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THE EFFECT OF MANAGEMENT PRACTICES ON THE YIELD AND QUALITY OF IRRIGATED SUNFLOWERS

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Sunflowers are a new crop in the irrigation areas in south eastern Australia where they have been grown commercially since 1968. Irrigated land occupies about one million hectares in the region which lies between latitude 33°S and 37°S. The areas has a semi-arid, temperate climate with mean extreme temperatures of about 31°C and 16°C in January and 14°C and 3°C in July. Rainfall varies from 30 cm to 50 cm and is uniformly distributed throughout the year. The soils of the area are primarily red-brown earths and grey and brown soils of heavy texture. The main irrigation farm enterprise is rice in the northern areas and dairying, beef cattle, fat lambs and winter cereal production in the south.

Sunflower seed production provides an alternate cash crop during the summer months. Commercial yields have been very variable and this study outlines the effect management could have on crop growth, seed yield and oil quality. The findings are based on surveys of commercial crops and a field experiment.

SURVEY OF COMMERCIAL CROPS

METHODS

A survey aimed to determine the influence of crop management on the yield of commercial crops was carried out in the 1971/72 and 1972/73 seasons in the northern irrigation areas (Murrumbidgee and Coleambally Irrigation Areas). Information was gathered on soil type, crop history of the field prior to sowing, fertiliser and seed rates, sowing date, irrigation practice, rainfall received, crop management and the final yield of the crop. Seed samples were collected from selected crops for oil content and quality determination. The data were analysed using multiple regression analysis.

RESULTS AND DISCUSSION

Crop yields were higher in 1971/72 (1380 kg ha^{-1}) than in 1972/73 (1150 kg ha^{-1}). In the first season seed yield was significantly associated with three management decisions — the date the crop was sown and the amount of water and nitrogen applied (table 1). A similar relationship was not established in the second season. Several factors probably contributed to these conflicting results. Firstly, the regression model is probably too simplified as it assumes a linear relationship between yield and the yield predictors and does not account for any interactions. Secondly, other factors which may influence yield in specific crops (e.g. weed population, disease, uneven irrigation) are not included in the model. The variation in the amount of irrigation water applied and rain received was considerably less in the second season.

Table 1

The multiple regression of management practices — sowing date (weeks after October 1), total rain and irrigation received after emergence (cm) and nitrogen applied (kg ha^{-1}) — on the yield of seed (kg ha^{-1})

Predictor	1971/72		1972/73		Both seasons	
	Coefficient	t	Coefficient	t	Coefficient	t
Intercept	1200		1300		1100	
Sowing date	—110	—4.22	21	0.50	—14	—0.51
Rain	29	2.34	—29	—1.50	— 5	—0.34
Irrigation	11	2.72	6	0.50	4	0.75
Nitrogen	8	2.30	—1	—0.13	3	0.73
100 R^2	75		22		7	
n	22		17		39	
Area of crop (ha)	1500		1900		3400	

The mean oil concentration in the achene was slightly higher in the 1971/72 season (45.0%) than in the 1972/73 season (43.5%). There was a significant decrease in oil concentration with the later sowing dates in 1971/72 but this relationship was not significant in the 1972/73 season (table 2).

Table 2

Effect of sowing date (weeks after October 1) on the oil concentration in seed (% oil)

Predictor	1971/72	1972/73	Both seasons
Intercept	48.9	44.4	45.1
Sowing date	—0.53	—0.22	—0.18
100 r^2	64**	13 ns	10 ns
n	13	19	32

The oleic acid concentration of the oil was negatively correlated with the linoleic acid concentration ($100r^2 = 96$, $n = 21$) fort both seasons. The linoleic acid concentration was very uniform for a single crop despite variations within the crop in soil type, seed yield and oil concentration in the achene (a.g. linoleic acid 71.9 ± 0.6 ($n = 4$); 71.8 ± 1.2 ($n = 9$). The protein concentration in the achene varied from 15.5% to 25.4% but was not significantly correlated with the oil concentration ($100r^2 = 1$).

The linoleic acid content of the fatty acids was significantly correlated with the sowing date (table 3). In the first season there was a steady increase in the linoleic acid concentration whereas in the second season there was a decline to the early November sowing and then an

Table 3

The effect of the time of emergence (weeks after October 1) on the linoleic acid concentration in the fatty acids of the seed

Predictor	1971/72	1972/73	Both seasons
Intercept	41	61	61
Time of emergence	4.2	—1.43	—0.40
(Time of emergence)^2	—0.14	0.15	0.082
100 r^2	87**	60**	50**
n	8	13	21

increase in the linoleic acid concentration. The linoleic acid concentration exceeded 70% of the fatty acids when the crop was sown after mid December. These results are consistent with those of Woodruff (1972) who showed that the linoleic acid concentration in the fatty acids of sunflowers was negatively correlated with temperature during the seed development phase.

SOWING DATE EXPERIMENT

METHODS

The effects of sowing date on the morphological development of sunflowers, seed yield and quality were studied in a trial set out in the 1973/74 season. The variety VNIIMK 6540 was sown at 3—4 week intervals with the first sowing in late autumn (May 24) and the last sowing in late summer (February 17). The seed was sown in rows 50 cm apart with two rows on beds separated by a furrow which was used for irrigation. Each plot was 11 m long and 8 rows (4 m) wide. Each treatment was replicated four times. The plants were thinned to a uniform density of 100,000 plants ha^{-1}. Fertiliser (30 kg P ha^{-1} and 100 kg N ha^{-1}) was applied at sowing. Irrigation was applied when the plants showed the first signs of water stress.

