PROJECT TITLE: Evaluation of Seed and Fertilizer Opener Configurations for Optimizing Seed and Fertilizer Placement in Simultaneous, Single-Pass Operations with Air Drills under Differing Cropping Systems.

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OBJECTIVES:

It is the objective of this project to evaluate air drill openers and systems for the production of cereal grains under varying cropping conditions and systems in northern Montana.

From crop year 1997 through crop year 2004, the project was limited primarily to evaluation of "double-shoot" air drill openers using a research-scale `Concord' air drill provided by Northern Ag Service of Malta, Montana with opener hardware provided by various cooperating manufacturers and dealers.

Beginning in crop year 2005, project investigations were expanded to include comparison of seed and fertilizer placement configurations via "double-shoot opener" and "mid-row bander" systems using loaned 'Bourgault' commercial-scale air seeder and air till drill equipment provided for research purposes by Bourgault Industries Ltd and supported by Tilleman Motor Company of Havre, Montana with opener hardware provided by various cooperating manufacturers and dealers.

RESULTS:

Results for crop year 2007 are strongly tempered by unique growing season climatic conditions not conducive to optimum production of spring grains. Early season conditions were generally cooler and wetter than normal while conditions later during critical crop development growth stages were hot and dry. Precipitation of 2.07 inches in April was 213 percent of the 92-yr average for this location. May precipitation was 129 percent of normal bringing the 2-month total to 4.34 inches added to an already optimum inventory of stored soil moisture. Such conditions result in later-than-optimum planting and can further limit depth to which crop root penetration is achieved. Root penetration measured after harvest for two air drill studies was only 20-24 inches. The potential efficiency of broadcast nitrogen fertilization is enhanced by the wetter conditions experienced in 2007 while the potential enhancement of efficiency under drier conditions with banded nitrogen fertilizer is masked under such conditions. The potential for germination and seedling damage associated with inadequate separation of seed and applied nitrogen fertilizer is further lessened under higher moisture conditions during early crop development. The normal number of July days at this location with maximum temperatures 90F or greater is 11. In 2007 there were 23 days with maximums 90F or greater with eight of those days 100F or greater. Such resulted in moderate reduction in yield and severe reduction in spring grain test weight associated with heat stress during critical heading, flowering and grain filling stages of production. The impact of such stress was also evidenced by reduced 1,000-kernel weights and high grain protein at harvest.

On-Going Opener Studies Conducted with the `Concord' Air Drill:

The agronomic performance of six "double-shoot" opener configurations under dryland chemical fallow conditions with 'Choteau' spring wheat direct-seeded into spring wheat stubble at Havre in 2007 is presented in Table 1. These evaluations were conducted using the `Concord' air drill with seeding rate and overall fertilizer rate (70-40-25) held constant on a 12-inch shank spacing. Statistically significant differences among treatments for the response variables measured included Stand Percent, Seed Band Width, Plants/SqFt, Fertile Culms/SqFt, Head Date, Yield, Moisture Percent, Test Weight, Kernel Weight and Protein Percent. Under 2007 conditions there were no statistically significant differences among treatments for Row Style, Fertile Culms/Plant or Plant Height.

Yield performance data for all such opener trials conducted at Havre by NARC-Agronomy since the air drill

investigations began in 1997 are presented in Table 2. A "9-Year, Comparable Average" summary for all openers evaluated in at least three of the nine years (1998-2007) with spring wheat on mechanical or chemical fallow at Havre is presented in Table 3. `Concord' air drill data for crop year 2005 is not included due to an equipment malfunction (not associated with the openers themselves) that variably impacted opener performance. Figures 1 through 6 comprise an opener and post-harvest photo gallery for spring wheat plots established with openers evaluated in 2007. See reports from previous years for data and photo galleries associated with other openers evaluated over time.

New Studies Conducted with the `Bourgault' Air Drill:

The results of new investigations featuring seven seed and fertilizer placement configurations under dryland chemical fallow conditions with `Choteau' spring wheat direct seeded into spring wheat stubble at Havre in 2007 are presented in Table 4. These limited, third-season results represent early progress with a new and expanding series of seed and fertilizer placement investigations now possible through manufacturer loan and dealer support of additional state-of-the-art air drill equipment being made available to the research center. These evaluations were conducted using the `Bourgault' air drill with seeding rate and overall fertilizer rate (70-40-0) held constant on a 9.8-inch shank spacing. Statistically significant differences among treatments for the response variables measured included Row Style, Seed Band Width, Plants/SqFt and Moisture Percent. Under 2007 conditions there were no statistically significant differences among treatments for Stand Percent, Row Style, Fertile Culms/SqFt, Fertile Culms/Plant, Head Date, Plant Height, Yield, Test Weight, Kernel Weight or Protein Percent.

Figures 7 through 13 comprise an opener and post-harvest photo gallery for spring wheat plots established with opener and fertilizer placements evaluated in 2007. See reports from previous years for data and photo galleries associated with other opener and fertilizer placements evaluated over time.

SUMMARY:

Producers contemplating purchase of an air drill logically base their decisions on a number of variables to include manufacturer, dealer support, features, availability, price, etc. A decade ago, limited attention was given to the type and style of interchangeable openers supplied with a new or used air drill. In some situations, dealers want to encourage a prospective buyer to consider a particular type of opener thought to be most appropriate for the grower's own conditions and needs, but they may be reluctant to do so if less sophisticated and less costly openers being selected on a competitor's machine would result in loss of a sale. Due to the cost associated with outfitting a machine of average width with openers, producers prefer to limit their on-farm inventory to one or at the most perhaps two differing scenarios to cover nearly all planting needs. Openers range widely in cost, but it is not uncommon for producers to spend an average of $100-$150 per shank which amounts to $4,500-$7,500 or more for a typical air drill. Thus, few producers can afford to make very many selection mistakes in a "trial and error" approach before finding the opener and placement configuration most appropriate for them. It is estimated that approximately 70% or more of the dryland wheat and barley in major producing areas of Montana is sown with air drills. Thus, producers are keenly interested in unbiased evaluation of air drill opener and system options.

Our involvement with air drill opener investigations began in 1997 when Northern Agricultural Research Center hosted the third Montana "Fields of Tomorrow" show sponsored by Monsanto Company and KMON Country Radio with trade show support of numerous other vendors of agricultural supplies, equipment and technology. Part of NARC's contract for hosting the show included on-site evaluation of air drill openers. The use of a research-scale 'Concord' air drill was provided to Northern Agricultural Research Center by the manufacturer in cooperation with area dealer, Northern Ag Service of Malta. At the same time, a research-scale 'Conserva-Pak' air drill was purchased by MSU for use in conducting a series of large-scale cropping systems projects in Montana funded by USDA's Special Grant Program. Initially the MSU unit was available for inclusion in the opener evaluation studies at Havre and Moccasin. Use schedules with other projects at two different research centers have since limited the use of the Conserva-Pak in specific seed and fertilizer placement investigations. Carlson has conducted air drill opener investigations each year since 1997 with the Concord machine. Manufacturers and/or dealers provide all opener hardware at no cost to the Research Center in exchange for development of unbiased performance evaluation information.

