

DOES CONSERVATION TILLAGE AFFECT NODULATION OF FIELD PEA?

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Abstract

Field experiments were conducted at Fort Vermilion and Beaverlodge, Alberta, and at Melfort and Tisdale, Saskatchewan to determine the effect of direct seeding on nodulation of field pea. There was significant reduction in soil temperatures and an increase in nodule numbers and weight under direct seeding at Fort Vermilion. Nodulation was also enhanced at Melfort and Tisdale. However, the enhanced nodulation did not always translate into increased grain yield. In no case was nodulation reduced with direct seeding. Soil temperature under reduced tillage systems does not appear to be a limiting factor in nodulation of field pea.

Introduction

In recent years, a significant portion of the annual crops grown in Western Canada have been seeded under conservation tillage. Tillage has been reduced because of the potential to increase net returns and to reduce soil degradation (McAndrew *et al.* 1993). Zero tillage (ZT) or direct seeding, a method of seeding directly into standing stubble, represents a significant portion of the area seeded under conservation tillage. Along with the increase in direct seeding there has been an increase in area cropped to field pea. In 1994, field pea was grown on approximately 0.69 million ha, up from the 0.49 million ha seeded in 1993.

Direct seeding of field pea has resulted in yield increases, as compared to conventional tillage (CT) (Lafond *et al.* 1992, Clayton *et al.* 1994). At Indian Head, Saskatchewan, ZT field pea yielded nine per cent higher than CT seeded field pea over the years 1988-1993, whereas at Fort Vermilion, ZT field pea yielded 21% higher than CT seeded field pea averaged over three years. In some cases there were no differences in yield between ZT and CT and yields were never lower under ZT compared to CT. Field pea grown under ZT had a 4% higher 1000 seed weight than field pea grown under CT at both Fort Vermilion and Indian Head. Also, water use was 9% greater by field pea grown under ZT than under CT at Indian Head (Lafond *et al.* 1992). The higher plant emergence, 1000 seed weight and water use found when field pea was direct seeded compared to conventional seeding in these studies would account for most of the differences in yield between ZT and CT. However, the effect of direct seeding on nodulation may also be a factor contributing to higher yields. Field studies were conducted to determine the effect of direct seeding on nodulation of field pea.

Materials and Methods

Field experiments were conducted in 1993 at Fort Vermilion, Alberta, and in 1994 at Fort Vermilion and Beaverlodge, Alberta, and at Melfort and Tisdale, Saskatchewan.

The experiment in 1993 at Fort Vermilion, on a sandy loam Dark Gray Luvisol, consisted of Montana field pea planted at three dates under conventional tillage and direct seeding in a RCBD 3x2 factorial with 4 replicates. Plots were 3.7 x 30.5m with 0.23-m row spacing. The plots were planted with a ConservPak seeder. Prior to seeding, Roundup was applied to all plots, and the conventional tilled plots were cultivated and harrowed. Fertilizer (1-5-1-0) was applied at 50 kg/ha with the seed. The pea seed was inoculated with Enfix P peat inoculant at 4g inoculant/kg seed,

using Nitraccoat sticker. Seed was planted to provide 75 plants/m². One week after emergence, 1-m² sample areas were selected in each plot. Ten plants from within this area were dug, excess soil was gently removed from the roots and the roots were washed in tap water. Pink nodules were counted, excised, dried and weighed. Plant height from crown to tip was measured, and the plant shoots were cut from the roots and combined with the rest of the shoots from the 1-m² area. The plant shoots were dried and weighed. This sampling procedure was repeated weekly until maturity. After the first 4-5 samplings, the plants were separated into pods and vegetative plant parts. At the last sampling, physiological maturity, pods were further separated into seeds and pod walls, and grain yield was measured on the remaining plot area.

The experiments in 1994 at Fort Vermilion (sandy loam Dark Gray Luvisol) and Beaverlodge (clay loam Black Solod) were the same as in 1993, except soil temperature was measured throughout the growing season at seeding depth and at 5 cm below the seed. Temperature measurements were made at the above depths on one complete replicate with type-T thermocouples (copper-constantan). These were connected to a Campbell Scientific model CR-10 datalogger through an analog multiplexer to allow sufficient channel capacity. Power was supplied through rechargeable batteries and a 10 w solar panel. The datalogger was programmed to scan once each minute and compute both hourly and daily values for each sensor and each treatment. In order to integrate the effects of diurnally varying temperatures, degree-day units (5°C base temperature) were also computed within the datalogger for all sensors. These were subsequently averaged by depth and treatment. Related variables such as air temperature and precipitation were also measured with this datalogger system.

