ZERO-MINIMUM TILLAGE SEEDING AND FERTILIZER PLACEMENT TECHNIQUES FOR ZERO-TILLAGE

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ABSTRACT

Preliminary results from the field evaluation of zero and minimum tillage seeding machines, as well as fertilizer placement techniques for zero-tillage are presented. Narrow hoe opener (Noble 2000), conventional double disc (Haybuster 1206), as well as two modified double disc press drills have been compared for their seeding performance and effects on crop yields in a continuous zero-till wheat test. Further, an airseeder, a discer and a conventional hoe press drill have been field evaluated both on cultivated fallow and stubble situations. Deep banding and side banding (approximately 2.5 cm from seed) of fertilizer using both disc and hoe press drills have been compared to seed placed fertilizer application.

INTRODUCTION

In all tillage system, one can find at least two different equipment types to perform a given tillage or seeding operation. Field evaluation of different tillage or seeding tools/implements is as old as agricultural research itself. Yet criteria for recommendation of a particular tillage or seeding tool/implement are still the same as in the early days of agricultural research, mainly crop yields.

Direct seeding or seeding without preseeding till offers labour, fuel and machinery (through less wear) saving over the traditional seed bed preparation followed by press drill seeding. In addition, such minimum tillage seeding may allow earlier seeding dates as the number of tillage operation replaced increases. Along with improved soil erosion control, it is possible to save the soil moisture present in the seed zone with direct seeding, otherwise wasted. Two direct seeding implement types, namely the discer and the airseeder were evaluated for their seeding performace and compared to the traditional preseeding tillage followed by hoe press drill seeding.

A second experiment was established in 1982 to evaluate different zero-till drill/furrow opener designs. Three different disc openers were evaluated and compared to a hoe opener. Disc openers usually create less soil disturbance than hoe furrow openers, which may or may not affect soil moisture losses, weed seed burial, etc., and could

result in depressed crop yields. However, some disc openers incorporate to much crop residues with the seed, while hoe type drill do not handle to well heavy crop residue cover. This test provides some information on the effects on these various aspects.

The technical feasibility of side banding (within 2.5 cm of the seed row) and deep banding of fertilizer in zero tillage situations was investigated and compared to placement of fertilizer with the seed. The high fertilizer requirements encountered in recropping situations may be detrimental to plant growth if placed with the seed while deep banding of fertilizer in the spring may deplete surface soil moisture as well as create unacceptable soil disturbance for zero tillage systems.

Preliminary results of field evaluation of different seeding systems for conventional or minimum tillage practices as well as that of seeding and fertilizer placement equipment for zero-tillage practices are presented and briefly discussed. New "testing criteria" for field evaluation of tillage/seeding equipment are also proposed.

MATERIALS AND METHODS

In the spring of 1982, three experiments were established on a Wood Mountain Clay Loam soil. Canuck hard red spring wheat was used for all three tests. Experiment I (Table 1) consisted in the field evaluation of direct seeding (no preseeding tillage) using two different seeding machines as compared to preseeding tillage followed by press drill seeding, which is the most widely used seeding practice in southwestern Saskatchewan. Experiment I was conducted both on cultivated fallow as well as on undisturbed stubble. All seeding treatments were followed by a packing operation within one week after seeding.

Table 1. Various equipment and treatments evaluated in Swift Current in 1982 and 1983.

Experiment	Equipment used	Treatments
I	Minneapolis hoe press drill + preseeding tillage	Fallow-Stubble
	Coop Implements Discer	Fallow-Stubble
	Wil-Rich Airseeder	Fallow-Stubble
II	Haybuster 1206 double disc	Zero-Till
	Noble 2000 hoe press	Zero-Till
	Noble 2000 modified double-triple disc	Zero-Till
	Swift Current offset double disc	Zero-Till
III	Noble 2000 hoe-side bander	fertilizer seed, side, deep placed
	Noble 2000 double-triple disc-side bander	fertilizer seed, side, deep placed