Square-wall, 6-inch wide 'Titan' pneumatic packer tires/ wheels were utilized with all openers in 2001-2007 trials with the Concord machine. Standard 165x15R radial pneumatic packer tires/wheels were utilized with all openers in previous Concord trials. The wider Titan packer tires afford more appropriate packing with opener scenarios featuring

wider seed bands, but may be less appropriate than narrower packer tires for packing narrow seed band scenarios. Interchanging packer wheels/tires in addition to the openers themselves for different openers configurations within a single trial is not feasible in view of the time and effort required when for experimental standardization all planting treatments must be imposed within a single day.

The Concord unit has also been integral to other research investigations conducted by Stougaard and Carlson involving the use of widened seed bands and increased rates of seeding for reduction of wild oat competition in the production of spring wheat. Carlson, Lamb, Stougaard and Whitmus are further involved in developing other crop and crop pest management strategies utilizing Variable Rate Technology (VRT) equipment added to the Concord with funds provided in part by the Montana Wheat and Barley Committee, Northern Agricultural Research Center and Northern Ag Service. Boss, Carlson and Lamb utilized these technologies in yet a fourth collaborative effort where they investigated the effects of barley class, variable seed band widths, variable seeding rates, and variable harvest end points on both forage and grain end use parameters.

The Bourgault equipment, consisting of the center section of a commercial-scale Bourgault 5710 Air Hoe Drill equipped with Series 25 Mid Row Banders and a three-compartment Bourgault 5350 leading air seeder/cart, was delivered to the research center in 2005 on loan for research purposes by Bourgault Industries Ltd at Minot, ND with local dealer support provided by Tilleman Motor Company of Havre.

Growers are generally aware that there are limits with respect to the amount of actual $N+K_2O$ that can be delivered together with seed before germination and seedling damage will occur. Older guidelines were developed via research conducted at a time when the principal granular nitrogen fertilizer source was Ammonium Nitrate. With Urea now being the most commonly used granular nitrogen fertilizer product, newer guidelines call for lower limits. In MSU's 2005 Extension Bulletin 161 (*"Fertilizer Guidelines for Montana Crops"*) http://www.montana.edu/wwwpb/pubs/eb161.pdf , the following statement appears under "Special Conditions" for spring and winter wheat fertilization:

> *Drill-row applications of $N+K_2O$ should not exceed 20 lbs/a. When using Urea as the N source, drill-row application of $N+K_2O$ should not exceed 10 lbs/a with a 6-7 inch row spacing. When using a wider spacing, do not apply any urea with the seed. With newer drill and openers, the mixture of seed, fertilizer and soil is much greater, so more fertilizer can be placed in the "row" due to the dilution of potential detrimental impacts from salts and ammonia on germination and growth.*

Optimum seedbed moisture, finer-textured soils, and wider seed/fertilizer distribution bands can each serve to reduce such detrimental effects, but there are still limits. Reluctance to meet the additional investment cost for air drills with dual-air delivery systems is cause for some growers to employ broadcast fertilizer application practices or to "push the envelope" with respect to applying $N+K_2O$ fertilizers with seed.

The Bourgault equipment has made it more feasible to evaluate such seed and fertilizer relationships under conditions more equivalent to those dealt with by commercial growers. Germination and/or seedling damage associated with over-application of $N+K_2O$ fertilizers delivered with seed is not always obvious via casual observation of stands. It is interesting to note that in the 2006 study reported previously – the number of Plants/SqFt was reduced by 29 percent when applying 30-40-0 with seed and 40-0-0 via pre-plant broadcast in comparison with plant populations achieved with the same seeding rate and seed openers where the entire 70-40-0 fertilizer application was placed via mid row banders. In 2006, this same treatment involving over-application of $N+K_2O$ with seed resulted in a 23% wheat plant population reduction in comparison to the overall average population achieved by the other seven treatment configurations in the trial. In this case, yield was not significantly reduced since the population reduction resulted in compensation with a greater number of fertile culms per plant. It is likely that such could not always be expected to occur. In 2007, even though higher rates of intentional "over-application" of urea nitrogen in direct contact with seed were employed; early plant development stages were favored by above normal precipitation likely serving to avert germination and seedling damage that would have otherwise been expected to occur.

FUTURE PLANS:

The Research Center plans to continue work with traditional opener evaluations using the Concord unit in response to continued interest expressed both by Montana and out-of-state producers. New opener configurations have been incorporated into the trials during several of the past five years, and after-market mid-row fertilizer banding capability

was added in 2001 for investigations with this unit. The Concord drill lends itself to easier head-to-head comparison of numerous sets of primarily “double-shoot” openers since changeovers involve only ten shanks and replicated plots can be established within a relatively small research area.

The new three-product compartment Bourgault equipment affords opportunity to further expand evaluations relative to nutrient delivery and placement. Primary initial emphasis will be placed on replicated comparison of low disturbance seed placement and fertilizer placement via mid banding versus seed and fertilizer placement with leading “double-shoot” opener systems. And, given the steep increases in cost of fertilizer materials, effort will be made to address comparison of low disturbance seed and fertilizer placement systems versus single-shoot seeding coupled with broadcast fertilization. Special emphasis will be placed on further investigation of seed and seedling damage associated with delivering too much nitrogen and/or potassium fertilizer via the seed delivery stream.

Stougaard and Carlson completed the third of three years of field research in 2001 evaluating the effects of seeding rate and placement patterns on spring wheat’s ability to compete with wild oats. It was difficult to secure extramural funding support for the pilot studies in this effort. With positive results from the pilot studies in hand, the next phase will logically involve replicated, commercial field-scale application of the technology in the presence of ‘already-established’ wild oat populations. It will not be possible to carry out the next phase of this research without an appropriate level of extramural funding from some yet unsecured source. The general expense and time investment required cannot be absorbed by existing resources. The researchers will continue to pursue potential sources of funding.

Carlson, Lamb and Whitmus will continue other existing investigations underway with VRT-equipped air drills in site-specific placement of nitrogen for optimized yield and protein relationships in wheat.

Boss, Carlson and Lamb completed the third of three years of field research in 2003 on, “Increasing Yield and Management Options for Producers who Traditionally Plant Barley for Forage or Grain Production.” The second and third years of this work were supported by a grant with the Montana Board of Research and Commercialization Technology. Publication of this work is pending.

Thus, although originally put to work at Havre solely for the purpose of evaluating opener configurations, air drills have served multiple research endeavors out of the Havre station.

