The effect of sowing time on the growth, yield and water use of safflower (*Carthamus tinctorius* L.): some preliminary results.

Wachsmann, N.G., Jochinke, D.C., Knights, S.E. and Norton, R.M.
JCCI, Department of Crop Production, Longerenong College, The University of Melbourne, VIC 3401

Abstract
In southern Australia, safflower (*Carthamus tinctorius* L.) is frequently planted in spring in years of high winter rainfall. This 'opportunistic' approach to sowing safflower can result in sub-optimal sowing times and variable yields. A sowing time (July – October) experiment was conducted near Horsham, Victoria. The number of days between sowing and flowering declined with delayed sowing (143 – 66 days), but growing day degree requirements were similar (822 – 776 GDD_{base7}). Maturity biomass declined from 5865 kg/ha (July) to 1382 kg/ha (October). Grain yield was highest for the July sowing (698 kg/ha) and yields declined by 38 kg/ha for each week that sowing was delayed beyond July 14. In the dry season, all treatments extracted all available water in the upper 1 m of soil, with little change below 1m.

Aim
Crops capable of producing economic yields from a range of sowing times are necessary when wet winter conditions or management rationale suggest spring sowing. Although Colton (1988) advised that delaying the sowing of safflower beyond June or July results in reduced yields, Stanley *et. al.* (1995) suggested that satisfactory yields can be obtained from September and October sowings, when moisture is adequate. Most growers currently sow safflower in August or September, but about 40 % have reported of poor or variable yields (Wachsmann *et. al.* 2001). The experiment reported here was undertaken to investigate the effect of four sowing times (July to October) on safflower growth, yield and water use.

Methods
The experiment was conducted at Longerenong (36.7 °S, 142.3 °E) in the Victorian Wimmera. Average annual rainfall is 420 mm (372 mm in the 12 months to February 2001). The Wimmera grey clay soil (pH 7.5_{CaCl_2}) was cultivated before predrilling fertiliser (14.7 kg P, 6.7 kg S and 2.2 kg Zn/ha). Trifluralin was applied before sowing each treatment and incorporated whilst predrilling urea (51 kg N/ha). Glyphosate was used to control weeds in unsown plots until their appropriate sowing time. Experimental design was a 4 × 4 Latin square with 6.8 m by 20 m plots. Treatments were sown on the 14 July, 14 August, 15 September and 16 October 2000. Seed (cv. Sironaria) was treated with fungicide and the target density was 40 plants/m^2. Sowing depth was 20 mm and the row spacing 220 mm. Pests were controlled with recommended rates of endosulfan (emergence) and deltamethrin (flowering). Broadleaf weed control was achieved with 3 g a.i. metsulfuron/ha at safflower elongation. Phenology was monitored and climatic data recorded by an onsite weather station. Biomass and Green Area Index (GAI) were assessed at elongation, branching, flowering and at maturity. Soil water (2 m depth) was determined gravimetrically before sowing and at the above growth stages. Grain yield was assessed from hand and header samples.

Results and Discussion
The time required to reach each phenophase declined ($P < 0.001$) with each delay in sowing time, but Growing Day Degree (GDD) requirements were similar for all treatments. For example, flowering commenced 143, 115, 87 and 66 days after sowing for the July to October treatments respectively, but the corresponding GDD_{base7} were 822, 795, 783 and 776. The result generally supports Esendal (1997) in that phenological development in safflower is largely dependent on temperature rather than photoperiod.

Total biomass at branching, flowering and maturity, progressively declined ($P < 0.01$) with each delay in sowing time. At branching, the July sowing (2235 kg DM/ha) had 2.5 times the biomass of the October sowing and the differences increased as the season progressed. By maturity, the July sowing (5865 kg DM/ha) had more than 4 times the biomass of the safflower sown in October. Over the entire season, the July and August (34.7 and 32.8 kg DM/ha/day) treatments averaged significantly ($P < 0.01$) faster growth rates than the September and October (23.7 and 15.4 kg DM/ha/day) treatments, which combined with a longer growing season allowed earlier sown treatments to accumulate a greater amount of biomass by maturity. There was a strong ($P < 0.01$) linear relationship between total biomass at maturity and sowing time; m*aturity biomass = 5945 – 48.9 days after July 14*, $r^2 = 0.91$ (Figure 1). Moisture stress caused premature leaf senesce resulting in very low GAI values, in the range of 0.3 to 0.6, at flowering.

