POTENTIAL FOR SUNFLOWER PRODUCTION IN CANTERBURY

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ABSTRACT

New Zealand's arable industry is based on very few crops and there is an urgent need for farmers to have more options available. One possibility is sunflower (*Helianthus annuus* L.). Previous sunflower trials and crops in New Zealand have used mainly open pollinated cultivars, but modern hybrids are superior, having yield and agronomic advantages. This paper presents the results of trials conducted at Ashburton and Lincoln during the 1987-88 season to assess the yield potential and agronomic performance of a hybrid sunflower cultivar. The objectives of the trials were to test the effects on yield and performance of different row spacings, plant populations, and desiccation treatments at maturity.

Good overall crop performance in both trials demonstrated the crop's potential. At Ashburton the mean seed yield was 2.60 t/ha with 46.7% oil content, or 1.22 t/ha oil yield. The corresponding values at Lincoln, where fertility and water supply were poorer, were 1.80 t/ha, 44.1%, and 0.80 t/ha. These results compare very favourably with yields from hybrids in sunflower producing regions of the world. In both trials the best yield was obtained at 55,000 plants per ha with a narrow (0.45 m) row spacing. This spacing also resulted in less weed and lodging problems. Desiccation at physiological maturity is usually recommended to minimise the duration of exposure to the risk of losses from bird damage, but there were no differences between the two desiccation treatments (glyphosate and diquat) tested in these trials.

INTRODUCTION

New Zealand's arable industry is based on very few crops, even though research has aimed for many years to increase the range of economically viable crops available to farmers (Wynn-Williams and Logan, 1985). In the present difficult economic circumstances, the need to have more options available for diversification is more urgent than ever, and it is necessary to re-evaluate the potential of alternative arable crops previously rejected as uneconomic or impractical.

One such possibility is sunflower (*Helianthus annuus* L.). There was a substantial research effort in the late 1960s and early 1970s which aimed to develop the crop in New Zealand (Currie, 1973; Gerlach, 1973; Lammerink, 1973; Lammerink and Stewart, 1974; Manning *et al.*, 1974; Wyn-Williams and Logan, 1985), and small commercial areas have been grown since then for bird seed production and the health food market. However, a combination of economic and agronomic factors has meant that larger areas have never been grown in New Zealand.

Plant breeding developments since the early 1970s mean that sunflower could now be a viable alternative to the traditional arable crops. The early trials and the small area of commercial crops grown in New Zealand previously used mainly old open pollinated cultivars. However, hybrid cultivars have several agronomic advantages, including reduced plant height, and increased yield potential, pest and disease resistance, self compatability, stalk strength and uniformity (McMullen, 1985). Hybrids are not produced in New Zealand, but changed quarantine requirements have made it possible to import hybrid seed. This paper presents results from two trials which investigated the agronomic potential in Canterbury of a hybrid sunflower cultivar.

The main objective of the trials was to assess the yield potential and agronomic performance of a hybrid under well-managed conditions in Canterbury. A secondary aim was to test the effects on crop performance of different row spacings, plant populations, and desiccation treatments at physiological maturity. Row spacing and plant population were tested because overseas experience has shown that plant spacing often has a substantial effect on both individual plant and overall crop performance (Holt and Campbell, 1984; Jessop, 1977; Majid and Schneiter, 1987; McMullen, 1985; Miller and Fick, 1978; Miller *et al.*, 1984; Prunty, 1983; Robinson *et al.*, 1980; Vijayalakshmi *et al.*, 1975). Also, the cost of imported hybrid seed means that optimum seeding recommendations will be important for the crop's economic prospects. Desiccation treatments were tested because, unlike many other crops, sunflower seeds reach physiological maturity well before the rest of the plant. A prolonged wait for natural drying increases the risk of seed losses from bird damage, so effective crop desiccation at the correct time is essential (Allen, 1982; McMullen, 1985).

MATERIALS AND METHODS

Treatments and Statistical Design

Two trials of identical design and layout were conducted at Lincoln and Ashburton in the 1987-88 season. A split-split-plot design with four replicates was used to test the effects of the following treatments: main plots, two desiccation treatments at physiological maturity (glyphosate and diquat); sub-plots, two row spacings (0.45 and 0.90 m); and sub-sub-plots, four plant populations (40,000, 55,000, 70,000 and 85,000 plants per hectare).

