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. (4W6131)

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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 utilizing 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. Air drill studies were not conducted in 2009 due to wet field conditions delaying planting beyond the cut-off date deemed reasonable for obtaining meaningful results with spring wheat at this location.

RESULTS:

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

The agronomic performance of twelve "double-shoot" opener configurations under dryland chemical fallow conditions with 'Choteau' spring wheat direct-seeded into spring wheat stubble at Havre in 2010 is presented in Table 1. This evaluation was 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, Row Style, Seed Band Width, Plants/SqFt, Fertile Culms/SqFt, Fertile Culms/Plant, Head Date and Grain Yield. Under 2010 conditions there were no statistically significant differences among treatments for Plant Height, Test Weight, Kernel Weight, Grain Protein, or Sawfly Cutting.

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 "10-Year, Comparable Average" summary for all openers evaluated in at least three of the ten years (1999-2010) 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. The study was not conducted in 2009 due to conditions that delayed planting beyond a reasonable date.

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 most years 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 2001-2010 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 opener 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://msuextension.org/publications/AgandNaturalResources/EB0161.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 drills 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.

FUNDING SUMMARY:

Expenditure information is to be provided by Montana State University, Office of Sponsored Programs. There is no other grant support for this project.

MWBC FY2012 GRANT SUBMISSION PLANS:

It is not planned to submit this project for funding consideration in the next fiscal year.


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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. 2010. (Exp# 10-SP08-OP)

ID	1/ ENTRY DESCRIPTION	STAND %	2/ ROW STYLE	3/ SEED BAND Inches	4/ PLANTS /FT2 No.	4/ CULMS /FT2 No.	4/ 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 %	8/ SAWFLY RATING %
9	FARMLAND SB1-SBS1 W/6" Sweep	99.7	1.0	5.9	43.0	80.5	1.9	194.7	25.8	47.7	12.2	57.6	31.6	14.6	3.0
10	FLEXICOIL STEALTH w/Paired Row Attachment	100.0	1.0	4.1	44.0	82.8	1.9	194.7	26.2	45.8	12.1	56.9	29.1	14.6	1.7
11	GEN 200 T2x2 Paired Row	100.0	3.0	6.3	40.7	88.2	2.2	195.3	26.0	44.7	12.1	56.6	29.0	15.3	4.3
1	ATOM JET Paired Row	99.9	2.0	5.8	43.3	78.5	1.8	194.3	26.3	44.4	11.9	56.5	29.0	15.3	3.0
6	DUTCH Low Draft 2829 Paired Row	99.7	1.0	4.9	36.0	74.2	2.1	195.0	25.9	44.2	12.1	57.0	30.2	14.8	3.7
12	GEN 300 T2 Paired Row	99.9	1.3	5.0	42.3	83.8	2.0	195.0	26.9	43.7	11.9	56.6	28.7	14.8	3.7
8	DUTCH Precision Paired Row	100.0	1.0	4.5	45.7	78.5	1.7	194.3	26.8	43.6	11.9	57.3	29.9	14.6	2.3
2	ATOM JET Side Band	99.9	1.0	3.0	43.3	81.2	1.9	194.0	26.3	43.2	11.9	56.7	29.6	15.1	1.0
5	DUTCH Low Draft 2825 Paired Row	99.2	1.3	5.2	38.0	75.0	1.9	195.3	25.9	41.1	12.0	56.9	28.9	14.9	3.0
7	DUTCH Low Draft 2195 Paired Row	99.5	1.3	4.7	32.0	63.0	2.0	196.7	26.2	39.7	11.8	57.7	30.7	14.8	3.7
3	Bourgault Tillage Tools Advantage Series Paired Row	99.7	1.0	4.9	41.3	64.7	1.6	194.7	25.8	39.4	12.0	56.7	28.9	14.9	3.7
4	Bourgault Tillage Tools Titan Series Paired Row	99.0	1.0	4.9	26.3	85.8	3.4	197.0	25.1	38.9	12.2	57.7	31.0	14.7	3.0
	EXPERIMENTAL MEANS	99.7	1.3	4.9	39.7	78.0	2.0	195.1	26.1	43.0	12.0	57.0	29.7	14.9	3.0
	LSD (0.05)	0.5	0.5	1.0	6.6	14.5	0.6	1.1	1.7	4.9	0.3	0.9	2.0	0.6	2.7
	C.V. 2: (S OF MEAN/MEAN)*100	0.2	12.5	6.7	5.7	6.3	10.2	0.2	2.3	3.9	1.0	0.5	2.3	1.4	30.9

1/ Treatment Description Detail: (Due to high initial soil profile N inventories, no fertilizer nutrient was applied in 2008).
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/ Based on means of multiple row counts. Culms = fertile culms (stems w/filled heads).

