DEVELOPMENT AND YIELD OF SAFFLOWER IN RELATION TO SOWING DATE AND PLANT POPULATION

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ABSTRACT

Safflower was sown at 4 to 6 weekly intervals from September to December 1976 and April to October 1977 at three plant populations using a 150mm row spacing.

Under cool spring and normal summer temperatures in year 1 crops matured, sequentially, from early March to late May with the September sowing giving the highest yield of 2.96 t ha $^{-1}$. Under cool spring but high summer temperatures and extreme moisture stress in year 2 crops sown over a 200 day period matured, sequentially, over 30 days from early February with the October sowing maturing 20 days earlier than in year 1. Under moisture stress in year 2 yields were reduced by 50% with all sowing dates giving equal yield.

Yield increased linearly over the population range to 10 to 30 pm $^{-2}$ for spring sowings of 1976. Under moisture stress in year 2 no yield response was obtained to the population range 100 to 200 pm $^{-2}$. As population was increased yield components decreased in the order heads per plant, seeds per head and seed weight.

Neither oil nor protein contents were proven to be affected by sowing date or population though winter sowings, at 23% oil content, averaged 3% less than spring sowings.

INTRODUCTION

Safflower makes only a small contribution to the world edible oil market. However, the oil is of considerable importance because of its high level (73-80%) of polyunsaturated fatty acids mainly in the form of linoleic acid. Principal uses are in cooking and margarine manufacture but the oil has industrial uses as a non yellowing, drying oil in the production of varnishes, lacquers and paints. As a by-product of oil extraction a whole seed or kernel meal is available for stock feed with the latter having a protein content of 65% (Godin and Spensley, 1971).

Oil of a similar quality to safflower is obtained from sunflower but production of sunflower, extensively tested in New Zealand, is unreliable and often uneconomic because of low yield through bird damage and fungal disease problems. Safflower offers an alternative and the discovery that meat and milk with reduced cholesterol levels can be produced by feeding vegetable oils high in polyunsaturated fatty acids has renewed interest in this crop's production in New Zealand (Raffar, 1976).

Climatically parts of New Zealand would appear suitable for safflower production. Yields ranging from 2.5-3.5 t ha $^{-1}$, satisfactory by overseas standards, have been obtained in Palmerston North with November sowing found to be more productive than December sowing (Massey University, 1973). However, the overseas practice of autumn to early spring sowing (Knowles, 1955; Beech, 1960; Dennis and Rubis, 1966; Harbison, 1968) has not been investigated. In the rosette stage safflower can tolerate an air temperature of -7°C (Purseglove, 1968). The survival of volunteer safflower, in a July sown lupin crop at this station, suggested over winter production was possible and that further information on the growth and yield of autumn to spring sowings was needed.

Overseas recommendation on plant population and row spacing vary considerably (Beech, 1960; Dennis and Rubis, 1966; Harbison, 1968). In New Zealand, trials at Palmerston North have shown a population of 150 pm $^{-2}$ in 150mm rows to be most productive (Massey University, 1973 and 1974) while on the square planting further increased yield (Raffar, 1976). Autumn sowings which allow a longer vegetative growth period could be expected to require a lower plant population than spring sowings to maximise yield and a combined sowing date population study was seen as desirable.

MATERIALS AND METHODS

A series of three, similar, sowing date x population trials were conducted in spring of 1976 and autumn and spring of 1977 on Horotiu sandy loam soil at the Rukuhia Research Farm, Hamilton. A split plot, randomised block design with four replicates was used. Main plots were three sowing dates and sub plots populations of 100, 150 and 200 pm $^{-2}$ made up of 16, 10m rows spaced at 150mm.

Each trial received a basal application of 26P and 52K kg ha $^{-1}$ during seedbed preparation and 1.0 kg a.i. ha $^{-1}$. Dinitramine was incorporated prior to each sowing for weed control. Nitrogen, 63 kg ha $^{-1}$, was applied at the 5 leaf stage to the 1977 plantings as the site was less fertile. Cultivar 022 was sown by grain drill at rates calculated to give the desired populations.

