Improving competitive ability of chickpea with sowthistle: roots or shoots?

S-Zahra-Hosseini Cici[12], Paul Kristiansen[3] and Brian M Sindel[13]
[1]Cooperative Research Centre for Australian Weed Management
[2]School of Land and Food, University of Queensland, Brisbane, 4072, Australia
[3]School of Rural Science and Agriculture, University of New England, Armidale, New South Wales, 2351, Australia

Summary An experiment was conducted to examine the extent of root and canopy interference of chickpea (*Cicer arietinum* L.) with sowthistle (*Sonchus oleraceus* L.). Sowthistle was surrounded with either two or eight chickpea plants. There were different types of competition: no competition, shoot competition, root competition and full competition (root and shoot).

The performance of sowthistle grown in full competition with two chickpea plants was the same as that grown with root competition only. Also, there were no significant differences between sowthistle grown with chickpea canopy shade and the control, where there was no competition.

On the other hand sowthistle grown with eight neighbours was significantly suppressed in full, canopy or root competition.

Keywords *Sonchus oleraceus* L., common sowthistle, *Cicer arietinum* L., chickpea, root competition, shoot competition, improving competitive ability

INTRODUCTION

Chickpea is an important legume in Australian agriculture (FAOSTAT 2005). One of the obstacles in growing this crop is its poor competitive ability with weeds. The best approach to control weeds in crops is using an integrated weed management (IWM) package (Swanton and Murphy 1996). Improving the competitive ability of the crop is one of the components of this package.

Competition can be below-ground and/or above-ground. One mode of competition will always be more important (Wilson 1988). This depends on the species, environment, and the resource availability.

Understanding the mode of competition can help manage weeds in crops better. To address this need, different experimental techniques have been reviewed by McPhee and Aarssen (2001). The authors proposed that the target techniques in which plants are fully surrounded by competing neighbours is more realistic than the other methods. In this method resource depletion occurs from all directions and there is no way of escaping for the target plant. This is especially important in shoot competition when the direction of light changes during the day (McPhee and Aarssen 2001).

The mechanism of interference may be dependent on the effects of the plants on resources and their responses to changed resources (Tilman 1997). The final dry weight of the target plant should be examined when comparing the modes of competition since longer-term effects are more important in agronomy (Wilson 1988), although other physiological and morphological measurements may also be important.

common sowthistle from the Asteraceae is one of the world's most widespread weeds (Holm *et al.* 1977) which little is known about its ecophysiology and competitive ability. Its ability to germinate at any time of the year, be an alternative host for aphids (Gu and Walter 1999) and diseases, and its interference with crop harvest are the most important features of this weed. A survey of the northern grain region of Australia showed that this weed is an emerging problem in the area (Widderick 2002).

We studied the influence of different modes of competition on the performance of sowthistle to assess the relative importance of root and canopy interaction of chickpea with this weed.

MATERIALS AND METHODS

Sowthistle seeds were collected from the Lockyer Valley, Queensland, Australia in 2004. A glasshouse experiment was conducted at the University of New England, Armidale, Australia. Rectangular pots (0.12 m^3) were filled with a sandy loam clay. Treatments consisted of four modes of interference and two levels of competing neighbours (2 or 8 chickpea Desi type var. 960331014) surrounding an individual sowthistle (target). Treatments were completely randomized with four replications.

In the root competition treatment (RC), canopy competition was prevented by holding back neighbouring plants using a wire. For the shoot competition treatment (SC), deep cardboard sheets were used to separate the roots of target plants from those of neighbouring plants. In the no competition treatment (NC) an individual sowthistle was planted in the middle of the pot and placed far away from the other pots.

For full competition (FC) one sowthistle was planted with two or eight chickpea surrounding it in the same pot (Figure 1). Plants were grown under natural daylengths at 17 ± 2 and 12 ± 1 ºC during day and night, respectively. There was no limitation in the amount of water applied. Sowthistle plants were harvested after 90 days.

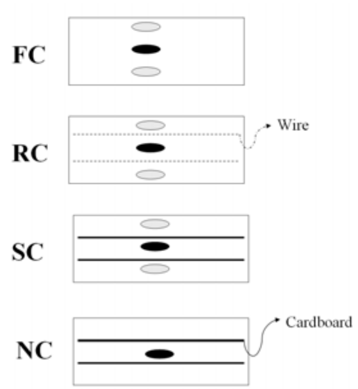

Figure 1. Protocol for the modes of competition (from above) when the number of neighbours was two; for full competition (FC) one sowthistle (black spot) was planted with two *C. arietinum* (white spots) surrounding it in the same pot. In root competition treatment (RC), canopy competition was prevented by holding back the neighbours using a wire (dashed line). For the shoot competition treatment (SC), deep cardboard sheets (black lines) were used to separate the roots of the target plant from those of neighbouring plants. In the no competition treatment (NC) an individual sowthistle was planted in the middle of the pot located far away from the other pots.

