SUMMARY 1994 GROWING SEASON
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EFFECTIVENESS OF DOUBLE SHOOT OPENERS FOR APPLYING ANHYDROUS AMMONIA AND UREA WHILE SEEDING WHEAT AND CANOLA FIELD TESTS

Research Project RL0394

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Abstract

This experiment outlines the effectiveness of double shoot openers for applying anhydrous ammonia and granular urea at different rates while seeding wheat and canola. Emergence, yield, maturity, protein and oil content were evaluated for five openers in three soil types applying four different rates of anhydrous ammonia and urea. Anhydrous ammonia losses with different openers were determined for a medium textured soil. For the field conditions tested, results indicated anhydrous ammonia and urea could be applied safely while seeding wheat or canola with little adverse effect on emergence or yield using double shoot openers.

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Introduction and Problem Definition

Many farmers on the prairies are changing from conventional farming to direct or one-pass seeding. The major problem encountered is how to apply all the fertilizer necessary for the crop. One method available is double shoot openers on air seeders or air drills.

Some information is available on the use of double shoot openers with granular fertilizer but very little is available on the use of double shoot openers with anhydrous ammonia. Interest in anhydrous ammonia is increasing because of the low cost of the fertilizer compared to other forms. Since high nitrogen concentrations can harm potential emerging seedlings, the effects and amount of placement of anhydrous ammonia with double shoot openers needs to be addressed.

This project outlines the effectiveness of double shoot openers while using anhydrous ammonia and granular urea at 0, 56, 112 and 168 kg/ha (0, 50, 100 and 150 lbs/ac) rates with wheat and canola. The project was completed on three soil types ranging from sand to heavy clay.

Statement of Objectives

The objective of the experiment was to outline the effectiveness and amounts of anhydrous ammonia and granular fertilizer that could be applied using double shoot openers without damage to wheat and canola. The following hypotheses were tested.

Hypothesis 1
Percentage of seed damage caused by anhydrous ammonia and granular fertilizer with double shoot openers is not significantly different under direct seeding conditions for both wheat and canola.

Hypothesis 2
Double shoot openers can safely apply up to 100 percent of the required nitrogen using either anhydrous ammonia or granular fertilizer for wheat and canola.

Hypothesis 3
Seed damage caused by anhydrous ammonia and granular fertilizer with different seed and fertilizer relative placements are not significantly different under direct seeding conditions for wheat and canola.

Hypothesis 4
The amount of anhydrous ammonia or granular fertilizer retained in the soil is not significantly different for double shoot openers under direct seeding conditions for wheat and canola.

Test Procedures

Selection of Experimental Factors and Treatments

The experimental factors include opener type, fertilizer type, fertilizer rate and seed type. **Table 1** outlines the levels of the factors used in the experiment.

Table 1. Experimental Factors and Levels

FACTOR	LEVEL
Opener Type (5)	Flexi-coil Stealth Shallow Point
	Flexi-coil Stealth Deep Point
	Farmland Agro 4 in (10 cm) Chrome
	Gen Side Band
	McKay Dart Sweep and DJ Fertilizer Tube
Fertilizer Rate (4)	0 kg/ha (Control)
(Actual Nitrogen)	56 kg/ha (50 lbs/ac)
	112 kg/ha (100 lbs/ac)
	168 kg/ha (150 lbs/ac)
Seed Type (2)	Wheat
	Canola
Fertilizer (2)	Granular (46-0-0)
	Anhydrous (82-0-0)
Soil Conditions (3)	Heavy Clay
	Clay Loam
	Sandy Loam
Replications (4)	

Experimental Constants

The following experimental constants, typical of seeding operations in Western Canada, were used.

Implements:

Travel Speed	P	6.7 km/h (4 mph)
Tractor	P	100 hp tractor
Soil Finishing	P	Mounted 10.2 cm (4 in) rubber packers
Row Spacing	P	24.5 cm (10 in)
Seeder	P	AFMRC plot air seeder

Seed:

Seed Type	P	Treated Leader Wheat seeded at 84 kg/ha (75 lbs/ac)
		Treated Reward Canola and granular Carbofuran seeded at 9 kg/ha (8 lbs/ac)
Seeding Depth	P	Into moisture (see Appendix 2 for specific placements)

Fertilizer:
- Anhydrous Ammonia P (82-0-0) electronically controlled
- Urea Nitrogen P (46-0-0) application based on lab calibrations
- Phosphate P 11-51-0-0 placed with the seed at 67 kg/ha (60 lbs/ac)

Soil:
- Soil Condition P No tillage, direct seeding
- Land Location P Heavy clay, clay loam and sand site

Other:
- Spray Applications: P Pre burn-off with 1.0 L/acre of Roundup one week prior to seeding
  Wheat application with recommended rate of Triumph Plus
  Canola application with tank mix of Muster and Poast at recommended rates

Ground Openers

The five ground openers tested were the Flexi-coil Stealth with shallow and deep fertilizer points, the Farmland Agro 4 inch (10 cm) chrome sweep and backswept knife, the Gen side band and a 30.5 cm (12 in) McKay Dart sweep with DJ NH_3 tubes, and a New Noble seed and fertilizer system.

