THE RELATIONSHIP BETWEEN LENTIL CROP POPULATION AND WEED BIOMASS PRODUCTION IN CANTERBURY

B.A. McKenzie, M.E. Miller, G.D. Hill

Plant Science Department
Lincoln University
Canterbury

ABSTRACT

An experiment examining the effect of crop population and phosphorus on two lentil cultivars was conducted on a Templeton silt loam soil near Lincoln in 1988-89. Titore and Primera lentils were sown on 14 October, 1988 at populations ranging from 100 - 500 plants/m^2. Phosphorous was applied at 0 or 50 kg P/ha.

The 1988-89 growing season was one of the driest on record with a total rainfall from 1 October 1988 until 31 January 1989 of only 119 mm. Maximum seed yields was of 1,190 kg of oven dry seed per hectare from Titore. While phosphorus had no effect on yield or any yield component, both population and cultivar did affect yield. There was a highly significant quadratic response of yield to population with 100 plants/m^2 producing 630 kg oven dry seed/ha and 500 plants/m^2 producing 1,080 kg seed/ha. At all populations, Titore outyielded Primera and averaged over all populations, yields were 1,190 and 680 kg seed/ha for Titore and Primera respectively. Higher seed yields were due to increased amounts of intercepted photosynthetically active radiation.

Weed biomass was measured on 22 December 1988. High lentil populations significantly reduced weed yields from 400 g/m^2 at 100 plants/m^2 to 178g/m^2 at 500 plants/m^2. Averaged over all populations, Titore plots had 306g weed DM/m^2 while Primera had 234 g weed DM/m^2.

The reduction in weed DM at higher populations was primarily due to increased light interception by the higher lentil populations. Transmissivity readings taken on 16 December 1988 showed a significant reduction in transmission of radiation through the crop canopy at populations above 200 plants/m^2.

This work has indicated that a late sown lentil crop can produce reasonable yields but only if plant population is increased. These results should be of interest to lentil growers and farm consultants.

Additional Keywords: Lens culinaris, *density, competition.*

INTRODUCTION

As recently as 1980 there were only small areas of lentils sown in Canterbury. However, by 1988-89 approximately 3,000 ha of the crop were sown. Research has indicated that the crop grows well in Canterbury and dryland yields of over 3 t/ha have been consistently obtained (McKenzie, 1987).

At present, recommendations for growing lentils include autumn sowing, particularly for the small red cultivar Titore, at populations of about 150 plants/m^2. Autumn sowings have provided higher yields than spring sowings (McKenzie *et al.*, 1985; McKenzie, 1987). These higher yields are due to increased solar radiation interception, longer growth duration and through reduced water stress over the crop growing season (McKenzie, 1987).

While autumn sowings have a higher yield potential than spring sowings, many farmers prefer to sow crops in the spring. This is primarily due to lower risk associated with spring sowings and to financial benefits from reduced interest payments on loans. Because of the high farmer interest in spring sowing, an experiment was conducted examining a late spring sown lentil crop at populations ranging from 100 to 500 plants/m^2. Additionally, phosphorus was applied as a treatment. The main objective of this experiment was to examine whether or not high crop populations would allow increased solar radiation and therefore increased yields. Additionally, the competitive effect of crop population on weed biomass was studied.

MATERIALS AND METHODS

Titore and Primera (a large seeded yellow lentil cultivar) lentils were sown on 14 October, 1988 at 100, 200, 300, 400 or 500 plants/m^2. Superphosphate at 9% P was applied at 0 or 50 kg of P/ha on 10 November.

The trial was located at the Lincoln College Henley block on a Templeton silt loam. The paddock had been in spring barley in 1987-88 and in red clover/ryegrass pasture for the preceding four years.

The trial design was a randomised complete block with a factorial combination of lentil cultivar by population by phosphorous. There were 20 treatments and 3 replicates. Plot size was 4.2 m x 10 m.

The trial site was prepared using standard farm practices. Titore and Primera lentils at thousand seed weights of 30.4 and 89.2 g respectively were treated with Orthocide 65 at 163 g a.i./100 kg seed before sowing. Sixty mm of irrigation was applied two weeks prior to sowing. Three days after sowing, cyanazine at 1.5 kg a.i./ha was applied for weed control.

