Effects of sowing date and sowing rate on seed yield of barrel medic

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Summary. A field experiment was conducted to examine the effects of time of sowing and sowing rate on phenology, leaf area development and seed yield in two cultivars of barrel medic (Medicago truncatula) of differing maturity. The study involved two sowing dates (27 May and 27 June). five sowing rates (I, 5, 25, 125, 625 kg/ha) and two cultivars (Parabinga, early flowering; Paraggio, late flowering). Seed yields were highest with early sowing and at sowing rates of 5 to 25 kg/ha and were related to the number of pods per m2 at maturity. Delayed sowing reduced seed yield through a reduction in the number of flowers produced in the early part of the season and the shorter period for seed growth. Higher sowing rates produced the highest number of flowers/m2 but seed yield at 125 and 625 kg/ha was significantly reduced by poor percentage pod set because of the occurrence of complete self-shading (LAI above 4) prior to the start of flowering. At the 5 and 25 kg/ha sowing rates, complete self-shading occurred at different times after the start of flowering but pod set was similar for both sowing rates. It was postulated that strategies for improving seed yield in annual medics should be based on strategies that encourage early flower production and that improve pod retention by improving light penetration during the early flowering period.

Introduction

South Australia, Victoria and Western Australia are the world's main producers and exporters of annual medic seed. In South Australia seed yields have ranged from 50 to 600 kg/ha both within and between seasons (South Australian Bureau of Statistics 1979-89). Potential seed yield, defined as the number of flowers per unit area is high in most medic cultivars but only less than 40% of this is realised as actual seed yield (3). Whereas much of the failure to attain potential seed yields and the variation between and within seasons is attributable to the limitation imposed by climatic factors, particularly rainfall, there is limited research data on management strategies that can reduce the gap between the potential and actual yields of medic seed and those that can minimise the variation between and within seasons.

Two agronomic practices that can greatly affect seed yields in medic are choice of time of sowing and sowing rate. Both of these influence the dry matter (DM) production of swards and the growth stage at which competition begins, while sowing time also determines the timing of important phenological stages. The importance of DM production and phenology to grain yield in winter cereals is generally well understood e.g. (6) but such understanding in medics is lacking, possibly because of the greater importance placed on herbage production in the past. The aim of this experiment was to examine the ways by which the amount of vegetative growth and environmental factors interact at different stages of reproductive growth to influence flower production, percentage pod set, seed growth and final seed yield.

Materials and methods

The experiment was conducted in 1989 at the Waite Agricultural Research Institute near Adelaide, South Australia (Latitude 34^{0} 58'S. Longitude 138? 38' E. Altitude 122.5 m, Mean annual rainfall 620 mm). The soil type is a hard-setting, red-brown earth (Urrbrae loam). Rainfall was 52 mm in September, 38 mm in October and 34 mm in November. Two cultivars of *Medicago truncatula,* Parabinga (early flowering) and Paraggio (late flowering) were sown on 27 May (early) and 27 June (late). Each cultivar was sown at I, 5, 25, 125, 625 kg/ha. The experimental design was a split plot, randomised complete block with 4 replicates. Each replicate was split into an early- and late-sown half (main plots) and the two cultivars at five sowing rates were randomised within the subplots (2x5 m) of each main plot. Seeds were inoculated with peat culture of *Rhizobium* , mixed with fertiliser and damp sand and broadcast by hand. Fertilizer was applied at rates of 9 kgP/ha as single superphosphate, 52 kgK/ha as potassium chloride and 46 kgN/ha as urea.

Total DM yield and leaf area index (LAI) data were estimated five times at approximately 28 day intervals from the first harvest occasion of each sowing date. The amount of photosynthetically-active radiation (PAR) transmitted through the canopy to the ground was calculated using the relationship 1 = 10 exp (-kL) where I is PAR measured at ground level under the canopy, I_o is incoming PAR, k is the light extinction coefficient and L is LAI at each harvest. In order to calculate the value of k. spot measurements of 1_0 and of 1 were made in swards that were intercepting about 90% of incident PAR using a line quantum sensor. The measurements were made on a clear day at about mid-day. From the data. k was found to be approximately 0.9 which was similar to that reported for subterranean clover swards (5). Radiation use efficiency (RUE; gDM/MJ PAR) was calculated from the growth rates of the swards and the total amount of PAR intercepted by the canopy.

The start of flowering was defined as the time when approximately 10% of the flowers had appeared in each plot. The number of plants per m^2 and number of racemes on 5 randomly-selected plants were counted in each treatment on three occasions. The number of flowers per raceme was also estimated by counting the number of flowers on 20 randomly-selected racemes on the three occasions and the total number of flowers was calculated by multiplying the total number of racemes by the number of flowers per raceme. Flower survival (percentage pod set) was calculated by dividing pod numbers at maturity by the estimated maximum number of flowers, expressed as a percentage. Pods were harvested by vacuuming an area of 0.5 I112. cleaned and threshed to determine seed yield and components.

