RESPONSE OF LENTILS TO IRRIGATION AND SOWING DATE

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ABSTRACT

Lentils (cv. Titore and Olympic) were sown on six dates from 16 April to 15 November, 1984 on a sandy soil with 150 mm AWC in the top metre. The response of five of these sowings to irrigation was examined. Spring and summer rainfall was only 72% of average.

Seed yield was most strongly influenced by sowing date. Late sowing depressed yield from 3.3 t/ha to 0.5 t/ha. The response of seed yield to irrigation ranged from a 26% decrease in the July sowing to an 83% increase in the November sowing. Seed yields were largest from the May sowing where Titore and Olympic produced 3.5 and 3.1 t/ha respectively.

Total dry matter accumulation was generally increased by irrigation. Irrigated Titore and Olympic produced 8.9 t DM/ha. Unirrigated, they produced 7.3 and 7.9 t/ha respectively. Irrigated autumn sowings all lodged severely and this may have accounted for their lack of seed yield response to irrigation.

Irrigation generally decreased harvest index (HI). Mean HI was 0.35 for irrigated plants and 0.43 for unirrigated plants. In the July sowing, irrigation decreased HI from 0.46 to 0.34, but irrigation did not decrease HI of the October sowing.

The results suggested that on this soil type in Canterbury, autumn sowing is essential to ensure high yields. Only spring-sown lentils should be irrigated and then only in a dry season.

Additional Key Words: seed yield, harvest index

INTRODUCTION

Interest in growing lentils (*Lens culinaris*) in New Zealand has recently increased. The crop has been shown to produce high yields in Canterbury (Jermyn *et al.,* 1981). Farm yields in Canterbury have been as high as 3 t/ha (Lill, pers. comm.). There is a promising outlook for a large increase in lentil production in New Zealand, with export potential to Asia and to supply the local health food industry.

Although the crop is relatively new to New Zealand, some basic agronomic research has already been conducted (Jermyn *et al.,* 1981; Butler and Jermyn, 1981; Jermyn, 1983). Present recommendations include: autumn sowing; no irrigation; low plant populations; and most importantly, control weeds. There is however, controversy over some of these recommendations. For example, El-sarraq and Nourai (1983) reported that high plant populations of approximately 600 plants/m^2 produced the largest seed yields. Saxena *et al.* (1983), however, found no differences in seed yield with populations ranging from 133 to 333 plants/m^2.

However, the most controversial aspect of lentil growing is the need for irrigation. Generally, lentils are considered a dryland crop. However, some authors have reported large seed yield increases from irrigation (Mehrotra *et al.,* 1977; El-sarraq and Nourai, 1983). Most other workers have found no response or a negative response of seed yield to irrigation (Jermyn *et al.,* 1981).

This trial was designed to determine the most suitable time for sowing the crop, explore the need for irrigation, and to examine cultivar differences between large and small seeded varieties. The results have direct application to lentil farmers and to farm advisers

MATERIALS AND METHODS

The trial was a split plot randomised complete block design with the six sowing dates as main plots. Subplots were a factorial combination of four treatments; full irrigation or none, and two cultivars, Titore, a small seeded variety and Olympic, a large seeded variety. These four treatments were randomly allocated within each main plot. There were four replications. Sowing dates were 16 April, 15 May, 26 July, 14 September, 15 October, and 15 November, 1984. Irrigation was intended to replace water lost by evapotranspiration calculated from Penman's formula (Penman, 1970). Water was applied when the calculated soil moisture deficit exceeded 50 mm. Trickle tubes were used with flow meters to measure the amount of water applied.

The trial was located on a Templeton silt loam (Soil Bureau, 1954) which had been in a red clover/perennial ryegrass pasture for the previous 18 months. Soil nutrient analysis showed acceptable figures for major nutrients. However, one application of 250 kg/ha superphosphate was made. The pasture was killed with glyphosate at 1.08 kg a.i./ha and dicamba at 0.14 kg a.i./ha one month before sowing. The site was cultivated by rotary hoeing, ploughing, subsoiling, rolling and grubbing. Weed growth was controlled with cyanazine at 1.5 kg a.i./ha applied pre-emergence. Weed growth in fallow plots before sowing was controlled with paraquat. Weed control in the first sowing was not adequate and metribuzin was applied post-emergence on 21 August at 0.175 kg a.i./ha.

