USE OF A CONVENTIONAL DRILL TO SEED BEANS AND PEAS

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Abstract

This project outlined whether conventional grain drills can be used to solid seed or row crop seed beans and peas. The project raised a number of concerns regarding row spacing, harvesting, seeding rates and weed control practices when solid seeding with conventional drills.

Othello Pinto beans and Radley peas were seeded using an air seeder, all-till drill, disker, hoe drill, press drill and two precision bean planters.

Results show that variations caused by different seeding implements and soil conditions significantly affected emergence of beans and peas under tilled and direct seeding conditions. Pea yields were also significantly affected by seeding implement and soil condition. No statistical difference was found in bean yield results. The lack of bean yield differences was attributed to the poor bean growing conditions of the test year in Southern Alberta.

Recommendations were made for further testing.

Introduction

Future advances in plant breeding of upright beans may allow a shift from intensive row cropping to narrow row cropping systems. This shift could have a major environmental impact since bean production is expanding outside traditional adapted areas to more environmentally sensitive areas. Current row crop practices for seeding and harvesting operations result in increased wind and water erosion risks. Since cereal grain production has addressed many soil erosion concerns, how the equipment and methods could be applied to pulse production was addressed. The objective of this study was to determine if different seeding implements and soil conditions significantly affect yields, costs and soil conservation concerns.

Equipment and Procedure

Using Othello Pinto beans and Radley peas, emergence and yield were evaluated under no-till and tilled field conditions. Seeding efficiency was evaluated, using emergence, for a double disk press drill, disker, hoe drill, air seeder, no-till drill, and two precision row crop planters. All implements were typical of current production models.

Equipment

The McCormick 100 press drill was 3.66 m in width, with 24 openers spaced at 152 mm. The openers were in two rows of 12 each. Seeding depth was controlled by an adjustable compression spring and pin setting on each opener. Metering wheels were chain driven from press wheels through a variable speed drive. Convoluted rubber hoses delivered seed and fertilizer separately to the disk openers. A V-shaped press wheel packed the soil directly behind each opener.

The Cereal Implements 2300 hoe drill had 203 mm spacing and a seeding width of 2.1 m. Seeding depth was set with an adjustable hydraulic cylinder equipped with a stop. Seed was metered by externally fluted feed wheels through cast seed cups equipped with adjustable feed gates. Metering wheels were chain driven from the press wheels through a series of gears and chains. A convex press wheel packed the soil directly behind each hoe opener.

The air seeder was constructed by the Alberta Farm Machinery Research Centre (AFMRC) from a Gandy applicator mounted on 3.66 m heavy duty cultivator. The cultivator had 305 mm sweeps mounted on six spring cushioned, 305 mm spaced shanks arranged in four rows. Seeding depth was controlled by an adjustable hydraulic cylinder with a rod stop assembly. The Gandy applicator metered the seed using a externally fluted feed wheels and adjustable feed gates. Metering wheel chains were driven from a ground wheel through a series of infinitely variable gears. A harrow packer drawbar equipped with tine harrows and spiral packers was used to pack the soil behind the air seeder.

The Cockshutt disker had 203 mm disk spacing and a 2.1 m seeding width. Seeding depth was controlled by an adjustable hydraulic cylinder equipped with a bolt stop. Seed was metered by externally fluted feed wheels through cast seed cups equipped with adjustable feed gates. Metering wheels were chain driven from a ground wheel through a series of gears and chains.

The John Deere 752 drill was 4.6 m wide with 191 mm opener spacing. The 752 was considered an all-till drill. Seed was metered by external straight fluted feed rolls. A flexible rubber hose delivered seed to the opener assemblies. Seed rate was adjustable by sliding the feed roll to vary the exposed length in the seed cup. The openers and packing assemblies consisted of a disk blade, pressure spring, gauge wheel, seed boot, press wheel and closing wheel. Seed depth was controlled by the gauge wheel. The force on the disk blade was controlled by a pressure spring. The assemblies were mounted on a hydraulic controlled rock shaft which rotated to raise and lower the openers.

The Pickett bean planter had 762 mm spacing and a 4.6 m seeding width. The drill had six double disk openers in one row. Seeding depth was controlled by an adjustable compression spring and pin setting on each opener. The metering wheels were chain driven from two ground drive wheels and a variable speed drive. Convoluted rubber hoses delivered seed and fertilizer separately to the disk openers. Adjustable covering disks placed soil over the seed directly behind each opener.

