Does Polymeria take-all? Competition for water and nutrients between *Polymeria longifolia* (Polymeria take-all) and cotton

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Summary *Polymeria longifolia* (Polymeria take-all) is a native Australian plant that is a particularly troublesome weed throughout the Australian cotton industry. This rhizomatous perennial species is extremely difficult to manage using the range of existing control options. Yield reductions of cotton of up to 100% have been observed in dense patches of this weed. Competition between *P. longifolia* and cotton was assessed with the aim of elucidating if competition for water and soil nutrients was likely to account for cotton growth and yield reductions.

Soil water and nutrient levels were examined in a commercial cotton field in the centre, at the edge, and outside patches of the weed. *Polymeria longifolia* appears to compete for soil water. This is most readily detected at levels approaching the refill point for cotton (the point at which fields should be irrigated to allow for optimal cotton growth). The weed may compete for nutrients at depth, although the soil cores sampled did not detect differences in the major soil nutrients in the upper soil profile. Several minor nutrients were affected. Allelochemical interference may have also caused yield reductions of cotton although this was not specifically examined in this study.

Keywords Cropping, interference, perennial.

INTRODUCTION

Polymeria longifolia Lindl. is a native Australian Convolvulaceae species and a weed of both irrigated and dryland cropping (Johnson *et al.* 2003b). The weed is difficult to manage and an increasing problem in cotton farming systems (Charles 1991, Johnson *et al.* 2003a). Recent research has focused on the biology and lifecycle of this weed (Johnson 2000, Johnson and Sindel 2005) because effective and consistent means of management are not available (Charles and Johnson 2002, Johnson *et al.* 2003b). For example, shallow inter-row cultivation under irrigated field conditions seems to favour the growth of *P. longifolia* (Johnson 2000) and the weed is easily spread from *in situ* or transplanted rhizome material or seeds (Johnson and Sindel 2005).

The competitive impact of many perennial weeds such as *P. longifolia* is neither well understood nor quantified. For example, nearly 65% of cotton consultants and farm agronomists managing this weed indicated that the weed results in 'large yield' reductions while only 46% felt these reductions were in excess of 25% (Johnson 2000, Johnson *et al.* 2003a). In contrast, observations suggest that yield reductions may be up to 100% in dense patches.

This paper reports investigations into the nature of the competition between *P. longifolia* and cotton and whether competition for water and soil nutrients was likely to account for cotton growth and yield reductions. Quantification of this competitive relationship will be documented elsewhere (Johnson and Sindel unpublished).

MATERIALS AND METHODS

This trial was conducted in a commercial cotton field at Moree during the 1997/98 growing season. Measurements for soil water and nutrient extraction were taken on the same experimental areas. Three well established patches of *P. longifolia* with a minimum diameter of 10–20 m were selected as replicates. Within each replicate, three treatment sites along the same cotton row were selected, these being in the centre of the *P. longifolia* patch (123 stems m^{-2}), on the edge of the patch (43 stems m^{-2}) and 10 m outside the patch.

Soil water extraction Soil water extraction was measured using a neutron probe meter and aluminium access tubes inserted to a depth of 135 cm (Greacen 1981). One tube was inserted at each treatment site (centre, edge and outside the patch). Two drying cycles were assessed, the first from 7–20 February when the final irrigation occurred and the second from 21 February to 12 March 1998, (three weeks prior to harvest).

Measurements were taken 48 hours after the irrigation, (field capacity), and then successively until the refill point was reached in the first cycle, or prior to harvest in the second cycle. The refill point is the volumetric water content of the soil below which economic yield loss occurs. Neutron count data were taken at 10 cm intervals down to 90 cm and then at 20 cm intervals to 130 cm. The profile moisture content of

the soil was determined by multiplying the volumetric soil water at each layer by the layer depth in mm. The change in profile moisture content was determined by subtracting the profile moisture content at each depth at the refill point or end date from the profile moisture content at field capacity. The results were analysed statistically using ANOVA with treatment means within each soil depth compared using a 5% LSD. Only soil water differences that were significantly different are discussed. The nutrient extraction and dry weight data were similarly analysed.

Soil nutrient extraction Soil nutrient levels were measured for the top 25 cm of the soil profile. This involved random sampling of 10 × 50 mm diameter soil cores over a six m^2 area and bulking these samples together for each treatment site. The cores were air dried, mixed and sub-sampled twice for analysis. The mean of the two sub-samples was used for data analysis. Commercial analysis of a range of commonly measured chemical parameters was undertaken. There were two times that soil cores were taken on 4 December 1997 (mid season) and 4 February 1998, (late season).