In experiment II, four different zero-till drills (table 1) were evaluated on adjacent fields under zero-till management for the last two and five years prior to 1982. The Haybuster 1206 furrow opener consisted of two 30.5 cm diameter discs symetrically mounted with a vertical angle of approximately 8 degrees between them. The Noble 2000 modified double disc drill was equipped with a disc type furrow opener actually made of three discs all mounted on the same support. The center one (38 cm diameter) was mounted vertically, while the second disc (36 cm diameter) was mounted to its side with the center below and behind the vertical disc to provide a leading edge for coulter action. The third disc (36 cm diameter) was mounted to the other side with its center at the same approximative horizontal location as the vertical one, but slightly behind. This modified double-triple disc opener could be used to seed only by dropping the seeds in the lowest side of the opener, while side banding was obtained by delivering the fertilizer in the same lowest side and the seed on the other side. The fertilizer was accurately placed 5 cm below the seed at approximately 2.5 cm to its side as well. The Swift Current zero-till double disc prototype built in Swift Current was equiped with an offset double disc consisting of a 38 cm diameter vertical disc and a 30.5 cm diameter disc mounted 2.5 cm and 5 cm below the vertical disc and at an angle of 7 degrees, thus providing a 7.5 cm leading edge for trash cutting. The Noble 2000 hoe drill was equiped with a narrow hoe opener (1.9 cm). A side banding attachment could be mounted behind the hoe opener shank. When used for side banding, the actual separation between the fertilizer and the seed could vary from 1 to 2.5 cm depending on soil conditions.

In Experiment III, the suitability of deep fertilizer placement for zero tillage systems was investigated by comparing spring deep banding of fertilizer to side banding (within 5 cm of seed row) and seed placement of fertilizer. The two Noble 2000 furrow opener described earlier were used for this experiment.

RESULTS AND DISCUSSION

Experiment I- Hoe press drill vs discer and airseeder seeding

Results from the seeding performance measurments made in 1983 and crop yields for are presented in Tables 2 to 4. The wide range of seed placement resulting from the seed drill as well as the seeding conditions (Table 2) did not significantly affect emerged plant density (Table 3). It is important to mention that the concept of seed placement is meanningless when used without making reference to soil moisture distribution in the soil upper layer.

Wheat grain yields acheived using those differentconventional-minimum seeding practices for the last two years are presented in Table 4. Deep seeding in wheat stubble with an airseeder may have caused significant ($p \leq 0.05$) yield reduction in continuous wheat over the yields achieved with a hoe drill. However, neither seed drill or even deeper seeding affected ($p < 0.05$) wheat yields on summerfallow.

Table 2. Seed depth results for the conventional-minimum tillage seeding techniques at Swift Current(1983).

Seeding treatment or equipment	Seed depth (mm from surface)*	
	Rotation	
	Wheat on fallow	Continuous wheat
Seed bed preparation + hoe press drill	39 b	51 a
Direct seeding -discer	50 b	24 b
Direct seeding -airseeder	73 a	72 a

* means followed by the same letter do not differ (Duncan's New Multiple Range Test $p<0.05$)

Table 3. Emerged plant density results for the conventional-minimum tillage seeding techniques at Swift Current(1983).

Seeding treatment	Plant density (# seedlings/sq.m)*	
	Rotation	
	Wheat on fallow	Continuous Wheat
Seed bed preparation + hoe press drill	132 a	121 a
Direct seeding -discer	135 a	112 a
Direct seeding -airseeder	125 a	91 a

* means followed by the same letter do not differ ($p<0.05$).

Table 4. Grain yields results for the conventional-minimum tillage seeding techniques at Swift Current.

Rotation	Year	Grain Yield (kg/ha)* Seeding treatment/equipment		
		Seed bed preparation + hoe press drill	Direct Seeding discer	airseeder
Wheat on fallow	1982	2706	2693	2614
	1983	2069	2046	2143
	Avg	2388 a	2369 a	2379 a
Continuous Wheat	1982	2775	2630	2379
	1983	1661	1765	1579
	Avg	2218 a	2197 ab	1938 b

* means followed by the same letter are not significantly different ($p<0.05$).

Experiment II -Zero-till drill/furrow opener evaluation.

As in experiment I, over two years, deeper seeding (Table 5) did not result in significant ($p<0.05$) increases in emerged plant density (table 6), whether the soil moisture was excellent (1982, 418 mm of rain) or average to dry (1983, 318 mm of rain). In zero tillage systems, because the soil moisture distribution is such that more moisture is present near the soil surface, shallow seeding may have some merit over the traditional seeding depth of 5 cm. Further, seeding with a hoe opener did not enhance plant germination as compared to at least one disc drill/opener in each year (Table 6).

