LABORATORY STUDIES ON THE ALLELOPATHIC POTENTIAL OF SORGHUM AND SUNFLOWER WATER EXTRACT AND POWDER AGAINST NARROW-LEAF SUMMER WEEDS

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ABSTRACT

Allelopathy refers to the direct indirect effect of one plant on nearby growing plants of another species in terms of inhibiting the germination and growth through release of chemical compounds. Weeds are major menace in reducing crop yield and can be managed effectively through phytotoxic properties of plants. The laboratory studies were carried out to evaluate the response of summer weeds to sorghum and sunflower water extract and powder in terms of germination and seedling growth at Seed Testing Laboratory, Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan during Kharif 2010 and 2011. The experiment was laid out in three replicated completely randomized design (CRD). The respective treatments included check (untreated), sorghum/ sunflower shoot/ root powder (10 g kg^{-1} soil) and shoot/ root water extract (10 ml kg^{-1} soil). The analysis of variance of two years pooled data showed that water extracts and powders of allelopathic crops caused substantial reduction in germination and growth of tested summer weeds such as jungle rice (Echinochloa colonum L.), bermuda grass (Cynodon dactylon L.) and purple nutsedge (Cyperus rotundus L.).

Keywords: *Sorghum, sunflower, allelopathic, water extract, powder, weeds*

INTRODUCTION

Weeds are one of the major biotic constraints in crop production system. The weeds compete with crops for nutrients, moisture, light, CO_2 and space as well as interfere through allelopathic properties. The weeds with allelopathic potential pose negative influences on crops through release of allelochemicals from their roots, leachates, volatilization and residues decomposition (Hozayn *et al*., 2011). Weeds decrease yield of crops and make their quality inferior as well as cause increase in the cost of crop production (Jabran *et al*., 2010). One of the major causes of low yield of

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summer field crops in Sindh is severe invasion of weeds. Both types of weeds narrow and broadleaf are found to attack crops. Among narrow-leaf summer weeds jungle rice (*Echinochloa colonum* L.), bermuda grass (*Cynodon dactylon* L.) and purple nutsedge (*Cyperus rotundus* L.) are one of the most harmful weeds of field crops. Weeds are unwanted and volunteer plants and the effective control of such weeds is necessary to achieve the desired yield of any variety of crops. The management of weeds through manual means is found to be expensive (Tanveer *et al*., 2010). The excessive and indiscriminate application of herbicides has polluted the environment (Narwal *et al*., 2005).

Allelopathy is defined as any direct or indirect growth suppressing influence of one plant species on nearby growing plants of another species through release of certain compounds known as allelochemicals (Tesio and Ferrero, 2010). The crops having allelopathic properties possess compounds in varying concentrations in their under and above ground organs viz. roots, leaves, stems, seeds and flowers (Weston and Duke, 2003). Sunflower and sorghum have been reported to possess great allelopathy, having many allelochemicals like alkaloids, flavonoids, terpenoids, sorgoleone, phenolics and glycosides. (Kamal, 2011; Ashraf and Akhlaq, 2007) The use of allelopathy includes mostly the material produced or left at farm. It is being considered as effective, low-cost, sustainable and environmentally safe strategy for weed management (Khaliq *et al*., 2011).

The laboratory studies are thought to pre-requisite and useful in assessing the allelopathic potential of plant species (Asgharipour, 2011). The commonly conducted laboratory experiments for allelopathic properties are done for germination of seeds and seedling growth. The germination and growth of sensitive plants is suppressed when they are exposed to allelopathic compounds (Nouri *et al*., 2012). The phytotoxic ability differs among various plant parts (Anjum and Bajwa, 2008). The water extracts of different plants parts with allelopathic properties caused significant suppressing effects on growth of weeds (Ashraf and Akhlak, 2007). The root exudates of sorghum checked growth of different species of weeds (Narwal *et al*., 2005). The allelopathic compounds lessen roots ability to uptake nutrients and water as a result many process and functions of plants like cell division, protein synthesis, respiration, photosynthesis and seminal roots thickness are inhibited (Jabran *et al*., 2010). The allelochemicals possessed by sunflower interrupted metabolic process of cells and ultimately reduced the germination and growth of plants (Macias *et al*. (2002). The allelopathic plants demonstrated more

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inhibitory influences on radicle germination in comparison with plumule growth (Iqbal and Cheema, 2009).