TABLE 1. Comparison of Differing "Double-Shoot" Opener Systems with a Research-Scale `Concord' Air Drill Under No-Till Dryland Fallow Conditions with Direct-Seeded `Choteau' Solid-Stemmed Spring Wheat. Northern Agricultural Research Center. Havre, Montana. 2007. (Exp# 07-SP08-OP)

ID	1/ ENTRY DESCRIPTION	STAND %	2/ ROW STYLE	3/ SEED BAND Inches	PLANTS /FT2 No.	4/ CULMS /FT2 No.	CULMS /PLANT No.	5/ HEAD DATE Julian	PLANT HEIGHT Inches	6/ GRAIN YIELD Bu/Ac	GRAIN MOIST. %	TEST WEIGHT Lbs/Bu	KERNEL WEIGHT g/1000	7/ GRAIN PROTEIN %
3	DUTCH Low Draft Paired Row	94.7	1.0	5.6	8.8	29.2	3.4	188.7	22.3	31.0	7.8	55.8	23.5	17.7
5	GEN 200 T2x2 Paired Row	97.5	2.0	6.7	11.4	35.3	3.3	187.8	21.9	30.8	7.6	54.7	21.3	18.1
4	FARMLAND SB1-SBS1 w/6” Swp&BkSwept Knife	98.5	1.0	6.0	12.6	35.7	2.9	187.2	22.8	30.6	7.6	54.7	21.2	18.0
2	DUTCH 3.5” Precision Paired Row	98.6	1.0	5.4	11.3	31.5	2.8	186.8	21.8	30.0	7.7	54.9	23.2	17.9
6	GEN 300 T2 Paired Row	97.5	1.0	5.8	12.0	33.4	2.8	187.5	20.7	29.5	7.6	54.9	21.9	18.0
1	BOURGAULT TILLAGE TOOLS 3” Paired Row	97.2	1.0	5.4	8.6	26.7	3.1	189.0	21.1	28.8	7.8	55.3	20.9	18.1
EXPERIMENTAL MEANS		97.3	1.2	5.8	10.8	32.0	3.0	187.8	21.8	30.1	7.7	55.0	22.0	18.0
LSD (0.05)		0.9	0.0	0.7	2.2	3.3	0.5	1.1	1.4	1.3	0.1	0.5	1.5	0.2
C.V. 2: (S OF MEAN/MEAN)*100		0.3	0.0	4.3	7.1	3.5	5.6	0.2	2.2	1.5	0.6	0.3	2.3	0.5

1/ Treatment Description Detail: ("Overall" Applied Fertilizer Nutrient was Constant at 70#N, 40#P_2O_5, and 25#K_2O per Acre via Granular 46-0-0, 11-52-0, and 0-0-62 Fertilizer Products)
Base Equipment = 10' (10-shank, research-scale) `Concord' Air Drill with 12" Shank Spacing and 6" `Titan' Square-Wall Pneumatic Packers

2/ Row Style/Appearance: 1=solid band, 2= paired/joined bands, 3=paired/separate bands.

3/ Average `splayed' stubble width 4" above soil surface at harvest maturity.

4/ Average no.of fertile culms (stems w/filled heads) per ft^2 (12.0" linear row w/ 12.0" row spacing).

5/ No. of Days from January 1 (188 = July 7).

6/ Volumetric yields are based on 60 lbs/bu as the standard test weight for wheat.

7/ Protein values are adjusted to 12 percent grain moisture.

Sawfly damage was minimal and uniform at 1% stem cutting among all treatments.

Site Resource & Management Data: (Exp# 07-SP08-OP)									
Field	B-1-1		Init K (ppm) 0-6"	428		Init PAW (in.) 6-24"	3.93		Herbicide App. Date	6/5
Quarter	NE		Init S (ppm) 0-24"	16		Init PAW (in.) 24-36"	2.35		Herbicide Product	Bronate Adv.
Section	32		Init Na (ppm) 0-6"	20		Init PAW (in.) 36-48"	2.03		Herbicide Rate (/ac)	16 oz
Township	32N		SaltHaz (MMHOS/cm) 0-6"	0.26		Init PAW (in.) 0-48"	9.43		Precip (in.) Apr1-Planting	3.12
Range	15E		SaltHaz(MMHOS/cm)6-24"	0.38		Cropping System	NT-ChmFlw		Precip (>.1) Apr1-Planting	2.95
Latitude	N48 29.750'		Soil Texture 0-6"	CL		Previous Crop	Barley		Precip (in.) Plnt'g-Harvest	4.36
Longitude	W109 47.023'		Soil Texture 6-24"	CL		Planting Date	5/18		Precip (>.1) Plnt'g-Harvest	3.15
Soil Texture	Joplin CLm		Soil Texture 24-36"	CL		Planting Depth (in.)	1.5		Harvest Maturity Date	7/26
pH 0-6"	6.5		Soil Texture 36-48"	CL		Moist Soil Depth @Plnt'g	48+		Harvest Date	8/9
Org.Matter (%) 0-6"	1.3		Ca (ppm)	1437		Dry Surf Soil (in.) @Plnt'g	0.25		Rooting Depth (in.)	20
Init N (lbs/ac) 0-6"	12		Init Zn (ppm) 0-6"	0.72		2" Soil Temp (^{o}F) @ Plnt'g	69		Post PAW (in.) 0-6"	0.39
Init N (lbs/ac) 6-24"	51		Init Mn (ppm) 0-6"	13.6		4" Soil Temp (^{o}F) @ Plnt'g	66		Post PAW (in.) 6-24"	1.90
Init N (lbs/ac) 24-36"	22		Init Mg (ppm) 0-6"	514		Fertilizer Formulation	Gran.Blend		Post PAW (in.) 24-36"	1.64
Init N (lbs/ac) 36-48"	-		Init Cu (ppm) 0-6"	1.3		Fertilizer Placement	Bnd at Plntg		Post PAW (in.) 36-48"	2.23
Init N (lbs/ac) 0-48"	85		Init Fe (ppm) 0-6"	32.5		Fert. Rate (lbs/ac) N	70		Post PAW (in.) 0-48"	6.16
Init P (ppm) Olsen 0-6"	31		CEC 0-6"	12.7		Fert. Rate (lbs/ac) P2O5	40		Precip (>.1) Hvst-Post	0.00
			Init PAW (in.) 0-6"	1.12		Fert. Rate (lbs/ac) K2O	25			

TABLE 2. [1]YIELD MEAN SUMMARY (Bu/Ac) FOR ALL "DOUBLE-SHOOT" AIR DRILL OPENER EVALUATIONS AT HAVRE - NORTHERN AGRICULTURAL RESEARCH CENTER
(1997-2007)

(See Reports for Individual Investigations for Additional Performance Parameters, Site & Climatic Specifics, and Project Management Details)