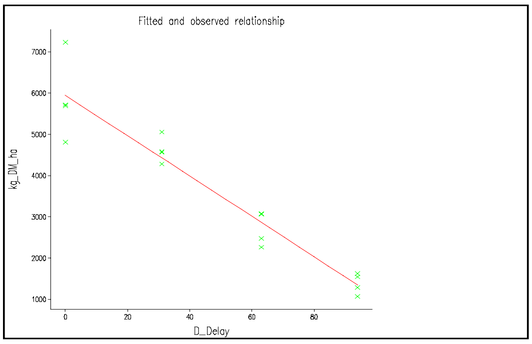

Figure 1: Biomass at maturity (kg DM/ha) vs. sowing time

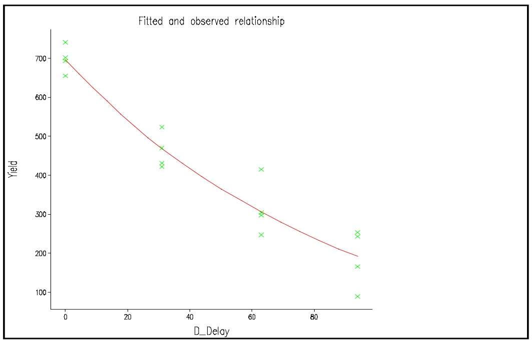

Figure 2: Grain yield (kg/ha) vs. sowing time

Grain yield declined from 698 kg/ha (July) to188 kg/ha (October), equating to a yield penalty of 38 kg/ha for each week that sowing was delayed beyond July 14; *grain yield = - 522 + 1248/(1 + 0.0072 × days after July 14)*, $r^2 = 0.92$ (Figure 2). Grain yield was strongly correlated to maturity biomass (Pearson's coefficient = 0.92). Although sowing time had minor effects on seed mass and seed number per capitula, the predominant factor reducing grain yield was a reduction in branching and associated primary capitula from 3.8 to 1.6 per plant (July to October). All treatments had a similar harvest index (mean = 0.11).

There were only six >10 mm rainfall events during the experiment period, totaling 90 mm. A further 95 mm fell over 57 days, but the soil did not accumulate significant (P = 0.17) moisture between sowing the first and last treatments (mean = 680 mm/2 m soil). The mean gravimetric soil water content at sowing decreased from 29.4% in the upper 0.25 m, to 24.7% between 0.5 and 0.75 m, before increasing to about 30 % below 1.5 m. O'Leary *et. al.* (1985) used a lower extractable limit of 24 % (volumetric) for a Wimmera grey clay which is equivalent to a gravimetric value of about 20%. On average, plant available water at sowing was therefore 280 mm/2 m soil, but 160 mm occurred below 1 m. There were no significant differences between treatments in the amount of soil water extracted at, or between any sampling stages. The water content in the top two meters of soil declined during the growing season (P < 0.001) with the means being; elongation (666), branching (656), flowering (616) and maturity (599 mm). At maturity, all treatments (mean = 20.2%) had dried the upper 1 m of soil to near the lower extractable limit and the respective value between 1 and 2 m was 29%. More than 90% of soil water extraction occurred from the upper 1 m. The inclusion of rainfall did not produce any significant differences in total water use at, or between any growth stages. Total seasonal water use was 243, 196, 204 and 166 mm for July to October, respectively. The July (24.2) and August (23.9) sowings had a higher (P = 0.01) water use efficiency (WUE) for biomass production (kg DM/ha/mm) than the September (13.5) and October (9.6) treatments. The WUE of grain production declined with delayed sowing and the means for the July to October treatments were 2.9, 2.4, 1.6 and 1.1 kg/ha/mm, respectively.

In summary, both biomass and grain production declined with each delay in sowing after July 14. To achieve maximum yields in dry environments, safflower should be planted in July, and possibly earlier. Although not statistically significant, soil water use, total water use and WUE tended to decline with delayed sowing. In the dry season, all treatments used all available water in the upper 1 m of soil making it difficult to detect differences between treatments. The experiment is currently being repeated at a high soil moisture site and once completed, data from both experiments will be combined for analysis.

Acknowledgements

We would like to thank P. Howie, T. Broomhall and N. McClure (The University of Melbourne) for their valuable contributions to this experiment. This work was funded by the GRDC (Project No: UM132).

References

Colton, R.T. 1988. *Safflower growing*. Agfact P5.2.2, Department of Agriculture, NSW, Australia.

Esendal, E.1997. Agro-physiology outlook on safflower. In, *Proceedings of the 4th International Safflower Conference*. Ed. A. Corleto and H.-H. Mündel. Bari, Italy. 2-7 June, pp. 155-163.

O'Leary, G. J., Connor, D.J. and White, D.H. (1985). Effect of sowing time on growth, yield and water-use of rain-fed wheat in the Wimmera, Vic. *Australian Journal of Agricultural Research*, **36**: 187 – 96.

Stanley, M., Hannay, J. and Potter, T. *Safflower agronomy*. Factsheet AGDEX 146/10, Primary Industries South Australia.

Wachsmann, N.G, Knights, S.E. and Norton, R.M. (2001). The potential role of safflower (*Carthamus tinctorius* L.) in Australia's southern farming systems. In, *Proceedings. of the 10th Australian. Agronomy Conference*. Ed. B. Rowe, N. Mendham and D. Donaghy. Hobart, Tasmania, 28 January - 1 February, (CD-ROM).