Weed suppressive potential of selected pasture legumes against annual weeds in southeastern Australia

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Summary Poor adaptation of numerous annual and perennial legumes across south eastern Australia due to acidic soils, insufficient rainfall resulting in false breaks, high input costs, soil acidification and the emergence of herbicide resistant weeds have resulted in limited options for producers seeking to establish productive pastures in the Riverina region of New South Wales (NSW). To overcome these challenges, numerous novel pasture species have been selected and recently released for establishment. However, limited knowledge exists regarding their ability to suppress weeds during establishment and in subsequent years when they regenerate. Field trials were conducted at Wagga Wagga, NSW over a two year period to evaluate: (a) the suppressive potential of eight selected pasture legumes against annual weeds; and (b) the impact of autumn (March) and winter (June) sowing dates on stand establishment. Weed and crop cover and biomass were assessed each year in replicated trials in 2016–2017. Results suggested that species mixtures with more than one pasture species were not significantly different ($P<0.05$) in terms of establishment and subsequent weed infestation. However, autumn sowing of arrowleaf clover, yellow serradella cv. Avila and French serradella/bladder clover generally resulted in increased ($P<0.05$) pasture crop cover over two growing seasons. Arrowleaf clover and biserrula cv. Casbah were strong performers and produced significantly greater crop biomass and also less weed biomass. However, weed suppression and subsequent biomass was not always related to competition for resources and production of total crop biomass. This was the case for yellow serradella cv. Santorini in both 2016 and 2017 where weed biomass was significantly reduced but total crop biomass produced was limited. This suggested that factors other than resource competition, such as allelopathy, were associated with weed suppression. Arrowleaf clover, biserrula cv. Casbah and yellow serradella cv. Santorini were generally the best and most reliable annual legumes with respect to yearly regeneration and pasture weed suppression in the Riverina.

Keywords Hard-seeded legume, weed suppression, competition, establishment.

INTRODUCTION

Pasture legumes have been an integral part of mixed farming systems in southeastern Australia as they provide high-quality nutrition for livestock and improve soil fertility due to their ability to fix atmospheric nitrogen. The selective use of pasture legumes has also been instrumental in effectively managing weeds in such rotational cropping systems (Mengel *et al.* 2001, Loi *et al.* 2005a, Loi *et al.* 2005b). Traditionally, subterranean clover has been the most widely used pasture in southern Australia but unpredictable weather patterns resulting in lower and inconsistent spring rainfall, high cost of legume establishment and low persistence mainly due to low hardseed levels have impacted on the suitability of subterranean clover in the region (Loi *et al.* 2001, Loi *et al.* 2005a).

To overcome these challenges, numerous novel self-regenerating annual pasture legumes including *Biserrula pelecinus* L. (biserrula), *Ornithopus sativus* Brot. (French serradella), *Ornithopus compressus* L. (yellow serradella), *Trifolium glanduliferum* Boiss. (gland clover), *Trifolium spumosum* L. (bladder clover) and *Trifolium vesiculosum* Savi. (arrowleaf clover) have been recently released in New South Wales (NSW). These pasture legumes are well adapted to the south eastern region, due to their successful establishment in diverse soils, drought tolerance, higher herbage production and nutritional quality relative to traditional pasture species. However, limited knowledge exists regarding their establishment following initial seeding and in subsequent years of regeneration. To maximise the adoption of introduced species/cultivars under suitable soil types and rainfall zones, further research is required in NSW to assess

the ability of selected pasture legumes to establish and produce improved yields while suppressing annual weeds to determine their suitability within sustainable cropping systems. Therefore, the objectives of this study were to evaluate: (a) the suppressive potential of selected annual pasture legumes against dominant annual weeds; and (b) the impact of sowing season; autumn (March) or winter (June) on establishment and regeneration of annual legumes in southeastern Australia.

MATERIALS AND METHODS

Field experiments were established in 2016 and 2017 at the Graham Centre field site and the Agricultural Research Institute field site in Wagga Wagga, NSW (35°S, 147°E). All experiments were arranged in a randomised complete block design with five replicates per treatment. The soil type was characterised as a fine red sodosol at both trial sites. Treatments were planted at standard sowing rates using a precision cone planter in 20 × 3 metre with 15 cm row spacing. All pasture treatments were sown on two different sowing dates either in the first week of March or first week of June and thereafter referred to as autumn and winter sowing dates respectively, except in the case of those not suitable agronomically for autumn sowing. All plots were fertilised with 100 kg ha^{-1} of fertiliser (Croplift® 12, 1:2:1, Incitec Pivot, Victoria) at the time of sowing. The second trial site was established similarly in winter 2017 at the Wagga Wagga Agricultural Research Institute using only monoculture pasture treatments in 9 × 2 m plots with similar row spacing and seeding rates.