	NO-TILL RECROP SW-1997 (>BLY) HAVRE	CHM+TILL FALLOW WW-1998 (>BLY) HAVRE	CHM+TILL FALLOW SW-1998 (>BLY) HAVRE	NO-TILL FALLOW SW-1999 (>BLY) HAVRE	NO-TILL FALLOW SW-2000 (>WW) HAVRE	NO-TILL FALLOW SW-2001 (>SW) HAVRE	NO-TILL FALLOW SW-2002 (>WW) HAVRE	NO-TILL FALLOW SW-2003 (>BLY) HAVRE	NO-TILL FALLOW SW-2004 (>WW) HAVRE	NO-TILL FALLOW SW-2006 (>SW) HAVRE	NO-TILL FALLOW SW-2007 (>BLY) HAVRE
ANDERSON (Case-Concord) Triple Shooter		39.3	27.4	35.9	26.7	26.6	38.1				
ATOM JET Side Band					27.9	31.1	37.9	19.4	33.6	27.0	
ATOM JET Paired Row							36.5	18.3	34.0	27.3	
ATOM JET CB-15 w/TECHNOTILL Precision Packer									32.8		
BOURGAULT TILLAGE TOOLS 3" Paired Row										29.1	28.8
CONCORD LD w/Case-McKay 6" LD Sweep & K3 Knife		38.1									
CONCORD LD w/Case-McKay 11" LD Sweep & K3 Knife		35.3									
CONSERVA PAK System	22.4	36.7	27.2								
DUTCH SUPER EAGLE w/3.5" Paired Row Attachment				38.9	30.8	30.6	40.1	17.7	32.6		
DUTCH SUPER EAGLE w/5.5" Paired Row Attachment				37.8	28.2	28.8	38.4	17.8	34.3		
DUTCH 3.5" Precision Paired Row								16.7	35.0	29.8	30.0
DUTCH Low Draft Paired Row										27.6	31.0
DUTCH S.E. w/FARMLAND Mid Row Fertilizer Banding Disk						27.2	36.8	16.0	34.5	25.4	
FARMLAND LD w/Case-McKay 6" LD Sweep & K3 Knife			28.2	38.7	25.6	28.5	38.1	17.3	35.0	28.4	
FARMLAND LD w/Case-McKay 11" LD Sweep & K3 Knife			25.9	38.6	23.6	26.4	40.4	16.7	33.4	27.9	
FARMLAND SB1-SBS1 w/3" Knock-On Spoon & K3 Knife		35.4	21.2								
FARMLAND SB1-SBS1 w/4" Chrome Sweep & K3 Knife	19.5										
FARMLAND SB1-SBS1 w/4" Knock-On Sweep & K3 Knife		40.0	25.6	35.4	26.6	27.4					
FARMLAND SB1-SBS1 w/6" Knock-On Sweep & K3 Knife	23.9	41.0	24.0	35.7	28.1	27.4	38.8	17.2	32.2	28.5	30.6
FARMLAND SB1-SBS1 w/10" Knock-On Sweep & K3 Knife			23.5	35.2							
FLEXICOIL STEALTH w/Single Side Band Attachment	23.5	42.2	25.3	30.7							
FLEXICOIL STEALTH w/Paired Row Attachment	23.4	31.2	25.7	27.8	27.9	27.5	40.4	17.4	34.5	26.0	
GEN 200 T2	23.4										
GEN 200 T2x2		41.1	26.3	37.0	27.1	28.1	38.9	16.5	33.1	26.7	30.8
GEN 300 T2 Paired Row										26.4	29.5
MORRIS Gumbo Boot					24.3	27.8		18.3			
SWEDE	22.5	36.8			26.3						
SITE MEANS	22.4	37.9	25.5	35.6	26.9	28.1	38.6	17.4	33.8	27.5	30.1
LSD (.05)	2.8	5.3	3.7	4.4	2.9	4.9	5.6	2.1	2.8	5.6	1.3

[1]G.R. Carlson, Northern Agricultural Research Center, Havre - 2005 data lost to intermittent seed metering roller malfunction

All openers are "double-shoot" configurations with target seeding rate at 60#/ac and fertilizer at 70#N, 40#P_2O_5, and 25#K_2O via blended granular fertilizer at 251# product/ac.

TABLE 3. Nine-Year Yield Summary on Selected Entries from Dryland Fallow Evaluation of Double-Shoot Air Drill Openers with Spring Wheat. Northern Agricultural Research Center. Havre, Montana. 1998-2007.


	No. of YEARS TESTED 2/	1/ YIELD (Bushels Per Acre) NO-TILL FALLOW SW-2000 (>WW) HAVRE	NO-TILL FALLOW SW-2001 (>SW) HAVRE	NO-TILL FALLOW SW-2002 (>WW) HAVRE	NO-TILL FALLOW SW-2003 (>BLY) HAVRE	NO-TILL FALLOW SW-2004 (>WW) HAVRE	NO-TILL FALLOW SW-2006 (>SW) HAVRE	NO-TILL FALLOW SW-2007 (>BLY) HAVRE	AVERAGE for YEARS TESTED	% of CHECK YIELD 3/	9-YEAR COMP. AVERAGE YIELD 4/
DUTCH SUPER EAGLE w/3.5" Paired Row Attachment	6	30.8	30.6	40.1	17.7	32.6			31.8	106.3	**31.0**
FARMLAND LD w/Case-McKay 6" LD Sweep & K3 Knife	8	25.6	28.5	38.1	17.3	35.0	28.4		30.0	103.4	**30.2**
DUTCH SUPER EAGLE w/5.5" Paired Row Attachment	6	28.2	28.8	38.4	17.8	34.3			30.9	103.3	**30.1**
DUTCH 3.5" Precision Paired Row	4				16.7	35.0	29.8	30.0	27.9	102.8	**30.0**
ATOM JET Side Band	6	27.9	31.1	37.9	19.4	33.6	27.0		29.5	102.7	**30.0**
GEN 200 T2x2	9	27.1	28.1	38.9	16.5	33.1	26.7	30.8	29.4	100.8	**29.4**
FARMLAND LD w/Case-McKay 11" LD Sweep & K3 Knife	8	23.6	26.4	40.4	16.7	33.4	27.9		29.1	100.4	**29.3**
ANDERSON (Case-Concord) Triple Shooter	5	26.7	26.6	38.1					30.9	100.4	**29.3**
FARMLAND SB1-SBS1 w/6" Knock-On Sweep & K3 Knife	9	28.1	27.4	38.8	17.2	32.2	28.5	30.6	29.2	100.0	**29.2**
FARMLAND SB1-SBS1 w/4" Knock-On Sweep & K3 Knife	4	26.6	27.4						28.7	99.8	**29.1**
ATOM JET Paired Row	4			36.5	18.3	34.0	27.3		29.0	99.5	**29.0**
FLEXICOIL STEALTH w/Paired Row Attachment	8	27.9	27.5	40.4	17.4	34.5	26.0		28.4	98.0	**28.6**
DUTCH S.E. w/FARMLAND Mid-Row Fertilizer Banding Disk	5		27.2	36.8	16.0	34.5	25.4		28.0	97.1	**28.3**
MORRIS Gumbo Boot	3	24.3	27.8		18.3				23.5	96.8	**28.2**
ENTRY MEANS (For Entries Included in this Summary)		27.0	28.1	38.6	17.4	33.8	27.4				29.4
SITE MEANS (For All Entries Included in Original Trial)		26.9	28.1	38.6	17.4	33.8	27.5				
LSD (.05) (For All Entries Included in Original Trial)		2.9	4.9	5.6	2.1	2.8	5.6				

Check Entry is (FARMLAND SB1-SBS1 w/6" Knock-On Sweep & K3 Backswept Knife).

1/ See separate reports for individual investigations by year for additional performance parameters, site & climatic specifics and project management details.

2/ Only the most recent 7 years data are shown, but summary calculations include all years noted (2005 data lost to equipment malfunction).

3/ Percent of check entry yield performance for the same data years as those in which a given entry was tested.

4/ 9-Yr Comparable Average Yield = (x/y)*z where x = average yield of a given entry for years tested, y = average yield for the Check Entry for the same years, and z = 9-Yr average yield for the Check Entry

2005 data lost to intermittent seed metering roller malfunction.