The International 295 planter had 762 mm spacing and a 4.6 m seeding width. The drill had six double disk openers in one row equipped with individual seed boxes. Seeding depth was controlled by an adjustable compression spring and pin setting on each opener. The metering rings on each openers were chain driven from ground drive wheels and a variable speed drive. Convoluted rubber hoses delivered seed and fertilizer separately to the disk openers. A convex press wheel packed the soil directly behind each opener.

Calibration

All seeding implements were calibrated to ensure proper seeding rates using standard AFMRC calibration test procedures for grain drills. Seeding rates for the conventional grain drills were set to 157 kg/ha for beans and 168 kg/ha for peas. The IH 295 planter used a seeding rate of 64 kg/ha for peas and the Pickett Seeder used 168 kg/ha. The seeding rates for precision seed drills were 64 kg/ha for beans. Row crop planter rates were typical of seeding rates used in Southern Alberta. The higher rates for solid seeding were recommended by the special crops group of Alberta Agriculture, Food and Rural Development. Higher rates on solid seeded beans were used to increase the crop canopy for better weed control through crop competition.

Test Procedures

Approximately 2.4 ha of clay loam soil was used for the tests. The land, located 2 km south of Turin, Alberta was divided into 4.6 x 15.2 m plots. The site was selected based on soil characteristics, frost occurrence, existing soil moisture, fertility requirements and residual weed populations. Three block replications of each trial were completed resulting in a 7 x 2 x 2 full factorial experiment with a total of 28 trials replicated three times for 84 plots.

No-till plots were mowed with a flail mower before seeding to chop surface residue. Tilled plots were mowed with a flail mower and tilled twice with a heavy duty cultivator and then tine harrowed and packed with spiral packers. Glyphosate was applied at a rate of 2.5 L/ha one day prior to seeding for quackgrass and volunteer weed control.

A soil sample was taken to determine fertilizer requirements. The soil sample indicated 52 kg/ha of Nitrogen, 46 kg/ha of Phosphorus, 16 kg/ha of Sulphur and 5.7 kg/ha of Zinc were required for a predicted bean yield of 3360 kg/ha. The fertilizer was broadcasted on both the pea and bean plots prior to seeding using a Gandy applicator. Beans and peas were inoculated prior to seeding.

Plot seeding took place on May 18, 1993. Twenty eight days after seeding, Sethoxydim was applied at a rate of 2.5 L/ha for control of grassy weeds. Broad leaf weeds were controlled 36 days after seeding using Bentazon at a rate of 2.2 L/ha. Good control of weeds occurred with the spray operations. However, frequent rains resulted in flushes of weeds reoccurring throughout the growing season. Benomyl was sprayed on the bean plots 78 days after seeding, at 50 percent full bloom, for control of Sclerotinia.

Moisture and stubble samples were taken to monitor surface soil conditions. Before seeding three random soil moisture samples were taken from the top 10 cm of each plot. Soil moisture was at a depth of 6 cm. All drills were set to attempt to seed into soil moisture. The same two-wheel drive tractor was used for all tests and driven at a speed of 7 km/h.

Analysis Procedure

Measurement of emergence took place 21 days and 72 days after seeding. Measurements were done by randomly finding a row in each plot and counting the number of plants in a 244 cm section of the row. Three random samples were taken from each plot. Once plant counts were found for each plot, the percentage of emergence and total plant counts per acre were determined using seeding rates and implement row spacing.

Bean yield samples were taken 135 days after seeding using three random 244 cm row samples. Bean plants were collected by hand along each row and shelled in the laboratory. Hand harvesting was used due to large number of weeds in the plots which caused combining problems. Seed sample weights were recorded. Peas were harvested 142 days after seeding using a Wintersteiger plot combine with lifters.

For the Othello Pinto beans a seeding rate of 157 kg/ha was used in the conventional grain drills. The International planters used a seeding rate of 64 kg/ha for beans and peas. A seeding rate of 168 kg/ha was used for the Radley peas in all implements except the International planter. The density of the Pinto beans was 28.6 kg/bu with 2314 seeds/kg. The Radley peas had a density of 28.9 kg/bu with 1083 seeds/kg.