The experiments at Melfort (Black Chernozem) and Tisdale (Gray Luvisol) consisted of Express field pea planted under conventional tillage and direct seeding in a RCBD with 4 replicates. Plots were 14.6 x 18.3m at Melfort, and 7.3 x 12.2m at Tisdale, with 0.23-m row spacing. The plots were planted with a ConservPak seeder. Prior to seeding Roundup was applied to all plots, and the conventional tilled plots were cultivated and harrowed. Fertilizer was side banded at 7.5 and 17.5 kg N/ha for Melfort and Tisdale, respectively, and 35 kg P₂O₅/ha at both locations. The pea seed was inoculated with Enfix P liquid inoculant at twice the recommended rate. Seed was planted at 225kg/ha. At the flat pod stage, 1-m² sample areas were selected in each plot, and sampled the same as for the Alberta experiments except only five plants were dug from each 1-m² area. At physiological maturity, the 1-m² samples were separated into vegetative plant parts, seeds and pod walls, and grain yield was measured on the remaining plot area.

Data for nodules per plant, nodule dry weight, grain yield and soil growing degree days at seeding depth will be discussed in this paper.

Results and Discussion

Preliminary data comparing nodulation under ZT and CT indicated that effective pink nodule numbers were greater, were established earlier and were sustained longer under ZT than under CT at Fort Vermilion in 1993 (Figure 1a). However, there were no significant differences in nodule weight between CT and ZT (Figure 1b), and there were no significant differences in grain yield between ZT and CT (Table 1).

Figure 1. Effect of zero (ZT) and conventional (CT) tillage on a) pink nodules per plant and b) pink nodule weight at Fort Vermilion in 1993.

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Table 1. Effect of tillage on grain yield of field pea at Fort Vermilion and Beaverlodge.			
	Grain yield (kg/ha)		
	Ft. Vermilion, 1993	Ft. Vermilion, 1994	Beaverlodge, 1994
Conventional tillage	2510	1540	3003
Direct seeding	2450	1970	2853
SE	ns	205	ns

Effective (pink) nodules were greater in number and weight under ZT than under CT at Fort Vermilion in 1994 (Fig. 2). The differences became evident 20-40 d after emergence. Soil temperature (GDD @ seed) throughout the growing season was lower under ZT than under CT. Grain yield on ZT was 28% greater than on CT at Fort Vermilion in 1994 (Table 1). At Beaverlodge, differences in nodule numbers and weight were not as apparent between ZT and CT (Fig. 3). There was a consistent trend for greater nodule numbers 15-30 d after emergence, but the differences were not significant. However, there was significantly more nodule weight under ZT than CT at 28 d. Differences in soil temperature were not apparent between ZT and CT at Beaverlodge in 1994 (Fig. 3). Grain yields among treatments at Beaverlodge were not significantly different (Table 1).

Figure 2. Effect of zero (ZT) and conventional (CT) tillage on a) soil growing degree days (5°C) at the seed (GDD @seed) and pink nodule number and b) soil growing degree days (5°C) at the seed (GDD @seed) and pink nodule weight at Ft. Vermilion, 1994.

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The data collected from Fort Vermilion in 1993 and 1994 were under dry conditions throughout the growing season so that nodulation differences between tillage systems may not be apparent under normal rainfall, a situation that occurred at Beaverlodge in 1994. Where higher soil moisture occurs, more energy is required to warm the soil. At Fort Vermilion, dry soil moisture conditions presumably caused differences in soil temperature between the tillage treatments, while at Beaverlodge soil temperature differences were not apparent because of more normal rainfall.

Figure 3. Effect of zero (ZT) and conventional (CT) tillage on a) soil growing degree days (5°C) at the seed (GDD @seed) and pink nodule number and b) soil growing degree days (5°C) at the seed (GDD @seed) and pink nodule weight at Beaverlodge, 1994.

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The study in Saskatchewan in 1994 showed that effective pink nodules were significantly greater under ZT than CT (Table 2.). However, final grain yield was not significantly different between ZT and CT. Consequently, some of the potential advantages from enhanced nodulation that occurred under ZT early in the growing season were not expressed in final yield. Thus factors other than tillage system may be important in determining crop yield, a result also observed in Manitoba (Borstlap and Entz 1994).

The effect cooler soil temperature has on emergence, rate of emergence and development of above ground stems and below ground roots and nodules when tillage is eliminated need not be detrimental and may be offset somewhat by shallower seeding, since moisture is usually present to the soil surface (Lafond 1994). Soil temperature must be considered in conjunction with the soil moisture conditions near the seed.