MATERIALS AND METHODS

The laboratory experiment was carried out at Seed Testing Laboratory, Department of Agronomy, Faculty of Crop Production, Sindh Agriculture University, Tandojam, Pakistan during summer 2010 and for accuracy of results the experiment was repeated during 2011. The experiment was laid out in completely randomized design (CRD) having three replications. The boxes of 9 cm x 3 cm x 3 cm size were used. The quantity of soil used was 5 kg box^{-1} and then moistened with water. The seeds, rhizomes and tubers (as the case may be) of test weeds were sown in 1st week of May each year. The boxes were kept at room temperature. Three most common and harmful narrow-leaf summer weeds like Kabah/ purple nutsedge (*Cyperus rotundus* L.), Chhabar/ bermuda grass (*Cynodon dactylon* L.) and Sawari/ jungle rice (*Echinochloa colonum* L.) were investigated under the influence of sorghum and sunflower root / shoot powder allelopathy. One check treatment (allelopathic material not applied) was also included for comparison. The treatments included: Check (Untreated), Sorghum shoot/root water extract/ powder (10 g/ 10 ml kg^{-1} soil), Sunflower shoot/ root water extract/ powder (10 g/ 10 ml kg^{-1} soil). The soil was collected from Malir Farm, Sindh Agriculture University, Tandojam, Pakistan with sandy loam texture, placed in Order *Aridisols* and Sub-group *Typic Camborthids* according to the classification of USDA system.

The allelopathic material of sorghum and sunflower and test weeds propagatory material was collected from Students' Experimental Farm, Department of Agronomy, Faculty of Crop Production, Sindh Agriculture University, Tandojam. Sorghum and sunflower plants were uprooted at peak of flowering stage, separated as roots and shoots, and then dried under sunlight. The shoots and roots of sorghum and sunflower were chopped into 2 cm, dried under sun pieces and ground to a fine powder. To prepare water extract, the powder of sorghum and sunflower shoots and roots was soaked in water in the ratio of 1:10 (w/v) for 24 hours. The extracts were filtered and boiled at 100 ^{0}C on a gas burner to concentrate 20 times. The water extracts prepared from shoot and root of sorghum and sunflower were applied immediately on soil as spray in respective weed boxes @ 50 ml box^{-1} after sowing.

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As regards, incorporation of powder in soil, the shoot and root powders of sorghum and sunflower were mixed before sowing of weeds thoroughly with soil @ 50 g box^{-1}. The respective twenty five rhizomes/ seeds/ tubers of *Cynodon dactylon* (L.), *Echinochloa colonum* (L.) and *Cyperus rotundus* (L.) were sown in specific box maintaining five rows. The canal water was applied to boxes as and when needed. The weed seedlings were uprooted at 30 DAS from each box and kept separately. Immediately after uprooting the shoot/ root length (cm) and fresh biomass (g seedling^{-1}) were determined. After that the seedlings were kept in oven for 72 hours at 70 ^{0}C and then dry weight seedling^{-1} (g) was measured. The data were statistically analyzed using Statistix 8.1 computer software (Statistix, 2006). The LSD test was applied for comparing treatments superiority accurately.

RESULTS AND DISCUSSION

Germination (%) of weeds under the influence of allelopathic crops

The results given in Table-1 showed that water extracts and powders of sorghum and sunflower shoots and roots significantly ($P<0.05$) inhibited the germination potential of test weeds. The lowest respective germination of 50.0, 51.7 and 50.0 % was recorded for *Echinochloa colonum* (L.), *Cynodon dactylon* (L.) and *Cyperus rotundus* (L.) under application of sorghum shoot powder (10 g kg^{-1} soil), followed by sunflower shoot powder (10 g kg^{-1} soil) with 50.0, 51.7 and 51.7 % differing non-significantly with each other. Water extract of sorghum/ sunflower shoot (10 ml kg^{-1} soil) were found 3rd and 4th in allelopathy. The water extracts and powders prepared from roots of sorghum and sunflower also adversely affected germination capacity of weeds as compared to check (untreated) treatment. Water extract and powder prepared from shoot proved more allelopathic as compared to root. It can be envisaged from the results that sorghum and sunflower possess several allelochemicals in both aerial and underground parts and the weeds germination inhibition could be due to suppressing influences of phytotoxic compounds present in water extracts and powders of shoots and roots. The results of this study with regard to germination are supported by Asgharipour (2011) who found that germination of plants is suppressed when exposed to allelopathic compounds. It is also clearly evident from the results of our study that phytotoxic influence of sorghum and sunflower were plant organ specific, where shoot caused more negative effects as compared to root. Similar results were also reported by Nouri *et al*. (2012) who suggested variation in allelopathic properties of different plant parts.