All plots were sown at rates calculated to produce approximately 150 plants/m². These were 50 and 70 kg/ha for Titore and Olympic respectively and were increased by 10% in the May and September sowings and by 20% in the July sowing, because of an expected reduction in winter survival.

Sampling

The April, July and October sowings were sampled for dry matter accumulation, leaf area, branch number, pod number, seed number and seed weight. One 0.1 m² quadrat was cut each month during the winter and every two weeks from the end of August. Final yield measurement was taken for all sowing dates from six 0.5 m² quadrats.

Measurements

Logistic curves describing dry matter accumulation of the crops were fitted using the MLP program from Rothamsted (Ross *et al.,* 1979). Harvest index was calculated from dry matter remaining at maturity. Leaf area measurements were made on subsamples of 8 plants using a Licor 3100 Area Meter. Solar radiation interception was measured fortnightly with a tube solarimeter at five points in each plot of the April, July, and October sowings. Maximum potential soil moisture deficit for the period of emergence to harvest was calculated for each sowing date from the Penman equation (1970).

All data were analysed using the Genstat statistical package. All crop data has been presented in three factor interaction tables, even where this interaction was not significant. This approach was taken because of the very large influence of sowing date. All tables presented list all significant interactions.

RESULTS

Climate

Rainfall from October to January was approximately 72% of normal. There was virtually no significant rainfall from 11 December, 1984 until 8 February, 1985 (Figure 1).

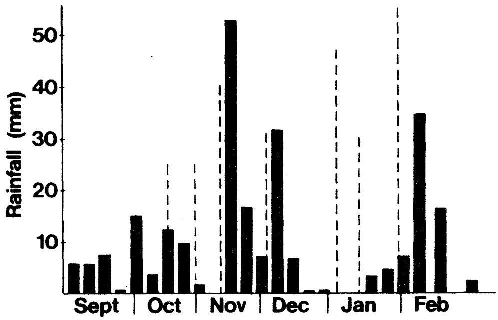

Figure 1: Weekly distribution of rainfall and irrigation events from 1 September 1984 until 28 February 1985 at Lincoln, Canterbury. Broken lines indicate irrigation events.

TABLE 1: Maximum dry matter accumulation (t/ha) of Titore and Olympic lentils irrigated and unirrigated at three sowing dates.

Sowing date	Titore		Olympic	
	Unirrigated	Irrigated	Unirrigated	Irrigated
April 16	7.9	12.5	9.7	12.5
July 26	9.8	9.0	9.1	9.2
October 15	4.3	5.1	5.0	5.0
Significant interactions		sowdate x water**		
S$\bar{x}$	0.66			

Temperatures over the growing season were near normal. However, the winter was mild and expected plant deaths in the winter sowing due to low temperatures did not occur. The plant population in the July sowing was 22.5% greater than that in the April or October sowings throughout most of the season.

Total Dry Matter Production

Total dry matter production was significantly increased by early sowing. The effect of irrigation, however, was inconsistent. Maximum DM accumulation was 12.5 t/ha in both cultivars when irrigated and April sown (Table 1). However, in the non-irrigated plots of the same sowing, dry matter accumulation was only 7.9 and 9.7 t/ha for Titore and Olympic, respectively. In the October sowing, there was no response to irrigation and mean total dry matter production was 4.8 t/ha. There was no significant cultivar effect on dry matter production.