Plots were 6 m long and 4.5 m wide (10 rows per plot in the 0.45 m row spacing, and 5 rows in the 0.90 m row spacing).

The desiccation treatments were abandoned at Lincoln and the crop harvested early because of bird damage when the crop was almost at physiological maturity. Therefore all results from the trial were analysed as a split-plot design with eight replicates. Results obtained from the Ashburton trial before final harvest were analysed in the same way, because there were no effects of the desiccation treatments until they were applied about 2 weeks before final harvest. Only the final harvest results were analysed according to the split-split-plot design.

Crop Management

Details of each site and its management are presented in Table 1. Crop management procedures were adapted from recommendations for sunflower crops in the U.S.A. (McMullen, 1985).

Pioneer 6440 hybrid seed (also called 'Emil'; supplied by Pioneer Overseas Corporation, Iowa, U.S.A.), treated with Apron-FL fungicide, was sown at both sites in early November 1987. Pioneer 6440 was chosen because it had performed well in a preliminary trial near Ashburton in the 1986-87 season in which several hybrids from the U.S.A. were evaluated (unpublished data). The trials were sown with a Stanhay precision seeder. Row spacing was 0.45 m and the seeder was set to achieve a 0.065 m seed spacing in the rows. About 3 weeks after plant emergence, the row spacing and plant population treatments were established by hand-hoeing alternate rows from the 0.90 m row spacing plots, and hand-thinning within rows to achieve the treatment plant populations in all plots.

After flowering was complete, on 18 and 21 February 1988 at Lincoln and Ashburton respectively, the diameters of two representative heads in each plot were recorded and they were then enclosed in calico bags to prevent seed losses. At maturity these heads were harvested separately so estimates could be made of losses from unprotected heads caused by bird damage or during post-harvest transport from the trial sites.

The desiccation treatments were applied to the main plots in the Ashburton trial on 23 March 1988, after the crop had reached physiological maturity. This was taken as the time when the bracts on the heads became yellow-brown (McMullen, 1985). Diquat was applied as Reglone at 3 l/ha and glyphosate as Roundup at 6 l/ha in 200 l/ha of water using a gas pressure operated backpack sprayer with a 2 m boom.

Measurements

Plant populations were determined about a month after planting and again at harvest time. The first measurement was to determine how effectively the treatments had been established, while the second was to determine losses during the season. On the first occasion (9 and 15 December 1987 at Ashburton and Lincoln respectively) counts were made of plants in three 6 m lengths of row per plot. At harvest, the number of heads removed from the area sampled in each plot for yield determinations was counted. Details of the harvest dates and procedure are given below.

Three characters which reflected the effects of the treatments on crop performance were measured in mid-January, about 2 weeks before flowering: plant height,

TABLE 1: Site details and crop management.

Location	Ashburton	Lincoln
Soil Type	Lismore silt loam, 0.3 m to gravel	Templeton silt loam, variable depth
Previous Crops	1985-86, barley 1986 winter, greenfeed oats 1986-87 field peas 1987, annual ryegrass	Pre-1985, grass/white clover pasture 1985-86, potatoes 1986-87, field peas
Cultivation	2 l/ha Glyphosate, plough, roll and disc, medium grub, maxi-till	Plough, winter fallow, grub, Cambridge roll
Herbicide	2 l/ha Trifluralin applied 1 week before sowing and incorporated by cultivation	
Fertiliser	130 kg/ha N:P:S = 20:10:8 broadcast and incorporated by cultivation immediately before sowing	125 kg/ha urea (N = 46) and 100 kg/ha DAP (N:P = 18:20) applied on 21 October 1987
Sowing Date	2 November 1987	3 November 1987
Irrigations	40 mm on 26 December 1987 40 mm on 9 February 1988	50 mm on 13 January 1988
Rainfall (mm) Nov. 1987 to Mar. 1988	224	145

ground cover, and stem strength. The heights of five representative plants were measured in each plot, and percent ground cover values were estimated visually. Stem strength was rated subjectively on a scale from 1 to 5. Immediately before harvest, plant heights were measured again using the same procedure as in mid-January. Subjective ratings were also made on scales from 1 to 5 of lodging severity, weed infestation and head angle. The latter character was related to head size, and the ratings were intended to reflect susceptibilities to neck break.