Figure 1. BOURGAULT 3” Paired Row (Row Style = Solid, Seed Band Width = 5.4 Inches)

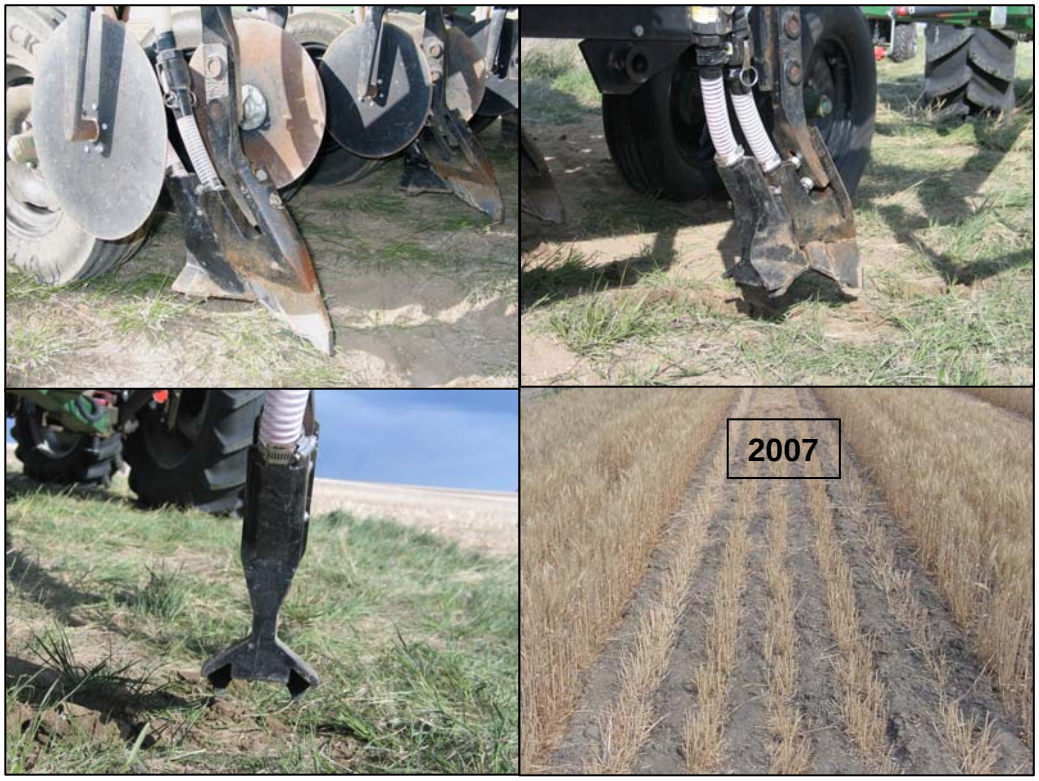

Figure 2. DUTCH 3.5” Paired Row (Row Style = Solid, Seed Band Width = 5.4 Inches)

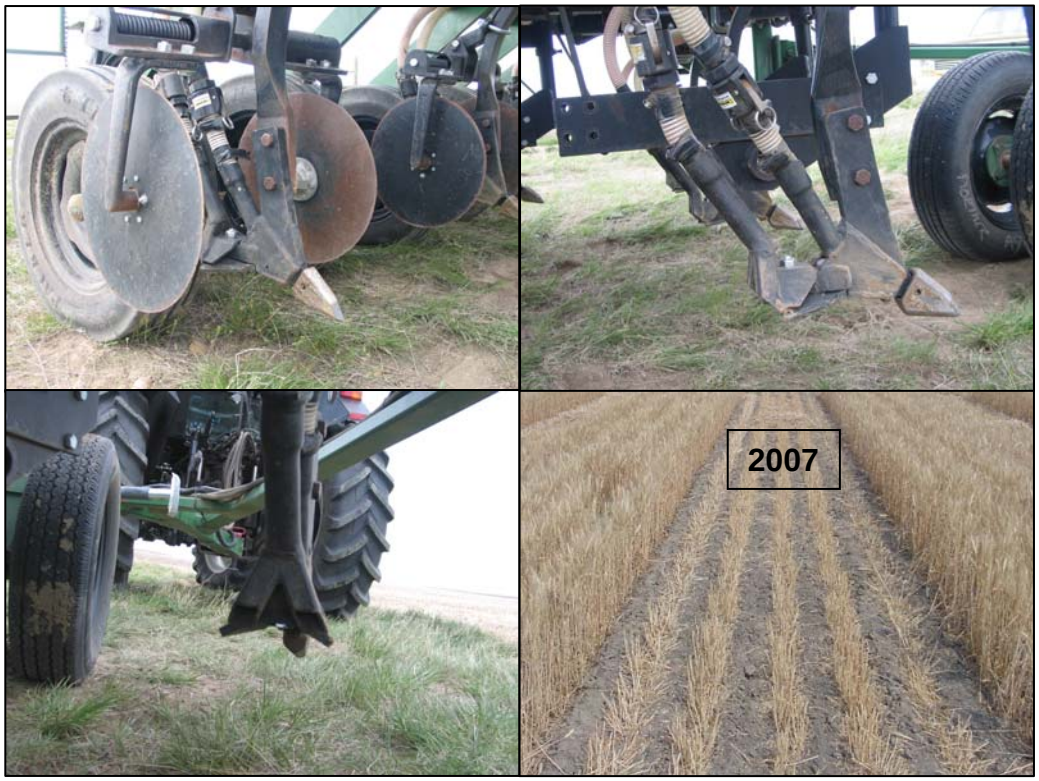

Figure 3. DUTCH Low Draft Paired Row (Row Style = Solid, Seed Band Width = 5.6 Inches)

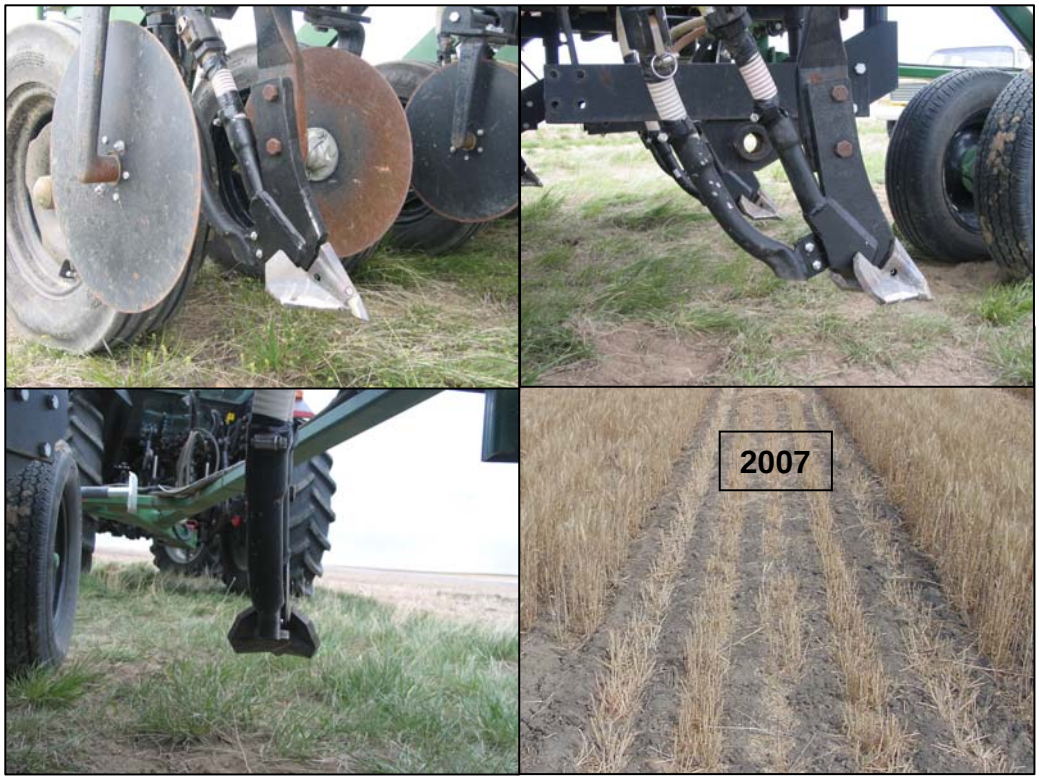

Figure 4. FARMLAND SB1-SBS1 w/ 6” Sweep & Backswept Knife (Solid, Seed Band Width = 6.0 Inches)