The Flexi-coil Stealth openers tested were equipped with a shallow and deep fertilizer point. Fertilizer was placed between and below two paired seed rows.

A 30.5 cm (12 in) sweep equipped with fertilizer tubes which placed the fertilizer under the ends of the sweep wings was equipped with a Farmland Agro seed splitter. The splitter placed the seed in two rows between the fertilizer rows. Since the fertilizer tubes could not apply granular urea, a New Noble paired row boot was used to place the urea in a similar pattern to anhydrous tubes.

The Farmland Agro opener was made up of a 10.2 cm (4 in) chrome sweep and a backswept knife. Seed was broadcast under the sweep with the fertilizer placed in a slot cut by the backswept knife.

The Gen Opener placed the seed in a band to the right and above the fertilizer row.

Plot Seeder

The plot seeder was a four-row seeder equipped with John Deere heavy-duty cultivator shanks spaced at 25.4 cm (10 in). The cultivator was pulled behind a Gandy air application system. Seed and urea were metered from the Gandy box to hoses which pneumatically distributed material to the ground openers. Phosphate was metered using a Beeline metering system. Flexi-coil's 10.2 cm (4 in) wide rubber packers were adjusted to supply moderate packing pressure to the seed rows of the openers. The anhydrous ammonia tank was mounted on top of the cultivator and supplied ammonia to a Raven anhydrous controller to control the ammonia flow rate.

Experimental Design

The experiment was a full factorial (5 x 4 x 2 x 2 x 3) block design with four complete replications for a total of 960 plots. Each block contained one complete replication for each seed type. Plots were 2.43 x 15.24 m (8 x 30 ft). A 12.2 m (40 ft) strip was left between each block to allow for turning and starting implements. Border effects were controlled through plot randomization and 7.6 m (25 ft) strips between blocks.

Units of Observation

Emergence counts, yield, seed and fertilizer placement, anhydrous ammonia loss, protein, oil and crop moisture contents were recorded.

Plant count samples were taken four to five weeks after seeding to determine effects of experimental factors on emergence. Three 61 cm (2 ft) random samples from different rows were taken from each plot.

Plot yield samples, 157 cm x 0.914 m (62 in x 30 ft), were taken using a Winterstieger plot combine. Crop moisture, protein and oil content analyses were also completed.

Anhydrous ammonia losses were measured by sampling the air above the plots and analyzing the samples with an ion chromatograph.

Soil Types

Three irrigated sites with varying soil types were used in the test. The soils on the sites were classified as clay (heavy texture), clay loam (medium texture) and sandy loam (light texture). Fall tillage was completed on the clay, and sandy loam soil the previous fall, making trash conditions difficult to work through. No previous tillage was completed on the clay loam site, allowing for better trash flow through the seeder. A complete outline of the soil tests is available in Appendix 1.

Calibration

Calibration of seeding and fertilizer rates were completed using AFMRC's calibration test procedures.

Granular urea, canola and wheat were metered using a Gandy seed box. Phosphate was metered using a Beeline metering system.

The Gandy box and Beeline system were calibrated prior to field work in accordance with AFMRC's test procedures.

Anhydrous ammonia flow rates were calibrated using AFMRC's data acquisition equipment. A correlation of the controller's ability to maintain flow and a given weight of anhydrous ammonia was completed. Application rates were controlled during the test using a Raven anhydrous ammonia controller. Manifold uniformity distribution tests were completed to ensure uniform flow across the seeder width.

Seeding depth and levelling were adjusted in the field prior to plot work to place the seed into moisture at a uniform depth over the width and front-to-back of the seeder.

Statistical Analysis

A full factorial analysis was applied using an analysis of variance (ANOVA) on the germination and yield results for specific sites and crops. The fixed effects of the ANOVA table were considered experimental factors as outlined in **Table 1**. The four blocks for replication were considered random effects nested within the fixed ANOVA format and therefore applied to the error term of the ANOVA. An analysis was completed and indicated the blocks were insignificant to the ANOVA effects. Least Significant Difference tests were used to outline levels causing statistically significant differences.

Results and Discussion

Growing Season Conditions

Soil moisture and temperature were measured prior to seeding. Moisture conditions for all seeding operations were excellent. Soil moisture was available in the top 2.5 cm (1 in) of all sites. **Table 2** outlines average soil moisture and temperature measurements for the three sites. Soil moisture was measured on a volume basis.

Table 2. Average Soil Moisture and Temperature

Soil Type	Average Soil Temperature C°		Average Soil Moisture (% v/v)
	2 in	6 in	0 to 4 in
Clay	12.11	9.29	31.56
Clay Loam	14.72	14.19	27.03
Sandy Loam	14.73	12.68	11.50