5/ No. of Days from January 1 (195 = July 14).

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.

8/ Sawfly Rating = Percent Stem Cutting.

Site Resource & Management Data: (Exp# 10-SP08-OP)							
Field	An5-5	Previous Crop	SB	Fert. Rate (lbs/ac) N	70	Precip (>.1) Plnt'g-Harvest	5.86
Quarter	NW	Planting Date	5/21	Fert. Rate (lbs/ac) P2O5	40	Harvest Maturity Date	8/30
Section	33	Planting Depth (in.)	1.5	Fert. Rate (lbs/ac) K2O	25	Harvest Date	9/13
Tow nship	32N	Moist Soil Depth @Plnt'g	48+	Herbicide App. Date	6/24	Rooting Depth (in.)	35"
Range	15E	Dry Surf Soil (in.) @Plnt'g	0.25	Herbicide Product	Brox-M	Post PAW (in.) 0-6"	1.08
Latitude	N48 29.279'	2" Soil Temp (^{o}F) @ Plnt'g	68	Herbicide Rate (/ac)	24 oz	Post PAW (in.) 6-24"	1.73
Longitude	W109 47.562'	4" Soil Temp (^{o}F) @ Plnt'g	60	Precip (in.) Apr1-Planting	3.42	Post PAW (in.) 24-36"	1.08
Soil Texture	unk	Fertilizer Formulation	Gran Blend	Precip (>.1) Apr1-Planting	3.17	Post PAW (in.) 36-48"	1.68
Cropping System	NT-ChmFlw	Fertilizer Placement	Bnd at Plntg	Precip (in.) Plnt'g-Harvest	7.32	Post PAW (in.) 0-36"	5.58

Photo by Peggy Lamb, 2010

Air Drill Openers with NARC Air Drill Crew Following Seeding - Left to Right: Gregg Carlson, Eric Olson, Jeff Whitmus, Jordan VanVoast, Tony Wirtzberger and Zach Evans.

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TABLE 2. [1]YIELD MEAN SUMMARY (Bu/Ac) FOR ALL "DOUBLE-SHOOT" AIR DRILL OPENER EVALUATIONS AT HAVRE - NORTHERN AGRICULTURAL RESEARCH CENTER (1997-2010)

(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	NO-TILL FALLOW SW-2008 (>OILS) HAVRE	NO-TILL FALLOW SW-2010 (>BLY) HAVRE
ANDERSON (Case-Concord) Triple Shooter		39.3	27.4	35.9	26.7	26.6	38.1						
ATOM JET CB-15 w/TECHNOTILL Precision Packer									32.8				
ATOM JET Paired Row							36.5	18.3	34.0	27.3			44.4
ATOM JET Side Band					27.9	31.1	37.9	19.4	33.6	27.0			43.2
BOURGAULT TILLAGE TOOLS 'ADVANTAGE' Series 3" Paired Row													39.4
BOURGAULT TILLAGE TOOLS 'TITAN' Series 3" Paired Row										29.1	28.8	31.9	38.9
CONCORD LD w/Case-McKay 11" LD Sweep & K3 Knife		35.3											
CONCORD LD w/Case-McKay 6" LD Sweep & K3 Knife		38.1											
CONSERVA PAK System	22.4	36.7	27.2										
DUTCH 3.5" Precision Paired Row								16.7	35.0	29.8	30.0	32.7	43.6
DUTCH Low Draft '2195' Paired Row													39.7
DUTCH Low Draft '2825' Paired Row (3/8" Fert/Seed Seprtn)										27.6	31.0	32.9	41.1
DUTCH Low Draft '2829' Paired Row (3/4" Fert/Seed Seprtn)													44.2
DUTCH S.E. w/FARMLAND Mid Row Fertilizer Banding Disk						27.2	36.8	16.0	34.5	25.4			
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				
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 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 SB1-SBS1 w/10" Knock-On Sweep & K3 Knife			23.5	35.2									
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	31.8	47.7
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			45.8
FLEXICOIL STEALTH w/Single Side Band Attachment	23.5	42.2	25.3	30.7									
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	32.2	44.7
GEN 300 T2 Paired Row										26.4	29.5	31.2	43.7
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	32.1	43.0
LSD (.05)	2.8	5.3	3.7	4.4	2.9	4.9	5.6	2.1	2.8	5.6	1.3	2.0	4.9