Percentage stand establishment of pasture crops and weeds was recorded using visual ratings on a scale of 0–100 performed at physiological maturity of the pasture crops when crops were at the flowering stage. In addition to qualitative data, two representative pasture samples were collected from each plot at a height of approximately 2 cm the soil surface (to simulate grazing by sheep) using 0.25 m^2 quadrants from monoculture plots to determine the total biomass of crop and weeds in 2016 and 2017. Plant matter was sorted into pasture legume and weed species before being dried at 90°C for 96 hours and weighed. All weeds were collected and bulked irrespective of species and dry weights were recorded. Above ground crop competitive traits including normalised vegetative index (NDVI), leaf area index (LAI), and light interception (LI) were assessed for each pasture legume species at physiological maturity in 2017 to determine the relative effect of each trait on total weed suppression. An analysis of variance (ANOVA) was performed to determine the effect of sowing season and pasture crop on ground cover and biomass of crops and weeds using the GenStat statistical software package (18th Edition, VSN International Ltd, Hertfordshire, United Kingdom). The fixed model included year, sowing date and pasture crops while the random effect was block number. A multivariate analysis was performed using IBM SPSS statistical package (IBM SPSS® Inc. 2001, version 24.0 for Windows, United States of America) using a partial least square regression (PLSR) analysis model to determine the relative effect of competitive traits of weed suppression (Reiss *et al.* 2018).

RESULTS

Results of visual ratings performed for pasture crops at physiological maturity demonstrated that percentage ground cover of crops and weeds varied significantly ($P<0.05$) across pasture species. Arrowleaf clover produced the highest ground cover of all pasture species followed by biserrula cv. Casbah and gland clover, while cultivars of yellow serradella produced the least pasture ground cover. Arrowleaf clover initially exhibited the lowest percentage of weed infestation followed by biserrula cv. Casbah and yellow serradella cv. Santorini (Figure 1).

Generally, mean percentage crop cover was slightly to moderately higher for the autumn sowing date compared to winter sowing but the overall effect of sowing date was not significant ($P>0.05$) except for arrowleaf clover and both cultivars of yellow serradella.

Biomass of pasture crops and weed species was also obtained in at crop maturity in 2016 and 2017 and these varied significantly ($P<0.05$) across pasture species. Overall, crop biomass of all treatments ranged from 44–90 g m^{-2} while weed biomass ranged from 5–30 g m^{-2} (Figure 1). Arrowleaf clover produced the highest crop biomass followed by biserrula cv. Casbah and gland clover. In contrast, yellow serradella cv. Santorini and subterranean clover produced the lowest crop biomass. Interestingly, arrowleaf clover had the lowest weed biomass followed by yellow serradella cv. Santorini. Remarkably, yellow serradella cv. Santorini produced the lowest biomass but also maintained low weed infestation.

A PLSR analysis was conducted to determine the relative effect of competitive traits on weed biomass. Competitive traits explained up to 30% of the variance in two latent factors when dataset from all species was analysed in one model suggesting a separate analysis for each species separately is appropriate. Overall, total weed biomass at physiological maturity was strongly correlated with crop biomass followed by LI.

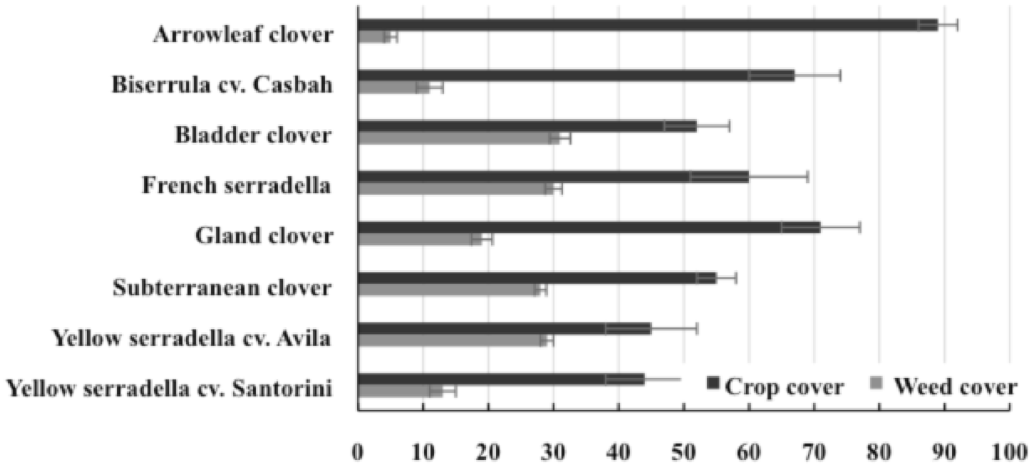

Figure 1. Visual ratings performed on a scale of 0 to 100 where zero represents no crop cover and 100 represents complete and uniform ground cover established in Wagga Wagga, NSW. Ratings were taken at physiological maturity of the pasture crops which was achieved in the third week of October and November, respectively, and averaged over both years. Error bars indicate the standard error of means.