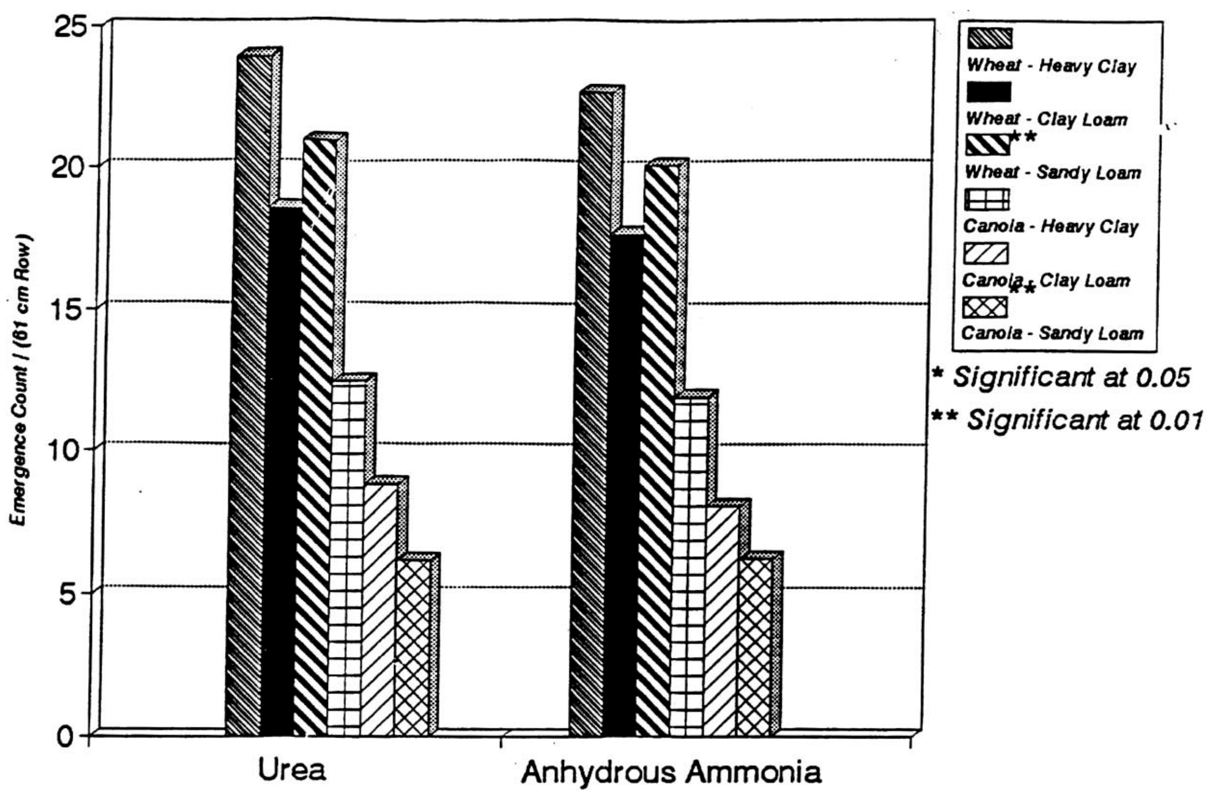
All site irrigation was left to the cooperating farmers in the study. Lack of rainfall and limited irrigation in the latter part of the growing season reduced yields of wheat and canola on the sandy loam soil site. In addition, high competition from volunteer barley in the wheat plots reduced wheat yields significantly on the sandy loam site. Yield data from this site was included in the results of this study. However, care should be taken when using the data from the sandy loam site to draw conclusions.

Emergence

Plant count samples were taken four to five weeks after seeding to determine effects of experimental factors on emergence. Three 61 cm (2 ft) random samples on three different rows were taken for each plot. Average emergence results are outlined in Appendix 4.

Effect of Anhydrous Ammonia on Emergence

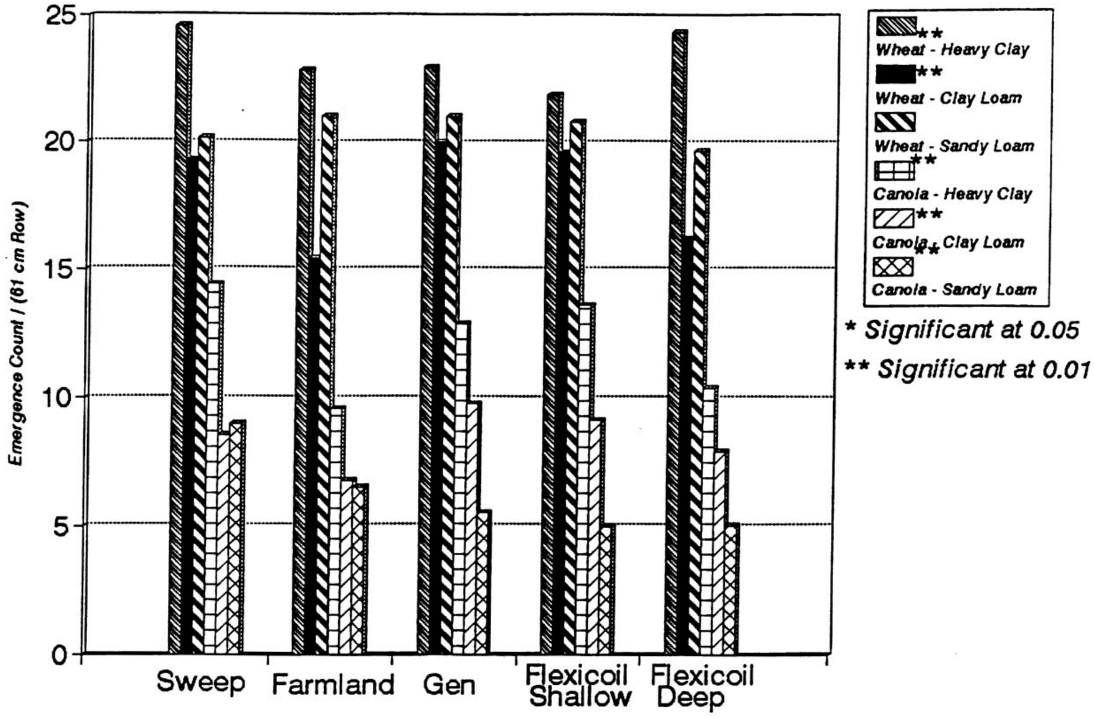
Graph 1 illustrates the average effect of fertilizer type on crop emergence. In general, the average emergence on the urea plots was slightly higher than the anhydrous ammonia plots. However, the effect of fertilizer on emergence was insignificant in all cases except the sandy loam soil conditions. Significant differences were found between the granular urea and anhydrous ammonia when seeding wheat and canola in the sandy loam soil condition. The anhydrous ammonia caused lower average emergence at the 0.01 level of significance for wheat on the sandy loam soil. When seeding canola, the urea caused lower average emergence than the anhydrous ammonia at the 0.01 level of significance. Emergence sampling on wheat was difficult because of the volunteer barley emerging at the same time. Based on the emergence results, the amount of seed damage caused by anhydrous ammonia and granular urea fertilizer was not significantly different under direct seeding conditions for both wheat and canola.