Table 5. Seed depth results for the zero-till drill/furrow opener experiment at Swift Current.

Drill/furrow opener	Seed depth (mm from surface)*	
	Year	
	1982	1983
Haybuster 1206 double disc	31 b	39 b
Noble 2000 hoe	46 a	38 b
Noble 2000 modified double disc	32 b	59 a
Swift Current offset double disc	34 b	38 b

* means followed by the same letter do not differ ($p<0.05$)

Table 6. Emerged plants density for different zero-till drill/furrow opener at Swift Current.

Seed drill/furrow opener	Emerged plants* (# seedlings/sq.m)	
	Year	
	1982	1983
Haybuster 1206 double disc	148 ab	146 a
Noble 2000 hoe	139 bc	123 b
Noble 2000 modified double disc	171 a	120 b
Swift Current offset double disc	122 c	110 b

* means followed by the same letter do not differ ($p<0.05$)

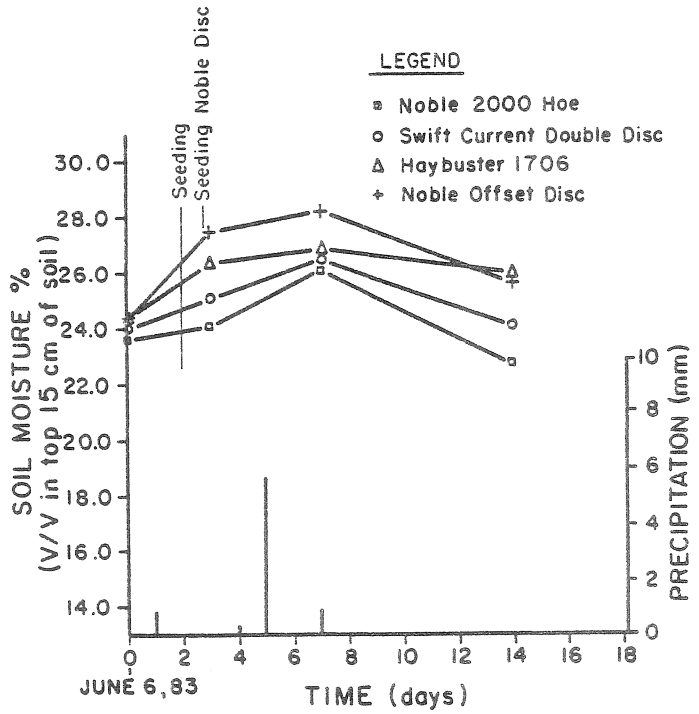

Figure 1. Drill/furrow opener effects on soil moisture of the first 15 cm of soil at Swift Current, 1983.

In 1983, in an attempt to measure the openers effects on the soil moisture content at the soil surface, preseeding and subsequent gravimetric soil moisture content measurements were made (Figure 1) for the first 15 cm of the soil. It is evident that the sampling interval used was not adequate to show sound information. Nevertheless, the soil moisture content of the first 15 cm of the soil appears to be very sensitive to drill/furrow opener action on the soil as well as that of minute rainfall. Carefull measurement of the soil moisture content of the soil upper layer along with the crop performance data could possibly help to draw firm recommendations with respect to conventional, minimum or zero tillage seeding or tillage equipment. For example, the rate of soil moisture change after seeding (Figure 1) could relate the furrow opener to the plant emergence rate, while subsequent data such as that after a small rain event could provide information on evaporative soil moisture losses caused by the medium term effect of drill/furrow openers.

As in experiment I, yields (Table 6) do not fully reflect the effects of drill/furrow openers on seed placement or plant density. Despite lower emerged plant densities in both a wetter than normal (1982) or a slightly drier than normal year (1983), the Swift Current offset disc drill resulted in significantly higher grain yields ($p<0.05$) than all other drills. Further, the Noble 2000 hoe drill had significantly lower yields ($p<0.05$) than discs drills when compared over two years.

Table 7. Wheat grain yields for the zero-till drill/furrow opener evaluation at Swift Current.