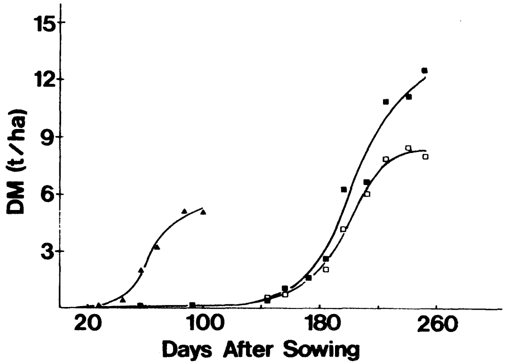

Figure 2: Dry matter accumulation of irrigated and unirrigated lentils cv. Titore at two sowing dates in Canterbury (■ = irrigated April sown, □ = unirrigated April sown, ▲ = irrigated and unirrigated October sown).

Generalised logistic curves adequately described dry matter accumulation (Figure 2). Maximum crop growth rates (CGR) derived from the fitted curves ranged from 260 kg/ha/day to 116 kg/ha/day in irrigated and unirrigated April-sown Olympic. Averaged over irrigation and cultivar, the July sowing showed the highest CGR at 230 kg/ha/day.

TABLE 2: Seed yield (t/ha oven dry) of Titore and Olympic lentils irrigated and unirrigated at six sowing dates.

Sowing date	Titore		Olympic	
	Unirrigated	Irrigated	Unirrigated	Irrigated
April 16	2.9	3.1	2.7	2.6
May 15	3.1	3.9	3.1	3.1
July 26	3.2	2.6	2.2	1.4
September 14	1.8	1.8	1.3	0.9
October 15	1.2	1.0	0.5	0.5
November 1	0.3	0.8	0.4	0.3

Significant interactions cultivar x water*
sowdate x cultivar*** sowdate x water***
S$\bar{x}$ 0.16

Maximum CGR in each sowing tended to occur in the period from early flowering until mid pod-fill.

Seed yield

Yield was strongly influenced by sowing date and autumn sowings outyielded all spring sowings (Table 2). Compared with May sowing, sowing in September reduced seed yield by 56% from 3.4 to 1.4 t/ha. Cultivar and irrigation were also significant as were the interactions between them. Titore responded more to irrigation than Olympic. Titore seed yield responsed significantly to irrigation in the May and November sowings but there was a decrease in yield in the July sowing. Over all sowings irrigation significantly reduced ($p < 0.01$) the seed yield of Olympic from an average of 1.7 t/ha (unirrigated) to 1.5 t/ha (irrigated).

TABLE 3: Harvest index of Titore and Olympic lentils, irrigated and unirrigated at six sowing dates.

Sowing date	Titore		Olympic	
	Unirrigated	Irrigated	Unirrigated	Irrigated
April 16	0.51	0.47	0.45	0.38
May 15	0.48	0.47	0.49	0.41
July 26	0.54	0.43	0.39	0.25
September 14	0.44	0.46	0.31	0.24
October 15	0.43	0.43	0.25	0.25
November 15	0.32	0.40	0.30	0.28

Significant interactions cultivar x water*
sowing date x cultivar*** sowing date x water***
S$\bar{x}$ 0.031

Harvest Index

Harvest index (HI) ranged from 0.32 in the November sowing to 0.46 in the May sowing (Table 3). Again, sowing date was the dominant factor. However, all of the two factor interactions were significant.

Over all plantings, HI in Titore was less affected by irrigation than in Olympic. Generally, irrigation depressed HI. This depression was greatest in the autumn sowings.

TABLE 4: Maximum potential soil moisture deficit (mm) from emergence to harvest of six sowing dates irrigated and unirrigated.

Sowing date	Unirrigated	Irrigated
April 16	295	205
May 15	285	195
July 26	271	152
September 14	271	151
October 15	263	115
November 15	287	130

Soil moisture status

Neutron probe readings taken at the beginning and end of the trial indicated that the plant available water content of the soil was approximately 150 mm. Logistical problems prevented the desired quantity of water from being applied and the maximum potential soil moisture deficits (Dm) reached in the irrigated plots (Table 4) were much larger than the desired 50 mm. The smallest accumulated deficit was 115 mm in the irrigated October sowing. There was no relationship between DM and seed or DM yield.

DISCUSSION

Dry matter production was most strongly influenced by sowing date. The autumn-sown plots yielded more because of the longer duration of growth (Figure 2).