The trials were harvested on 14 and 31 March 1988 at Lincoln and Ashburton respectively. The same procedure was used at each site, except that a smaller area of each plot (5.4 m^2) was sampled at Lincoln than at Ashburton (8.1 m^2). All but four heads were cut by hand from the sample area in each plot and placed in onion bags. The four exceptions were the two heads in calico bags which were kept separate, and two further unbagged heads of the same diameters which were harvested separately into calico bags. All samples were placed on a forced air drier until the seed moisture content was reduced to 10%.

After drying, the number of heads and the diameter of every head were recorded before they were threshed using a stationery Hege combine harvester. The threshed samples were dressed and weighed, and 1000 seed weights of sub-samples determined. The pairs of damaged and undamaged bagged heads were threshed separately by hand, and the seed weight differences used to adjust the larger sample yields to account for bird damage and transport losses. Estimates of mean seed numbers per head and per m^2 were calculated from the results.

Oil content was measured by nuclear magnetic resonance (NMR) analysis on seed sub-samples from all plots, and oil yield estimates were calculated.

RESULTS AND DISCUSSION

The Ashburton site proved to be uniform and fertile and the resulting consistent crop performance meant that reliable assessments were obtained of the effects of the treatments on yield and agronomic performance. In contrast, the Lincoln site was more variable and less fertile and treatment effects were masked. There were no significant pest or disease problems in either trial.

Plant Populations

The target plant populations were not achieved precisely, even though the seed was sown with a precision seeder and plants were thinned by hand. The lowest population (40,000 per ha) was achieved in both trials, but in all other treatments occasional sowing misses and minor thinning errors caused progressively larger reductions of the actual values below the targets (Table 2). These effects were greater in the wider row spacing treatment and in the Lincoln trial.

However, the populations achieved in both trials spanned the expected optimum and more than covered the range likely to be used in practice. They were therefore considered to be sufficient to test adequately the effect of plant population on crop performance. Estimates soon after sowing showed excellent agreement with those at harvest (Table 2), indicating uniform populations with few plant losses during the growing season.

Agronomic Characters

Observations and measurements of agronomic characters (Table 3) were made with the aim of identifying the row spacing and plant population combinations with the least risk of crop damage and seed loss. Good results were obtained from the Ashburton trial which was twice subjected to very strong winds which caused significant

TABLE 2: Plant populations 5 weeks after sowing and head populations at harvest.

Treatment	Ashburton Plants per ha 9 December 1987	Ashburton Heads per ha 31 March 1988	Lincoln Plants per ha 15 December 1987	Lincoln Heads per ha 14 March 1988
Row spacing:				
0.45 m	59610	59420	58450	59670
0.90 m	55500	54880	54580	55970
Significance	**	**	**	*
SED	1140	760	700	1280
Target plant population:				
40000	40280	40990	38660	40400
55000	51390	50560	52440	54520
70000	63430	62450	61230	64470
85000	75120	74610	73730	71880
Significance	**	**	**	**
SED	1240	1460	1410	1920
R.S. x P.P.	N.S.	N.S.	***	**
C.V. (%)	6.1	7.2	7.0	9.4

lodging in some plots. Plants were considerably shorter than most cultivars tested previously in New Zealand (Lammerink and Stewart, 1974), with strong stems conferring good resistance to lodging, and crops were very uniform.

Plants at higher populations were generally taller, had thinner, weaker stems, and therefore showed more susceptibility to lodging than those at lower populations. On the other hand, ground cover was higher at the higher populations and this resulted in better suppression of

TABLE 3: Agronomic characters.

