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Winter sown sunflowers on the Darling Downs, Queensland

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Summary

Sunflowers sown on the Darling Downs during August in 1976, 1977 and 1978 produced substantial yields for dryland conditions, but oil contents were generally low. In 1977, July sowings had lower yields than the August sowing, due to frost damage.

Early maturing cultivars had higher harvest indices than later cultivars, but early and late cultivars produced similar achene yields because early cultivars had lower biological yields, even at high plant population densities. Nevertheless, the early cultivars were more efficient in producing these yields and produced them faster.

Sunflowers are recommended for August sowings on the Darling Downs, provided sites are relatively frost free and winter weeds can be controlled. Early cultivars should be sown at 100 000 plants ha^{-1} and mid-maturing and late cultivars at 50 000 plants ha^{-1}.

1. INTRODUCTION

On the Darling Downs in Queensland, oilseed sunflowers (*Helianthus annuus* L.) are normally grown as a dryland summer crop. Growing conditions are characterized by low unreliable rainfall (700 mm per annum) and high temperatures (32°C max. and 18°C min.) (Vandersee 1975).

Downes (1974) pointed out that oilseed sunflower is not suited to dryland summer cropping in such an environment. The sunflower's C-3 pathway of photosynthesis is less efficient in utilizing available water than the C-4 pathway of other summer crops such as sorghum and maize. Ecologically, C-3 species are dominant in high latitudes, in high altitude communities and during cool seasons (Moore 1981). Furthermore, sunflower yield declines as temperature rises under phytotron conditions (Downes 1974). Data from irrigated time of sowing studies in the field also indicate that high temperatures reduce sunflower yield (Lehman, Robinson, Knowles and Flock 1973; Leon Lopez 1974).

Achene quality is also adversely affected by water stress and high temperatures. Sunflower oil content declines with soil water stress (Muriel and Downes 1974; Talha and Osman 1975) and with increase in temperature when other environmental factors are held constant in a phytotron (Downes 1974; Harris, McWilliam and Mason 1978). Percentage linoleic acid (desirable) also declines at high soil water stress (Talha and Osman 1975) and at high temperatures (Grindley 1952; Kinman and Earle 1964; Canvin 1965; Keefer, McAllister, Uridge and Simpson 1976).

High yield and quality should, therefore, be possible when achenes develop in spring or autumn when temperature and evaporative demand are low.

The aim of this work was to assess the field performance of sunflowers sown in late winter on the Darling Downs. Early maturing cultivars were used in an attempt to confine the growing period to low temperatures and low evaporative demand. Later maturing cultivars were grown for comparison. Since early maturing cultivars develop into small plants, particularly when sown in winter (Downes 1974), high plant population densities could be necessary to maximize crop yield. Field experiments were designed with cultivars of different maturities and a range of plant population densities to examine the response of sunflowers to winter sowing on the Darling Downs.

2. MATERIALS AND METHODS

Experimental and cropping data are presented in Table 1. Soil samples for gravimetric soil water determination were taken at sowing at intervals of 10 cm from 0 to 30 cm and 30 to 120 cm in 1976 and 1977, and at intervals of 20 cm from 0 to 140 cm in 1978. Weeds were removed by hoeing. In 1977, infestations of Rutherglen bug (*Nysius vinitor* Berg.) on all three sowings were controlled with methidathion on 1 and 16 November. In 1978, *Heliothis* larvae were controlled with thiodan on 20 November. All experiments were virtually disease free. Birds were deterred with scare-web spread over the plots at the completion of flowering.

Table 1. Experimental and cropping data

Attribute	Sowing date				
	3 Aug 76	13 Jul 77	28 Jul 77	17 Aug 77	10 Aug 78
Site	Brookstead	Nangwee	Nangwee	Nangwee	Toowoomba
Row spacing (cm)	42	36	44–132	44	50
Plot size (m)	2.52 × 10	. .	3.52 × 10	3.52 × 10	2 × 20
Harvest datum area (m)	0.84 × 6	1.84 × 4.3	1.76 × 6	1.76 × 6	1 × 8
Soil type*	Anchorfield clay	Mywybilla clay	Mywybilla clay	Mywybilla clay	Kynoch clay loam
Available soil water at sowing (mm)	184	218	218	218	140
Fertilizer applied (kg ha^{-1})	N:80	N:90 P:25 Zn:32	N:90 P:25 Zn:32	N:90 P:25 Zn:32	N:50 P:15 S:2

*Reeve, Thompson and Beckmann (1960).