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Table 1. Germination (%) of narrow-leaf summer weeds under the allelopathic impact of sorghum and sunflower

Treatments	***Echinochloa colonum*** **(L.)**	***Cynodon dactylon*** **(L.)**	***Cyperus rotundus*** **(L.)**
Check (Untreated)	91.7 a	93.3 a	93.3 a
Sorghum shoot powder (10 g kg^{-1} soil)	50.0 d	51.7 e	50.0 e
Sorghum root powder (10 g kg^{-1} soil)	53.3 d	56.7 d	56.7 d
Sorghum shoot water extract (10 ml kg^{-1} soil)	53.3 d	56.7 d	56.7 d
Sorghum root water extract (10 ml kg^{-1} soil)	58.3 c	61.7 c	61.7 c
Sunflower shoot powder (10 g kg^{-1} soil)	50.0 d	51.7 e	51.7 e
Sunflower root powder (10 g kg^{-1} soil)	58.3 c	61.7 c	60.0 cd
Sunflower shoot water extract (10 ml kg^{-1} soil)	61.7 bc	61.7 c	58.3 cd
Sunflower root water extract (10 ml kg^{-1} soil)	63.3 b	66.7 b	66.7 b
S.E ±	2.08	2.36	2.10
$LSD_{0.05}$	4.37	4.95	4.35

Shoot and root length (cm) of weeds under the influence of allelopathic crops

The data presented in Table-2 illustrated that allelopathic crops water extracts and powders exerted significant ($P<0.05$) reduction in shoot and root length of summer weeds. The minimum respective 12.6, 10.6 and 9.7 cm shoot length and root length of 4.8, 7.3 and 4.3 cm for *Echinochloa colonum* (L.), *Cynodon dactylon* (L.) and *Cyperus rotundus* (L.) was noted under the influence of sorghum shoot powder (10 g kg^{-1} soil), followed by shoot powder of sunflower (10 g kg^{-1} soil) showing non-significant statistical differences with each other. The allelopathic ability of water extract reduced as compared to powder where shoot length of 13.4, 11.2 and 11.4 cm and root length of 5.3, 8.3 and 6.4 cm of *Echinochloa colonum* (L.), *Cynodon dactylon* (L.) and *Cyperus rotundus* (L.) was registered under the impact of shoot water extract of sorghum (10 ml kg^{-1} soil).

Similarly, the application of sunflower shoot water extract (10 ml kg^{-1} soil) ranked 4^{th} in allelopathic efficacy against weeds in terms of shoot and root length. It could be depicted from the above trend of results that reduction in weeds growth through sorghum and sunflower water extracts and powders shows the presence of solubility of allelochemicals and their inhibitory influences. The allelochemicals contained in allelopathic crops (sorghum and sunflower) probably affected perhaps directly to the roots, curling of leaves decreased transpiration of water and regulation of stoma of weeds. The water extracts and powders sorghum and sunflower were found more

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allelopathic to roots as compared to shoot. The results in accordance with the findings of Sadegi *et al*. (2010) who found that application of sunflower material inhibited germination of plant seeds and reduced content of chlorophyll, and shoot/ root length. The incorporation of powders in soil and spray of water extracts prepared from different parts of plants with allelopathic potential suppressed weed growth significantly (Peng *et al*., 2004).

Table 2 Shoot and root length (cm) of narrow-leaf summer weeds under the allelopathic impact of sorghum and sunflower

Treatments	***Echinochloa colonum* (L.)**		***Cynodon dactylon* (L.)**		***Cyperus rotundus* (L.)**	
	Shoot	Root	Shoot	Shoot	Shoot	Root
	length (cm)					
Check (Untreated)	19.8 a	8.4 a	18.1 a	15.7 a	19.8 a	10.7 a
Sorghum shoot powder (10 g kg^{-1} soil)	12.6 f	4.8 f	10.6 f	7.3 f	9.7 e	4.3 f
Sorghum root powder (10 g kg^{-1} soil)	13.8 de	5.5 de	11.0 ef	8.1 e	11.3 d	5.5 de
Sorghum shoot water extract (10 ml kg^{-1} soil)	13.4 e	5.3 def	11.2 e	8.3 e	11.4 d	6.4 d
Sorghum root water extract (10 ml kg^{-1} soil)	14.4 cd	5.9 cd	11.9 d	9.1 d	13.2 c	7.7 c
Sunflower shoot powder (10 g kg^{-1} soil)	13.1 ef	4.9 ef	10.5 f	7.9 f	10.7 d	4.8 ef
Sunflower root powder (10 g kg^{-1} soil)	14.5 cd	6.5 bc	12.4 cd	9.4 cd	12.7 c	6.1 d
Sunflower shoot water extract (10 ml kg^{-1} soil)	14.6 c	6.3 bc	12.6 c	9.7 c	12.8 c	7.5 c
Sunflower root water extract (10 ml kg^{-1} soil)	15.5 b	6.9 b	13.3 b	10.5 e	14.6 b	8.7 b
S.E ±	0.35	0.32	0.26	0.27	0.38	0.48
$LSD_{0.05}$	0.74	0.67	0.55	0.57	0.80	1.02