Graph 1. The Effect of Fertilizer Type on Emergence.

Effect of Openers on Emergence

Graph 2 illustrates the average effect of the openers on crop emergence. In general, the Sweep and Gen performed better than the other openers over a variety of soil conditions. The shallow point on the Flexi-coil opener caused higher emergence than the Flexi-coil deep point in most soil conditions. **Table 3** outlines the significant differences measured. Openers with the same letter did not have significantly different average emergence at the 0.01 level.



Graph 2. The Effect of Opener Type on Emergence.

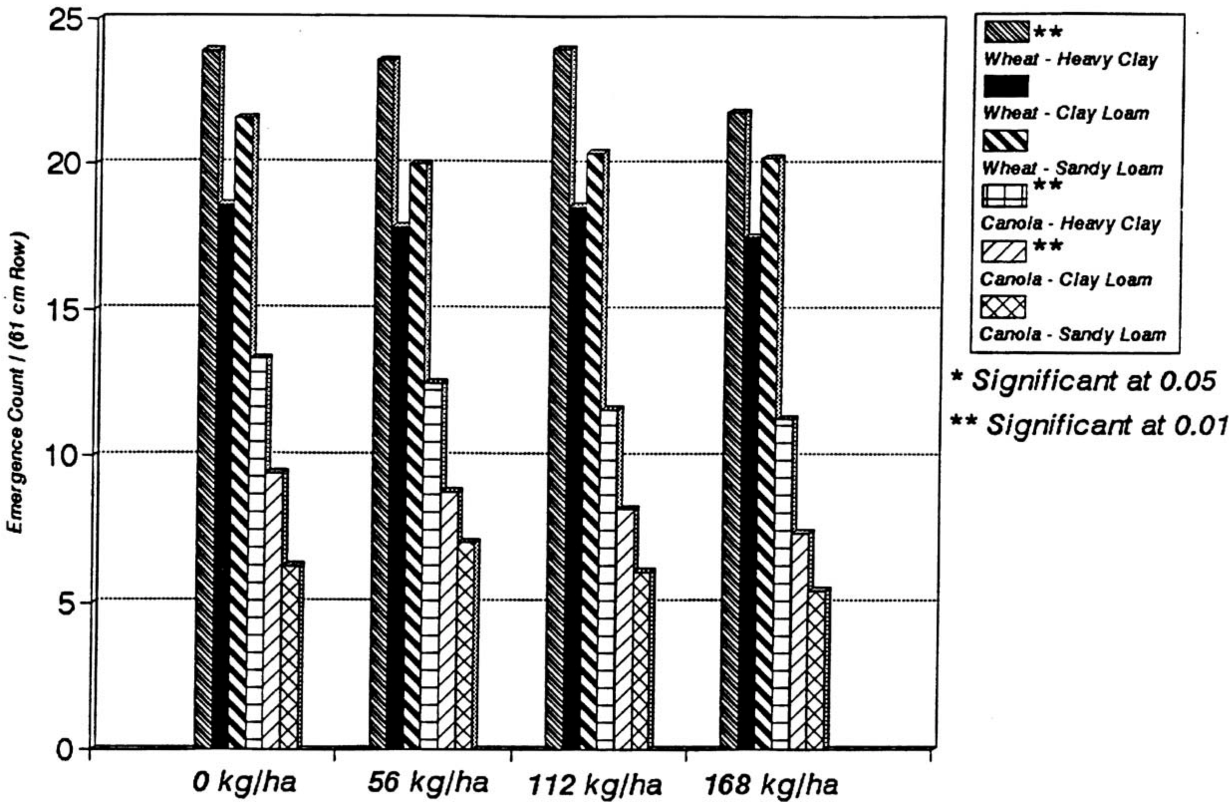
Table 3. The Effect of Opener Type on Emergence.