A statistic analysis using an analysis of variance (ANOVA) was done on emergence and yield. The fixed affects of the ANOVA consisted of seven implements and two soil conditions. Bean and pea trials were analyzed separately. Statistical significance for implements was completed based on both tilled and direct seeding conditions. Some implements may perform better in specific soil conditions. However, Duncan Range Analysis Tests were not completed for specific conditions. TABLE 1 outlines ANOVA factors and levels. A Duncan's Multiple Range test was performed on ANOVA tables with significant results to determine the causes of the differences.

TABLE 1. ANOVA Factors and Levels.

FACTOR	LEVEL
Soil Condition (2)	Tilled No-Till
Implements (7)	Air Seeder CI 2300 Cockshutt Disker International 295 John Deere 752 McCormick 100 Pickett Planter

Results and Discussion

Soil Moisture Content

Soil moisture samples were taken before seeding using a Trace TDR soil moisture meter. Soil moisture measurements from the soil surface to a depth of 10 cm, ranged from 18.7 to 29.4 percent on the tilled plots. No-till plot moisture ranged from 20.5 to 31.7 percent. The average soil moisture was 25.3 and 27.6 percent on the tilled and no-till plots, respectively.

Soil moisture conditions were above average for the region throughout the growing season.

Seeding Depth

All drills were set to attempt to seed into soil moisture at a depth of 6 cm. However, penetration forces varied depending on the seeding implement. TABLE 2 outlines average seeding depths.

TABLE 2. Average Seeding Depth.

IMPLEMENT	AVERAGE SEEDING DEPTH (cm)			
	TILLED		NO-TILL	
	Beans	Peas	Beans	Peas
Air Seeder	6.78	6.78	7.82	6.99
CI 2300	4.25	4.45	4.25	4.45
Cockshutt Disker	6.99	6.15	2.97	4.65
International 295	3.18	5.08	0.84	1.91
John Deere 752	1.47	2.97	1.91	4.88
McCormick 100	2.97	5.28	1.47	1.84
Pickett Planter	3.81	2.74	2.11	1.70

Weed Growth

In row crop systems, weed growth is normally controlled through cultivation and herbicide use. Since cultivation was not practical in narrow row systems, herbicide application was the only weed control solution.

Wet conditions over the growing season caused severe weed problems in the plots. Problems increased because of recommendations not to spray bean plants after blooming. A second weed growth on the plots was not controlled due to poor field conditions and plant blooming. Lack of weed control resulted in significant yield reductions. Problems were compounded due to the previous years early snowfall which caused swathing and combining problems and severe volunteer cereal growth. Round leaf mallow and field bindweed furthered the weed concerns.

Based on the weed control problems, an outline of weed control through herbicide application in no-till narrow row systems should be completed. This study illustrated the importance of pre-seeding field preparation and the non-competitive nature of beans.

Bean and Pea Emergence

Two sets of seed emergence data were taken for the bean tests and one for the pea tests (TABLE 3 and TABLE 4). The first bean and pea emergence counts were completed 21 days after seeding. Percentage emergence was used as a comparison because of the different seeding rates used in the trials.

A minimum bean percent emergence of 2 percent was measured for the International planter in no-till conditions. The John Deere 752 drill had the maximum bean percent emergence of 90.8 percent on a tilled plot. The statistical analysis indicated a difference at the 0.01 level for the soil condition factor causing emergence in the tilled plots to be statistically higher than in no till plots. At the 0.05 level of significance the replications and implement factor caused significant differences in the percentage emergence data. The multiple range test indicated that the John Deere 752 had significantly higher percentage emergence results than the International 295 planter, McCormick 100, Pickett planter and the Cockshutt disker. No other significant differences occurred. Since the percent emergence of conventional grain drills is as good as or better than row crop planters, recommendations on using higher seeding rates for solid seeding should be reviewed. Bean emergence data is outlined in TABLE 3.

On the pea plots, a minimum percent emergence of 9.3 percent was measured for the McCormick 100 in no-till conditions. The maximum percent emergence occurred using the Cockshutt disker with 94.3 percent of the pea plants emerging. The soil condition and implement factors were significant at the 0.01 level for the pea percentage emergence tests. The percent emergence for the Cereal Implements 2300 and Cockshutt disker was significantly higher than the air seeder, McCormick 100, International planter and Pickett planter. The percentage emergence for the John Deere 752 was significantly higher than the Pickett seeder. Pea emergence data is outlined in TABLE 4.

