EFFECT OF IRRIGATION ON YIELD AND YIELD COMPONENTS OF SWEET LUPINS

Roger Stoker
Winchmore Irrigation Research Station
Ministry of Agriculture and Fisheries
Private Bag, Ashburton

ABSTRACT

(Trials were carried out in two seasons investigating seed yield of the sweet lupin cultivars Uniharvest, Uniwhite and Weiko 111 both without irrigation and under different irrigation regimes.

In both seasons there was little difference in yield between Uniharvest and Uniwhite but both of these cultivars yielded better than Weiko 111. No benefit was obtained from irrigation prior to flowering but irrigation during flowering and pod swelling increased yield greatly. Increase in yield was mainly the result of an increase in the number of lateral branches bearing pods, although the number of seed in each pod was also significantly greater with irrigation. 1000 seed weight showed variable trends. Irrigation during the vegetative phase caused earlier flowering; irrigation from the start of flowering prolonged flowering and delayed harvest.

¶ Seed of Weiko 111 had the highest percentage of nitrogen, but the total production of nitrogen was greater with Uniharvest and Uniwhte because of the higher yields.

INTRODUCTION

According to Claridge (1972) the area devoted to lupins in New Zealand reached a peak of over 4000 hectares in the 1949-50 season. Virtually all of this was grown in the Ashburton County and the major use of the crop was for greenfeed. Due to changing patterns of agriculture, and several inherent disadvantages in the cultivars available, the area has steadily declined.

However, breeding programmes mainly in Germany and Western Australia have led to the release of improved cultivars. Since 1950 over a dozen new cultivars have been released (Gladstones 1970). These have a low alkaloid content, a pod that does not shatter at harvest and seed that germinates uniformly. Concurrent with the introduction of these new cultivars there has been a large increase in world production of lupins. Interest in the crop is now mainly for the seed as a high protein stock feed supplement. In New Zealand small areas have been grown for the last five years.

The soil and climatic requirements of lupins vary considerably between cultivars but in general they will grow adequately where many other crops are limited through soil acidity or low fertility. Similarly the moisture requirements of lupins are not high. Gladstones (1972) stated that Uniharvest and Uniwhite are reasonably reliable in the northern areas of Australia where rainfall averaged 500-550 mm, and the Weiko 111 prefers slightly higher rainfall areas. However, the literature contains very little work on the water relations of lupins and a complete lack of reports on irrigation experiments. For instance, in a comprehensive review, Salter and Goods (1967) concluded that in annual legumes flowering is the most moisture sensitive phase of growth, but they include no specific reference to lupins. Gates (1968) found the lupin apex to be sensitive to moisture stress and this reduced shoot primordia initiation. Withers **et al.** (1974) found that dry conditions associated with later showing dates caused a reduced number of laterals shoots and a lower seed yield.

Several species of lupins have been used agriculturally but Allen (1949) indicated that **Lupinus anguitifolius** and **L. luteus** were the two most suited to local conditions. The purpose of the present investigation was to assess the potential of two modern cultivars of **L. angustifolius** (Uniharvest and Uniwhite) and one of **L. luteus** (Weiko 111) at Winchmore both under dryland and a range of irrigation regimes.

EXPERIMENTAL

Field trials were carried out at Winchmore in the 1973/74 and 1974/75 seasons. The soil type is a Lismore stony silt loam varying in depth between about 300 and 400 mm. Some soil physical properties measured in the 1973/74 season are given in table 1. Available moisture declines steadily with soil depth and the total available moisture in the top 300 mm is 51.8 mm. Below 300 mm there is very little available moisture.

TABLE 1 : Soil physical properties 0-300 mm sample of Lismore stony silt loam 1973/74.

Depth (mm)	Bulk Density (g/ml)	Field Capacity (W/W%)	Wilting Point (W/W%)	Available Moisture (V/V%)	Available Moisture (mm)
0-75	1.02	32.2	10.2	22.4	16.8
75-150	1.02	29.0	10.4	19.0	14.2
150-225	1.16	23.4	10.1	15.4	11.6
225-300	1.10	21.0	9.9	12.2	9.2

In both trials seed was sown with a belt-type precision seeder with an inter-row width of 200 mm and an intra-row spacing of 48 mm. In 1973/74, pH in the top 150 mm of soil was 5.8. The trial was sown on 28 September and topdressed with superphosphate (240 kg/ha) and muriate of potash (60 kg/ha). In 1974/75 pH in the top 150 mm was again 5.8. The trial was sown on 17 September and topdressed with superphosphate (260 kg/ha) and muriate of potash (65 kg/ha). In both seasons weeds were controlled well by a pre-sowing incorporation of 1.2 l/ha a.i. of trifluralin.

