Allelopathic Impact of Sorghum and Sunflower on Germinability and Seedling Growth of Cotton (*Gossypium hirsutum* L.)

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Abstract: Sorghum and sunflower are considered as highly allelopathic plants with inhibitory efficacy on plants of other species. In a pot study, the phytotoxic potential of sorghum and sunflower shoot and root on germination and seedling growth of cotton was evaluated through soil incorporation of powders and spray of water extracts. The experiment was conducted at Department of Agronomy, Sindh Agriculture University Tandojam during Kharif (summer) 2010 and 2011. The analysis of pooled data suggested that all the powders and water extracts of both allelopathic crops caused substantial suppression of germination and related traits of cotton seedlings as compared to control (untreated). Sorghum shoot powder (10 g kg^{-1} soil) caused highest allelopathic effects and reduced cotton seed germination by 12.8%, root length by 45.4%, shoot length by 51.9%, fresh weight $seedling^{-1}$ by 41.7% and dry weight $seedling^{-1}$ by 36.7%, followed by sunflower shoot powder (10 g kg^{-1} soil) in phytotoxic efficiency for inhibiting seed germination, seedling growth and weight in contrast to control (untreated). Sorghum showed superiority over sunflower in allelopathic efficiency. Powder of both crops was found more allelopathic in contrast to water extract. Among plant parts phytotoxic potential, shoot proved higher in inhibitory effect than root. However, it was concluded from the results of present study that both sorghum and sunflower possess allelopathic compounds with growth suppressing ability which could be utilized for effective weed management in cotton under field conditions as eco-friendly low-cost alternate of herbicides with wise strategy.

Keywords: Sorghum, sunflower, allelopathy, cotton, germination, growth.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the important revenue generating crops of Pakistan [1]. There are several reasons that are responsible for lower yield of cotton but weed infestation is an important and major one. Weeds are one of the chief biotic menaces which interfere with cotton field through competition and allelopathy and eventually cause significant reduction in crop produce [2]. Utilizing allelopathic properties of plants provide a great opportunity to control weeds effectively [3].

Allelopathy refers to release of certain compounds with promoting or inhibitory effect. These compounds are mostly the secondary metabolites which are produced by plants during metabolic process [4]. When phytotoxic are leached in the adjacent rhizosphere, they interfere strongly with the germination and growth of neighboring flora of other species [5]. Allelochemicals are present in both vegetative and reproductive organs of plants. However, these compounds are found in larger quantities in leaves. The phytotoxic compounds are generally emancipated in surrounding environments as volatiles from leaves, leachates from aerial parts mostly leaves through rain, downward stem flow, exudates from roots and decomposition of plant residues [6]. The allelopathic influence of released chemicals may be inhibitory or stimulatory depending on their type and concentration [7]. These compounds impede cell division, seed germination, leaf expansion, inhibit stomatal movement and respiration, internode elongation and alter the biomass partitioning into the leaves [8]. **S**orghum is reported to contain many allelochemicals like protocateuic acid, gallic acid, vanillic acid, syringic acid, p-coumaric acid, benzoic acid and p-hydroxybenzoic acid [9]. Sorgoleone has demonstrated remarkable phytotoxicity in numerous plant growth bioassays and is primarily an inhibitor of plant growth through inhibition of photosynthesis [10]. Similarly, sunflower is a putative source of bioactive allelochemicals. It contains many major groups of allelochemicals such as flavonoids, terpenoids and phenolics [11].

The phytotoxic impacts of sorghum and sunflower on crops plants and weeds are well documented in literature [12]. Soil incorporation of residues and foliar spray of sorghum and sunflower water extracts exhibited significant inhibitory effects on germination of seeds, and root and shoot growth of cotton [13], wheat [14], rice [15] and mungbean [16] in the laboratory, pot

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and field experiments. Water extracts of sorghum plant parts considerably suppressed seed germination and seedling growth of *Amaranthus retroflexus* [17], *Echinochloa colonum* [18], *Phalaris minor, Chenopodium album, Senebiera didyma*, *Cyperus rotundus* and *Rumex dentatus* [19]. Sunflower inhibited broadleaf weeds more than narrow leaf weeds. Sunflower leaf extracts substantially inhibited seed germination, growth and dry biomass of broad leaved weeds such as *Trianthema portulacastrum* [20], *Chenopodium album* and *Rumex dentatus* [21]. The chopped residues of sorghum and sunflower inhibited the germination and growth of *Trianthema portulacastrum* (L.) and *Cyperus rotundus* (L.) [22, 23]. Soil incorporation of sorghum residues showed pronounced suppressing influence on seedling number and dry biomass of and *Echinochloa colonum* (L.) [15].