Year	Years of zero-till management	Grain Yields* (kg/ha) Seed Drill/opener Haybuster 1206 double disc	Noble 2000 disc hoe	Swift Current offset disc
1982	2	2401	2369	2412**	2458
	5	2373	2650	2668**	2790
1983	3	1240	1326	1148	1435
	6	1452	1389	1215	1665
Average		1867 b	1635 c	1971 b	2087 a

* means followed by the same letter do not differ ($p<0.05$)
** two plots out of four lost to opener obstruction by soil

Experiment III -Fertilizer placement techniques X drill furrow opener

The seed placement and emerged plant density result for this test are presented in table 8 and 9. The year X opener and year X fertilizer placement were significant ($p< 0.05$) for both seed placement and emerged plant density, thus yearly treatment means were compared. The trends in the seed placement are similar to those observed in the zero-till drill evaluation. The main conclusion to be drawn from the seed depth results is that the use of side banding options (triple disc or side banding boot) was not a limitation to seed placement. In 1982, both furrow openers and fertilizer placement method had significant effects on emerged plant population (Table 9).

Table 8. Seed depth for the fertilizer placement X furrow opener for zero tillage at Swift Current.

Year	Furrow opener	Seed depth (mm from surface)* Fertilizer placement technique Seed placed	Side banded	Deep banded	Avg
1982	hoe	42	39	48	43 a
	disc	41	42	47	43 a
	Average	42 b	40 b	47 a	
1983	hoe	46	52	48	49 a
	disc	33	41	37	37 b
	Average	39 c	46 a	43 b	

* means followed by the same letter do not differ ($p<0.05$)

Table 9. Emerged plant density for the fertilizer placement X furrow opener in zero tillage at Swift Current.

Year	Furrow opener	Emerged plants (# seedlings/sq.m)*			
		Fertilizer placement technique			Avg
		Seed placed	Side banded	Deep banded	
1982	hoe	149	156	184	163 b
	disc	184	178	217	192 a
	Average	166 b	167 b	201 a	
1983	hoe	122	135	126	128 a
	disc	119	119	130	123 a
	Average	121 a	127 a	128 a	

* means followed by the same letter do not differ ($p<0.05$)

Crop yields data for the fertilizer X furrow opener evaluation experiment are shown in table 10. Averaged over two years, there was a significant ($p<0.05$) fertilizer placement X furrow opener interaction thought to be due to the greater fertilizer-seed separation in the side banding treatment with the triple disc opener (about 5 cm) as compared to that acheived with the hoe-side banding opener (1 to 2.5 cm). The use of a starter fertilizer placed with the seed could possibly take care of of this effect which could be caused by a lack of phosphorus fertilizer in the proximity of the seed in the earlier stages of the growth, fact very important in zero tillage if soil are somewhat cooler than in conventional tillage systems. Thus the opener and fertilizer placement treatments means averaged over the two years where compared using the 0.1 level of significance. The better seed placement achieved with the disc furrow opener seem to have resulted in an increased

Table 10. Wheat yields for the fertilizer placement X furrow opener for zero tillage test in Swift Current.

Furrow opener	Year	Grain yields (kg/ha)*		
		Fertilizer placement technique		
		Seed placed	Side banded	Deep banded
Hoe	1982	1618	2310	2038
	1983	1590	1746	1606
	Average	1604 Bb	2012 Aa	1822 Ab
Disc	1982	2056	2041	2361
	1983	1605	1646	1690
	Average	1831 Ba	1843 Ba	2025 Aa

* means followed by the same capital letter do not differ ($p<0.1$) within the furrow opener treatments; means followed by the same lower character letter do not differ ($p<0.1$) within the fertilizer placement treatment

($p<0.1$) within the seed placed and the deep banding treatments as compared to the hoe opener. Further, placement of the fertilizer away from the seed with a hoe opener appears to increase ($p<0.1$) crop grain yields in zero tillage, while deep banding resulted in higher yields ($p<0.1$) when seeding was performed with a disc opener. However, it is thought that the potential soil moisture losses resulting from deep banding of fertilizer prior to seeding in the spring may in some cases hamper crop yields, but this fact still has to be proven.

SUMMARY

Direct seeding with an airseeder (Wil-Rich) resulted in a deeper seed placement (73 mm) than either direct seeding with a discer (Coop Implement, 50 mm on fallow and 24 mm on stubble) or seeding with a hoe press drill on prepared seed bed (39 mm on fallow, 51 mm on stubble) in 1983. However, none of the direct seeding equipment or preseeding tillage followed by hoe press drill affected affected plant population in 1983. Neither the abscence of preseeding tillage nor the equipment type used for direct seeding affected spring wheat yields on summerfallow over two years, whereas deeper seeding observed with the airseeder resulted in depressed yields of 1938 kg/ha averaged over two years as compared to preseeding tillage and hoe press drill seeding (2218 kg/ha) when seeding on wheat stubble. Yields obtained with a discer were comparable to those of the airseeder and hoe drill both on summerfallow and stubble.

