Allelopathic response of wheat (*Triticum aestivum* L.) straw on germination and growth of selected weed species

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Summary The present study was conducted to determine the allelopathic effect of wheat straw on three weed species, viz. *Chenopodium album* L., *Boerhavia diffusa* L. and *Parthenium hysterophorus* L. Straw treatments linearly decreased the germination and the length of roots and shoots of the test weeds relative to controls. At the higher concentrations of wheat straw leachates, seed germination was least affected in *Parthenium hysterophorus* and most affected in *Boerhavia diffusa* under burned and unburned straw treatments, whereas, at lower concentrations (25%) of the burned straw treatment, it remained similar to the water control. Seedling growth was less affected under lower concentrations. Thus, straw management practices should be considered when developing an integrated weed management program.

Keywords Allelopathic response, wheat straw, weed species.

INTRODUCTION

Wheat is a major winter crop of Northern India. However, in multiple cropping or mono cropping systems the proper management of wheat residues after harvest poses a great problem. The negative impact of allelopathy of wheat on agricultural production system has been identified when wheat straw is retained on the soil surface (Wu *et al.* 2001). Adverse effects of crop residues on plant growth are possible through mechanisms such as leaching of toxin directly from fresh/unweathered crop residues or production of microbial and other toxins during residue decomposition (Guenzi *et al*. 1962, McCalla and Haskins 1964). Wheat straw's ability to influence the management of weeds, pests and diseases has also been recognised (Muminovic 1991). The degree of inhibition of growth depends on the type of residues, quality, placement and degree of decomposition, microbial activity, nutrient status and other physical parameters (Rice 1984). The allelopathic nature of wheat straw can significantly inhibit emergence, seedling growth and dry matter production.

MATERIAL AND METHODS

The present study was conducted at Dayalbagh Educational Institute of Agra (India) in 2007–08. Seeds of the selected weed species, i.e. *P. hysterophorus*, *C. album* and *B. diffusa*, were collected from experimental crop fields. The bioassay experiment consisted of three treatments, viz. leachate of unburned straw, leachate of burned straw and water control. The leachates were prepared by following the methodology of Al-Hamdi *et al*. (2001). Fresh wheat straw was collected at harvest from agricultural farms. Wheat straw (50 g; burned and unburned separately) was soaked in 900 mL distilled water for 72 h. The suspensions were filtered by muslin cloth. The undiluted filtrate was used in the 100% treatment, while 50% and 25% concentrations were made by dilution with the appropriate amount of distilled water. Twenty seeds of selected weeds were soaked in each of the leachates. Seeds soaked in distilled water were considered as a water control. After soaking, the seeds were transferred to Petri dishes lined with Whatman filter paper No. 41, and moistened with distilled water. Each Petri dish was provided with 5 mL of leachate or distilled water (in case of control) on alternate days. Moisture was maintained by providing distilled water as required by the seeds. Observations were recorded after 15 days of soaking and analysed statistically.

RESULTS

Parthenium hysterophorus was least affected by wheat straw treatments (Table 1). *P. hysterophorus* is highly adaptable, enabling the plant to grow in soils of different quality and chemical status. The other two weeds, *C. album* and *B. diffusa* showed almost the same ability to tolerate the effect of wheat straw leachate. The least inhibition occurred in *P. hysterophorus* indicating tolerance by this grass species of the toxic allelochemicals present in wheat straw. It was observed that roots were more influenced than shoots by the unburned straw leachate. In *B. diffusa* root and shoot both remained unaffected at 25% concentrations, while the 100% concentrations stunted this weed slightly. All

concentrations of burned straw leachate showed much less inhibition than unburned straw on these weeds. Differential toxicity of aqueous leachates of wheat straw in both the treatments (burned and unburned) was observed, with the degree of inhibition depending upon the extract concentrations. At 25% concentrations this leachate did not affect germination while the same treatment (either burned or unburned) was inhibitory at 100% concentrations. A similar trend was observed in seedling growth. There is a likely variation in types and amounts of the leachate. The straw leachate at 100% concentrations has the ability to reduce the growth of the weed, but at 25% concentrations the plantlet tolerated the straw treatments. The burned straw leachate could not suppress vigour in seeds and seedlings of the target weed.