A second set of emergence data on the beans was taken 72 days after seeding. In general, all percent emergence values increased during the later test. During the second tests the minimum bean percentage emergence measured was 4.8 percent for the International planter on no-till. The maximum percentage emergence was 68.5 percent using the CI 2300 on tilled soil. Results of the statistical analysis indicated that the soil condition and implement factors caused significant differences in the percentage emergence data. The multiple range test indicated that the Cereal Implements 2300 had significantly higher percentage emergence than the air seeder, Cockshutt disker, McCormick 100 and International 295 planter.

A second set of emergence data for the peas was not taken due to intertwining of the pea plant which caused errors in emergence counts. TABLES 3 and 4, and GRAPHS 1. and 2 contain the overall plant emergence. Details of the factorial analysis (ANOVA) are provided in TABLES 5 and 6.

TABLE 3. Bean emergence data.

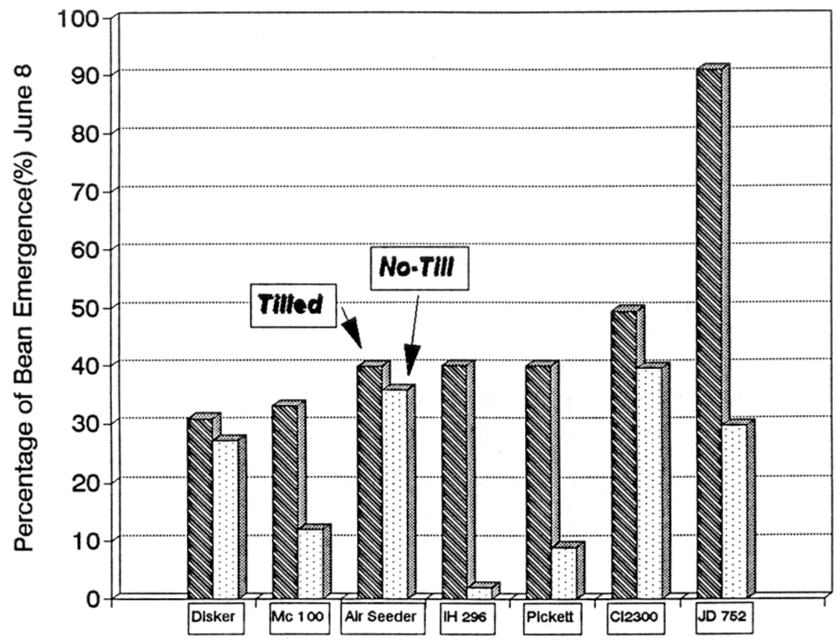
IMPLEMENT	PLANT COUNT (plants/acre)		PERCENTAGE EMERGENCE* (%)	
	June 8	July 30	June 8	July 30
Tilled Soil				
Cockshutt Disker	45375	56265	30.8 b	38.3 bc
McCormick 100	48746	71563	33.1 b	48.7 c
Air Seeder	58685	73810	39.9 ab	50.2 bc
International 295	23958	25894	40.0 b	43.2 c
Pickett Planter	23958	37510	40.0 b	62.6 abc
CI 2300	72600	100733	49.4 ab	68.5 a
John Deere 752	133584	95832	90.8 a	65.2 ab
No-Till Soil				
International 295	1210	2904	2.0	4.8
Pickett Planter	5324	18392	8.9	30.7
McCormick 100	17631	23854	12.0	16.2
Cockshutt Disker	39930	51728	27.1	35.2
John Deere 752	43560	62920	29.6	42.8
Air Seeder	52635	45375	35.8	30.8
CI 2300	58080	106178	39.5	72.2