Treatment	Plant Height (cm) January	Plant Height (cm) March	Stem[1] Strength	Ground Cover (%)	Lodging[2]	Weeds[3]	Head[4] Angle	Head Diameter (cms)
Ashburton Trial:								
Row spacing:								
0.45 m	76.7	104.2	3.31	85.8	1.81	1.53	3.28	15.7
0.90 m	85.8	98.3	3.06	54.5	3.63	2.43	3.75	15.4
Significance	**	N.S.	*	**	**	**	**	N.S.
SED	1.9	3.3	0.09	1.2	0.18	0.18	0.14	0.2
Target plant population:								
40000	75.9	100.6	3.88	66.3	2.19	2.56	3.00	17.7
55000	80.3	102.5	3.25	68.8	2.63	2.00	3.19	16.1
70000	82.1	99.7	2.94	71.3	2.81	1.81	3.75	14.7
85000	86.6	102.2	2.69	74.4	3.25	1.56	4.13	13.7
Significance	**	N.S.	**	**	**	**	**	**
SED	1.3	1.6	0.15	1.3	0.19	0.15	0.19	0.3
R.S. x P.P.	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	4.6	4.5	13.5	5.4	19.4	22.0	15.5	4.9
Lincoln Trial:								
Row spacing:								
0.45 m	33.0	83.1	3.38	58.3	1.50	2.52	2.66	12.4
0.90 m	16.9	83.9	2.78	59.1	1.78	3.21	2.97	11.4
Significance	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SED	4.0	5.3	0.34	4.9	0.26	0.35	0.23	0.79
Target plant population:								
40000	20.6	78.4	3.19	56.9	1.63	3.50	2.63	13.2
55000	25.0	84.4	3.19	60.0	1.63	2.83	2.75	12.3
70000	26.3	84.4	3.13	58.8	1.75	2.55	2.75	11.3
85000	27.8	86.9	2.81	59.1	1.56	2.59	3.13	10.9
Significance	*	*	N.S.	N.S.	N.S.	**	*	**
SED	2.3	2.7	0.23	2.3	0.09	0.27	0.17	0.47
R.S. x P.P.	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.
CV (%)	26.2	9.0	20.9	11.2	16.0	26.2	17.4	11.1

NOTES:

[1] Stem strength scored on 15 January 1988. Rated on a scale from 1 to 5; 1 = thin, weak stem, susceptible to lodging or stem break; 5 = thick, strong stem, unlikely to lodge or break.

[2] Lodging scored on 14 March 1988. Rated on a scale from 1 to 5; 1 = no lodging; 5 = severe lodging.

[3] Weeds scored on 14 March 1988. Rated on a scale from 1 to 5; 1 = no weeds; 5 = bad weed infestation.

[4] Head angles scored on 14 March 1988. Rated on a scale from 1 to 5; 1 = heads horizontal, facing upwards; 3 = heads vertical; 5 = heads horizontal, facing downwards.

weeds. Head diameters at maturity were greatest at the lower populations but, despite the large size, the head angles in those plots were the most vertical, a result of their good stem strength.

There were no consistent plant height differences between the two row spacing treatments, particularly later in the season. However, the spacings caused other important differences, especially in the trial at Ashburton. Stems were thicker and stronger, and lodging much less at the 0.45 m row spacing. Also, ground cover and suppression of weeds were better with the narrow row spacing. However, row spacing had little effect on head size or angle.

Seed Yields and Yield Components

There were no significant differences in the effects of the two desiccation treatments on any of the yield or yield component results in the Ashburton trial. Therefore, results were re-analysed as a split-plot design with eight replicates.

The higher seed yield was obtained from the narrow row spacing treatment in both trials, although the difference was not statistically significant in the more variable Lincoln trial (Table 4). However, this result is of little practical significance, because it is mainly an artefact of the failure of the population treatments to achieve their targets; the yield differences between the row spacing treatments in the Ashburton trial were associated closely with the unintentional plant population differences. The row spacing treatments had no significant effect on either of the other two seed yield components, the 1000 seed weight or the number of seeds per head. These results agree with other reports which have found little effect of row spacing, within the range tested in these trials, on seed yield (Radford, 1978; Vijayalakshmi *et al.*, 1975).

Seed yields were highest at the lower plant populations in the trial at Ashburton but the population treatments had no significant effects on yield at Lincoln (Table 4). As numbers of heads and seeds per unit area increased, the number of seeds per head and 1000 seed weight both declined. These yield component trends agree generally with results found elsewhere, but the consequent responses of seed yield to plant populations vary widely among growing conditions (Holt and Campbell, 1984; Jessop, 1977; Majid and Schneiter, 1987; Miller and Fick, 1978; Miller *et al.*, 1984; Prunty, 1983; Robinson *et al.*, 1980; Vijayalakshmi *et al.*, 1975). However, our results agree generally with recommendations elsewhere. A consensus recommendation in the U.S.A. is to adjust plant populations in the range from 37,000 per ha in lower yield potential situations to 62,000 per ha on heavier, fertile soils with a good water supply. These populations are recommended regardless of row spacing (McMullen, 1985).