RESULTS

Soil water extraction There were no differences in total profile moisture content in the soil between the centre, edge and outside the *P. longifolia* patch when the soil profile was comparatively full. As the soil profile dried below the refill point, the total soil profile within the *P. longifolia* patch became significantly drier (40.8 cm H_2O) than the soil profile outside the patch (42.2 cm H_2O, 5% LSD 1.3 cm H_2O) at the final sampling date. The total profile moisture content of the edge treatment was intermediate between the centre and outside the *P. longifolia* patch.

There was a reverse sigmoidal trend in volumetric water content over all treatments with low water content in the surface 10 cm increasing to 30 cm and then decreasing again from 40–70 cm (Figure 1). The volumetric water content between 80 and 110 cm then appeared to increase again. Soil water decreased at each successive measurement date at shallower depths than 80 cm due to the extraction of water from the soil profile by both cotton and *P. longifolia* and from other losses such as evaporation. Very little water was extracted in any treatment below 80 cm excepting 130 cm.

The main differences in volumetric water content between the treatments were in the surface 10 cm of the soil profile throughout the trial period (Figure 1) and as refill point and beyond were reached (Figure 1b, c). In both the 10 cm and 70 cm profiles, the volumetric

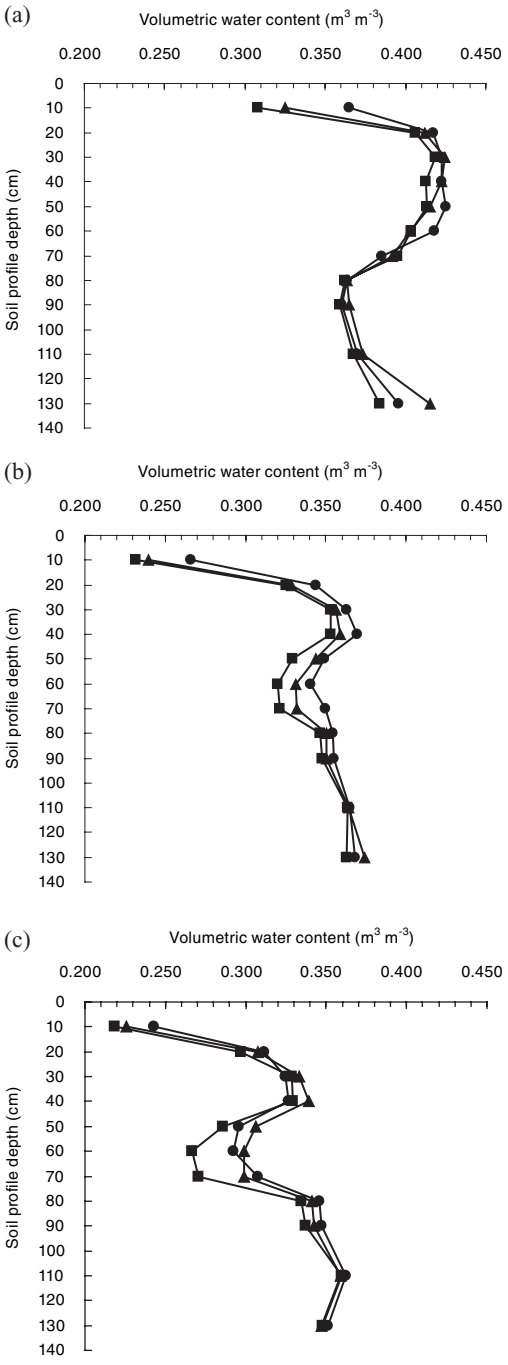

Figure 1. Volumetric water content of soil profile layers in the centre (■), on the edge (▲) and outside (●) *P. longifolia* patches. These measurements were taken during the second drying cycle from the field capacity of the soil: (a) 48 hours after the irrigation, (b) near the refill point and (c) three weeks prior to harvest.

water content was significantly lower in the centre and on the edge of the *P. longifolia* patch than outside (Figure 1b, c). The centre and edge; however, were not significantly different from one another. There were no other significant differences between the treatments within each soil layer even though there was a definite trend towards greater soil water extraction in the centre of the patch in the 50-80 cm soil profile as time progressed.

Soil nutrient extraction Analyses of soil parameters at each sampling time revealed very few differences between the centre, edge and outside of *P. longifolia* patches. In general, Fe concentration was lower in the centre of the *P. longifolia* patch compared with the weed free area at the December and February sampling dates. The Mg concentration in February was also lower in or at the edge of the patch compared with the area outside the patch.

When the soil nutrient data were averaged over the two sampling dates, levels of Fe and Mg were greater outside the patch area than on the edge or in the centre. Associated with these levels was a higher Ca/Mg ratio in the centre of the patches than that outside the patches. There were significant decreases in electrical conductivity, cation exchange capacity, nitrate N, Mg and Cl^- levels and a significant increase in Fe levels from December to February.