Sampling: Lentil dry matter accumulation was sampled fortnightly using 2 x 0.1 m^2 quadrat cuts. Weed dry matter production was determined by a 0.1 m^2 quadrat cut from the weediest area of each plot on 21 December 1988. Solar radiation interception was measured using a tube solarimeter model TSM (Delta-T devices, Cambridge, England, see Szeicz, 1965). The measurements were taken fortnightly from 5 December 1988. Solarimeter output was integrated for 20 s using a two channel integrator (Systel Engineering, Christchurch). Measurements were always taken between 1000 and 1400 hours NZST.

The fraction of total incident radiation transmitted through the canopy (T_i) was calculated according to Equation 1

$$T_i = R_s * (C_b/C_a) \qquad \text{Equation 1}$$

where R_s is the relative sensitivity and C_a and C_b are the integrated counts above and below the canopy respectively.

Measurements of transmitted radiation were halted when dead leaves in the canopy began intercepting light.

Transmissivity readings were recalculated into the fraction of total radiation intercepted (F_i) using the technique of Gallagher & Biscoe (1978).

$$F_i = \frac{(1.0 - T_i^{1.2})}{1.11} \qquad \text{Equation 2}$$

As reported by Szeicz (1974), photosynthetically active radiation was assumed to be equal to 0.5 of the total incident shortwave radiation. The amount of PAR absorbed (S_a) was calculated from Equation 3.

$$S_a = F_i \times S_i \qquad \text{Equation 3}$$

where Si is the total amount of incident PAR.

RESULTS

Climate: The 1988-89 growing season was one of the driest on record. Total rainfall from 1 October until 31 January was only 119 mm compared to a long term mean for the same period of 219 mm. Temperature and radiation receipts were, however, higher than the long term average. Figure 1 shows that mean daily incident radiation in January was considerably higher than the long term average, all other months except December were near the long term average. While December had a lower average radiation receipt, rainfall was only 34 mm.

Lentil yield: Oven dry seed yield was affected by population ($P < 0.001$) and ranged from 630 g/m^2 at 100 plants/m^2 to 1,079 g/m^2 at 400 plants/m^2 (Table 1). Titore outyielded Primera by 74 %; while there was no effect of phosphorus there were similar trends with dry matter production. Maximum dry matter at final harvest was 2,676 kg/ha and was produced at 400 plant/m^2 with Titore producing 12.6 % more DM than Primera. Maximum total biological productivity (Table 1) was unaffected by either cultivar or phosphorus. However, the higher production of 4,792 kg DM/ha at 500 plants/m^2, was a 35 % increase over production at 100 plants/m^2.

Lentil and weed yield: Lentil and weed dry matter was measured on 21 December 1988 when weed and lentil growth were both vigorous. While lentil DM increased at higher populations (Table 2), weed DM was significantly reduced by higher lentil populations from 400 g/m^2 at 100 plants/m^2 to 178 g/m^2 at 500 plants/m^2. Primera reduced weed biomass by 23 % more than Titore.

Harvest index, calculated from DM remaining at final harvest was consistent over all populations and both phosphorus levels (Table 1). However, Titore had a high HI at 0.49 while Primera had a HI of only 0.32.

Crop populations: At final harvest crop populations were higher than intended and were 131, 225, 347 and 591 plants/m^2 for the 100, 200, 300, 400 and 500 plants/m^2 sowings respectively.

