Competitive effects of wireweed (*Polygonum aviculare* L.) in field and glasshouse studies

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Summary Wireweed (*Polygonum aviculare* L.) is a widespread weed of agricultural systems in Australia. Field and glasshouse experiments investigating inter and intra specific competition were conducted between wireweed and lucerne or wheat. At the vegetative stage, branch number declined, and wireweed dry matter (DM) increased, with increasing wireweed density. Dry matter per plant generally decreased with increasing density. At flowering similar trends were observed for plot DM and plant DM. Above average rainfall in the spring may have contributed to better growth at higher densities but the result is consistent with previous density studies by Donald (1951). In the glasshouse experiment, irrespective of wheat density, there was a 19% reduction in wheat DM between one and three wireweed plants per pot (314 cm^{-2}), and a 57% reduction in wheat DM between three and six wireweed plants per pot. Where lucerne and wireweed were grown together, lucerne DM was reduced by 52% and 81% between one and three, and between three and six wireweed plants respectively. It is recommended that wireweed densities are kept below 10 plants m^{-2} in wheat, and below five plants m^{-2} in establishing lucerne.

Keywords Wireweed, *Polygonum aviculare* competition, wheat, lucerne.

INTRODUCTION

Wireweed, (*Polygonum aviculare* L.), is a widespread weed of agricultural systems in Australia, affecting cereal crops (Lemerle *et al.* 1996, Martin and McMillan 1984), canola (Lemerle *et al.* 2001), field peas (Amor and Francisco 1987) and establishing pastures (Auld and Medd 1987). Wireweed has a range of competitive attributes including hard-coated seeds and a large dormant seed pool (Saunders and Field 1983, Medd 1986). Its requirement for low soil temperature to break innate dormancy (Courtney 1968) makes it difficult to manage prior to pasture and crop seeding. Its growth habit is semi-prostrate with lengthy branching enabling it to interfere with pasture and crop species (Fisher *et al.* 1988). It has a long tap-root that allows growth through the drier months of the year in southern Australia.

Competition has been defined as the struggle between plants for a resource (water, light, nutrients) that is in short supply (Zimdahl 2004). Competition is keenest when individuals are most similar, make the same demands on the habitat and adjust themselves less readily to their mutual interactions. This study investigated how wireweed competed inter-specifically with wheat or lucerne in glass house pot studies, and intra-specifically in field studies conducted during the period October 2005 to February 2006.

MATERIALS AND METHODS

Field experiments consisting of six wireweed densities (1, 5, 10, 20, 50 100 plants m^{-2}) laid out in a randomised complete block design (RCBD) replicated four times were conducted for each growth stage (vegetative, flowering, maturity, senescence). Plots (1 m^{-2}) were established in the field, cultivated to remove all plant growth and planted with the appropriate density of wireweed in a grid pattern. Wireweed was counted and destructively sampled at each growth stage, with total plot dry weight and dry weight per plant recorded.

Glasshouse pot experiments were conducted to investigate competition effects between wireweed and wheat or lucerne. These were two-factor factorials laid out in an RCBD. There were four levels of wireweed (0, 1, 3, 6 plants pot^{-1}), four levels of wheat or lucerne (0, 1, 2, 3 plants pot^{-1}), four replicates and three times of wireweed harvest (vegetative, first branching, and maturity). Pots (20 cm diameter) were filled with 5 L of a commercial seed raising mix consisting of fine sand and organic matter. A slow release complete fertiliser (Osmocote Plus for Pots, Planters and Indoors™ 12 g pot^{-1}), was mixed through the profile of each pot. Wheat, lucerne and wireweed seeds were planted in trays containing seed raising mixture to obtain emerged seedlings, which were then planted symmetrically into the prepared pots. Pots were randomly placed on tables in the glasshouse and rotated on a weekly basis. Average daily temperatures were 14.8°C (min.) and 38.3°C (max.). The wireweed-lucerne experiment was harvested 36, 64 and 99 days after planting and the wireweed-wheat experiment at 27, 82 and 97 days after planting. Dry weight (g) was recorded for wireweed, wheat and lucerne.

Linear regression was used to analyse the field data to determine relationships between wireweed density and branch number, plot DM and DM per plant at the vegetative stage. Analysis of variance was used to analyse the glasshouse data, which were presented as percentage crop or wireweed, to determine whether wireweed and crop density have any significant impact on their dry matter production. All statistical analyses were conducted using GenStat 10 (Payne *et al*. 2007).

RESULTS

The regression equation relating branch number (BN) and plant density (PD) was 52.49 − 0.266PD (r = 0.89, SE of regression co-efficient of 0.0673). Similar equations are used to express total plot DM and DM per plant in terms of PD. Branch number declined with increasing wireweed density at the vegetative stage (r = 0.89) (Table 1). Total plot dry weight increased linearly with increasing PD (r = 0.98). Dry weight per plant decreased with increasing density (r = 0.79). At flowering similar relationships were observed for plot DM and plant DM but there was no relationship between wireweed density and branch number (data not shown).

