Phalaris spp. competition with wheat using an additive design series

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Summary A field experiment was conducted using an additive design series to determine the approximate onset of competition between *Phalaris* spp. and spring wheat, the density of *Phalaris* plants necessary to reduce wheat yield significantly and to investigate the relative aggressiveness of *Phalaris paradoxa* and *Phalaris minor* in relation to wheat. Seeds of *Phalaris* spp. were sown to achieve densities ranging from 0 to 400 plants m^{-2}, whereas the density of wheat cv. Axona was maintained constant at 350 plants m^{-2}. Wheat height and number of tillers were significantly reduced in the presence of *P. minor* 42 days after sowing, whereas in competition with *P. paradoxa* such a reduction occurred a week earlier. Wheat fresh weight was significantly reduced at 200 *P. minor* m^{-2}, whereas for *P. paradoxa* 100 plants m^{-2} were necessary to significantly reduce wheat yield. Overall it was found that competition with *Phalaris* spp. reduced vegetative biomass, number of ears, ear length, absorption of photosynthetically active radiation, transmission beneath the crop and weed canopies with increasing weed density.

Keywords Wheat, *Phalaris minor*, *Phalaris paradoxa*, additive design, crop-weed interference

INTRODUCTION

Wheat (*Triticum aestivum* L.emend. Fiori & Paol.) occupies approximately 17% of the world's cropped land and contributes 35% of the staple food (Anon. 2002). Weed competition is one of the most important factors, which poses a threat to the maintenance of wheat production. Among grass weeds, *Phalaris minor* Retz. (littleseed canarygrass) is the most noxious weed of wheat in a rice-wheat cropping system over an area of about 10 million hectares in India (Chhokar *et al*. 2006) and can reduce wheat yield by 30% at a density of 150 plants m^{-2} (Malik and Singh 1995). It is also reported to be an important weed in Israel, Mexico, South Africa and Pakistan. *Phalaris paradoxa* L. (hood canarygrass) is an annual grass of the Mediterranean region and has been known as a casual species in Britain for at least 100 years.

Thurley and Chancellor (1985) found that some farms in Britain were severely infested with *P. paradoxa* during the early 1980s and predicted that it could become a major weed in Britain. In a recent survey, this weed has been found to be the third most common weed among winter cereals in the north-east grain cropping region of Australia (Alemeseged *et al*. 2001). It is regarded as a very aggressive weed, which if not treated may reduce wheat yield by 40% (Walker *et al*. 2001). Therefore, it was considered appropriate to compare the competitive abilities of these two grassy weeds in relation to wheat.

An additive design series experiment was used to fulfil this objective. In additive experiments two species are grown together, the density of one is maintained constant while the density of the other is varied. The first species can be regarded as an indicator and experiments of this sort can be used to compare the relative aggressiveness of a group of species relative to the indicator (Harper 1977). The experiments documented here are crop-weed competition studies involving wheat-*P. minor* and wheat-*P. paradoxa* where wheat is considered to be the indicator species.

MATERIALS AND METHODS

Crop weed competition studies involving wheat and *Phalaris spp.* were conducted during the spring of 2005 in an experimental area of the School of Plant Sciences, Reading, UK and netted to exclude birds. The experiment was laid out in a randomised complete block design (RCBD) with four replicates per treatment. Seeds of *Phalaris minor* and *Phalaris paradoxa* were sown in the field in 1 m × 1 m square plots in mixture with wheat. Five densities of both weed species were investigated viz. 25, 50, 100, 200, and 400 plants m^{-2}, whereas wheat density was kept constant at 350 plants m^{-2}. Viability tests were conducted for both grass weed seed samples to determine the amount of seed required to obtain the specified seedling densities in the field. Wheat seeds were sown at the depth of 2 cm, whereas weed seeds were broadcast on the soil surface and were watered as necessary.

Crop height, number of leaves, tillers, ears and wheat ear length m^{-2} were determined. Crop fresh weight, dry weight and grain yield were taken from the central rows excluding outer rows as borders. Fresh weight, dry weight and grain yield of *Phalaris* spp. were taken m^{-2}. Transmission of photosynthetically active radiation (µmol m^{-2} s^{-1}) was recorded using a Sunfleck ceptometer.

All the data collected were subjected to analysis of variance using Genstat 7th edition. The treatment means with significant P values were further separated using the least significant test at 5 % level of significance level.

RESULTS AND DISCUSSION

Wheat height was significantly reduced by *Phalaris minor* from 42 days after sowing (DAS) (Table 1), whereas the effects of increasing densities of *P. minor* on wheat leaf number and tillers were not significant (data not shown). These findings are in agreement with the observations reported by Khan *et al.* (2002), in which the critical period of crop weed competition was determined as the period between 42 and 46 DAS in wheat.