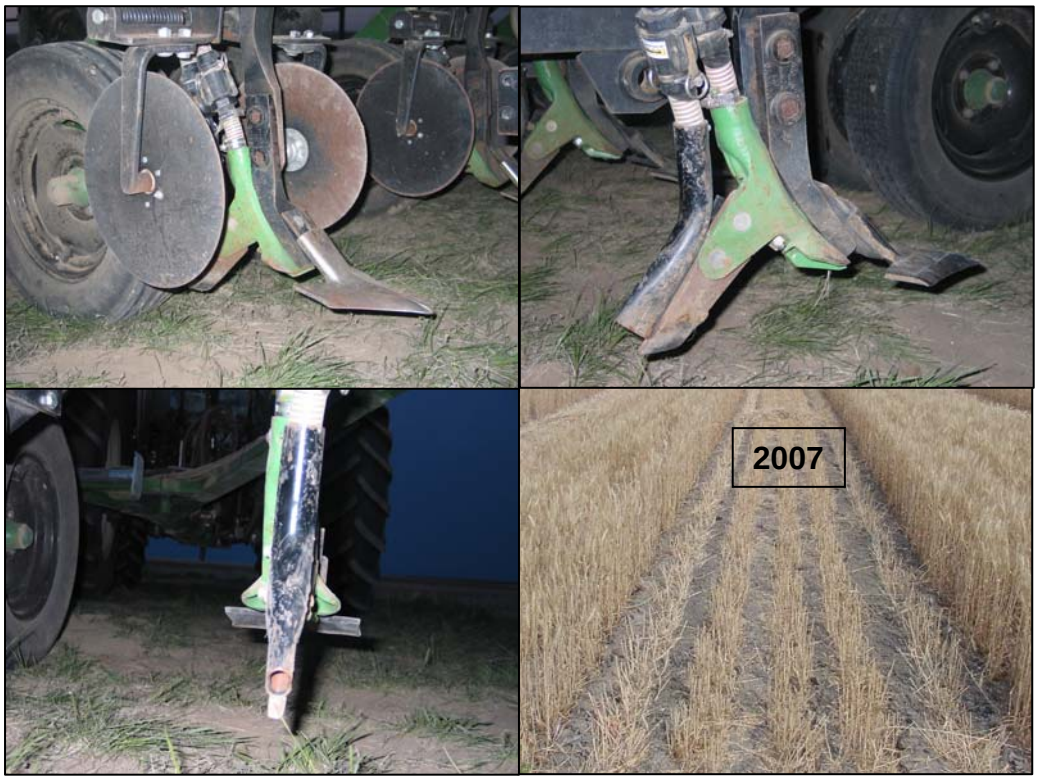

Figure 5. GEN 200 T2x2 Paired Row (Row Style = Paired/Joined, Seed Band Width = 6.7 Inches)

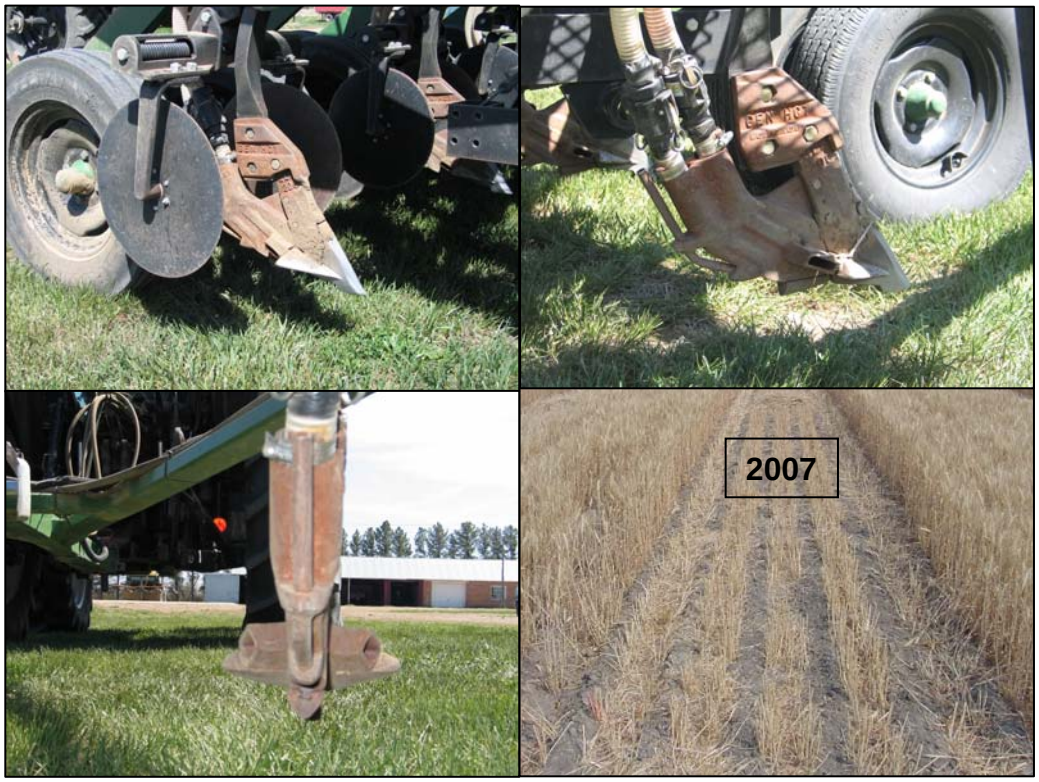

Figure 6. GEN 300 T2 Paired Row (Row Style = Solid, Seed Band Width = 5.8 Inches)