Table 2. Nodulation and grain yield of field pea grown under conventional (CT) and zero tillage (ZT) averaged over sites at Melfort and Tisdale in 1994.		
Variable	CT	ZT
Nodules/plant	17.94b	24.62a
Nodule dry wt. (mg/plant)	240	250
Grain yield (kg/ha)	2965	3043
a,b - Means within a row with a different letter are significantly different at the 0.05 level.		

Conclusions

In the Black and Gray soil zone, soil temperature under reduced tillage cropping systems did not appear to be a limiting factor in nodulation of field pea. Where there was significant reduction in soil temperature under direct seeding, nodulation was enhanced. However, the enhanced nodulation did not always translate into increased grain yield. In no case was nodulation reduced with direct seeding.

References

- Borstlap, S. and M.H. Entz. 1994. Zero-tillage influence on canola, field pea and wheat in a dry subhumid region: Agronomic and physiological responses. *Can. J. Plant Sci.* 74: 41 1-420.
- Clayton, G.W., G.P. Lafond and W.A. Rice. 1994. Field pea production under conservation tillage. Pages 80-86 **in Proceedings** of the 1994 Peace River Soil Conservation Association Workshop, Canada-British Columbia Soil Conservation Program, BCMAFF, Dawson Creek, B.C.
- Lafond, G.P. 1994. Soil temperature and direct seeding: Is it an issue... Pages 125-136 **in Proceedings** 1994 Conservation Workshop: Moving to sustainable agriculture and Alberta Conservation Tillage Society 16th annual meeting. Jan. 16-19, 1994. ACTS and CAESA.
- Lafond, G.P., H. Loeppky, and D.A. Derksen. 1992. The effects of tillage system and crop rotations on soil water conservation, seedling establishment and crop yield. *Can. J. Plant Sci.* 72: 103-115.
- McAndrew, D.W., L.G. Fuller, K.R. Handford, R.P. Zentner, M. Gorda and J. Doner. 1993. Feasibility of zero-tillage in the Dark Brown, Black and Grey soil zones of NE Alberta. Pages 106-117 **in** 30th Annual Alberta Soil Science Workshop Proceedings, Sherritt Fertilizers, Edmonton.

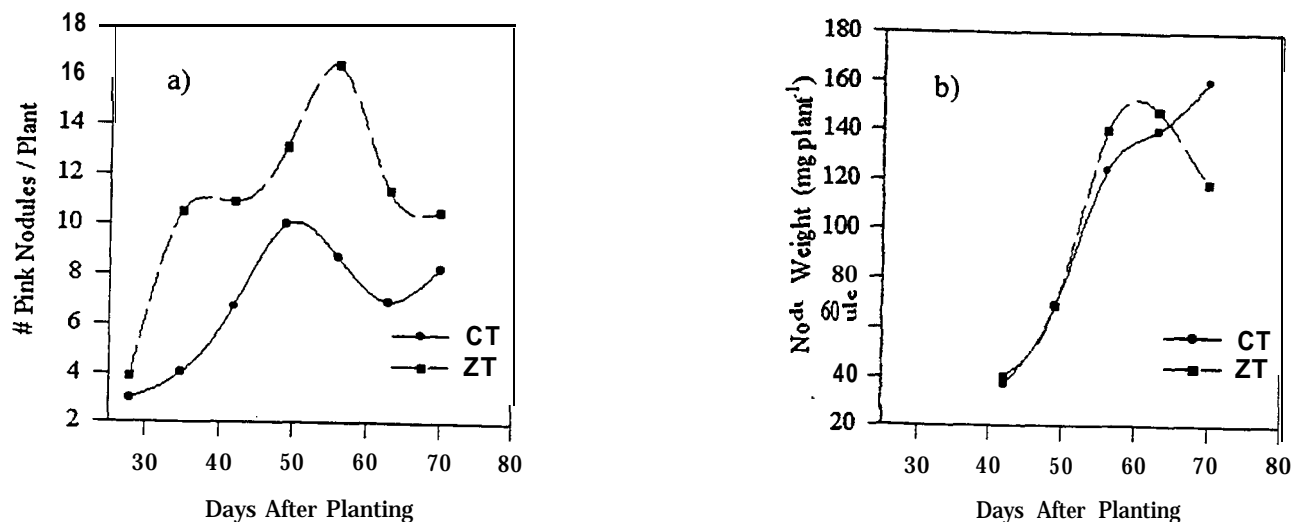


Figure 1. Effect of zero (ZT) and conventional (CT) tillage on a) pink nodules per plant and b) pink nodule weight at Fort Vermilion in 1993.