Results and discussion

When sown on 27 May, Parabinga flowered on I September and Paraggio on 6 September 1989, whereas when sown a month later Parabinga flowered on 15 September and Paraggio on 19 September 1989. Total dry matter production at the end of the season was independent of sowing date and cultivar but was highest at the sowing rates of 5 and 25 kg/ha and significantly reduced at 625 kg/ha (Table I). The stage at which complete self-shading occurred (LAI 4) only varied with sowing rate (Fig. 1). Seed yields were highest with early sowing and at 5 and 25 kg/ha sowing rate (Fig. 2), a result in contrast to earlier work at the Waite Institute (I). The similarity in seed yield between sowing rates and sowing dates in Adem's work was attributed to a favourably long, wet season which resulted in similar DM yields during the flowering season. This highlights the importance of seasonal weather in determining the optimum sowing rate.

The highest sowing rates produced the greatest number of flowers/m2 but seed yield was reduced by the low percentage pod set (Table 1). At 5 and 25 kg/ha complete self-shading occurred during the flowering period whereas at the higher sowing rates complete self-shading occurred before the start of flowering (Fig I) indicating that the growth stage at which complete self-shading occurred was an important factor limiting pod set. Ludlow and Wilson (8) have shown that maximum efficiency of light utilization for canopy photosynthesis in prostrate pasture swards occurs when all the leaves are illuminated at about 10% (4.5% PAR) and when the LAI is between 3 and 4 (7). Although the results in Fig. I do not show the average level of PAR at different levels from the apex of the sward to the base. they indicate that canopy photosynthesis at higher sowing rates may have been low throughout the flowering period.

The RUE at sowing rates between 5 and 625 kg/ha was 3.3 g/MJ and was not significantly reduced by sowing date and cultivar maturity. This value is within the range of those reported for other crops when more than 90% of PAR is intercepted (9) indicating that the differences in seed yield were not due to differences in RUE but to the amount of PAR intercepted by the canopy. The loss of flowers at the higher sowing rates suggests that complete self-shading prior to and throughout the flowering limits the ability of the canopy to supply photosynthate to the flowers and immature pods during the pod setting period.

Comparisons of the crop growth rate during the reproductive period and pod growth rates indicate that in order to achieve higher seed yields. high growth rates should occur during the early flowering period (Table 1), which again supports the importance of high canopy photosynthesis during the early flowering period. It is therefore postulated that environmental or agronomic stresses which decrease dry matter production during this period would be expected to reduce seed yield.

Delayed sowing resulted in significantly fewer flowers/m2 at the end of the flowering period (18 October) in the late-flowering cultivar, Paraggio but not in Parabinga. Later sowing delayed flowering by about 2 weeks to the middle of September, by which time soil moisture contents were significantly lower (data not presented) and air temperatures were higher than at the start of flowering in the early-sown swards.

An analysis of the yield components indicated that seed yield was related to the number of mature pods per m2; similar results were reported by Adem (l) and Cocks (3). Low mean seed weight significantly reduced seed yield at higher sowing rates and at late sowing but the influence was small compared to the number of pods per m^2. The number of seeds per pod was relatively stable except at the sowing rate of 625 kg/ha when it was reduced from 7 to 6.

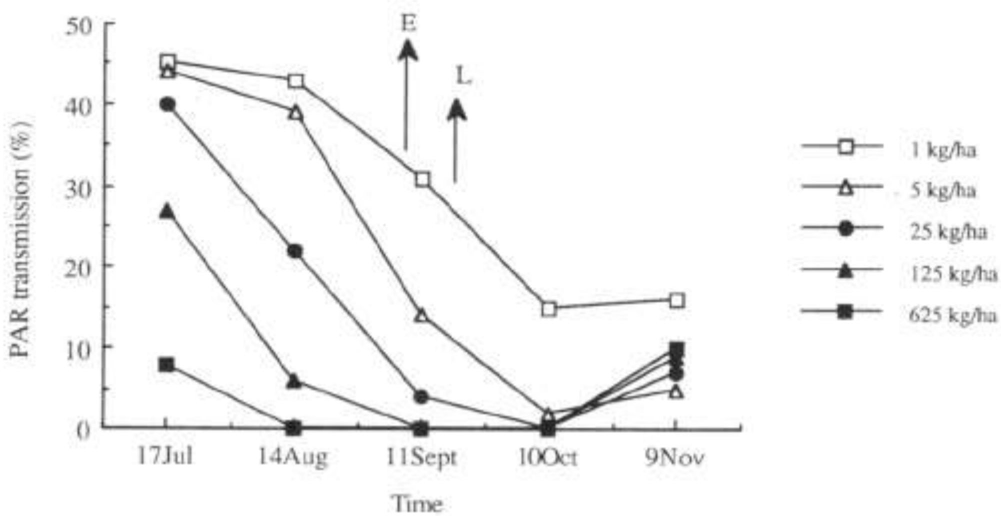

Figure 1 Effects of sowing rate on PAR transmission through canopy (mean of two sowing dates and two cultivars). The start of flowing for early and late sowing is indicated by E and L respectively.