Soil Type (Crop)	Highest Emergence			Lowest Emergence
Heavy Clay (Wheat)	Sweep a	Flexi (d)^ a	Gen ab	Farmland b	Flexi (s)^ b
Clay (Wheat)	Gen a	Flexi (s)^ a	Sweep a	Flexi (d)^ b	Farmland b
Sandy Loam (Wheat)	Gen *	Farmland *	Flexi (s)^ *	Sweep *	Flexi (d)^ *
Heavy Clay (Canola)	Sweep a	Flexi (s)^ a	Gen a	Flexi (d)^ b	Farmland b
Clay (Canola)	Gen a	Flexi (s)^ ab	Sweep bc	Flexi (d)^ c	Farmland d
Sandy Loam (Canola)	Sweep a	Farmland b	Gen b	Flexi (d)^ b	Flexi (s)^ b

* No Significant Differences
^ (s) - Shallow (d) - Deep

Effect of Rate on Emergence

Graph 3 illustrates the effect of fertilizer rate on average emergence. In general, as fertilizer rates increased from 0 kg/ha to 56, 112 and 168 kg/ha (50, 100 and 150 lbs/ac), the emergence decreased. However, the decrease was only significant for the wheat seeded at the clay site and the canola seeded at the clay and clay loam sites. For the wheat on the clay site, the average emergence for the 168 kg/ha (150 lbs/ac) rate was significantly lower than the 0, 56 or 112 kg/ha (0, 50 or 100 lbs/ac) rates. For the canola on the clay, the 112 and 168 kg/ha (100 and 150 lbs/ac) rates had significantly lower emergences than the 0 kg/ha rate. The canola seeded on the clay loam at the 168 kg/ha (150 lbs/ac) rate had statistically significant lower average emergence than the 0, 56 and 112 kg/ha (0, 50 and 100 lbs/ac) rates at the 0.01 level. The 112 kg/ha (100 lbs/ac) rate had lower average emergence than the 0 kg/ha rate.



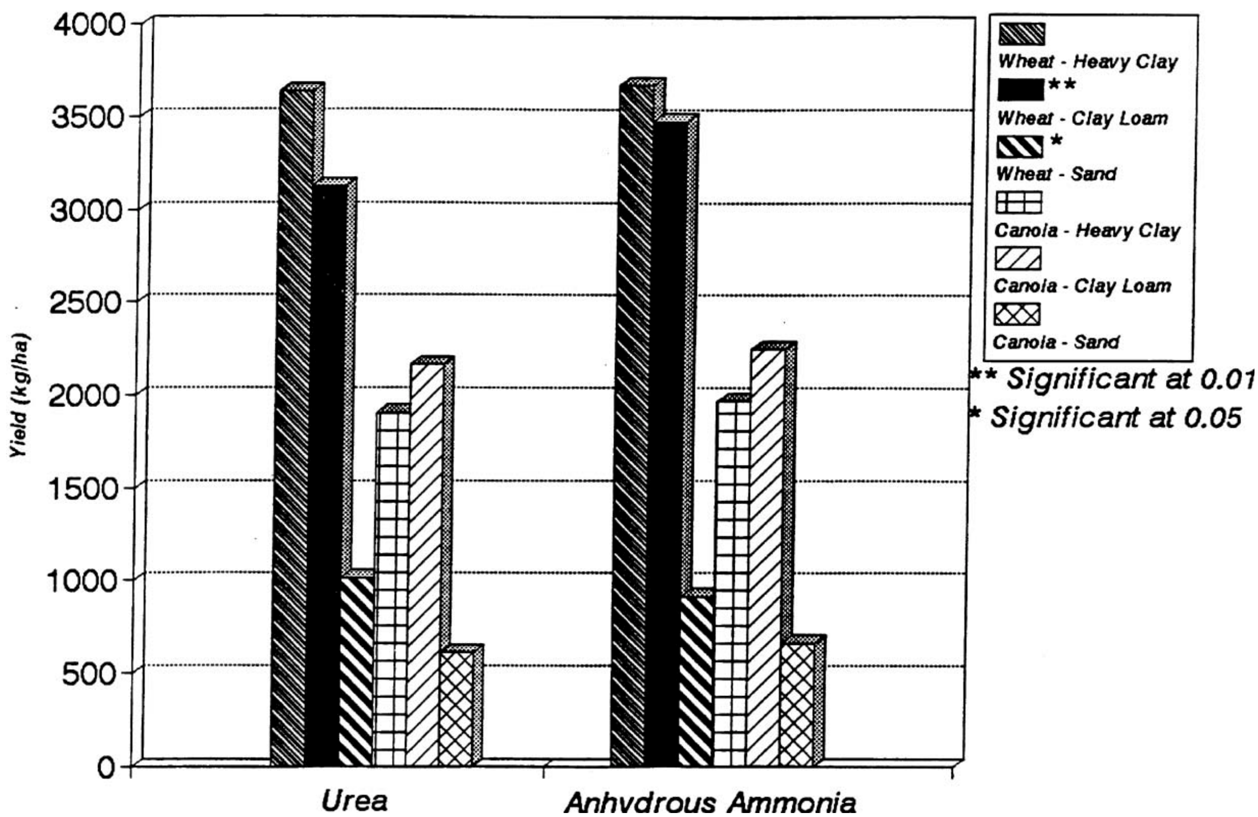
Graph 3. Rate Factor Effect on Emergence.