Fresh/ dry weight seedling^{-1} (g) of weeds under the influence of allelopathic crops

The data in Table-3 clearly shows that water extracts and powders prepared from shoot and root sorghum and sunflower inhibited markedly ($P<0.05$) the fresh/ dry weight of summer weeds. The sorghum shoot powder incorporation in soil (10 g kg^{-1} soil) demonstrated high inhibitory effects and resulted in lowest values of 4.6, 2.9 and 4.4 g $seedling^{-1}$ for fresh weight and 1.9, 1.6 and 1.9 g $seedling^{-1}$ for dry weight of *Echinochloa colonum* (L.), *Cynodon dactylon* (L.) and *Cyperus rotundus* (L.), followed by sunflower shoot powder (10 g kg^{-1} soil) having non-significant differences with each other for almost all traits. The respective shoot water extracts of sorghum and sunflower (10 ml kg^{-1} soil) also caused significant reduction in

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weeds weight. The powder and water extract from roots of both sorghum and sunflower also showed allelopathic effects on fresh and dry weight of tested summer weeds as compared to check treatment. The decline in fresh/ dry weight of weeds was possibly due to decreased root/ shoot length of weeds which was as a consequence of allelochemicals found in sorghum and sunflower.

The phytotoxins depress uptake of water and minerals through roots eventually negative effects on plant processes and functions such as respiration, photosynthesis, cell division, protein synthesis and roots thickness (Tesio and Ferrero, 2010). The results of this study are at par with the findings of Asgharipour (2011) who disclosed that sunflower reduced chlorophyll contents, seedling length, and finally seedlings biomass. In this study the overall results suggested that allelopathic effect of sorghum and sunflower was form and plant part specific, where powder from shoots of both crops suppressed fresh and dry weight of test summer weeds more successfully over root and water extract.

Table 3. Fresh and dry weight seedling^{-1} (g) of narrow-leaf summer weeds under the allelopathic impact of sorghum and sunflower

Treatments	***Echinochloa colonum* (L.)**		***Cynodon dactylon* (L.)**		***Cyperus rotundus* (L.)**	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
	weight seedling^{-1} (g)					
Check (Untreated)	9.6 a	3.9 a	5.6 a	2.4 a	10.0 a	4.0 a
Sorghum shoot powder (10 g kg^{-1} soil)	4.6 e	1.9 f	2.9 e	1.6 c	4.4 e	1.9 e
Sorghum root powder (10 g kg^{-1} soil)	5.4 d	2.3 e	3.6 bcd	1.8 bc	5.2 d	2.1 d
Sorghum shoot water extract (10 ml kg^{-1} soil)	5.5 d	2. de	3.5 bcd	1.7 bc	5.2 d	2.1 d
Sorghum root water extract (10 ml kg^{-1} soil)	6.5 c	2.7 cd	3.6 bcd	1.9 bc	6.2 c	2.5 c
Sunflower shoot powder (10 g kg^{-1} soil)	4.8 e	2.2 e	3.2 cd	1.6 c	4.6 e	1.9 de
Sunflower root powder (10 g kg^{-1} soil)	6.5 c	2.7 cd	3.8 bc	1.8 bc	6.0 c	2.4 c
Sunflower shoot water extract (10 ml kg^{-1} soil)	6.5 c	2.8 bc	3.6 d	1.7 bc	6.0 c	2.4 c
Sunflower root water extract (10 ml kg^{-1} soil)	7.2 b	3.0 b	3.9 b	2.0 b	7.0 b	2.8 b
S.E ±	0.29	0.14	0.34	0.17	0.19	0.08
$LSD_{0.05}$	0.60	0.29	0.72	0.35	0.40	0.17

CONCLUSIONS AND RECOMMENDATIONS

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It is concluded from the results of this study that sorghum and sunflower applied in powder or water extract form caused suppressing effects on germination and subsequent growth of tested summer weeds. Sorghum showed more allelopathic effects against sunflower. The minimum values for germination (%) as well as seedling length and weight of weeds were noticed under sorghum shoot powder. The shoots of both crops proved more allelopathic over roots. The mixing of powders in soil posed higher phytotoxic effects on weeds than water extracts due to decomposition in soil and direct contact with roots. Hence, it is proved from the laboratory study results that sorghum and sunflower contain allelopathic compounds which could be utilized for managing summer weeds effectively and cheaply under filed conditions as environmentally safe approach.

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