Total dry matter production was more responsive to irrigation than seed yield. Irrigation caused a large increase in dry matter production in the April sowing but had no influence on the July and October sowings. The April sowing was sprayed with metribuzin to control excess weed growth. Metribuzin is not registered for use on lentils, but has been recommended (Jermyn *et al.*, 1981). The spray provided good weed control but also scorched some lentil leaves. It is possible that in this sowing, the irrigated plants were more able to overcome the set back caused by herbicide damage.

Crop growth rates were similar to previously reported values for lentils. Pandey (1980), found that the maximum CGR for lentils sown in India in October was about 130 kg/ha/day, and occurred during pod filling for all genotypes tested. Maximum crop growth rates in our trial were usually higher than this. The difference was probably due to the longer day length which occurred in this trial and to more favourable climatic and edaphic conditions.

The July sowing consistently showed the highest CGR. This sowing did not suffer from either herbicide damage or disease.

The spring sowings yielded less than earlier sowings because their leaf canopies never closed and growth duration was short. The maximum fraction of incident solar radiation intercepted by the October-sown crop was 65%. If crop yields are dependent upon the amount of intercepted radiation as is now generally accepted (Monteith, 1977) then the low yields of the spring sowings occurred because of reduced radiation interception. Crop development was rapid in the spring sowings because of high temperatures and the crop matured before the canopy closed. On the other hand, all autumn sowings reached full canopy closure. This suggests that increasing the seeding rate of spring sowings would increase yield by ensuring full canopy cover.

The value of sowing lentils early is clearly shown by the higher seed yields obtained (Table 2). Except for the April sowing, seed yields declined as crop growth duration declined. Similar results have been reported in the literature (Saraf and Baitha, 1979; Saxena *et al.,* 1983). The failure of the April sowing to outyield the May sowing was probably due to herbicide damage and the presence of Sub-clover red leaf virus. The disease occurred because the April sowing was infected by a late aphid flight. This indicates that April is probably too early to sow the crop without insecticide.

Of the unirrigated sowings, the July sowing yielded the most grain, (Table 2). This might have been due to the increased plant population. The winter of 1984 was quite mild and few plants died. Highest yields were achieved from the unirrigated July sown Titore. However, yield reductions in the other July sown treatments were caused by lodging.

The October sowing became infected with *Fusarium* wilt which produced a patchy stand and a poor crop. The seed yield from this sowing would have been considerably higher if the crop had been disease free.

Seed yield was remarkably unresponsive to irrigation. This lack of response was associated with severe lodging. All autumn sowing lodged while spring sowings did not. Lodged plants quickly rotted and radiation interception was markedly reduced. The increased seed yield which occurred in the May sowing cannot easily be explained. However, the potential soil moisture deficit (Dm) of 195 mm was high enough to suggest that additional irrigation may have resulted in even higher yields. The low seed yield in the unirrigated November-sown Titore crops was probably because of the large DM which occurred over a short period of time. Also, irrigation in the November sowing caused no lodging and thus no subsequent loss of seed. The lack of response of seed yield to irrigation suggests that only spring-sown crops should be irrigated and then only if the season is dry.

The cultivar 'Olympic' was more prone to lodging than Titore which had a shorter growth habit. All autumn-sown irrigated Olympic plants lodged severely and seed yield was consequently reduced.

Irrigation significantly reduced HI for most sowing dates. This was usually because of increased DM present which occurred with no corresponding increase in seed yield. The lodging which occurred in the irrigated autumn sowings also reduced HI because seed yield was reduced in lodged crops.

The irrigation treatment imposed in this experiment provided only a preliminary indication of the likely response of lentils to irrigation and further work is required on this aspect.

CONCLUSIONS

Lentils are a high value crop capable of yielding more than 3 t/ha under dryland Canterbury conditions. The crop should be sown in the autumn. Delaying sowing until spring usually results in reduced yields. Irrigation caused early-sown crops to lodge and although it increased total dry matter production, it generally had little effect on seed yield. The objective of further work is to determine the water usage of the crop, and the interaction between sowing date and population on yield.

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