Crop vegetative and floral development were monitored weekly. At harvest measurements were made of yield (5, 9m rows) by small plot combine, plant populations (5 sets of 1m), heads per plant (3 sets of 10 plants), seeds per head (10 plants) and 100 seed weight. Oil content of seed was subsequently measured on an NMR unit and protein content estimated from seed nitrogen x 6.25.

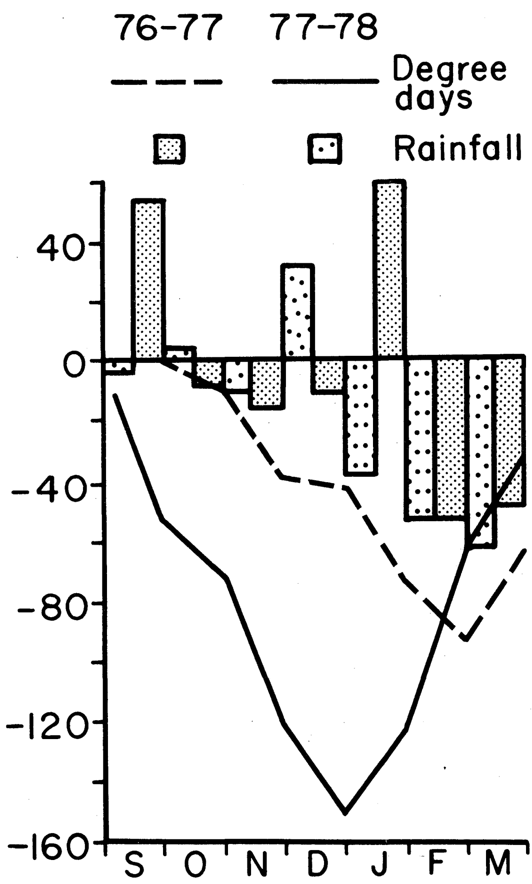
RESULTS AND DISCUSSION

Weather

Both temperature and rainfall patterns had a marked influence on crop development and yield. The differences between normal and seasonal monthly temperatures and rainfall are depicted in Figure 1.

Proceedings Agronomy Society of New Zealand 8; 1978

Figure 1. Seasonal differences from normal in monthly rainfall (mm) and accumulated degree days.

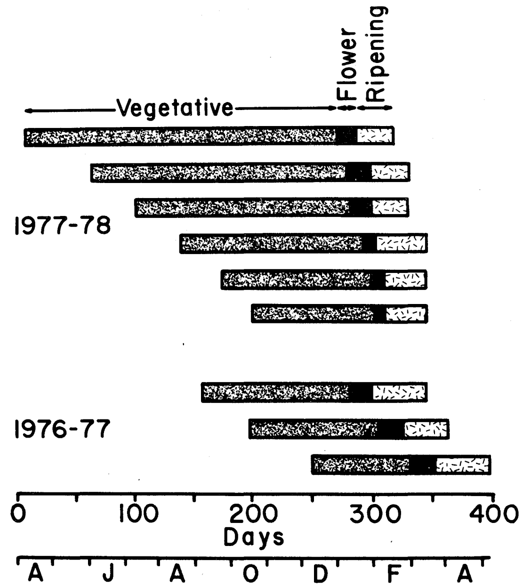


Sowing date effect

Development: In the winter to spring sowings of 1977 crop life span shortened progressively as sowing date was delayed (Figure 2). Sowings made over a 200 day period flowered and matured within 30 days of each other with the earliest sowing maturing in mid February. Flowering in safflower is promoted by long days and high temperatures (Zimmerman, 1955; Purseglove, 1968) which would account for the sowing date crop development pattern recorded. A pattern similar, though less pronounced, to that recorded in California under higher seasonal temperatures (Knowles, 1955). Under the lower summer temperatures of 1976-77 the spring sowings flowered and matured later and there was a less pronounced shortening of the growth season.