In contrast to *P. minor*, *P. paradoxa* reduced wheat height significantly 35 DAS at equivalent plant densities (Table 2). *P. paradoxa* also had a significant effect on wheat leaf number and tiller number.

The number of ears, foliar fresh and dry weights and yield were significantly reduced with increasing *Phalaris* spp. densities. In terms of yield components, competitive effects of *Phalaris minor* occurred at a density of 200 plants m^{-2} (Table 3) whereas for *P. paradoxa* yield loss was evident at a density of 100 plants m^{-2} (Table 4) indicating a greater competitive ability of the latter species.

Grain yield of wheat was reduced by 14.8% with *P. minor* at a density of 200 plants m^{-2} and 17.4% in competition with *P. paradoxa* at 100 plants m^{-2} (Figure 1). This indicates that *P. paradoxa* is a more aggressive competitor with wheat than is *P. minor*. The reduction in yield with *P. minor* and *P. paradoxa* reported here is similar to that in other studies. Dhima *et al.* (2000) reported a 14% reduction in grain yield with *P. minor* at 400 plants m^{-2}. Afentouli and Eleftherohorinos (1996) reported *P. minor* at a density of 304 plants m^{-2} reduced wheat grain yield by 36 to 39%. Dhaliwal *et al*. (1997) reported a 10% yield loss at densities of 60–70 plants m^{-2}. Tessema and Tanner (1997) found in their study that 320 plants of *P. paradoxa* m^{-2} reduced the grain yield by 48% and suggested that the reduction in grain yield is primarily due to a decrease in reproductive spikes.

The findings of the current study clearly indicate that *P. paradoxa* is a stronger competitor relative to *P. minor*, despite the similar growth rate of *P. minor* and *P. paradoxa*. *Phalaris*-wheat competition was mainly influenced by weed density as has been observed previously (Bhan and Froud-Williams 2005).

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Table 1. Wheat height as affected by *Phalaris minor* density at different times after sowing.

Weed density	Wheat height (cm)			
	35 DAS	42 DAS	49 DAS	56 DAS
0	2.6	3.4	5.4	7.8
25	2.6	3.3	5.4	7.7
50	2.5	3.3	5.3	7.6
100	2.5	3.3	5.3	7.6
200	2.4	3.2	5.2	7.2
400	2.3	2.9	4.8	6.9
LSD	0.3 ns	0.24*	0.19*	0.22*

Table 2. Wheat height (cm) as affected by *Phalaris paradoxa* density at different times after sowing.

Weed density	Wheat height (cm)			
	35 DAS	42 DAS	49 DAS	56 DAS
0	2.5	3.2	5.4	7.9
25	2.4	3.1	5.4	7.8
50	2.4	3.1	5.4	7.7
100	2.3	3.0	5.3	7.6
200	2.3	3.0	5.1	7.2
400	2.2	2.9	4.9	7.0
LSD	0.1*	0.1*	0.1	0.3*

Table 3. Yield and yield components of wheat as affected by *Phalaris minor* density.

Weed density	No. of ears (m^{-2})	FW ($g\ m^{-2}$)	DW ($g\ m^{-2}$)	Yield ($g\ m^{-2}$)
0	250.3	2632.4	1361.8	402.2
25	244.0	2497.3	1335.8	391.6
50	242.5	2462.8	1257.0	396.4
100	240.8	2462.0	1237.4	369.6
200	225.3	2238.4	1207.6	362.8
400	210.8	1788.4	1057.0	318.0
LSD	19.82*	400.4*	157.6*	34.2*

Table 4. Yield and yield components of wheat as affected by *Phalaris paradoxa* density.

Weed density	No. of ears (m^{-2})	FW ($g\ m^{-2}$)	DW ($g\ m^{-2}$)	Yield ($g\ m^{-2}$)
0	252.3	2343.6	1245.8	383.6
25	253.8	2268.0	1210.0	366.4
50	235.0	2196.0	1173.8	351.4
100	213.3	2042.2	1101.0	317.0
200	204.5	1828.8	958.6	306.6
400	190.0	1613.8	920.0	297.4
LSD	34.1*	467.0*	193.2*	42.6*