[1]G.R. Carlson, Northern Agricultural Research Center, Havre - 2005 data lost to intermittent seed metering roller malfunction; 2009 trial not seeded do to wet soil and prolonged periods of rain. 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 (except 2008 at 0-0-0 fertilizer due to residual soil N inventory).

TABLE 3. Ten-Year Yield Summary on Selected Entries from Dryland Fallow Evaluation of Double-Shoot Air Drill Openers with Spring Wheat. Northern Agricultural I Center. Havre, Montana. 1999-2010.


	No. of YEARS TESTED 2/	1/ YIELD (Bushels Per Acre) 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	NO-TILL FALLOW SW-2008 (>OILS) HAVRE	NO-TILL FALLOW SW-2010 (>BLY) HAVRE	AVERAGE for YEARS TESTED	% of CHECK YIELD 3/	**10-YEAR COMP. AVERAGE YIELD 4/**
DUTCH SUPER EAGLE w/3.5" Paired Row Attachment	6	40.1	17.7	32.6					31.8	106.3	**33.8**
DUTCH SUPER EAGLE w/5.5" Paired Row Attachment	6	38.4	17.8	34.3					30.9	103.3	**32.8**
FARMLAND LD w/Case-McKay 6" LD Sweep & K3 Knife	7	38.1	17.3	35.0	28.4				30.2	101.8	**32.4**
ATOM JET Side Band	7	37.9	19.4	33.6	27.0			43.2	31.4	100.1	**31.8**
FARMLAND SB1-SBS1 w/6" Knock-On Sweep & K3 Knife	10	38.8	17.2	32.2	28.5	30.6	31.8	47.7	31.8	100.0	**31.8**
DUTCH 3.5" Precision Paired Row	6		16.7	35.0	29.8	30.0	32.7	43.6	31.3	99.9	**31.8**
FARMLAND LD w/Case-McKay 11" LD Sweep & K3 Knife	7	40.4	16.7	33.4	27.9				29.6	99.6	**31.7**
GEN 200 T2x2	10	38.9	16.5	33.1	26.7	30.8	32.2	44.7	31.5	99.1	**31.5**
FARMLAND SB1-SBS1 w/4" Knock-On Sweep & K3 Knife	3								29.8	98.0	**31.2**
ANDERSON (Case-Concord) Triple Shooter	4	38.1							31.8	97.9	**31.1**
ATOM JET Paired Row	5	36.5	18.3	34.0	27.3			44.4	32.1	97.7	**31.1**
DUTCH S.E. w/FARMLAND Mid-Row Fertilizer Banding Disk	5	36.8	16.0	34.5	25.4				28.0	97.1	**30.9**
MORRIS Gumbo Boot	3		18.3						23.5	96.8	**30.8**
FLEXICOIL STEALTH w/Paired Row Attachment	8	40.4	17.4	34.5	26.0			45.8	30.9	96.8	**30.8**
DUTCH Low Draft '2825' Paired Row (3/8" Fert/Seed Seprtn)	4				27.6	31.0	32.9	41.1	33.2	95.7	**30.4**
GEN 300 T2 Paired Row	4				26.4	29.5	31.2	43.7	32.7	94.4	**30.0**
BOURGAULT TILLAGE TOOLS 'TITAN' Series, 3" Paired Row	4				29.1	28.8	31.9	38.9	32.2	92.9	**29.5**
ENTRY MEANS (For Entries Included in this Summary)		38.5	17.4	33.8	27.5	30.1	32.1	43.7			31.4
SITE MEANS (For All Entries Included in Original Trial)		38.6	17.4	33.8	27.5	30.1	32.1	43.0			
LSD (.05) (For All Entries Included in Original Trial)		5.6	2.1	2.8	5.6	1.3	2.0	4.9			

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/ 10-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 = 10-Yr average yield for the Check Entry.
2005 data lost to intermittent seed metering roller malfunction.
2009 not seeded due to extreme delay caused by excess precipation.