Yield

A 158 cm x 914 m (62 in x 30 ft) yield sample was taken from each plot using a Wintersteiger plot combine to determine the effects of the experimental factors on yield. All yield data was converted to a standard moisture of 12 percent prior to analysis. Average yield results are outlined in Appendix 4.

Effect of Anhydrous Ammonia and Urea on Yield

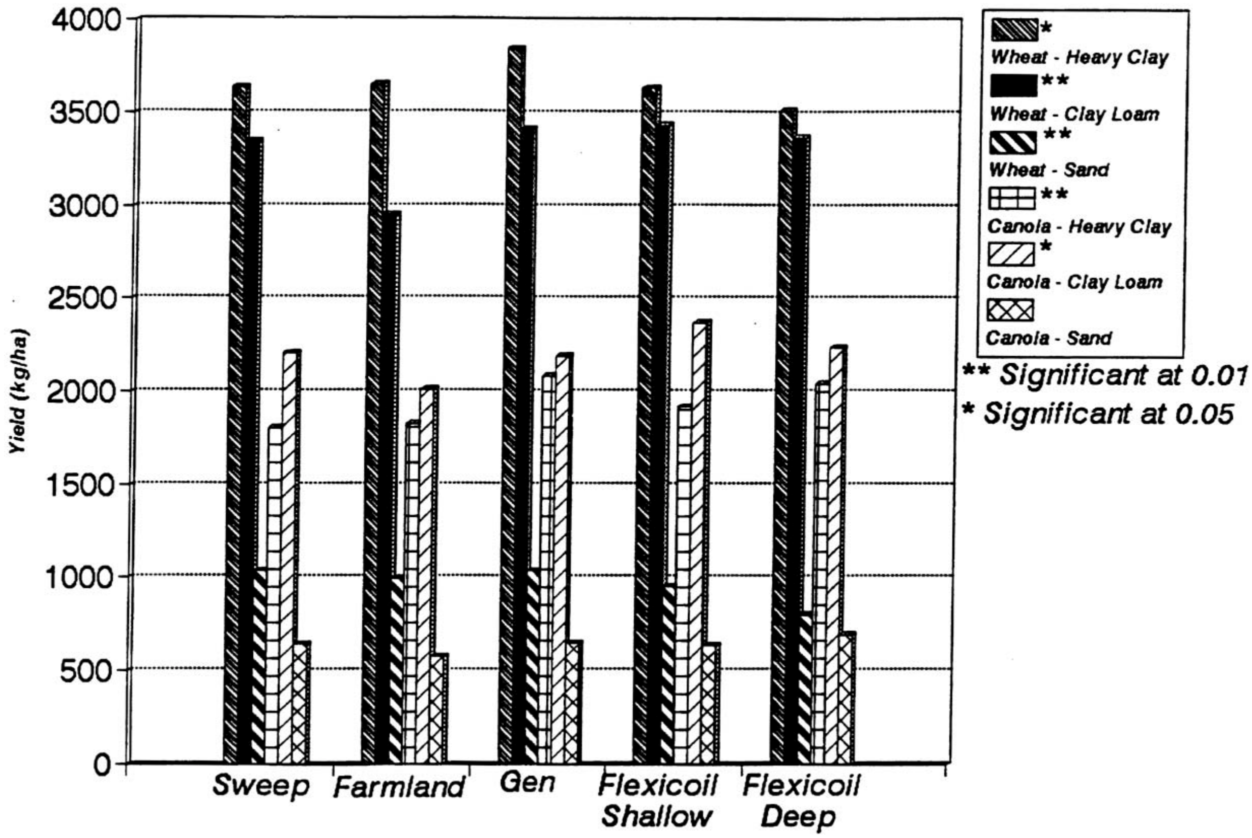
Graph 4 illustrates the average effect of fertilizer type on crop yield. Overall, the average yield on the anhydrous plots was higher than the granular urea plots. However, the fertilizer type effects were statistically insignificant to yield in all cases except when wheat was seeded on the sandy loam and clay loam sites. The anhydrous ammonia caused lower average yield at the 0.05 level for the wheat on the sandy loam soil. For the wheat on the clay loam site, the urea caused lower average yield than the anhydrous ammonia at the 0.01 level.



Graph 4. Effects of Fertilizer Type on Yield.

Effect of Opener on Yield

Graph 5 illustrates the average effect of the openers on crop yield. In general, no one opener performed better than another opener in the soil conditions tested. However openers with less soil disturbance at seeding tended to produce better yields and emergence. In addition, openers with less anhydrous ammonia losses (see NH_3 loss test section) tended to cause better overall yields. **Table 4** outlines the significant differences measured. For the wheat on the clay loam and sandy loam, and canola on the heavy clay and clay loam, the differences were at the 0.01 level of significance. For the wheat on heavy clay and the canola on clay loam the differences occurred at the 0.05 level.