In the glasshouse experiments (Table 2), there was a significant ($P < 0.001$) wireweed by crop interaction for both the wheat and lucerne. Closer examination revealed that the interactions were not cross-over and therefore the two factors can be interpreted in the usual way. The main effects of wireweed and crop were both highly significant ($P < 0.001$) for both wheat and lucerne. Wheat and lucerne dry weight decreased with increasing density of wireweed.

When grown with lucerne, wireweed DM occupied a greater proportion of the total DM than when grown with wheat at all wireweed densities. Similar trends in dry weight between species were observed at first branching and at maturity.

Table 1. Effect of wireweed density (plants m^{-2}) at the vegetative stage.

Density (plants m^{-2})	Branches plant^{-1}	Total plot dry weight (g)	Dry weight plant^{-1} (g)
1	54.33	7.4	7.4
5	59.25	21.82	4.968
10	44.52	41.3	4.13
20	42.3	72.88	3.828
50	36.98	132.83	3.032
100	28.07	207.32	2.212
Slope	−0.2660	1.979	−0.0372
SE	0.0673	0.162	0.0147
Intercept	52.49	19.23	5.414
r	0.89	0.98	0.79

Table 2. Wheat (wireweed) and lucerne (wireweed) DM as a percentage of total DM at the vegetative stage.

Wireweed	Crop	Wheat (wireweed) DM%	Lucerne (wireweed) DM%
0	0	0.00 (0.00)	0.00 (0.00)
	1	100.00 (0.00)	100.00 (0.00)
	2	100.00 (0.00)	100.00 (0.00)
	3	100.00 (0.00)	100.00 (0.00)
1	0	0.00 (100.00)	0.00 (100.00)
	1	68.00 (32.00)	45.50 (54.50)
	2	90.75 (9.25)	66.75 (33.25)
	3	93.25 (6.75)	80.75 (19.25)
3	0	0.00 (100.00)	0.00 (100.00)
	1	53.50 (46.50)	27.25 (72.75)
	2	79.25 (20.75)	50.00 (50.00)
	3	81.50 (18.50)	51.50 (48.50)
6	0	0.00 (100.00)	0.00 (100.00)
	1	36.50 (63.50)	15.75 (84.25)
	2	44.75 (55.25)	20.75 (79.25)
	3	55.75 (44.25)	39.75 (60.25)
LSD (5%)		9.95	10.67
F test prob.	Wireweed (WW)	<0.001	<0.001
	Crop (C)	<0.001	<0.001
	WW*C	<0.001	<0.001

DISCUSSION

In the field experiment, wireweed vegetative growth plant^{-1} decreases steadily with density but total plot dry weight increases steadily. This suggests strong competition between wireweed plants but that resources were still sufficient to result in increased overall biomass at the higher densities. In contrast, by flowering, the greatest wireweed biomass was achieved at a density of 50 plants m^{-2} (data not shown). This suggests there was a threshold of resource (light, moisture, nutrients) utilisation above which there were no significant differences in growth measurements between the different densities of wireweed. This result concurs with early research by Donald (1951) that showed a linear relationship between density and yield in early growth of annual pasture plants. As growth proceeded, the relationship between yield and density changes such that a maximum yield is achieved irrespective of density. In the case of wireweed, the maximum dry weight per plant was achieved at 10 plants m^{-2} at the maturity sampling (176 days after planting, data not shown). Given the above average rainfall during this experiment, competition for moisture may have been less and this density may be artificially high. The maximum competitive density of wireweed may be more realistically between 5 and 10 plants m^{-2}.

Interspecific competition between wheat and wireweed in the glasshouse showed that wheat was competitive against wireweed at the vegetative stage. The data would suggest that if wheat is sown to achieve a standard density of 200 plants m^{-2} and moisture and nutrients were not limiting, it would be highly competitive against wireweed at 37 plants m^{-2} (one plant pot^{-1}). Previous field observations have shown that this density of wireweed can persist into December so yield reductions due to competition for moisture could be expected. Yield reductions in linseed have been measured at five wireweed plants m^{-2} (Carver *et al*. 1997) and at seven plants m^{-2} (Lutman *et al.* 2002) so achieving wireweed densities that remain below 10 plants m^{-2} is recommended.

Lucerne was more affected by wireweed than wheat in the glasshouse. The data would suggest that because of the similar growth habit of wireweed and lucerne, they compete directly for light resources and the superior branching capacity of wireweed may provide a physical competitive advantage. Where lucerne is being established, it is recommended that wireweed densities are kept below five plants m^{-2}.

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