Before harvest, the height of plants was measured and the number of lateral branches counted. The plants were then removed from the pots and the soil from the roots washed. Above ground and below ground parts of the plants were dried separately at 70º C for 72 hours and weighed. The resulting data were analysed by one way ANOVA using the Minitab 14.0 software package (Carver 2004). Differences between averages were tested by LSD test for a significance level of $P < 0.05$.

RESULTS

There were no significant differences ($P > 0.05$) between NC and SC or RC and FC treatments in performance of sowthistle grown in the presence of two chickpea plants (Figure 2 and Table 1). The canopy and root biomass, height and number of branches were decreased significantly ($P < 0.05$) in both RC and FC in comparison with those in NC and SC.

However, the growth and development of sowthistle was extremely sensitive to a high population of chickpea (8 plants). The canopy biomass, root biomass, height and number of branches of sowthistle were significantly decreased in SC, RC and FC (Figure 2 and Table 1). For example, the canopy biomass was reduced by approximately 65, 77, and 82% in SC, RC, and FC, respectively, in comparison with the NC treatment.

In both low and high populations of chickpea, the number of branches in sowthistle showed high plasticity in response to all modes of competition (Table 1). In most of the treatments, plant allocations to branch outgrowth decreased up to 100%.

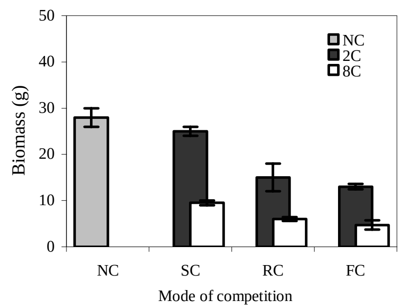

Figure 2. Effect of the mode of interference on canopy biomass of sowthistle (g plant^{-1}) when surrounded by no (NC) two (2C) and eight (8C) chickpea plants, Treatment abbreviations are: NC (no competition), SC (shoot competition), RC (root competition) and FC (full competition). Bars are dry weights and interval bars are standard errors

Table 1. Sowthistle responses (mean ± standard error) of RDW (root dry weight - g/plant), H (height - cm), and NB (number of branches) to two populations of chickpea (2 and 8) in different modes of competition. NC (no competition - control), SC (shoot competition), RC (root competition) and FC (full competition)

Type	RDW	H	NB
NC	5.6±0.4 a	101±8 a	13±1 a
2 chickpea plants around sowthistle			
SC	5 ± 0.4a	104 ± 7 a	7± 1 b
RC	3± 0.5 b	84± 2 b	1 c
FC	3 ±0.1b	83 ±3b	0 c
8 chickpea plants around sowthistle			
SC	3± 0.1b	58.9 ±1 c	0 c
RC	2 ±0.2c	17.8 ±4 d	0 c
FC	1.8±0.3 c	11 ± 3 d	0 c

Means ± se within the same column followed by the same letter are not significantly different

DISCUSSION

In this study, the dry weight of sowthistle was reduced more by root interference than canopy interference from chickpea. Canopy interference was only significant when the population of chickpea was high.

The result of two chickpea plants around sowthistle suggests that the roots of chickpea plants have more potential to interfere with the growth and development of sowthistle than the shoot. Number of branches was highly sensitive in sowthistle to all the modes of competition (SC, RC and FC). It indicates the high plasticity (Pigliucci 2001) of this weed in response to stress and resource availability.

Such a result was reported by Wilson (1988) examining the importance of shoot and root competition in 23 cases. He found that in 70% of published literature, root competition was more intense than shoot competition.

It has been reported that root competition decreased the canopy dry weights and height of maize (*Zea mays* L.) and pea (*Pisum sativum* L.) while canopy competition had no significant effect on these traits (Semere and Froud-Williams 2001). This is contrast to the study of Mohammadi *et al.* (2004), who found that shoot competition had an approximately two-fold greater effect on biomass than root competition in soybean (*Glycine max* L.)-sorghum (*Sorghum bicolour* L.) interactions.

In summery, the results of our research would imply that in order to improve the competitive ability of chickpea with sowthistle, either the seeding rate should be increased or the canopy of individual varieties should be manipulated.

Future work would be developing architectural models of chickpea and sowthistle to simulate the effect of different chickpea genotypes on sowthistle morphogenesis and find chickpea ideotypes *in silico*. Such work is ongoing as part of PhD project at University of Queensland (Cici, unpubl.).

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