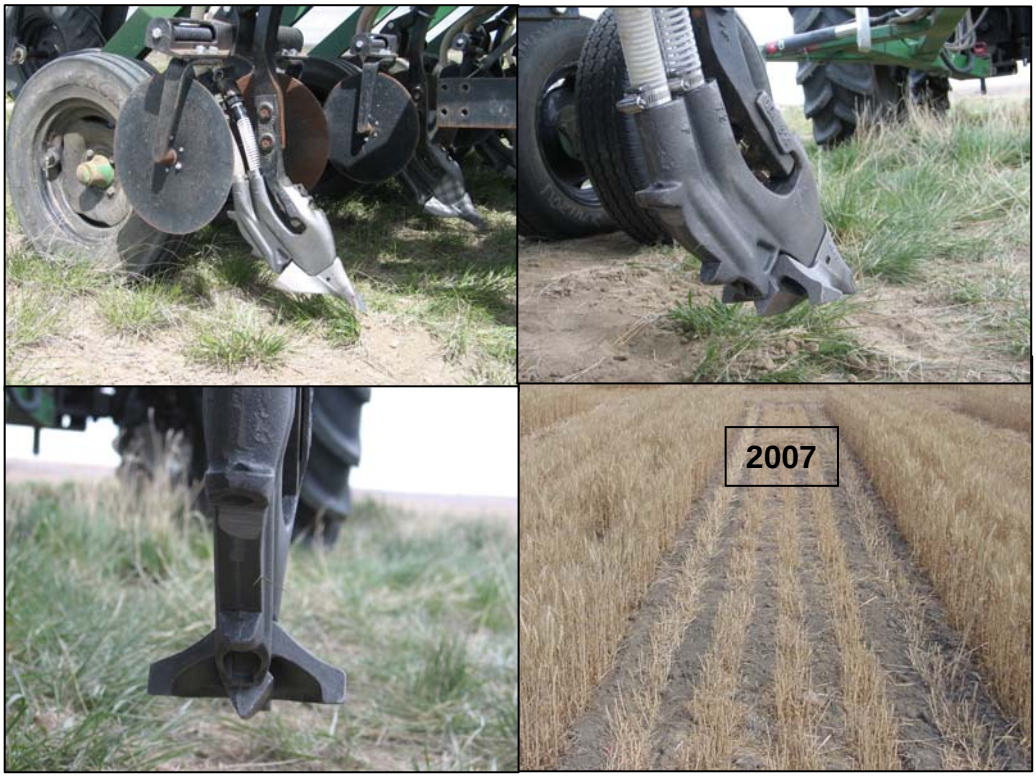

TABLE 4. Comparison of Differing Seed and Fertilizer Placement Configurations with a `Bourgault' Air Drill System Under No-Till Dryland Fallow Conditions with Direct-Seeded `Choteau' Solid-Stemmed Spring Wheat. Northern Agricultural Research Center. Havre, Montana. 2007. (Exp# 07-SP14-OP)

ID	1/ ENTRY DESCRIPTION	STAND %	2/ ROW STYLE	3/ SEED BAND Inches	PLANTS /FT2 No.	4/ CULMS /FT2 No.	CULMS /PLANT No.	5/ HEAD DATE Julian	6/ PLANT HEIGHT Inches	GRAIN YIELD Bu/Ac	GRAIN MOIST. %	TEST WEIGHT Lbs/Bu	KERNEL WEIGHT g/1000	7/ GRAIN PROTEIN %
07	Bourgault Double-Shoot Opener - Config A	98.6	1.0	5.2	15.1	30.4	2.1	182.3	23.9	33.9	7.8	55.0	22.0	17.9
06	Bourgault Single-Shoot Opener w/Bd'Cst - Config D	97.6	1.0	3.4	13.2	28.9	2.3	182.8	24.2	32.7	8.1	55.9	24.5	17.2
03	Bourgault Single-Shoot Opener w/Bd'Cst - Config A	97.8	1.0	3.2	12.3	27.3	2.2	183.3	22.7	31.9	8.0	55.8	21.0	17.3
08	Dutch Low-Draft Double-Shoot Opener - Config A	97.0	2.0	6.0	13.9	32.4	2.3	182.8	24.3	31.0	7.7	54.6	22.3	18.1
01	Bourgault Single-Shoot Opener w/MRB - Config A	97.1	1.0	3.4	8.8	24.3	2.8	184.3	22.8	31.0	8.1	56.1	22.3	17.1
04	Bourgault Single-Shoot Opener w/Bd'Cst - Config B	99.0	1.0	3.3	11.4	30.1	2.7	182.3	24.3	30.8	8.0	55.6	23.4	17.6
05	Bourgault Single-Shoot Opener w/Bd'Cst - Config C	97.5	1.0	3.1	14.6	29.7	2.1	182.0	24.5	30.7	7.9	55.6	22.4	17.6
EXPERIMENTAL MEANS		97.8	1.1	3.9	12.7	29.0	2.4	182.8	23.8	31.7	7.9	55.5	22.5	17.5
LSD (0.05)		1.7	0.0	0.6	3.3	5.0	0.6	1.9	1.7	2.5	0.2	1.0	2.5	0.6
C.V. 2: (S OF MEAN/MEAN)*100		0.6	0.0	5.2	8.7	5.8	8.0	0.4	2.4	2.6	1.0	0.6	3.7	1.2

1/ Treatment Description Detail: ("Overall" Applied Fertilizer Nutrient was Constant at 70#N, 40#P_2O_5, and 0#K_2O per Acre via Granular 46-0-0 and 11-52-0 Fertilizer Products)
Base Equipment = 15' (18-shank center section) `Bourgault' 5710 Air Hoe Drill with 9.8" Shank Spacing, 3-1/2" Steel Packers, `Bourgault' Series 25 Mid Row Banders and `Bourgault' 5350 Leading 3-Compartment Air Cart

ID 01 = Bourgault Industries Ltd Series 25 Mid Row Banders & BTT 200-4010 Single-Shoot (SS) Seed Opnr+200-0801 Tip w/ Entire 70-40-0 Delivered via the Mid Row Banders - Config A
ID 03 = BTT 200-4010 Single-Shoot (SS) Seed Openers+200-0801 Tip w/ 8.5-40-0 Delivered w/Seed + 61.5-0-0 Delivered via Pre-Plant Broadcast - Config A
ID 04 = BTT 200-4010 Single-Shoot (SS) Seed Openers+200-0801 Tip w/ 20-40-0 Delivered w/Seed + 50-0-0 Delivered via Pre-Plant Broadcast - Config B
ID 05 = BTT 200-4010 Single-Shoot (SS) Seed Openers+200-0801 Tip w/ 30-40-0 Delivered w/Seed + 40-0-0 Delivered via Pre-Plant Broadcast - Config C
ID 06 = BTT 200-4010 Single-Shoot (SS) Seed Openers+200-0801 Tip w/ 40-40-0 Delivered w/Seed + 30-0-0 Delivered via Pre-Plant Broadcast - Config D
ID 07 = Bourgault Tillage Tools Dbl-Shoot (DS), Paired Row Seed Opener System w/ Entire 70-40-0 Delivered to Fertilizer Band Between & Below Seed Band - Config A
ID 08 = Dutch Industries Low Draft Dbl-Shoot (DS), Paired Row Seed Opener System w/ Entire 70-40-0 Delivered to Fertilizer Band Between & Below Seed Band - Config A

2/ Row Style/Appearance: 1=solid band, 2= paired/joined bands, 3=paired/separate bands.
3/ Average `splayed' stubble width 4" above soil surface at harvest maturity.
4/ Average no.of fertile culms (stems w/filled heads) per ft^2 (14.7" linear row w/ 9.8" row spacing).
5/ No. of Days from January 1 (183 = July 2).
6/ Volumetric yields are based on 60 lbs/bu as the standard test weight for wheat.
7/ Protein values are adjusted to 12 percent grain moisture.
Sawfly damage was minimal and uniform at 1% stem cutting among all treatments.