DISCUSSION

In some recent studies, the influence of wheat straw on selected weed species was quantified. Boyhan *et al.* (2006) reported that wheat straw reduced plant population and yield of weeds in *Allium cepa* L. production. Dikic (2005) reported that wheat straw reduced biomass production in quack grass (*Agropyron repens* P.Beauv). It is stated that the toxicity of the straw may be species dependent. Thus, it can have a stimulatory effect on some weeds but an inhibitory effect on others. Therefore, differential toxicity may be the reason for the variable findings reported in the literature. Wang *et al.* (2004) tested the effect of returning straw on weeds of rice and wheat fields and the efficiency of chemical weeding, and observed that *Leptochloa chinensis* (L.) Nees, *Echinochloa crus-galli* Schnizl. and *Commelina diffusa* Schnizl. were the main weeds in rice fields after mulching with wheat straw. The weeds decreased significantly with increasing wheat straw mulch. Wheat straw mulching at higher doses reduced chemical control efficiency compared with chemical control alone. Thus, results clearly show differential phytotoxicity of aqueous leachates of wheat straw in both burned and unburned treatments. The reduced growth of weed parameters in the experiment demonstrated that water soluble toxins released from the straw or produced by microorganisms affected weed growth.

CONCLUSION

In multiple cropping systems where the time interval between the harvest of the previous crop and sowing of the subsequent crop is very short, the residue gets little time to decompose, causing adverse effects on germination and seedling growth of succeeding crops.

Table 1. Effect of wheat straw leachate on the seed germination (%) and root length (cm) and shoot length (cm) of *Parthenium hysterophorus*, *Chenopodium album* and *Boerhavia diffusa* (*in vitro*). Values are the mean ± SD.

	Leachate (unburned straw)			Leachate (burned straw)		
Leachate concentration (%)	Germination	Root length	Shoot length	Germination	Root length	Shoot length
Parthenium hysterophorus						
0 (water control)	65.0 ± 2.7	1.5 ± 0.18	1.4 ± 0.29	65 ± 2.7	2.5 ± 0.18	5.2 ± 0.29
25	52.5 ± 2.9	2.3 ± 0.24	5.2 ± 0.25	52.5 ± 2.6	2.5 ± 0.17	4.8 ± 0.24
50	43.75 ± 2.0	1.5 ± 0.22	4.0 ± 0.17	48.5 ± 2.5	2.5 ± 0.17	3.8 ± 0.23
100	37.5 ± 2.7	1.2 ± 0.18	3.8 ± 0.22	42.5 ± 2.7	1.5 ± 0.16	3.5 ± 0.20
CD[1] at 5%	4.3	1.5	1.4	3.8	0.69	0.34
Chenopodium album						
0 (water control)	72.5 ± 2.8	2.0 ±0.23	4.5 ± 0.25	72.5 ± 2.9	2.0 ± 0.18	4.5 ± 0.34
25	43.75 ± 2.9	1.3 ± 0.26	2.5 ± 0.19	50 ± 3.0	1.6 ± 0.15	4.0 ± 0.2
50	38.75 ± 2.7	1.3 ± 0.22	2.5 ± 0.20	52.5 ± 2.1	1.3 ± 0.26	3.5 ± 0.30
100	32.5 ± 2.5	1.2 ± 0.11	1.5 ± 0.17	48.5 ±2.5	1.2 ± 0.28	3.0 ± 0.26
CD at 5%	1.9	0.18	0.28	3.7	0.8	0.49
Boerhavia diffusa						
0 (water control)	62.5 ± 2.9	2.0 ± 0.24	4.0 ± 0.30	62.5 ± 2.7	2.0 ± 0.27	4.0 ± 0.19
25	50 ± 2.0	1.8 ± 0.25	3.5 ± 0.26	51.25 ± 2.7	2.0 ± 0.22	4.0 ± 0.23
50	40 ± 2.2	1.5 ± 0.3	3.5 ± 0.26	45 ± 2.3	2.0 ± 0.34	3.8 ± 0.34
100	37.5 ± 2.8	1.5 ± 0.27	2.8 ± 0.19	47.5 ± 2.1	1.5 ± 0.27	2.0 ± 0.27
CD at 5%	3.2	0.22	0.34	4.6	0.76	0.63

[1] CD = critical difference; level of significance ($P < 0.05$).

In the present study selected weeds responded differentially to the treatments under identical conditions. Seed germination of *P. hysterophorus* was found to be least affected followed by that of *C. album* and *B. diffusa*. In terms of seeding growth, *B. diffusa* faced the stress given by wheat straw primarily followed by *P. hysterophorus* and *C. album*. Burned straw leachate did not suppress the vigour of emergence and growth of the target weed to the same extent as unburned straw. It is suggested therefore that further research is needed to find ways of incorporating straw management practices into an Integrated Weed Management Program. Better utilisation of this crop residue in weed management and soil quality improvement will lead to more sustainable crop production systems.

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