Sowings on 3 August 1976 and 17 August 1977 consisted of 4 × 4 factorial, randomized block designs (two and three replications respectively) with four cultivars (Siroleo, Hysun 10, Sunfola 68-2 and Hysun 30) and four plant populations (25 000, 50 000, 100 000 and 150 000 plants ha^{-1}). The desired plant populations were obtained by oversowing and thinning. On 13 July 1977, a block of Siroleo only was sown at 150 000 plants ha^{-1}. On 28 July 1977, all four cultivars were sown in three replications and, because of low emergence in some rows, were thinned to 100 000 plants ha^{-1} in paired rows 44 cm apart with 176 cm between paired row centres. On 10 August 1978, all four cultivars were sown in four replications and thinned to 50 000 plants ha^{-1}.

Climatic data consisted of daily rainfall (Figure 1) and daily maximum and minimum temperatures in a Stevenson screen. Mean daily temperatures (maximum + minimum)/2 are shown in Figure 1. A heavy frost was defined as a minimum screen temperature of 0°C or lower and a light frost as a minimum from 0 to 2°C. Frost data are shown in Figure 1.

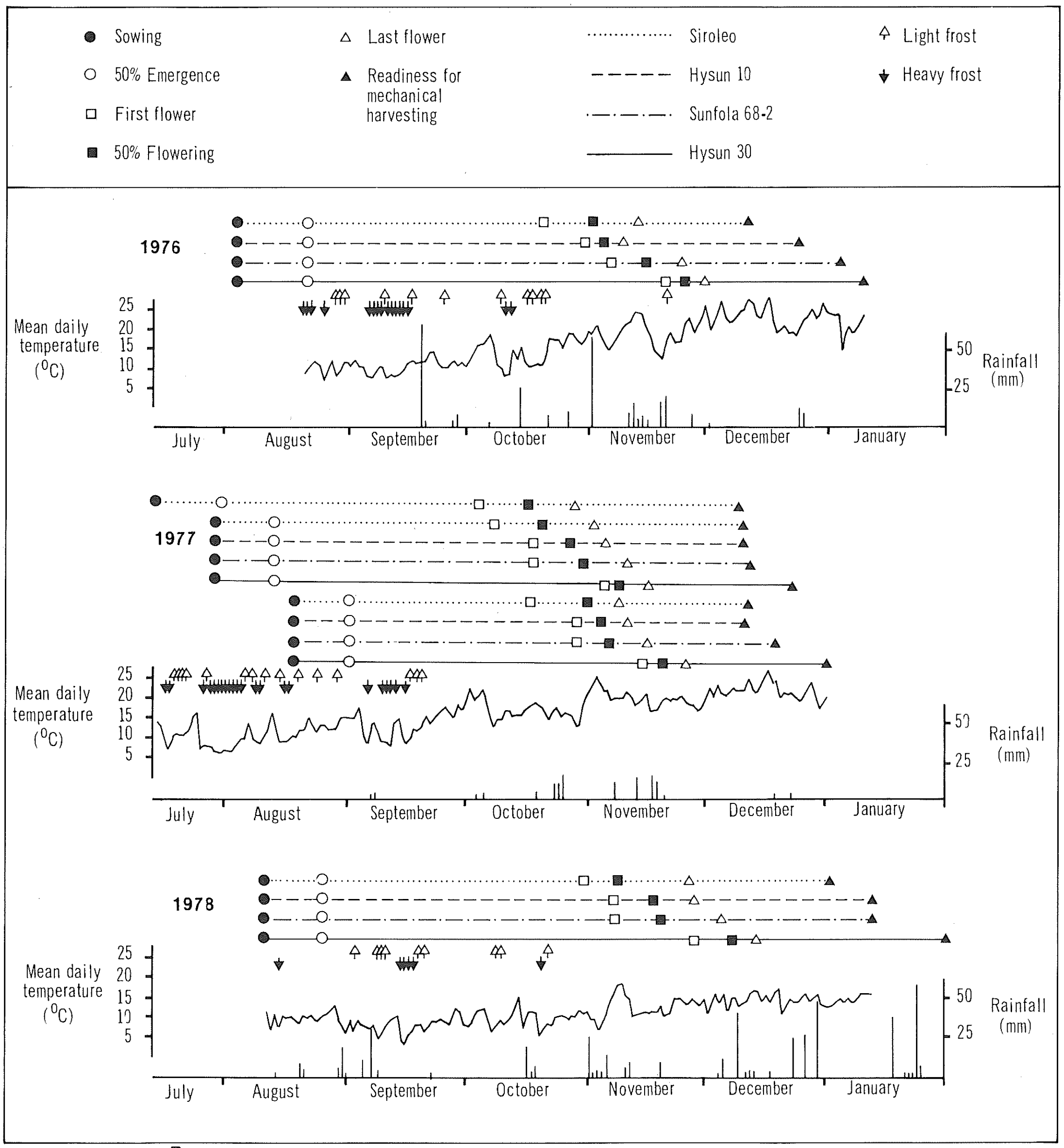

Figure 1. Temperature, frost incidence, rainfall and phenology during crop growth.

Fifty percent flowering (50F) was defined as the time when 50% of plants had open ray florets. Plant height from ground level to the centres of heads was determined on 10 plants per plot. Harvest index was determined from weight of achenes at zero moisture percentage and total weight of oven dry tops at harvest. The hand harvested heads were threshed in a stationary thresher to determine achene yield. In 1976 and 1977 oil percentage was determined by nuclear magnetic resonance (NMR), and linoleic acid percentage (on bulk samples of each cultivar) by refractive index (Simpson 1977).