A split plot design was adopted with irrigation as the main plots and cultivars as the subplots. There were four irrigation treatments, three cultivars and six replicates. Irrigation treatments were based on a combination of the soil moisture level and the growth phase of the crop, and are given in tables 2 and 3. Soil moisture was determined gravimetrically from cores taken from the top 150 mm of soil. Water was applied each time the soil moisture fell to the levels indicated during each growth phase. The number of irrigations in each phase is also given in the tables. Plots were watered by the border strip method with sufficient water being applied at each irrigation to restore the full soil depth to field capacity.

Trial plots were sampled by hand. Counts were made of the number of plants and the total number of pods. Total seed and 200 seed weights were also measured. From these measurements the seed yield standardised to a 14% moisture basis, the number of seed per pod and the 1000 seed weight were calculated. Counts of the number of lateral branches bearing pods were made in the 1974/75 season. In addition, samples of whole seed were analysed for total nitrogen content by the Kjeldahl digestion method.

RESULTS

The split plot design of the trial necessitated the simultaneous irrigation of all three cultivars. The soil moisture under each cutlivar at irrigation was normally within 1% of the mean, with no consistent differences. Irrigation treatments were therefore not affected by the design of the trial.

In 1973/74 the soil moisture of treatments receiving no water in the vegetative phase fell to a minimum of 8.7 percent prior to flowering. The minimum recorded soil moisture in the non-irrigated treatment after the start of flowering was 9.7 percent. The corresponding figures in the 1974/75 season were 9.7 percent in the vegetative phase and 4.9 percent after the start of flowering.

In 1973/74 the treatments receiving water during the vegetative phase flowered on 24 December and were followed four days later by the treatments receiving no water during the vegetative phase. In the following season the corresponding dates were 3 December and 5 December. The harvest date of the non-irrigated treatment was 5 March in the first season and 30 January in the next season. The different irrigated treatments became ready for harvest at intervals up tofour weeks after the non irrigated treatments.

The effect of irrigation on seed yield is given in tables 2 and 3. Yields are analysed as a mean of the three cultivars. Yield components, again analysed as a mean of the three cultivars, are given in tables 4 and 5. Yield from the three cultivars is compared in tables 6 and 7. The comparison is made both without irrigation and under optimum irrigation conditions. In 1973/74 the mean of the three irrigated treatments was used as there were no significant differences between them.

TABLE 2 : Irrigation and yield details 1973/74

Trt	Vegetative phase	Flower & Pod Fill Phase	Yield (kg/ha)
1	non irrigated (0)	non irrigated (0)	1190 bB
2	15% moisture (2)	15% moisture (2)	3490 aA
3	non irrigated (0)	20% moisture (5)	3350 aA
4	15% moisture (2)	20% moisture (5)	3050 aA

The number of irrigations is given in parentheses. Yields are the mean of all three cultivars.

TABLE 3 : Irrigation and yield details 1974/75

Trt	Vegetative Phase	Flower & Pod Fill Phase	Yield (kg/ha)
1	non irrigated (0)	non irrigated (0)	980 dD
2	non irrigated (0)	12% moisture (3)	2230 bB
3	non irrigated (0)	20% moisture (6)	3160 aA
4	12% moisture (1)	12% moisture (2)	1970 cC

TABLE 4 : Yield components under different irrigation regimes 1973/74.

Irrigation Treatment	Pod/plant	Seed/pod	1000 seed wt (g)	Total N %
1	3.82 dD	2.66 cC	142 aA	6.06 aA
2	7.70 cC	3.99 aA	140 aA	5.68 abAB
3	9.53 aA	3.41 bB	137 aAB	5.85 aAB
4	8.62 bB	3.73 aAB	122 bB	5.40 bB

TABLE 5 : Yield components under different irrigation regimes 1974/75.

Irrigation Treatment	No. laterals	Pods/plant	Seed/pod	1000 seed wt (g)	Total N (%)
1	0.14 cC	3.39 cC	3.15 cC	146 bB	5.82
2	2.30 bB	6.31 bB	3.59 bB	186 aA	5.82
3	2.81 aA	9.26 aA	4.00 aA	177 aA	5.80
4	2.22 bB	6.21 bB	3.96 aA	178 aA	5.50

DISCUSSION

The irrigation treatments in the first season were based on treatments previously found suitable for peas at Winchmore. However lupins have a longer growing season than peas and hence the total number of irrigations applied was higher. Irrigation treatments were altered in the second season to reduce the number of water applications to a more practical level. In the first season there were no significant differences between irrigated treatments but average irrigation response was high at 177%. In the second season there were significant differences in yield between irrigated treatments. Yield was highest in treatment 3 receiving no water before flowering and irrigated at the 20% soil moisture level from the start of flowering. Irrigation response was 222%.