Oil Contents and Yields

There were no significant treatment effects on seed oil content or oil yield in the Lincoln trial, but both were significantly higher in the narrow row spacing treatment at Ashburton (Table 5). Oil contents were little affected by the treatments, and oil yields were highest at the lower populations, mainly in line with seed yield differences. These results also agree with trends found in other trials overseas.

CONCLUSIONS

Good yields and oil contents were achieved in both trials. The better crop was at Ashburton where the fertility and water supply were better. The mean seed yield was 2.60 t/ha with 46.7% oil content, or 1.22 t/ha oil yield while the

TABLE 4: Seed yields and yield components.

	Ashburton				Lincoln			
Treatment	1000 seed weights (g)	Seeds per head	Seeds per m²	Yield (t/ha)	1000 seed weights (g)	Seeds per head	Seeds per m²	Yield (t/ha)
Row spacing:								
0.45 m	34.4	1410	8060	2.74	41.3	840	4860	2.04
0.90 m	34.8	1370	7170	2.48	39.3	700	3960	1.57
Significance	N.S.	N.S.	**	*	N.S.	N.S.	N.S.	N.S.
SED	0.5	40	190	0.08	2.3	130	760	0.35
Target plant population:								
40000	39.1	1700	6960	2.72	44.8	850	3460	1.60
55000	35.8	1520	7610	2.73	41.4	900	4990	2.13
70000	32.4	1270	7910	2.55	37.4	700	4590	1.74
85000	31.1	1070	7980	2.43	37.5	630	4600	1.75
Significance	**	**	**	**	**	*	N.S.	N.S.
SED	0.7	40	260	0.08	1.9	100	590	0.24
R.S. x P.P.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S
CV (%)	5.8	8.7	9.5	8.6	13.5	34.9	37.6	37.3

TABLE 5: Seed oil contents and oil yields at 10% moisture content.

Treatment	Ashburton Oil Content (%)	Ashburton Oil Yield (t/ha)	Lincoln Oil Content (%)	Lincoln Oil Yield (t/ha)
Row spacing:				
0.45 m	47.0	1.29	43.7	0.89
0.90 m	46.4	1.15	44.6	0.70
Significance	**	**	N.S.	N.S.
SED	0.2	0.04	0.8	0.18
Target plant population:				
40000	45.8	1.25	44.1	0.71
55000	46.8	1.28	44.3	0.94
70000	46.9	1.20	44.1	0.77
85000	47.3	1.15	44.0	0.77
Significance	**	**	N.S.	N.S.
SED	0.2	0.04	0.5	0.12
R.S. x P.P.	*	N.S.	N.S.	N.S.
C.V. (%)	1.2	8.9	3.1	38.6

corresponding values at Lincoln were 1.80 t/ha, 44.1%, and 0.80 t/ha. The seed yields compare favourably with yields from hybrids in the U.S.A. where annual means vary from 1.0 to 1.5 t/ha, although 2.0 t/ha may be expected in favourable growing conditions, and 3.0 t/ha is considered exceptional (McMullen, 1985). Oil contents commonly range from about 38% to 50%, so the results from both these trials were relatively high.

The best overall crop performance was obtained from the combination of the narrower row spacing and the 55,000 plants per ha population. Although seed and oil yields were no higher than at 40,000 plants per ha, the agronomic characters were generally better. However, the practical recommendation in view of the cost of seed would be to aim for the lower end of the range. A possibility not tested in these trials is that populations below 40,000 per ha may be practicable. Some other trials have found no substantial yield reductions at populations as low as about 30,000 per ha (Miller *et al.*, 1984), but these run increasing risks of agronomic problems. Whatever plant population is selected, care is essential at planting to achieve a uniform stand of the target population. Robinson *et al.* (1982) showed that substantial yield losses result from unevenly spaced plants in a crop.

No differences were found between the desiccation treatments in the Ashburton trial. Therefore, although crop desiccation at physiological maturity is usually recommended to hasten drying to a harvestable moisture content, the present results showed no preference for either of the two chemicals tested.

The results from these preliminary trials demonstrate that there is good agronomic potential for hybrid sunflower to be a viable alternative to traditional arable crops in Canterbury. Ultimately, economic and market factors will determine whether or not it becomes established successfully. In its favour, sunflower has relatively low production costs compared with most other arable crops, and the potential to produce high yields. Further trials will be conducted in 1988-89 on different soil types at several locations in Canterbury, with the aim of testing consistency of performance.

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