3. RESULTS

Phenology

Time from sowing to emergence, first flower, 50F, last flower and readiness for mechanical harvesting are shown in Figure 1. Siroleo was generally slightly quicker to flower and mature than Hysun 10, which was quicker than Sunfola 68–2, which was quicker than Hysun 30. The earliest dates of 50F were in late October–early November.

Frost damage

Symptoms of frost damage included leaf and head distortion, white venation of the leaves and partial sterility. August sowings were generally frost tolerant, but July sowings suffered frost damage, which reduced yield (Table 2).

Table 2. Effect of cultivar and plant population on achene yield at 6% moisture content (kg ha^{-1}) and oil percentage. (Oil percentages on a moisture-free basis are shown in parentheses)

Sowing date	Cultivars	Plant population ha^{-1}				l.s.d. (P = 0.05)
		25 000	50 000	100 000	150 000	
3 Aug 76	Siroleo	1538 (38.7)	1832 (38.8)	2013 (36.8)	1880 (37.1)	447 (1.5)
	Hysun 10	1362 (34.4)	1544 (34.7)	2248 (35.7)	1995 (36.2)	
	Sunfola 68-2	1725 (37.5)	2277 (36.9)	1732 (36.7)	1766 (37.7)	
	Hysun 30	1708 (40.2)	1753 (37.6)	1663 (38.4)	1732 (38.0)	
13 Jul 77	Siroleo				532 (39.1)	
28 Jul 77	Siroleo			789 (42.5)		N.S. (1.7)
	Hysun 10			965 (42.2)		
	Sunfola 68-2			1018 (43.5)		
	Hysun 30			1000 (46.6)		
17 Aug 77	Siroleo	763 (41.4)	1054 (42.3)	1084 (42.9)	964 (42.6)	183 (1.2)
	Hysun 10	1306 (41.2)	1366 (40.1)	1293 (40.7)	1286 (42.0)	
	Sunfola 68-2	1048 (41.3)	1397 (41.6)	1276 (42.1)	1082 (42.7)	
	Hysun 30	1108 (39.1)	1420 (42.2)	1062 (43.7)	897 (44.4)	
10 Aug 78	Siroleo		1232			312
	Hysun 10		1890			
	Sunfola 68-2		1777			
	Hysun 30		2658			