Comparison of treatments 3 and 4 in 1973/74 indicates no benefit from preflowering irrigation. Comparison of treatments 2 and 4 in 1974/75 indicates a reduction in yield from preflowering irrigation. The optimum irrigation level from the start of flowering is not clearly revealed but comparison of treatments 2 and 4 in 1973/74 and 2 and 3 in 1974/75 suggests a level of 15-20%. It is interesting that no response to irrigation before flowering was obtained in either season even though soil moisture fell below wilting point. This contrasts with results from garden peas on the same soil type (Stoker 1973). In this crop a response to preflowering irrigation at the 15% soil moisture level was found.

Without irrigation there were very few lateral branches bearing pods (Table 5). In fact non-irrigated Weiko 111 had no laterals. In all cultivars there was a large increase in the number of laterals with irrigation and this is reflected in the number of pods per plant. This agrees with the work of Biddiscombe (1975) who showed that moisture stress increased flower drop in lupins. As with peas the number of pods per plant is the factor having most effect on yield.

Where soil moisture was kept above 15% from the start of flowering between two and three times as many flowers formed seed bearing pods. In both seasons the number of seeds in each pod was increased by irrigation, but not to the same extent as the number of pods per plant. 1000 seed weight was, if anything, reduced by irrigation in 1973/74. In the next season 1000 seed weight was increased by irrigation. No explanation is offered for this but similar variations have been found in peas. In both seasons total nitrogen in the seed was unchanged or reduced by irrigation. In the first season there was an apparent trend of decreasing nitrogen content with number of irrigations applied. This was not confirmed in the next season but it should be noted that where irrigation was applied before flowering total nitrogen content was lower.

TABLE 6 : Yield of different cultivars 1973/74

Cultivar	Non-irrigated (kg/ha)	Irrigated (kg/ha)
Uniharvest	1320 a	3610 aA
Uniwhite	1340 a	3570 aA
Weiko 111	900 a	2710 bB

Irrigated yield is the mean of the three irrigated treatments.

Table 6 shows that in 1973/74 both with and without irrigation the cultivars Uniharvest and Uniwhite gave similar seed yields and were both appreciably better than Weiko 111. This was confirmed in the 1974/75 season (Table 7).

Total nitrogen content of seed was similar in Uniharvest and Uniwhite. (Table 7). Weiko 111 seed had a significantly higher total nitrogen content than either of these cultivars. The difference in total nitrogen content was insufficient to offset the better yielding characteristics of Uniharvest and Uniwhite in terms of total nitrogen (or crude protein) production per hectare.

TABLE 7: Yield and nitrogen content of different cultivars 1974/75.

Cultivars	Non-irrigated (kg/ha)	Irrigations trt. 3 (kg/ha)	Total N (%)
Uniharvest	1220 aA	3870 aA	5.36 bB
Uniwhite	1250 aA	3890 aA	5.32 bB
Weiko 111	480 bB	1710 bB	6.52 aA

Total N is the mean of the non-irrigated and all three irrigation treatments.

CONCLUSION

No benefit was found from irrigating sweet lupins in the vegetative phase but large responses were obtained from irrigations applied from the start of flowering. On the light soils at Winchmore the cultivars Uniharvest and Uniwhite outperformed Weiko 111.

ACKNOWLEDGEMENTS

Mr K. Carter for assistance with field work; laboratory staff at Winchmore for chemical analyses, and the Biometrics Section, Ministry of Agriculture and Fisheries, for analysis of results.

REFERENCES

Allen, F.C. 1949. Lupins. Agronomy Review **2**: 1-6.

Biddiscombe, E.F. 1975. Effect of moisture stress on flower drop and seed yield of narrow-leafed lupin. Journal of the Australian Institute of Agricultural Science **41**: 70-72.

Claridge, J.H. 1972. Arable Farm crops of New Zealand. D.S.I.R. and A.H. & A.W. Reed, Wellington, 171-172.

Gates, C.T. 1968. Water deficits and growth of herbaceous plants. **In** "Water deficits and plant growth". Vol **2**. T. Kozlowski (Ed) Academic Press, London. 135-190.

Gladtsones, J.S. 1970. Lupins as crop plants. Field Crop Abstracts **23**: 123-148.

Gladstones, J.S. 1972. Lupins in Western Australia. Bulletin 3834, Department of Agriculture, Western Australia. pp. 1-37.

Salter, P.J. and Goode, J.E. 1967. Crop responses to water at different stages of growth. Research Review No. 2: Commonwealth Bureau of Horticulture and Plantation Crops, East Malling. 59-60.

Stoker, R. 1973. Response of viner peas to water during different phases of growth. New Zealand Journal of Experimental Agriculture **1**: 73-76.

Withers, N.J. Baker, C.J. and Lynch, T.J. 1974. Some effects of date, rate and method of sowing on lupin seed yield. Proceedings Agronomy Society of New Zealand **4**: 4-8.