***** Emergences with the same letter are not significantly different.

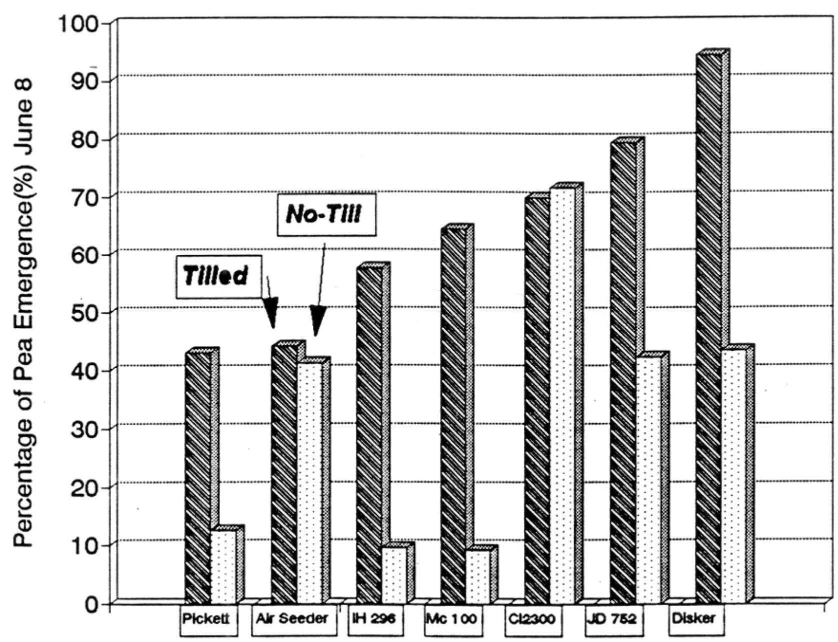
TABLE 4. Pea emergence data.

IMPLEMENT	PLANT COUNT (plants/acre)	PERCENTAGE EMERGENCE* (%)
Tilled Soil		
Pickett Planter	154154	43.0 c
Air Seeder	158510	44.3 bc
International 295	78650	57.8 bc
McCormick 100	231283	64.6 bc
CI 2300	250470	69.9 a
John Deere 752	284592	79.5 ab
Cockshutt Disker	337590	94.3 a
No-Till Soil		
McCormick 100	33189	9.3
International 295	34122	9.5
Pickett Planter	45012	12.6
Air Seeder	148225	41.1
John Deere 752	151976	42.4
Cockshutt Disker	156090	43.6
CI 2300	256823	71.7

***** Emergences with the same letter are not significantly different.



GRAPH 1.Bean Emergence.



GRAPH 2.Pea Emergence.

TABLE 5. Analysis of variance for bean percentage emergence, 8 June 1993.

SOURCE OF VARIATION	df	SUM OF SQUARES	MEAN SQUARE	F
Replication	2	98.96	49.48	0.265
Implement	6	10202.98	1700.49	9.12
Soil Condition	1	9211.86	9211.86	49.39
Interaction	6	4305.78	717.63	3.85
Error	26	4849.33	186.51	
TOTAL	41	28668.91		

TABLE 6. Analysis of variance of pea percentage emergence, 8 June 1993.

SOURCE OF VARIATION	df	SUM OF SQUARES	MEAN SQUARE	F
Replication	2	276.70	138.35	0.445
Implement	6	9626.38	1604.40	5.157
Soil Condition	1	15317.50	15317.50	49.235
Interaction	6	8012.62	1335.44	4.292
Error	26	8088.91	311.11	
TOTAL	41	41322.11		

<u>**Uniformity of Emergence**</u>

Based on the plant counts taken for emergence data on June 8, 1993 coefficients of variation (CV) were determined for seeding implements (TABLE 4). Lower CV's are an indication of more uniform emergence across the drills than high CV's. Generally, the drills using high penetration openers provided more uniform plant stands in tilled and no-till soil conditions for beans.

TABLE 7. Uniformity of emergence, 8 June 1993.

IMPLEMENT	**PLANT COUNT UNIFORMITY** - CV (%)			
	BEAN		**PEA**	
	Tilled	No-Till	Tilled	No-Till
CI 2300	21.81	26.36	14.21	6.68
Air Seeder	23.12	33.12	22.23	12.90
Pickett Planter	23.47	63.36	6.65	36.11
John Deere 752	25.90	68.56	14.54	18.12
International 295	36.98	141.42	24.85	56.36
Cockshutt Disker	38.35	41.78	13.77	8.17
McCormick 100	48.84	63.60	12.88	46.89