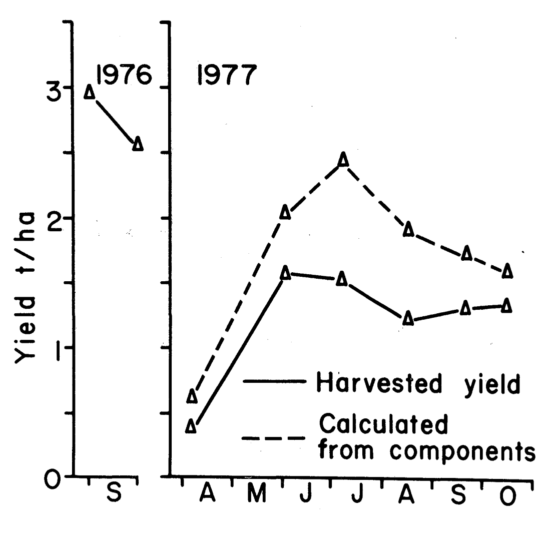
For autumn or early spring sowings the possibility of frost damage must be considered. The lowest grass minimum temperature experienced by the 1977 sowings was -4°C and in ongoing trials -8°C, without any crop damage occurring. The patterns of development recorded confirmed the possibility for making sowings of safflower through from autumn to late October in Waikato with the production of mature crops from February to late March.

Figure 2. Safflower development with time relative to sowing date.



Yield: Spring sowings in 1976 produced good yields (Figure 3). Comparable to yields obtained in the USA (Knowles, 1955) and in Palmerston North (Massey University, 1973 and 1974) despite established populations being only 25% of those intended and considered necessary for maximum yield in Palmerston North. The September sowing yielded 16% more than the October sowing. This, together with the loss of the December sowing through over late maturity, suggested a trend favouring early spring sowing as was found in Palmerston North (Massey University, 1973).

Figure 3. Yield sowing date relationship.



Sowings made from May through to October in 1977 (Figure 3) produced yields only 50% of those achieved in the previous spring trial even though the desired plant populations were achieved. An exceptionally low yield from the April sowing followed excessive population (225 pm^{-2}) and the development of a leaf and bud scorch in November, the cause of which remained unidentified. Low yields from the remaining sowings and the lack of response to sowing date were attributed to the extreme summer moisture stress experienced, under low rainfall and high temperature conditions (Figure 1) and were considered uncharacteristic of a normal season. None of the sowings commenced flowering before January and thereafter moisture stress increased throughout the flowering and filling period of each sowing.

Harvested yield did not respond to sowing date but yield calculated from the components suggested a pattern of increasing yield for the autumn-winter sowings and declining yield for the spring sowings. Each component, head number, seeds per head and seed weight tended to follow the calculated yield trend though only seed weight showed significant changes (Table 1). The suggested yield trend calculated from components was both more reasonable and acceptable in relation to the seasonal weather pattern than that recorded at harvest. However, the authenticity of the calculated yield trend must remain doubtful and the sufficiency of the sample size taken to assess each component, especially head number per plant, questioned.

Oil and protein levels: Oil content averaged 26% and though low by US standards of 36-40% (Knowles, 1955) was characteristic of the cultivar. Oil contents were equal to (Raffar, 1976) or up to 6% higher (Massey University, 1973) than recorded at Palmerston North. Autumn sowings appeared to average some 3% lower in oil content than spring sowings but the use of separate trials precluded a reasonable statistical comparison. Oil levels from spring sowings in the two years showed close agreement. Within autumn or spring sowings oil content was little affected by sowing date though a 1% improvement was recorded for the September sowing of the 1977 spring trial (Table 1).

Protein content, averaging 14% on a whole seed basis, would give a crude protein content for undercorticated meal of 19%. A level similar to overseas levels for thick hulled cultivars (Knowles, 1955). Sowing date had no significant effect on protein content though a trend for an increase in protein content as sowing was delayed from autumn into winter may have been masked by high sample variability (Table 1).

Population effects

Low field emergence in the spring sowings of 1976 resulted in populations 75% below those required (Table 2). Despite low populations high yields were obtained with yields showing a linear response within the population range achieved. In 1977, neither winter nor spring sowings showed any increase in yield to populations ranging from 90-187 pm^{-2}. While lack of response was most probably due to the pattern of moisture stress during the growing season the yield achieved with low populations in the previous spring sowings suggest the population range selected may have been altogether too high. An interaction between sowing date and plant population which was anticipated did not occur. The persistence of the rosette form until a similar date for all sowings and the absence of branching in the crop may in fact preclude prolonged winter growth from contributing to increased reproductive development and yield. As plant population was increased all components of yield were decreased in the order heads per plant, seeds per head and seed weight.