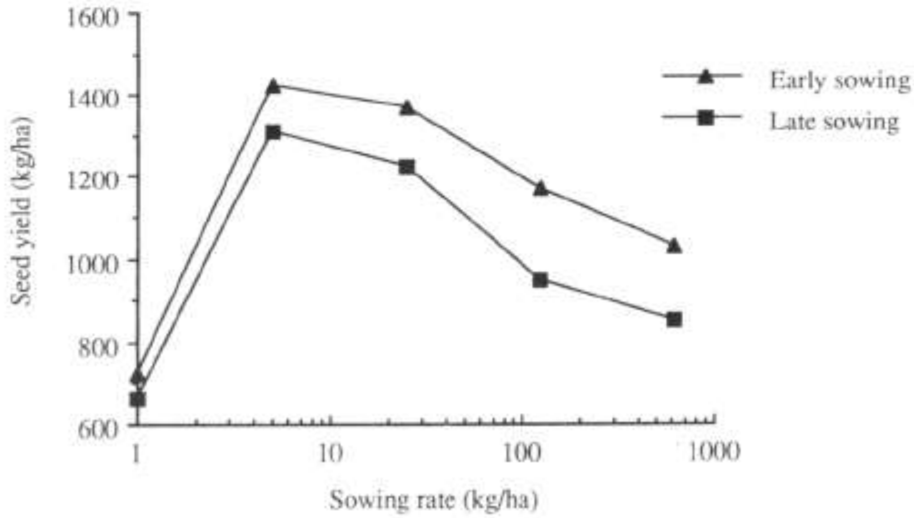

Figure 2 Effects of sowing date and sowing rate of mean seed yield of two cultivars of barrel medic.

Table I. Effects of sowing rate on herbage production, seed yield, crop growth rates, flower numbers percentage pod set and pod growth rates. The values are the means of two cultivars and two sowing dates.

Sowing rate	Maximum production (DM g/m^2)	Seed yield (g/m^2)	Crop growth rate (g/m^2/day)		Flowers (#/m^2)	Pod set (%)	Pod growth rates (g/m^2/day)
			Early flowering	Peak to end of flowering	End flowering		Peak to end of flowering
1	519	69.5	6.2	11.0	NA[a]	NA	8.1
5	1010	136.6	16.1	16.7	14400	35.7	13.0
25	979	129.6	18.7	7.3	14900	33.8	11.6
125	872	106.0	12.7	3.4	18600	22.3	9.5
625	796	94.1	10.6	2.3	22800	18.2	9.5
l.s.d.(P=0.05)	134	13.7	3.7	5.8	4200	7.9	1.0

[a]NA=data not collected

The smaller seeds at higher sowing rates were possibly due to stress imposed by complete self-shading throughout the reproductive period (Fig. I) as there was no significant difference in the soil moisture content between the different sowing rate treatments at the end of flowering. The lower seed weights at the second sowing were probably due to the combined effects of later flowering reducing the length of the seed filling period, and lower amounts of available soil moisture increasing the levels of stress within the crop. Andrews *el al.* (2) have demonstrated that water stress during the reproductive period reduces mean seed weight in subterranean clover swards.

The finding that the number of mature pods is affected by percentage pod set is in agreement with Cocks (3). However, the present results suggest that percentage pod set is limited in dense swards only when complete self-shading occurs prior to the start of flowering; if the number of plants/m^2 is low, pods/m2 will be limited by the number of flowers produced. Complete self-shading prior to the start of flowering is common, even when recommended sowing rates are used (1). Commercial medic seed producers in SA use grazing, mechanical defoliation or low rates of herbicides to control vegetative growth before flowering with the aim of increasing seed yield. Such strategies could help increase seed yield at the higher sowing rates, as shown in studies with subterranean clover (4), but the relationship between light penetration and flower production following defoliation at the start of flowering needs further investigation in medics as improved light penetration by defoliation may reduce seed yield if flowers per m2 is reduced (10). From this study it is postulated that strategies for improving seed yield in rainfed annual medics should be based on improving light penetration during the early flowering period as well as producing a large number of flowers during the early part of spring.

References

1. Adem, L. 1977. M.Ag.Sc. Thesis., The University of Adelaide. 171p.

2. Andrews, P., Collins, W.J. and Stern, W.R. 1977. Aust. J. Agric. Res. 28, 301-7.

3. Cocks, P.S. 1990. Aust. J. Agric. Res. 41, 923-31.

4. Collins, W.J. 1978. Aust. J. Agric. Res. 29, 789-807.

5. Davidson, J.L. and Phillip, J.R. 1958. Symp. Climatology and Microclimatology, Canberra, Australia pp. 181-87 (UNESCO: Paris).

6. Fisher, R.A. and Wood. J. T. 1979. Aust. J. Agric. Res. 30, 1001-20,

7. Fukai, S. and Silsbury, J.H. 1977. Aust. J. Plant Physiol. 4, 156-67.

8. Ludlow , M.M. and Wilson, G.L. 1971. Aust. J. Biol. Sci. 24, 449-70.

9. Monteith, J. L. 1977. Philos. Trans. R. Soc. London, Series B 281, 277-94.

10. Muyekho, F.N., Carter E.D., McDonald, G.K. 1992. Proc. 6th Aust. Agron. Conf., Armidale, NSW. p.539.