Growth and yield data

Achene yields are shown in Table 2. In both the factorial trials, there were significant cultivar × population interactions for achene yield. In the 3 August 1976 sowing, highest yields (that is yields not differing significantly from the highest treatment yield) were produced by Siroleo (50 000 to 150 000 plants ha^{-1}), Hysun 10 (100 000 to 150 000 plants ha^{-1}) and Sunfola 68-2 (50 000 plants ha^{-1}). In the 17 August 1977 sowing, highest yields were produced by Hysun 10 (all populations), Sunfola 68-2 (50 000 to 100 000 plants ha^{-1}) and Hysun 30 (50 000 plants ha^{-1}). Hysun 30 had the disadvantage of drier finishing conditions than the other cultivars in both seasons. In 1978 when finishing conditions were favourable for all cultivars, Hysun 30 produced the highest yield. Yields of other cultivars in 1978 may have been reduced by sub-optimal plant populations.

Early cultivars appeared to require higher population densities than medium and late cultivars. In 1976, when rainfall during crop growth was similar to the long term average for that period, populations of 50 000 to 150 000 plants ha^{-1} were optimum for Siroleo, 100 000 to 150 000 for Hysun 10, 50 000 for Sunfola 68-2 and 25 000 to 150 000 for Hysun 30. In 1977, when rainfall was below average, the optimum populations were 50 000 to 150 000 for Siroleo, 25 000 to 150 000 for Hysun 10, 50 000 to 100 000 for Sunfola 68-2 and 50 000 for Hysun 30.

In both factorial trials, there were significant cultivar × population interactions for oil percentage, but little absolute variation in oil percentage in any one year (Table 2).

Harvest index increased with the earliness of maturity of cultivars (Table 3). In both factorial trials, there were significant cultivar × population interactions for harvest index (Table 3). Increase in plant population tended to lower harvest index except in 1976 when Hysun 10 populations of 100 000 to 150 000 plants ha^{-1} had higher harvest indices than 25 000 plants ha^{-1}.

Table 3. Effect of cultivar and plant population on harvest index

Sowing date	Cultivars	Plant population ha^{-1}				l.s.d. (P = 0.05)
		25 000	50 000	100 000	150 000	
3 Aug 76	Siroleo	35.9	38.3	38.1	35.3	4.9
	Hysun 10	28.3	32.6	35.4	35.2	
	Sunfola 68-2	36.5	37.3	30.0	27.5	
	Hysun 30	27.7	26.3	24.3	23.3	
17 Aug 77	Siroleo	42.8	39.4	38.6	32.8	3.0
	Hysun 10	42.1	39.8	36.6	35.4	
	Sunfola 68-2	40.5	37.1	35.0	29.8	
	Hysun 30	23.5	26.4	21.7	19.3	
10 Aug 78	Siroleo		43.2			3.3
	Hysun 10		37.7			
	Sunfola 68-2		37.4			
	Hysun 30		33.8			

Plant height decreased with the earliness of maturity of cultivars (Table 4). There was a significant cultivar × population interaction for plant height in 1977 but not in 1976 (Table 4). In 1977, high population densities reduced the height of Hysun 10, Sunfola 68-2 and Hysun 30 but not Siroleo.

Table 4. Effect of cultivar and plant population on plant height (cm)

Sowing date	Cultivars	Plant population ha^{-1}				l.s.d. (P = 0.05)
		25 000	50 000	100 000	150 000	
3 Aug 76	Siroleo	94.3	80.8	93.5	94.3	10.1
	Hysun 10	89.1	92.2	93.7	94.0	
	Sunfola 68-2	121.5	120.8	128.5	119.5	
	Hysun 30	136.3	142.7	140.4	152.1	
17 Aug 77	Siroleo	54.0	53.5	54.5	55.3	6.1
	Hysun 10	72.4	66.5	63.8	61.2	
	Sunfola 68-2	69.5	74.2	66.2	67.2	
	Hysun 30	108.6	100.4	92.2	86.6	
10 Aug 78	Siroleo		82.1			8.8
	Hysun 10		99.5			
	Sunfola 68-2		103.4			
	Hysun 30		127.1			

Linoleic acid percentages are shown in Table 5. Two values were much higher than the others: Siroleo in 1976 (70.5%) and Sunfola 68-2 in 1976 (68.9%).