The time of 50% seedling emergence, head emergence, first anthesis and last anthesis was measured for each sowing. Dry matter production at bud emergence and last anthesis was determined by harvesting 10 randomly selected plants. The final grain yield was measured on 10 m lengths of the 2 rows on the centre bed.

RESULTS AND DISCUSSION — IRRIGATION

The total amount of irrigation water applied to each sowing date treatment increased to the early October emergence and then declined (table 4). The above average rains received in January (11 cm) reduced the amount of irrigation water required for the later sowings.

Table 4

Number of irrigations and amount of water applied to each sowing after crop emergence

Date of 50% emergence	Number of irrigations	Amount of water applied (cm)
24.V.73	2	18
24.VI.73	4	30
22.VII.73	4	31
23.VIII.73	4	26
15.IX.73	5	39
5.X.73	6	44
23.X.73	4	34
12.XI.73	4	23
5.XII.73	3	25
31.XII.73	4	31
24.I.74	3	18
17.II.74	3	17

Table 5

The effect of the time of emergence on morphological development

Date of 50% emergence	Days after emergence to 50%		
	Bud appearance	First anthesis	Last anthesis
24.V.73	93	137	149
24.VI.73	86	117	129
22.VII.73	71	99	114
23.VIII.73	58	85	95
15.IX.73	44	73	83
5.X.73	38	64	75
23.X.73	34	59	70
12.XI.73	31	55	65
5.XII.73	29	52	63
31.XII.73	32	50	57
24.I.74	28	50	59
17.II.74	27	54	62

Crop vigour as affected by diseases. The early-sown treatments developed a light infection of white blister rust *(Albugo tragopogonis)* and stem rot *(Botrytis* sp.) between bud emergence and anthesis. Rust *(Puccinia helianthi)* appeared on mature plants in early summer, spread to young plants during the summer and caused a severe reduction in growth on treatments sown between mid-November and late-December. The outbreak was partially controlled by routine spraying with mancozeb. The late January sowing was heavily infected with head rot *(Botrytis* sp.) during an extended wet period in April.

Morphological development. The time from seedling emergence to bud appearance decreased from 93 to 27 days as sowing was delayed from May to February (table 5). However, there was little change in the time from emergence to bud appearance for sowings from mid-November to mid-Februarly. The time from bud emergence to first anthesis decreased from 44 to 18 days (late May to late December emergence) and then increased to 27 days for the mid-February sowing. Anthesis lasted for about 10 days and was only slightly affected by the sowing dates.

Crop growth. Plant weight at bud appearance increased from the May to the September sowing and then declined to the late January sowing (table 6). Rust infection appeared to be responsible for the reduced plant weight in the later sowings. The effect at bud emergence was reflected in the plant weight and leaf area index at last anthesis. Yield reduction by rust infection can now be largely prevented by the use of suitable hybrid varieties.

Table 6

The effect of time of emergence on crop growth and seed yield (over dry weight)

Date of 50% emergence	Plant* weight g m^{-2}	Bud appearance last anthesis						Seed yield g m^{-2}
		Relative growth rate day^{-1}	Leaf*) area index	Plant weight g m^{-2}	Crop growth rate g day^{-1}	Leaf area index		
24.V.73	134	0.058	n.a.	750	11	2.0		118
24.VI.73	141	0.065	n.a.	n.a.	n.a.	n.a.		165
22.VII.73	185	0.083	n.a.	n.a.	n.a.	n.a.		214
23.VIII.73	181	0.102	1.44	1050	20	2.1		210
15.IX.73	222	0.136	2.12	1150	23	2.3		220
5.X.73	209	0.155	1.45	1250	25	2.0		201
23.X.73	191	0.175	1.41	1170	25	2.5		n.a.
12.XI.73	124	0.178	0.94	840	16	1.8		n.a.
5.XII.73	114	0.187	0.92	500	9	1.0		n.a.
31.XII.73	113	0.169	0.76	860	35	2.6		218
24.I.74	96	0.188	0.82	930	22	2.4		n.a.
17.II.74	147	0.211	1.05	680	15	3.0		n.a.
l.s.d. 5%	*27*	*0.004*	*0.13*	*120*	*3*	*0.4*		*27*

*) Corrected to value at bud appearance assuming exponential growth from emergence to harvest at about bud appearance; n.a. not available.

Maximum yield was reached with sowings from July to October and also in late December. The yield of the intermediate sowings was probably reduced by rust infection. The yield of the very early sowings was adversely influenced by climatic conditions unfavourable for growth and the yield of the late sowings was reduced by disease.

The high plant population used in the experiment may have reduced seed yield. *Fenton* (pers. comm.) recommended a plant population of 60,000 plants ha^{-1} under irrigated conditions in the region. Despite the high plant population, the maximum leaf area index of 3.0 was low when compared with other high yielding crops.

CONCLUSIONS

Climatic conditions have a major effect on the morphological and physiological development of sunflowers sown at different times in the irrigation areas of south-eastern Australia. Winter sown crops take twice as long to reach last anthesis as crops sown in summer. Preliminary results show that the yield potential of rust resistant varieties would be similar when sown between late-winter and mid-summer.

Variations in the yield of commercial crops was related to sowing date, amount of irrigation water and rainfall received and amount of nitrogen applied in one season but not in a second season. As other factors can influence the yield of specific crops, simple regression models to predict yield are likely to be unreliable.

The oil concentration in the achene was relatively high in commercial crops sown from September to January.

The linoleic acid concentration in the fatty acids increased with later sowings and exceeded 70% for mid-summer sown crops.

The early winter and late summer sown crops were subjet to head and stem rots and insect damage. Further research is required on the control of insects and fungal diseases, optimum plant populations and fertiliser and irrigation requirements in the irrigation environment.

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REFERENCES

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