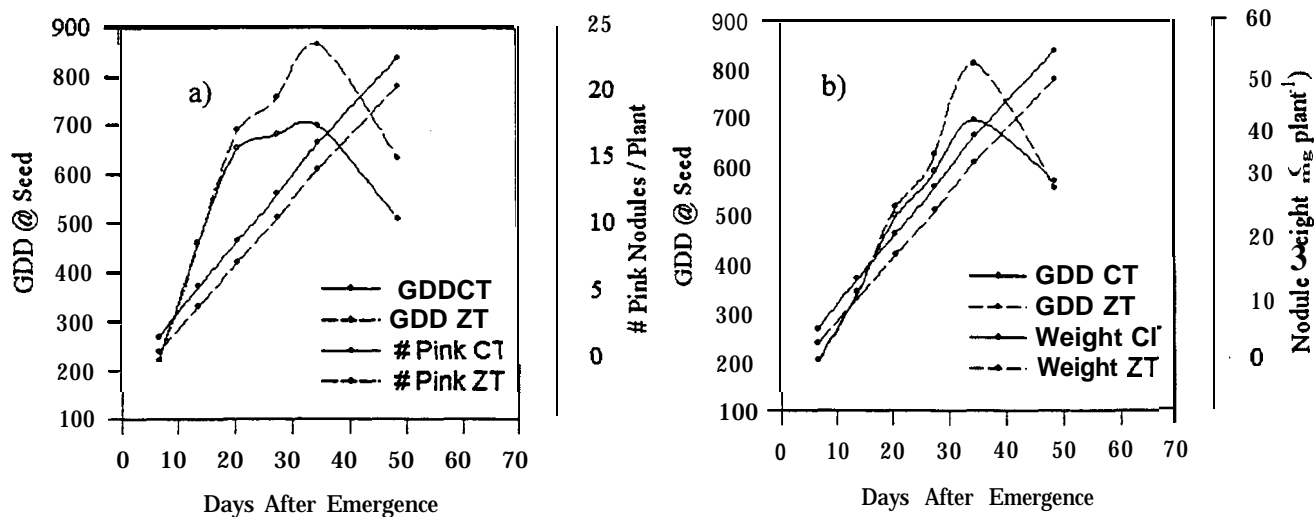


Figure 2. Effect of zero (ZT) and conventional (CT) tillage on a) soil growing degree day: (5°C) at the seed (GDD @ seed) and pink nodule number and b) soil growing degree days (5°C) at the seed (GDD @ seed) and pink nodule weight at Ft. Vermilion, 1994.

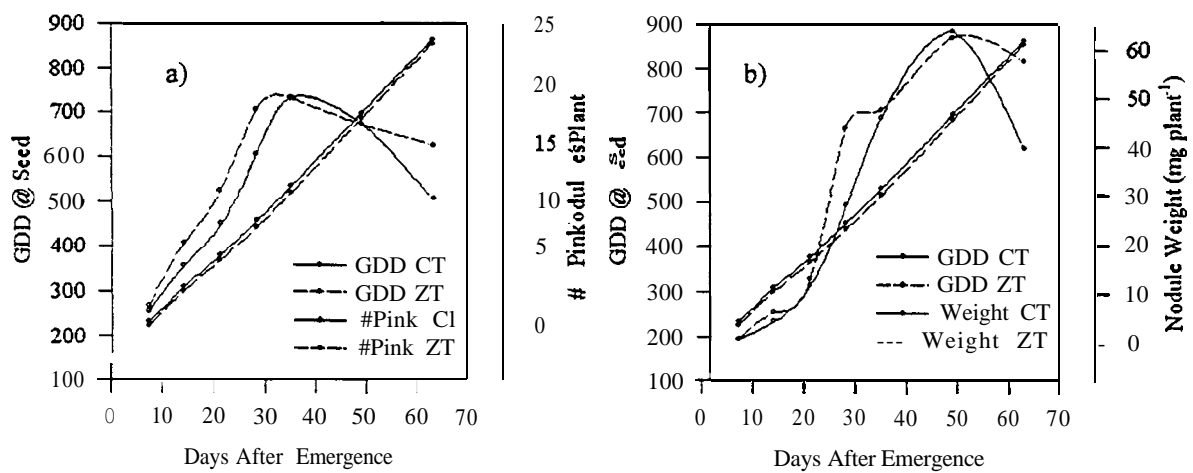


Figure 3. Effect of zero (ZT) and conventional (CT) tillage on a) soil growing degree days (5°C) at the seed (GDD @ Seed) and pink nodule number and b) soil growing degree days (5°C) at the seed (GDD @ seed) and pink nodule weight at Beaverlodge, 1994.