Table 5. Percentage linoleic acid in oil from bulk samples of each cultivar. (Predicted values from Keefer *et al.* 1976 are shown in parentheses)

Cultivar	Sowing date		
	3 Aug 76	28 Jul 77	17 Aug 77
Siroleo	70.5 (69.3)	52.7 (60.7)	56.2 (54.2)
Hysun 10	57.0 (63.6)	58.8 (64.2)	55.0 (63.7)
Sunfola 68-2	68.9 (58.0)	58.8 (64.2)	58.5 (63.7)
Hysun 30	52.2 (68.7)	48.0 (61.2)	56.2 (55.3)

4. DISCUSSION

Substantial yields of August sown, dryland sunflowers on the Darling Downs were recorded in 1977, despite below average rainfall, and in 1976 and 1978, despite late frosts. Sound performance during the drought conditions of 1977 was attributed to the high water holding capacity of the black earth soil and the relatively low temperatures and evaporative demand at flowering in late October–November. Frost tolerance was attributed to the sunflower's moderate resistance to low temperature in the early stages of growth (Matheson 1972) in combination with slow early growth and plant hardening at low temperatures.

However, slow early growth makes winter sown sunflowers susceptible to competition from faster growing winter weeds. While many of these can be controlled with the pre-emergence herbicide trifluralin (for example graminaceous weeds and some broadleaf weeds), some cannot be controlled in sunflowers at present (for example *Polygonum convolvulus* and *Rapistrum rugosum*). Where such weeds occur, winter sown sunflowers are not recommended.

Oil contents were low for the cultivars studied, particularly in 1976. It appears that the influence of low temperatures at flowering is not sufficiently dominant to increase oil content under field conditions. This has also been shown by Keefer *et al.* (1976) and Harris *et al.* (1978).

Linoleic acid percentages lay within the range reported for Queensland by Bridge, Crossley and Hilditch (1951) (50 to 71%), but variation within this range could not be explained in terms of mean daily temperatures 3 to 5 weeks after flowering, as suggested by Keefer *et al.* (1976).

Harvest index increased with cultivar earliness. Achene yields were no higher in early cultivars, however, because biological yield (total dry weight of plant tops) decreased with earliness, even when early cultivars were grown at high plant populations. Production of a given achene yield from a lower biological yield represents a more efficient cropping system with less use of water and plant nutrients from the soil. This reduced water use is not due to shallower rooting depths in the short, early cultivars but to lower daily water use and reduced crop duration (Dubbelde, Harris and McWilliam 1982). Thus more water should remain in the soil and more rainfall should be available for fallow moisture accumulation. This additional soil water is then available for use by subsequent crops and can enhance the prospects of opportunity cropping after sunflower. Furthermore, if early cultivars can produce the same achene yield in less time, this represents an agricultural advantage in terms of reduced time in the field and therefore fewer risks to the grower. The lower plant height of early cultivars also helps mechanical harvesting.

If early cultivars are to be sown in winter, higher plant populations than the 40 000 to 60 000 plants ha^{-1} recommended for summer crops on the Darling Downs (Radford 1978) appear necessary. A population of 100 000 plants ha^{-1} is recommended for early cultivars (such as Siroleo and Hysun 10) sown in August on the Darling Downs; 50 000 plants ha^{-1} is recommended for late cultivars (such as Hysun 30).

Since winter sown sunflowers are grown during the same period as winter crops, they should be evaluated as an alternative winter crop. In 1976, raingrown Gamut wheat sown in early June beside the sunflower site yielded 3360 kg ha^{-1} compared with the highest yielding sunflower treatment of 2277 kg ha^{-1}. Sunflower prices are typically double those of wheat, however, and input costs for both crops are similar. In 1977, the best wheat crops in the area yielded 2500 kg ha^{-1}, while the highest yielding sunflower treatment was 1420 kg ha^{-1}. However, wheat sown in August produces lower yields than earlier sown wheat (Stevens 1965). Therefore, sunflowers are a more profitable alternative for August sowings, provided a relatively frost free field is available and winter weeds can be controlled. August sowing is for opportunity crops only, however, since the probability of sowing rains at this time is low.

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