Light interception: Light transmitted through the canopy was measured throughout the growing season. Two days before the lentil and weed dry matter

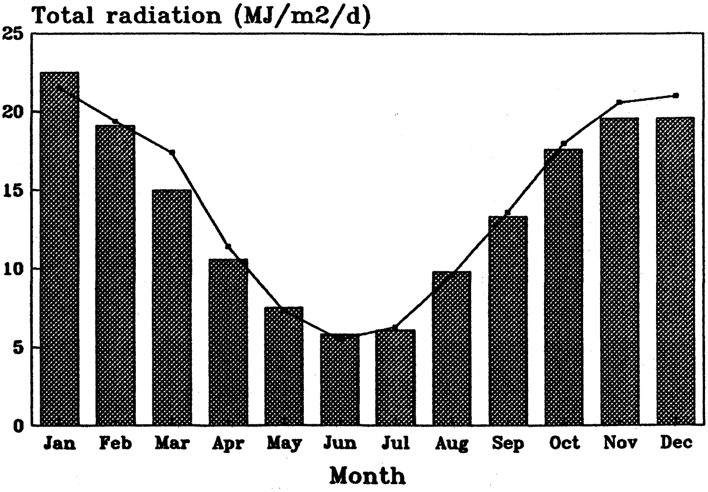

Figure 1. Mean daily total incident radiation in Canterbury for July 1988 until April 1989 and long term mean (curve = mean; histograms = actual).

Table 1. The effect of crop population (plants/^{2} and phosphorus (kg/ha) on yield and harvest index of Titore and Primera lentils.

	Seed yield kg/ha, (oven dry)	Dry matter at final harvest (kg/ha)	Maximum dry matter (kg/ha)	Harvest index
Cultivar				
Titore	1,191	2,411	4,410	0.49
Primera	684	2,141	4,365	0.32
SEM	33.8	75.0	131	0.006
Significance	***	*	NS	***
Population				
100	630	1,566	3,530	0.39
200	915	2,164	4,441	0.40
300	989	2,370	4,446	0.40
400	1,079	2,676	4,729	0.40
500	1,076	2,607	4,792	0.40
SEM	53.5	118.6	208	0.009
Significance	***	***	***	NS
Phosphorus				
0	931	2,265	4,332	0.40
50	945	2,288	4,443	0.40
SEM	33.8	75.0	131	0.006
Significance	NS	NS	NS	NS
Significant Interactions	nil	nil	nil	nil
CV %	19.8	18.0	16.4	8.2

* significant at $P < 0.05$, *** significant at $P < 0.001$.

measurement, only population affected transmissivity. At the lowest population 61 % of incident radiation was transmitted through the canopy (Table 3) while at 500 plants/m^2, only 42 % of radiation reached the soil surface. There was no significant difference in transmissivity at 200 plants/m^2 or above.

Table 2. Lentil and weed dry matter production on 22 December 1988.

	Lentil DM g/m^2	Weed DM g/m^2
Cultivar		
Titore	144	306
Primera	170	234
SEM	8.6	19.0
Significance	NS	NS
Population		
100	72	400
200	151	291
300	148	285
400	199	197
500	217	178
SEM	13.5	30.1
Significance	***	***
Phosphorus		
0	162	257
50	153	283
SEM	8.6	19.0
Significance	NS	NS
Significant Interactions	nil	nil
CV %	29.8	38.6

* significant at P < 0.05, *** significant at P < 0.001.

Over the growing season, total intercepted PAR was affected by both cultivar and population. Primera intercepted 412 MJ PAR/m^2 while Titore intercepted 340 MJ PAR/m^2. At 100 plants/m^2 only 306 MJ PAR/m^2 was intercepted at 500 plants/m^2 396 MJ PAR/m^2 was intercepted. There was little difference in intercepted PAR at populations of 300 plants/m^2 or more.

Table 3. The effect of population and phosphorus on transmitted and intercepted radiation of two lentil cultivars 1988.

	Fractional transmissivity at 16/12/88	Total intercepted PAR MJ/m^2
Cultivar		
Titore	0.46	340
Primera	0.49	412
SEM	0.023	11.1
Significance	NS	***
Population		
100	0.61	306
200	0.45	374
300	0.43	400
400	0.45	402
500	0.42	396
SEM	0.036	17.5
Significance	**	**
Phosphorus		
0	0.48	371
50	0.46	380
SEM	0.023	11.1
Significance	NS	NS
Significant Interactions	nil	nil
CV %	21.3	13.2

* significant at P < 0.05, *** significant at P < 0.001.