Bean and Pea Yield

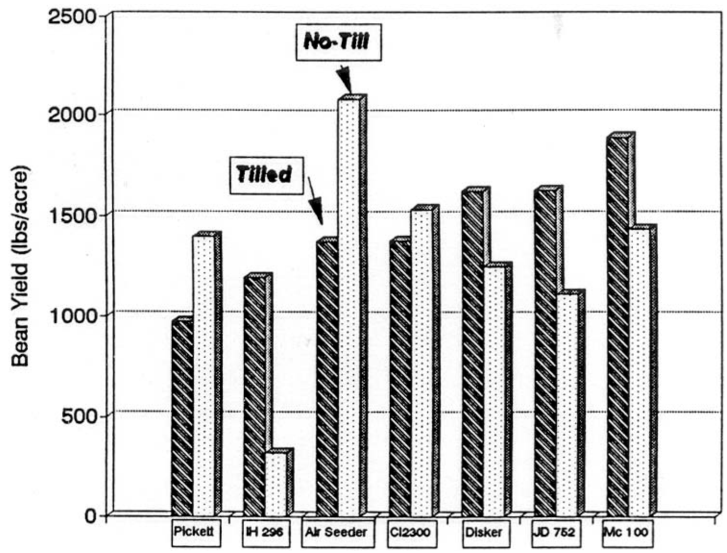
Yield data was taken 135 days after seeding for beans and 149 days after for peas. Prior to harvest and bean maturity, a heavy frost occurred reducing yield. A minimum yield of beans, 285 kg/ha (320 lb/ac), was measured for the International planter in no-till conditions. The air seeder had the maximum bean yield of 1855 kg/ha (2080 lb/ac) on the tilled plot.

On the pea plots, the minimum and maximum yield of 770 kg/ha (860 lb/ac) and 3670 kg/ha (4110 lb/ac) occurred using the McCormick press drill on no-till and tilled conditions, respectively

TABLES 8 and 9 and GRAPHS 3 and 4 contain the yield data for the bean and pea plots. Details of the factorial analysis (ANOVA) are provided in TABLEs 10 and 11.

TABLE 8. Bean yield data.

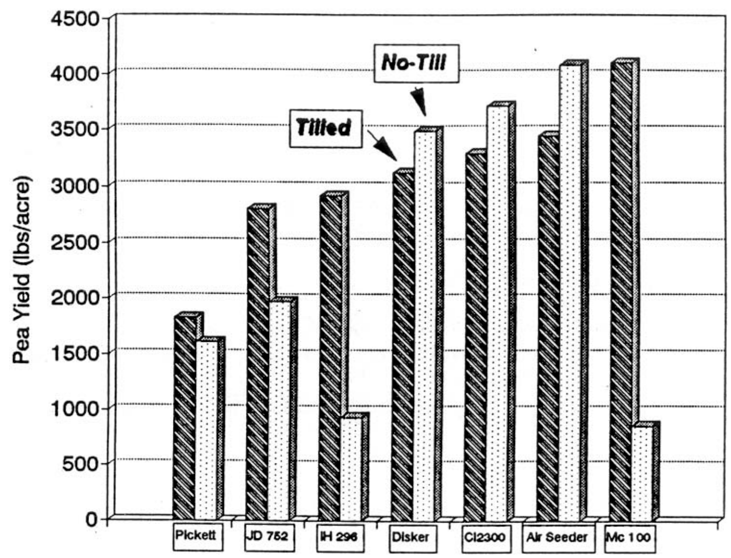
IMPLEMENT	PLOT YIELD	
	kg/ha	lb/ac
Tilled Soil		
Pickett Planter	865	970
International 295	1070	1200
Air Seeder	1220	1370
CI 2300	1230	1380
Cockshutt Disker	1445	1620
John Deere 752	1455	1630
McCormick 100	1685	1890
No-Till Soil		
International 295	285	320
John Deere 752	990	1110
Cockshutt Disker	1115	1250
Pickett Planter	1250	1400
McCormick 100	1275	1430
CI 2300	1365	1530
Air Seeder	1855	2080



Graph 3. Bean Yield.

TABLE 9. Pea yield data.

IMPLEMENT	PLOT YIELD kg/ha	PLOT YIELD lb/ac
Tilled Soil		
Pickett Planter	1630	1830
John Deere 752	2510	2810
International 295	2605	2920
Cockshutt Disker	2790	3130
CI 2300	2940	3300
Air Seeder	3080	3450
McCormick 100	3670	4110
No-Till Soil		
McCormick 100	770	860
International 295	840	940
Pickett Planter	1440	1610
John Deere 752	1770	1980
Cockshutt Disker	3120	3500
CI 2300	3310	3710
Air Seeder	3650	4090



Graph 4. Pea Yield.

TABLE 10. Analysis of variance for bean yield.