Site Resource & Management Data: (Exp# 07-SP14-OP)									
Field	B-1-3		Init K (ppm) 0-6"	239		Init PAW (in.) 6-24"	3.19		Herbicide App. Date	6/5
Quarter	NE		Init S (ppm) 0-24"	15		Init PAW (in.) 24-36"	1.94		Herbicide Product	Bronate Adv
Section	32		Init Na (ppm) 0-6"	11		Init PAW (in.) 36-48"	-		Herbicide Rate (/ac)	16 oz
Township	32N		SaltHaz (MMHOS/cm) 0-6"	0.19		Init PAW (in.) 0-48"	6.12		Precip (in.) Apr1-Planting	2.23
Range	15E		SaltHaz(MMHOS/cm)6-24"	0.25		Cropping System	NT-ChmFlw		Precip (>.1) Apr1-Planting	2.06
Latitude	N48 29.610'		Soil Texture 0-6"	CL		Previous Crop	WW & SW		Precip (in.) Plnt'g-Harvest	5.26
Longitude	W109 47.023'		Soil Texture 6-24"	CL		Planting Date	5/11		Precip (>.1) Plnt'g-Harvest	4.78
Soil Texture	Joplin Loam		Soil Texture 24-36"	CL		Planting Depth (in.)	1.5		Harvest Maturity Date	7/18
pH 0-6"	7.1		Soil Texture 36-48"	CL		Moist Soil Depth @Plnt'g	48+		Harvest Date	8/9
Org.Matter (%) 0-6"	1.2		Ca (ppm)	1635		Dry Surf Soil (in.) @Plnt'g	0.25		Rooting Depth (in.)	24
Init N (lbs/ac) 0-6"	4		Init Zn (ppm) 0-6"	0.57		2" Soil Temp (^{o}F) @ Plnt'g	78		Post PAW (in.) 0-6"	0.49
Init N (lbs/ac) 6-24"	54		Init Mn (ppm) 0-6"	7.7		4" Soil Temp (^{o}F) @ Plnt'g	69		Post PAW (in.) 6-24"	2.69
Init N (lbs/ac) 24-36"	24		Init Mg (ppm) 0-6"	440		Fertilizer Formulation	Gran.Blend		Post PAW (in.) 24-36"	1.80
Init N (lbs/ac) 36-48"	48		Init Cu (ppm) 0-6"	1.2		Fertilizer Placement	*		Post PAW (in.) 36-48"	1.88
Init N (lbs/ac) 0-48"	130		Init Fe (ppm) 0-6"	18.2		Fert. Rate (lbs/ac) N	70		Post PAW (in.) 0-48"	6.86
Init P (ppm) Olsen 0-6"	32		CEC 0-6"	12.5		Fert. Rate (lbs/ac) P2O5	40		Precip (>.1) Hvst-Post	0.00
			Init PAW (in.) 0-6"	0.98		Fert. Rate (lbs/ac) K2O	0			

* As per trial protocol for individaul openers and/or fertility regimes.

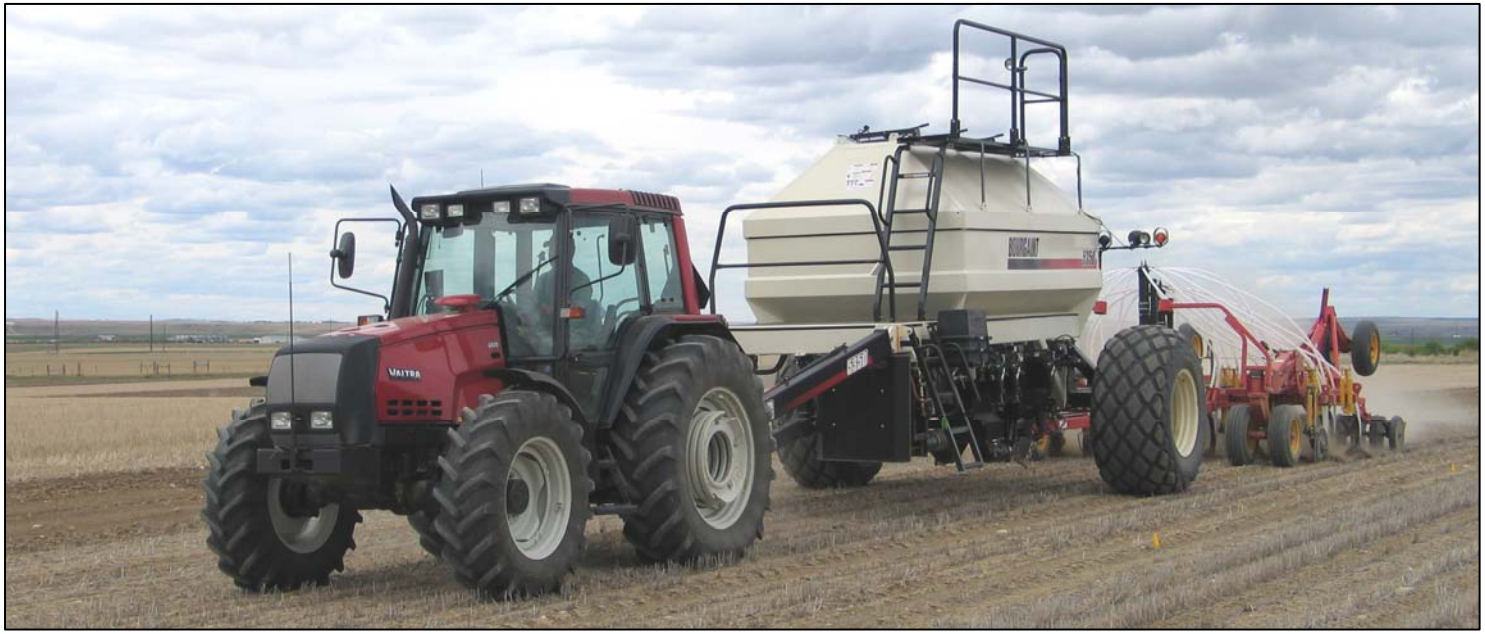

Figure 7. BOURGAULT Single-Shoot: 0-0-0 w/Seed +70-40-0 via MRBs (Solid, Seed Band Width = 3.4 Inches)

Figure 8. BOURGAULT Sngl-Shoot: 8.5-40-0 w/Seed+61.5-0-0 via PP-Bd'Cst (Solid, Seed Band Width = 3.2 Inches)

Figure 9. BOURGAULT Sngl-Shoot: 20-40-0 w/Seed+50-0-0 via PP-Bd'Cst (Solid, Seed Band Width = 3.3 Inches)

Figure 10. BOURGAULT Sngl-Shoot: 30-40-0 w/Seed+40-0-0 via PP-Bd'Cst (Solid, Seed Band Width = 3.1 Inches)

Figure 11. BOURGAULT Sngl-Shoot: 40-40-0 w/Seed+30-0-0 via PP-Bd'Cst (Solid, Seed Band Width = 3.4 Inches)

Figure 12. BOURGAULT Dbl-Shoot: 0-40-0 w/Seed+70-0-0 via FertBand (Solid, Seed Band Width = 5.2 Inches)

Figure 13. DUTCH Low Draft Dbl-Shoot: 0-0-0 w/Seed+70-40-0 via FertBand (Paired/Joined, Band Width = 6.0 Inches)