TABLE 1: Effect of sowing date on plant and seed characteristics

Month and year sown	Plant Popn m^{-2}	Height cm	Heads per plant	Seeds per head	100 seeds wt. (g)	oil %	Protein %
Sept 1976	15	132 a	–	–	3.7 a	25.3 a	14.6 a
Oct	29	125 a	12.8$^+$	–	3.5 a	26.8 a	14.8 a
Nov	36$^+$	103$^+$	11.7$^+$	–	–	–	–
C.V.%	5.7	5.2	–	–	4.2	4.5	8.6
Apr	231$^+$	135$^+$	1.4$^+$	7.3$^+$	2.8$^+$	25.0$^+$	13.1$^+$
June	105	127 aA	4.79 a	12.2 a	3.29 bB	22.0 a	13.6 a
July	134	108 bB	5.29 a	10.1 a	3.39 aA	24.5 a	15.1 a
C.V.%	6.5	8.5	15.9	23.9	1.0	29.0	37.0
Aug 1977	126	116 a	3.72 a	12.0 a	3.38 aA	26.1bB	14.2 a
Sept	163	113 a	3.13 a	10.7 a	3.25 abAB	27.3 aA	12.6 a
Oct	141	114 a	3.67 a	10.0 a	3.10 bB	26.0bB	14.8 a
C.V.%	27.9	10.6	27.4	19.6	5.4	2.5	22.0

$^+$ values not included in analysis

Statistical analyses apply only within each group of three sowings.

TABLE 2: Effect of population on yield and plant and seed characteristics

	Plant popn m^{-2}	Height cm	Heads per plant	Seeds per head	100 seeds wt. (g)	Yield t ha^{-1}	Oil %	Protein %
1976 Spring	15	127 bA	15.1^{+}	–	3.55^{+}	2.39 bB	26.0 a	15.2 a
	24	128 abA	12.5^{+}	–	3.63^{+}	2.88 aA	26.1 a	14.9 a
	28	131 aA	9.1^{+}	–	3.55^{+}	3.00 aA	26.1 a	14.0 a
C.V.%	19.8	2.2	–	–	–	8.0	2.5	8.7
1977 *Autumn	90	120 aA	6.06 aA	13.2 aA	3.41 aA	1.60 a	23.1 a	13.6 a
	120	114 bA	4.38 bAB	11.8 aA	3.30 bA	1.54 a	23.3 a	14.8 a
	149	119 aA	4.22 bB	8.6 bB	3.31 abA	1.58 a	23.4 a	14.6 a
C.V.%	14.4	3.5	17.0	18.2	2.8	14.3	5.2	8.1
1977 Spring	100	117 aA	4.29 aA	11.8 aA	3.32 aA	1.28 a	26.6 a	14.1 a
	143	116 aA	3.46 bB	11.3 aA	3.27 aA	1.30 a	26.2 a	13.6 a
	187	110 bB	2.77 cC	9.6 bB	3.15 bB	1.34 a	26.6 a	13.9 a
C.V.%	10.1	3.8	15.5	11.9	2.2	7.7	1.6	11.0

* Analysis of June and July sowings only
$^{+}$ Values not included in analysis
Statistical analyses apply only within each group of three sowings.

Neither oil nor protein levels were affected by plant population changes.

CONCLUSIONS

Autumn-winter sowings while possible for Waikato give only a small time advantage in maturity date over spring sowings. Winter sowings need then to outyield spring sowings. No such yield advantage was found under the cold spring - hot dry summer conditions experienced and further study under more normal weather conditions is required.

Spring sowings must be made no later than early November if crops are to mature, in all years, before April 1st.

No conclusion was reached as to optimum plant population.

ACKNOWLEDGEMENTS

The authors wish to thank Messrs R. Kidd and J. Poll for field assistance, Mr J. Lammerink, C.R.D., DSIR for oil content analysis, Mr F. Dorofaeff for analysis of nitrogen content and Mr J. Waller for direction in statistical analysis.

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