Graph 5. Opener Factor Effect on Yield.

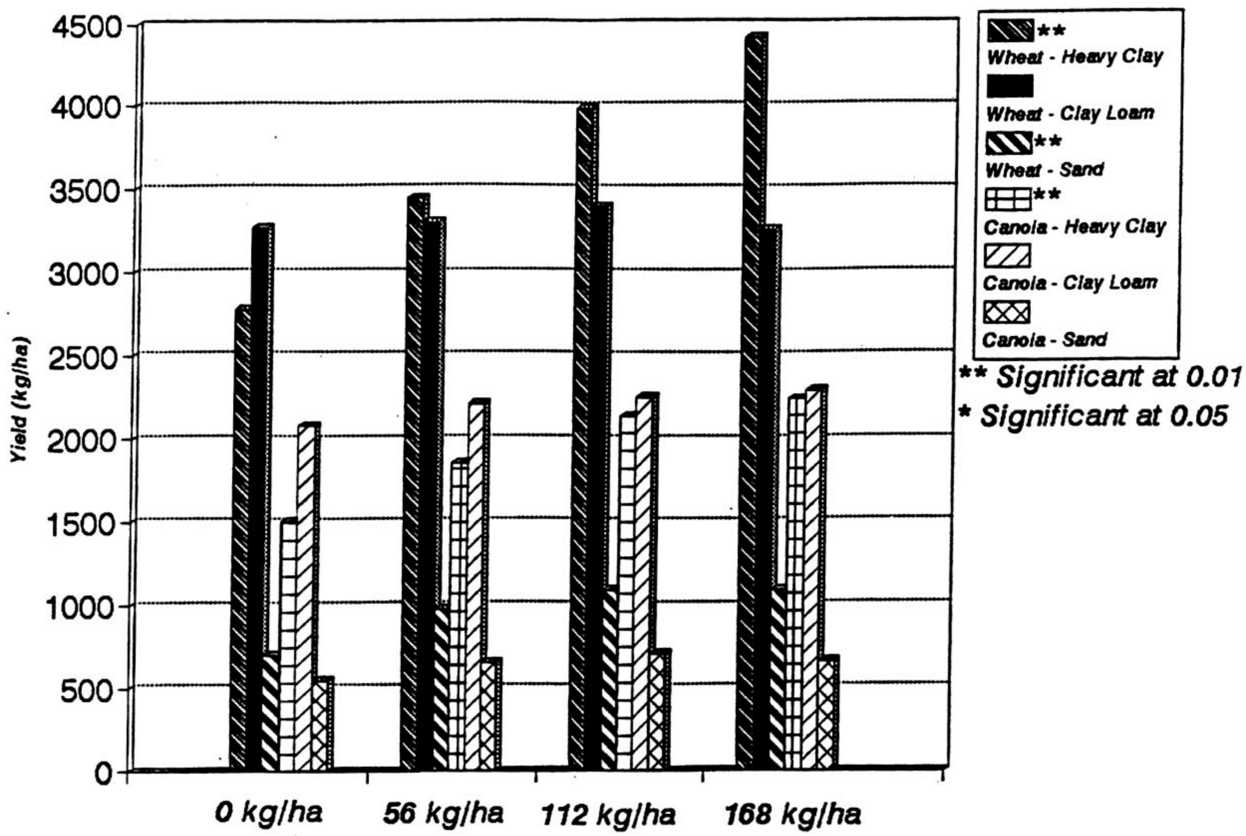
Table 4. Yield as Related to Openers.

Soil Type	Highest Yield				Lowest Emergence
Heavy Clay (Wheat)	Gen a	Farmland b	Flexi (s)^ b	Sweep b	Flexi (d)^ b
Clay (Wheat)	Flexi (s)^ a	Gen a	Flexi (d)^ a	Sweep a	Farmland b
Sandy Loam (Wheat)	Gen a	Sweep a	Farmland a	Flexi (s)^ ab	Flexi (d)^ b
Heavy Clay (Canola)	Gen a	Flexi (d)^ a	Flexi (s)^ ab	Farmland b	Sweep b
Clay (Canola)	Flexi (s)^ a	Flexi (d)^ ab	Sweep ab	Gen ab	Farmland b
Sandy Loam (Canola)	Flexi (d)^ *	Gen *	Sweep *	Flexi (s)^ *	Farmland *

* No Significant Differences
^ (s) **-** Shallow (d) **-** Deep

Effect of Rate on Yield

Graph 6 illustrates the effect of fertilizer rate on average yield. Overall, as fertilizer rates increased from 0 kg/ha to 56, 112 and 168 kg/ha (0, 50, 100 and 150 lbs/ac), the yield increased. However, the increase was only significant for wheat seeded at the clay and sandy loam sites and canola at the clay site. No significant difference at the clay loam site was attributed to high background nitrogen concentration in the soil prior to seeding. This may have resulted in little crop response to the added nitrogen during seeding operations. For the wheat on the clay site, the average yield for the 168 kg/ha (150 lbs/ac) rate was significantly higher than the 0, 56 or 112 kg/ha (0, 50 or 100 lbs/acre) rates at the 0.01 level. The average yield of the 112 kg/ha (100 lbs/ac) rate was significantly higher than the 0 and 56 kg/ha (50 lbs/ac) rates and the 56 kg/ha (50 lbs/ac) rate was significantly higher than the 0 kg/ha rate, both at the 0.01 level. For the wheat on the sandy loam site the 0 kg/ha rate was significantly lower than the other rates. For the canola on the clay the 112 and 168 kg/ha (100 and 150 lbs/ac) rates had significantly higher yields than the 0 and 56 kg/ha (50 lbs/ac) rates at the 0.01 level.



