shows early plant emergence.

Figure 5. Emergence of Flax at the Jim Bloom Farm, Taylor, ND, 2004

Figure 6. Field pea establishment on hill side where compaction had occurred from wheel traffic from the previous cropping year. Little corn residue was present since few plants were established at this compacted area of the field. In other areas of the field corn residue was present and did not cause any problems with seeding. Spartan was applied preplant but the lack of rainfall after application resulted in poor weed control. Rezult was used post-emerge in the crop to control the weeds in the field that escaped Spartan.

Figure 7. Emergence of pea in grass pasture at the Dickinson Research Extension Center, Dickinson, ND, 2004. Note vegetation was not controlled prior to or after seeding yet there was enough moisture for pea to germinate and emerge in July.