DISCUSSION

Phosphorus caused no significant effects in this experiment, probably due to the dry conditions, therefore, only the effects of cultivar and population will be discussed.

At maximum seed yields of about 1.1 t/ha, yields were not high when compared with yields of over 3t/ha obtainable from autumn sowings (McKenzie, 1987). However, the higher populations produced yields that were higher than the 0.8 t/ha produced in a 15 October 1984 experiment (McKenzie *et al.*, 1985).

Previous reports have found inconsistent responses of lentil seed yield to changes in crop population. Jermyn *et al.* (1981) reported increased seed yield with increased crop population at three sowing times and no change at two other sowing times. These results were however from weed infested plots and the authors felt that the higher yields were due to less weed competition in the higher population plots. McKenzie *et al.* (1986) and Krarup, (1984) found no change in seed yield at higher plant populations. Both of these reports were from much earlier sowings which would have allowed the lower populations to achieve a greater canopy cover.

Late spring sowings of lentils in Canterbury have been shown to be low yielding (McKenzie, 1987). Lower yields with spring sowings are quite common (Jermyn *et al.*, 1981; Saxena *et al.*, 1983; Sihna & Chowdhury, 1984). There are probably two mechanisms causing these lower seed yields. In temperate countries with dependable rainfall, early sowing allows the crop to produce large plants which intercept the maximum amount of solar radiation (McKenzie, 1987). In arid countries, early sowing also allows increased radiation interception, but yields are increased primarily because the crop matures early before severe water stress occurs.

This experiment has clearly shown that increasing plant population can increase total intercepted radiation. McKenzie (1987) found a highly significant relationship between lentil DM production, seed yield and intercepted radiation. The increased radiation interception has contributed to the increased yield at higher populations. Higher populations result in more rapid crop cover and less wasted radiation.

The significantly increased seed yield produced by Titore was expected (Table 1). Titore is a New Zealand selection and tends to be one of the highest yielding cultivars in Canterbury. Primera a large seeded yellow cultivar was much less productive. In Canterbury, large yellow cultivars tend to yield less than Titore because of problems with lodging, less efficient light utilisation and lower harvest indices.

Dry matter production followed similar trends to seed yield, and for similar reasons. Lentil DM yields of up to 12.5 t/ha have been obtained from autumn sowings (McKenzie, 1987).

Harvest index was stable over populations (Table 1). However, Titore had a HI of 0.49 while that of Primera was 0.32. In Canterbury, large yellow seeded cultivars have been shown to have low HI due to excessive vegetative growth (McKenzie, 1987). In this experiment the low HI of Primera was due to low seed yield. This suggests that this cultivar is not suitable for Canterbury conditions. Another explanation for the lower HI could be the three week longer crop duration of Primera. Primera plants were concurrently filling pods and growing vegetatively over a longer period of time than Titore plants. Pyke & Hedley (1985) found that in peas this may result in more assimilate being partitioned into vegetative growth with a resultant drop in HI.

Weed biomass: The 1988-89 season was not a good lentil growing season. Most herbicides used on lentil crops in Canterbury require soil moisture for increased efficacy. As mentioned previously, the 1988-89 growing season was one of the driest on record and herbicide failure was very common in lentil crops.

In this experiment, the reduced herbicide efficacy led to an excellent opportunity to study the relationship between crop and weed populations. As shown in Table 2, as lentil population increased, weed DM production decreased. The transmissivity measurements taken five days prior to the weed DM cut indicated that the higher crop populations were more effective at intercepting radiation than the lower lentil populations (Table 3). At populations of 200 plant/^{2} or higher about 55 % of incident radiation was intercepted. However, weed DM production continued to decline at the higher crop populations. This indicates that the higher crop populations were probably competing more aggressively for soil moisture. At the highest lentil populations, the combination of high radiation interception and increased water use would result in severe competition for the weeds and hence lower weed DM production.

The reduction in weed DM in the Primera plots was probably due to the larger leaf size of Primera. This cultivar intercepted more radiation than Titore. Although there was no significant difference in transmissivity on 16 February 1989, Primera did reach a transmissivity of 50 % about one week before Titore

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