SOURCE OF VARIATION	df	SUM OF SQUARES	MEAN SQUARE	F
Replication	2	1922400	961200	1.401
Implement	6	3794038	632339	0.922
Soil Condition	1	187883	187883	0.274
Interaction	6	2955573	492595	0.718
Error	26	17833913	685919	
TOTAL	41	26693807		

TABLE 11. Analysis of variance of pea yield.

SOURCE OF VARIATION	df	SUM OF SQUARES	MEAN SQUARE	F
Replication	2	371749	185874	0.341
Implement	6	23103059	3850510	7.065
Soil Condition	1	5057525	5057525	9.279
Interaction	6	18824513	3137419	5.756
Error	26	14170781	545030	
TOTAL	41	61527627		

The statistical analysis indicated that implements and soil conditions did not cause any significant differences in the bean yields at 0.05 level. However, the pea yields were significantly affected by the implement, soil condition and interaction between implements and soil condition at the 0.01 level.

For the pea plots the air seeder had higher pea yield at the 0.01 level than the Pickett planter, International 295, John Deere 752 and the McCormick 100. The Cereal Implements 2300 and Cockshutt disker had statistically higher pea yield than the Pickett planter and International 295.

Implements

The statistical analysis indicated the implement factor caused significant results at the 0.01 level in the yield of peas. The implement factor was significant at the 0.01 and 0.05 levels in the pea and bean emergence, respectively. No significant difference was found for bean yield results.

Tractor traffic from spraying and mowing operations resulted in higher soil densities on the no-till than tilled plots. High soil densities resulted in penetration problems when using low penetration force openers such as the double disks. Since the double disk openers tended to ride on the surface rather than place the seed in the seedbed, percentage emergence values decreased as compared to other implements. Openers with higher penetrating forces were able to place seed in the seedbed resulting in higher bean and pea percentage emergence. While emergence values were affected by the implements used, yield results for the beans were not significantly different. The absence of a relationship between emergence and yield was attributed to weed competition in the plots. Pea yields were unaffected by cultivation and emergence differences. There was little relationship, R^2 less than 0.2, between pea yield and emergence results.

Soil Conditions

Except for bean yield results, soil condition was a significant factor at the 0.01 level in all emergence and yield data. In general, tilled soil conditions provided statistically higher emergence and yield results. Solid seeding of beans could be a viable alternative to row crops if seeding rates, weed control problems and harvesting concerns are addressed.

Recommendations

The steps involved in bean production can be grouped as tillage, seeding, fertilizing, pest control and harvesting. Major differences between different production systems include implements used and how and when operations are completed. Unfortunately, changing one part of the system usually requires alterations to all future activities. The same is true when using conventional drills to solid seed rather than using row crop planters. Before solid seeding can be recommended, seeding effects on other operations in the system should be addressed.

Changing the type of seeding implement used in a bean production system will change row widths, seed placement along the row and subsequent weed control operations. Since conventional grain drills have typical row spacing varying from 7 to 12 in, using grain drills to seed beans results in two changes to the system. Changing the row width results in the inability to cultivate for weed control, as occurred in this project. The alternative to weed control by cultivation is herbicide application. Unfortunately, there is only a limited application time for herbicide application before plant flowering. If the weather does not permit sprayer operations, the ability to control weeds is reduced.

The results of this research project have outlined the need for the following:

1. Research on seeding rates for solid seeding beans should be completed in Southern Alberta conditions.

2. Weed control practices using a solid seeding system should be outlined, especially in no-till systems.

3. The project should be repeated under normal growing conditions in Southern Alberta so we can better understand the application of solid seeding systems.

Conclusions

Using Othello Pinto beans and Radley peas, emergence and yield were evaluated under no-till and tilled field conditions. Implements evaluated included a double disk press drill, disker, hoe drill, air seeder,
no-till drill and two precision row crop planters.

Results indicated implements caused significant differences in the yield of peas. Implements were also significant in pea and bean emergence. In general, implements with higher penetration force openers caused better uniformity of and percentage emergence.

Soil condition was a significant factor in all emergence and yield data except for the bean yield results. Tilled soil conditions provided statistically higher emergence and yield results.

Critical to all seeding trials was weed control. A number of concerns over recommendations on seeding rates, yields and weed control were raised.

The project concluded, from an emergence standpoint, that conventional grain drills can be used to solid seed or row crop seed beans and peas in high moisture conditions. However, row spacing, harvesting and weed control practices need consideration before using conventional drills. The results of the use of conventional drills on bean yield were inconclusive.