Despite shallow seeding (36 mm) and the lowest ranking emerged plant counts (122 seedlings/sq. m in 1982 and 110 seedlings/sq. m in 1983), the Swift Current offset double disc zero-till drill prototype yields averaged 2087 kg/ha over two years which was better than the Haybuster 1206 double disc drill which had a two year average yield of 1867 kg/ha, the Noble 2000 hoe drill averaged 1635 kg/ha over two years and the Noble 2000 modified double disc drill averaged 1971 kg/ha over two years. In addition, the Noble 2000 hoe drill yields were significantly lower than those of any other drill mentionned above over the two years of evaluation.

Side banding of fertilizers using either a triple disc or a hoe furrow opener equipped with a side banding attachment was not a limitation to seed placement while plant germination was enhanced by the deep banding of fertilizer treatment in 1982, mainly due to the tillage action caused by the deep banding operation. Averaged over two years, the crop yields acheived with the Noble 2000 modified disc opener outperformed ($p<0.1$) those acheived with the hoe opener within the seed placed and deep banded fertilizer treatments. Using a hoe opener, banding the fertilizer away from the seed row increased crop yields ($p<0.1$), while only deep banding of fertilizer resulted in yield increase with a disc furrow opener.

Current methodology for field evaluation of seeding, tillage or fertilizer placement techniques often leads to weak recommendations based solely on crop growth indicators such as plant emergence, days to

maturity or crop yields. There is evidence that carefull measurement of the effects of seeding equipment or techniques on the soil moisture content of the soil upper layer may provide a better base for recommendation. Further, unless the soil moisture distribution in the seeding zone is measured, few conclusions can be made as to the effect of shallow seeding depth on subsequent crop performance.

CONCLUSIONS

The preliminary results of theses three experiments conducted at Swift Current in 1982 and 1983 enable us to cautiously draw the following conclusions:

1- Direct seeding with an airseeder on tilled fallow and over the two years as compared to 2218 kg/ha for the hoe press drill seeding on prepared seed bed when seeding on wheat stubble. The average yields acheived by the discer were 2369 kg/ha and 2197 kg/ha on fallow and stubble respectively, and were comparable to those of the hoe press drill and the airseeder.

2- Seeding depth, preseeding tillage or equipment type used for direct seeding did not have an effect on emerged plant density in either fallow or stubble seeding in 1983, nor on the average crop yields on fallow for 1982 and 1983. However, the airseeder presented a lower average grain yield of 1938 kg/ha over the two years as compared to 2218 kg/ha for the hoe press drill seeding on prepared seed bed when seeding on wheat stubble. The average yields achieved by the discer were 2369 kg/ha and 2197 kg/ha on fallow and stubble respectively, and were comparable to those of the hoe press drill and the airseeder.

3- Despite shallow seed placement (36 mm) and the lowest emerged plant density (116 seedlings/sq. m on average), the Swift Current offset double disc zero-till drill resulted in a crop yield of 2087 kg/ha outperforming the haybuster 1206 double disc, Noble 2000 hoe and the Noble 2000 modified double disc drills (1867 kg/ha, 1635 kg/ha and 1971 kg/ha respectively).

4- Carefull measurement of the effects of seeding equipment on the soil moisture content of the soil upper layer as well as the moisture distribution in the seed zone is a must for field evaluation of seeding or fertilizer placement equipment or techniques.

5- Side banding attachments for double disc and hoe furrow openers were not a limitation to seed placement.

6- Banding of fertilizer (side, deep banding) in zero tillage may result in increased crop yields provided that soil moisture losses caused by the fertilizer placement are not excessive.

7- It is likely that a triple disc opener side banding the fertilizer no further than 2.5 cm away from the seed row would increase crop yield in the same fashion as side banding with a modified hoe opener.

Note that these conclusions pertain only to the analysis of the preliminary results gathered to date and that further results and analysis may change in part or in whole those conclusions.

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