DISCUSSION

There were limited differences detected in the extraction of soil water between the cotton only (outside) and the cotton plus *P. longifolia* treatments (edge and centre) at any depth and at any time. Differences occurred when water in the soil profile dropped below the refill point, when more soil water was extracted in the centre of the *P. longifolia* patches, where *P. longifolia* and cotton were growing together, than outside the patch where cotton was growing alone. The cessation of irrigation is timed to ensure adequate soil water to mature the cotton crop and to reduce soil compaction at harvest.

Another difference was between the 50–70 cm soil depths where more water was extracted in the centre and on the edge of *P. longifolia* patches compared with outside the patch areas. This was not expected as over 80% of rhizomes and 65% of roots of *P. longifolia* were found in the top 40 cm of soil (Johnson *et al.* 2003b). The water extraction at this depth did not preclude the possibility that fine roots, which were not necessarily visible in that study, resulted in this water extraction or that extraction from higher levels affected the levels below.

A third difference was identified in the top 10 cm of the soil profile, which was always drier in the centre of the *P. longifolia* patch area than outside the patch. In contrast, the extraction of water over the drying cycles was greater outside the patch area than in the centre of the patch in this layer (data not shown). It appeared that *P. longifolia* had already extracted water in this surface layer after an irrigation event and before the initial probe measurements occurred. This is plausible given that around 18% of all rhizome and root material in the top metre of soil occurred in the top 10 cm of the soil (Johnson *et al.* 2003b). This extraction before measurements commenced resulted in a lower initial water level in this layer and therefore a 'reduced' amount of extraction in the centre of the patch. Other factors such as the shading of the soil by *P. longifolia* may have reduced evaporation from the soil surface within the patch. Probe drift could explain the soil water extraction at 130 cm.

Polymeria longifolia does compete with cotton for water. The point at which interference for available soil water started in this trial was not determined, but *P. longifolia* was clearly depleting the soil profile of water as the refill point was approached, and beyond this point. Irrigated cotton is generally managed to ensure that irrigation above the refill point occurs, except after final irrigation. Soil water levels in dryland (unirrigated) crops would be below the refill point for far longer than in irrigated crops and hence competition from *P. longifolia* for soil water may be more severe. Since dryland production regularly accounts for approximately 18% of the area sown to cotton (Dowling 1998) and that final irrigation/s are missed due to inadequate water supply in a drought season, it is likely that *P. longifolia* would be competing with cotton for water and differential extraction would be occurring in more of the soil profile than that observed here.

There was no measurable increase in the extraction of major plant nutrients including N, P and K down to 25 cm in *P. longifolia* patches over cotton alone. Fe and Mg levels; however, were lower in the centre of the patches compared with outside the patches. Steenhagen and Zimdahl (1979) similarly compared soil samples to 20 cm depth in areas of low, moderate and high stem density of *Euphorbia esula* L., another hard-to-control perennial species, and found no difference in P, K, NO_3^-, Zn, Fe and organic matter levels. They concluded that this weed's principal interference mechanism might have been allelopathy.

There are several explanations as to why differential extraction of the major nutrients was not detected in the presence of *P. longifolia*. Firstly, the extraction of soil nutrients by cotton with or without the *P. longifolia* may have been so small that it was not detectable by these measurements. This explanation

is unlikely given that changes in a number of soil parameters were measured over time. Secondly, the combined nutrient extraction of *P. longifolia* with a weakened cotton crop may have been similar to the more vigorous cotton extraction alone. Thirdly, differential extraction between the two species may have been occurring further down the profile and this was not detected by the relatively shallow soil cores. This explanation seems likely given that more than 30 and 40% of *P. longifolia* rhizomes and roots respectively were detected lower than 30 cm in the soil profile (Johnson *et al.* 2003b) and that extraction of soil water appeared to be occurring down to 80 cm. In contrast, Kapur and Sekhon (1985) indicated that cotton roots were more concentrated in the top 45 cm, which was generally an area of high fertility. It is probable that nutrient extraction for *P. longifolia* occurs at around the same depth as water extraction occurs and that this was not sampled thoroughly by the shallow soil cores used.

Polymeria longifolia clearly interfered with the growth of cotton in this trial as data not reported here showed reductions in cotton plant dry weights in *P. longifolia* patches and that increases in dry weights did not occur in the centre of *P. longifolia* patches in contrast to cotton plants outside patches (Johnson 2000). Although these measurements were also taken mid way and late in the crop's growth, competition for water and nutrients early in the crops growth is unlikely to fully explain the lack of dry weight accumulation observed during the trial period. Rather, allelopathy common in a number of perennial weeds, which also form monocultures like *P. longifolia* (Putnam 1985), may also have been occurring. This mechanism, although suggested by anatomical studies (Johnson 2000), requires further research, initially in glasshouse or laboratory culture where environmental factors can be controlled.

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