Graph 6. Fertilizer Rate Effects on Yield.

Seed and Fertilizer Placement

Seed and fertilizer placement measurements were completed for the openers tests. Appendix 2 outlines the seed and fertilizer placement results. Varying field conditions made accurate and consistent measurements of seed and fertilizer band widths and depths difficult. However, some trends were present. In general, the width of the anhydrous ammonia zone was larger than the urea. The zone magnitude was dependent on the opener, fertilizer rate and soil condition.

Results for the soil finishing of each opener were also completed to determine volumes for NH_3 retention tests. The illustrations in Appendix 3 outline the seedbed finishing characteristics of the openers and packers used on the clay loam soil conditions.

Anhydrous Ammonia Loss Test

Tests were conducted on the medium-textured clay loam site to determine the amount of anhydrous ammonia lost to the atmosphere during seeding. The 168 kg/ha (150 lbs/ac) fertilizer rate was used. The air above the plot was sampled for a one hour period after seeding using three sample tents. A vacuum pump sucked the air from the tents 1 x 1 m (3.3 x 3.3 ft) through 2 x 30 ml impingers containing 20 ml of 0.08 N HCl acid. The concentration of ammonium in the HCl was determined using a Dionex ion chromatograph. **Table 5** outlines the average percentage losses for a one hour period after seeding for the openers tested under the clay loam soil condition. Results indicated percentage loss was dependent on the type of opener.

Based on the yield data, continued work should be completed to determine if a significant relationship exists between the loss of anhydrous ammonia and final yields. Continued work also needs to be completed to determine the effect of soil moisture, time and opener type on anhydrous ammonia loss.

Table 5. Percentage Loss of Anhydrous Ammonia.

Opener	% of Anhydrous Ammonia Lost in a One Hour Period After Seeding
Flexi-coil Shallow	0.34
Gen	1.15
Flexi-coil Deep	2.38
Sweep	4.13
Farmland	7.45

Crop Moisture Content

Crop moisture was determined when recording yield weights. Moisture was determined using a Motomco moisture meter. Results are outlined in **Table 6** below. Moisture readings for the canola and the wheat on the Sandy loam are near the bottom end of the moisture meter's reading ability. Low moisture contents were due to harvest timing.

Table 6. Crop Moisture Content.

Crop	Soil Type	Fertilizer Rate Percentage Moisture (%) (kg/ha)			
		0	56	112	168
Wheat	Heavy Clay	12.29	12.49	12.92	13.06
	Clay Loam	10.97	11.00	11.08	10.95
	Sandy Loam	9.27	9.36	9.29	9.34
Canola	Heavy Clay	5.50	5.50	5.50	5.50
	Clay Loam	5.96	5.87	5.92	5.92
	Sandy Loam	5.70	5.78	5.69	5.86

Oil and Protein Contents

Oil and protein contents were determined for the canola and wheat, respectively. Appendix 5 outlines the results. No relationships were apparent between opener type, fertilizer type or fertilizer rate and protein or oil contents.

Conclusions

In general, under ideal soil moisture conditions, the openerers tested provided reasonable application of anhydrous ammonia and urea in a one-pass seeding operation. Research should continue to outline the effects of reduced soil moisture and varying soil textures on emergence and yield.

While the average yield on the anhydrous plots was higher than the granular urea plots, there was no significant difference in the effect of the type of fertilizer on the final yields or emergence of either wheat or canola.

Under the test conditions, emergence tended to drop with increasing fertilizer rates. However, no significant difference was found between urea or anhydrous ammonia. Work should continue to determine if 100 percent of the required fertilizer can be safely applied using double shoot openers for seeding wheat and canola under a variety of field and moisture conditions.

Emergence results indicated seed damage caused by anhydrous ammonia and granular urea fertilizer is not significantly different under direct seeding conditions for both wheat and canola. In general, as fertilizer rate increased from 0 to 56, 112 and 156 kg/ha (0 lbs/ac to 50, 100 and 150 lbs/ac), the emergence decreased. However, the decrease was not statistically significant under most of the field conditions tested.

Tests on the retention of anhydrous ammonia by different openers ranged from a minimum loss of 0.34 percent to a maximum loss of 7.45 percent for the soil conditions tested. The results indicated loss was dependent on the opener used. Further work should be completed to support the research into measuring loss completed in this project. In addition, the amount of loss under a variety of field conditions and with different opener designs should be outlined. Correlations with final yield should also be determined.