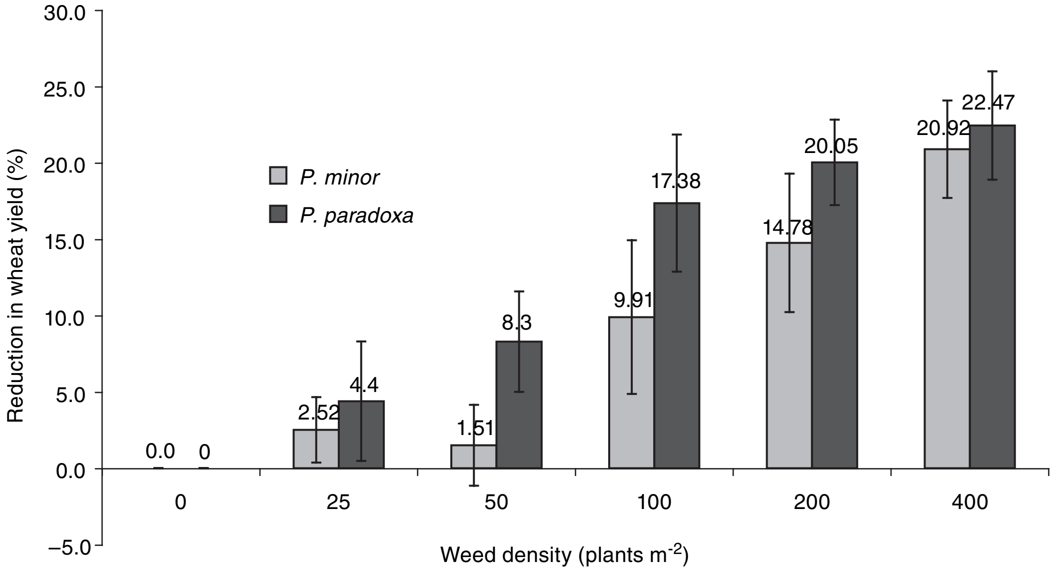

Figure 1. Reduction in wheat yield as influenced by *Phalaris minor* and *Phalaris paradoxa* plant density. Vertical bars indicate ± SE of means.

REFERENCES

Afentouli, C.G. and Eleftherohorinos, I.G. (1996). Littleseed canarygrass (*Phalaris minor*) and short spiked canarygrass (*Phalaris brachystachys*) interference in wheat and barley. *Weed Science* 44, 560-5.

Alemseged, Y., Jones, R.E. and Medd, R.W. (2001). A farmer survey of weed management and herbicide resistance problems of winter crops in Australia. *Plant Protection Quarterly* 16, 21-5.

Anon. (2002). World wheat facts. Fact sheet November 2002. Web page: http://www.org/pdfs/world/wheat_facts.pdf.

Bhan, A. and Froud-Wiliams, R.J. (2005). Wheat-phalaris spp. competition/interference studies using an additive design series. Proceedings of the 2005 Glasgow Crop Protection Conference, pp. 495-8.

Chhokar, R.S., Sharma, R.K., Chauhan, D.S. and Mongia, A.D. (2006). Evaluation of herbicides against *Phalaris minor* in wheat in north-western Indian plains. *Weed Research* 46, 40-49.

Dhaliwal, B.K., Walia, V.S. and Brar, L.S. (1997). Response of wheat to *Phalaris minor* population density. Proceedings of 1997 Brighton Crop protection Conference – Weeds, Farnham, UK, pp. 1021-4.

Dhima, K.V., Eleftherohorinos, I.G. and Vasilakoglou, I.B. (2000). Interference between *Avena sterilis*, *Phalaris minor* and five barley cultivars. *Weed Research* 40, 549-59.

Harper, J.L. (1977). 'Population biology of plants'. (Academic Press, London).

Khan, M.A., Gul, H., Shah, W.A. and Afridi, M.Z. (2002). Duration effect of wheat competition on the yield and yield components of wheat. *Sarhad Journal of Agriculture* 18, 335-7.

Malik, R.K. and Singh, S. (1995). Littleseed canary grass (*Phalaris minor*) resistance to isoproturon in India. *Weed Technology* 9, 419-25.

Thurley, B. and Chancellor, R.J. (1985). Occurrence, distribution and spread of *Phalaris paradoxa* L. in Britain. *Annals of Applied Biology* 107, 79-86.

Tessema, T. and Tanner, D.G. (1997). Grass weed competition and calculated economic threshold densities in bread wheat in Ethiopia. *African Crop Science Journal* 5, 371-84.

Walker, S.R., Robinson, G.R. and Medd, R.W. (2001). Management of *Avena ludoviciana* and *Phalaris paradoxa* with barley and less herbicide in subtropical Australia. *Australian Journal of Experimental Agriculture* 41, 447-54.