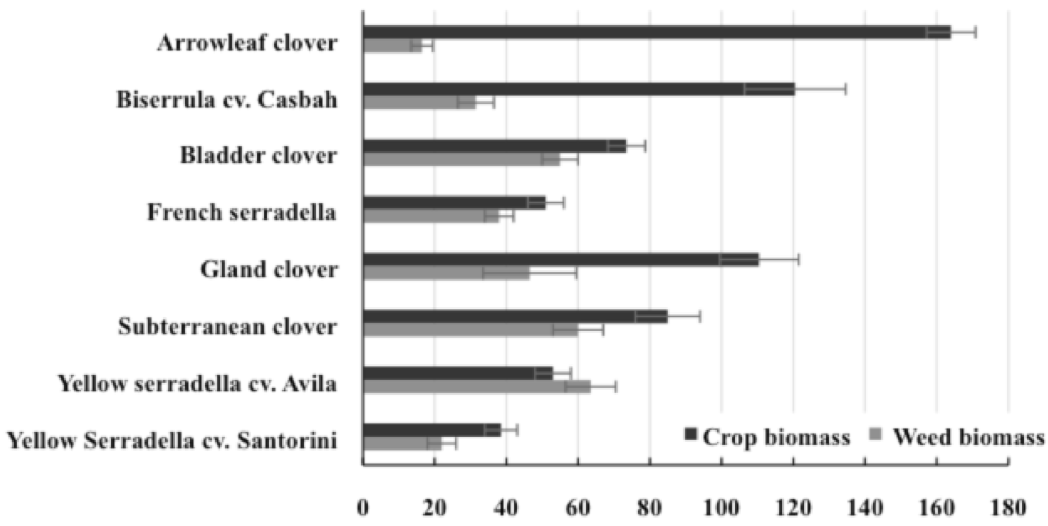

Figure 2. Biomass of crop and weeds (g m^{-2}) assessed at physiological maturity of the pasture crops averaged across 2016 and 2017 Wagga Wagga, NSW. Weed biomass represents the composite biomass of all weeds. Error bars indicate the standard error of means.

Crop biomass appeared to have the strongest inverse effect on total weed biomass in the case of biserrula cv. Casbah, bladder clover, French serradella, subterranean clover and yellow serradella cv. Avila. In addition, LAI was observed to have a strong inverse effect on total weed biomass in the case of arrowleaf clover and gland clover. Clearly, crop biomass, NDVI and LAI were not associated with weed suppression in case of yellow serradella cv. Santorini.

DISCUSSION

Results of two years of several field trials in the Riverina region of NSW clearly demonstrated significant variation in the competitive ability of individual pasture legumes species and cultivars, resulting in variable weed suppression against annual weeds. Arrowleaf clover, biserrula and yellow serradella were generally the most reliable and competitive annual legumes with respect to stand establishment, yearly regeneration and consistent suppression of pasture weed species in two years of experiments performed at multiple field sites in Wagga Wagga. Sowing of pasture legumes in autumn or winter is feasible but crops performed more consistently when sown in June. In this study autumn sowing did not offer significant advantages compared to winter sowing in suppressing annual weeds. Arrowleaf clover and biserrula have been reported to have greater ability to successfully regenerate in Mediterranean-like climatic conditions. In general, these two legumes produced significantly greater crop biomass, and as a result, considerably less weed biomass due to low light penetration of the dense crop canopy and competition for resources. Results of PLSR analysis demonstrated that, in general, crop biomass had the strongest inverse effect on total weed biomass for many pasture species and likely also impacted weed seed germination and seedling growth. Several mechanisms could be associated with the ability of these pasture legumes to suppress weeds including their ability to rapidly develop dense canopies limiting light interception at the soil surface. In addition, yellow serradella may exhibit the ability to suppress weeds through allelopathic interference. Additional information related to the mechanisms involved in weed suppression, including the potential for some species to release allelochemicals over time, will be useful in the selection of new pasture species/cultivars for sustainable weed management solutions, particularly when considering the increasing importance of herbicide resistance in pasture weeds.

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REFERENCES

Loi, A., Howieson, J.G., Nutt, B.J. and Carr, S.J. (2005a). A second generation of annual pasture legumes and their potential for inclusion in Mediterranean-type farming systems. *Australian Journal of Experimental Agriculture* 45, 289-99.

Loi, A., Howieson, J.H. and Carr, S.J. (2001). Register of Australian herbage plant cultivars. *Biserrula pelecinus L*. (biserrula) cv. Casbah. *Australian Journal of Experimental Agriculture* 41, 841-2.

Loi, A., Revell, C. and Nutt, B.J. (2005b). Domestication of new forage legumes improves the productivity and persistence of pastures in Mediterranean environments. Proceedings of the 1st COST 852 Workshop, eds B.E. Frankow-Lindberg, R.P. Collins, A. Luscher, M.T. Sebasria, A. Helgadottir, pp 165-75. (Swedish University of Agricultural Sciences, Sweden).

Mengel, K., Kirkby, E.A., Kosegarten, H. and Appel, T. (2001) 'Principles of Plant Nutrition'. (Springer, Dordrecht).

Reiss, A., Fomsgaard, I.S., Mathiassen, S.K. and Kudsk, P. (2018). Weed suppressive traits of winter cereals: Allelopathy and competition. *Biochemical Systematics and Ecology* 76, 35-41.