Now-a-days throughout the world allelopathy is being focused by the researchers and agriculture scientists as alternative of herbicides, cheap and environment friendly approach for effective and sustainable management of weeds in field crops. Sorghum and sunflower are considered as highly allelopathic crops and recommended to use for weed control in different ways. In Pakistan, sorghum and sunflower are also grown in rotational sequence and sometimes as intercrops with field crops like cotton, rice, sugarcane, maize and wheat, soybean. Hence, it is imperative to conduct lab bioassays to assess the allelopathic effects of such plants on field crops such as cotton etc.

MATERIALS AND METHODS

The pot study was undertaken at Seed Testing Laboratory, Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan during Kharif (summer) 2010 and 2011. The design used for experiment was completely randomized design, replicated three times. The aluminium boxes having size of 9 x 3 x 3 cm were filled with canal sand @ 5 kg box^{-1} and watered to moisten the soil. The sand boxes were kept in wire house. The treatments comprised of (9 treatments) respective sorghum and sunflower root/ shoot powder (10 g kg^{-1} soil), sorghum and sunflower root/ shoot water extract (10 ml kg^{-1} soil) and one control (untreated). The herbage of sorghum and sunflower was collected from Sindh Agriculture University Tandojam's Experimental Farm. The allelopathic plants (sorghum and sunflower) were uprooted when they attained the flowering stage, roots and shoots were separated.

Preparation of Powder and Water Extract

The plant material was chopped into 2 cm with a sharp electric cutter, dried under sun and fine powder was prepared after grinding. For preparing water extract, sorghum and sunflower root and shoot powder 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 root and shoot powder of sorghum and sunflower was incorporated thoroughly in soil @ 50 g box^{-1} then seeds of cotton were sown. The water extracts prepared from root and shoot of sorghum and sunflower were applied immediately after sowing on soil as spray in respective boxes @ 50 ml box^{-1}.

Sowing of Seeds and Harvesting of Seedlings

The twenty five seeds of cotton were in rows on 1st week of May. Five rows per box were maintained and five seeds were sown in each box. The boxes were irrigated with canal water to fulfill water requirements of seedlings. The cotton seedlings were uprooted separately from each box 30 days after sowing. The root and shoot length (cm), and fresh weight seedling^{-1} (g) were recorded immediately after uprooting. The seedlings were dried in oven for 72 hours at 70 ^{0}C and dry weight seedling^{-1} (g) was noted.

Statistical Analysis

The collected data were statistically analyzed using Statistix 8.1 computer software (Statistix, 2006). The HSD test was applied to compare treatment means superiority.

RESULTS AND DISCUSSION

The results (Table **1**) of this study indicated that both powder and water extract of sorghum and sunflower prepared from their root and shoot caused significant inhibitory effect on germination, seedling root and shoot length and fresh and dry weight of cotton seedlings. Shoot of both sorghum and sunflower was found strong allelopathic as compared to root. Among application methods, soil incorporation of powder was found more phytotoxic than water extract. Sorghum shoot powder (10 g kg^{-1} soil) demonstrated highest allelopathic effects and inhibited cotton seed germination by 12.8%, root length by 45.4%, shoot length by 51.9%, fresh weight seedling^{-1} by 41.7% and dry weight seedling^{-1} by 36.7%, followed by sunflower shoot powder (10 g kg^{-1} soil) in phytotoxic efficiency and reduced seed germination by 12.0%, root length by

Table 1: Germination and Seedling Growth of Cotton under the Allelopathic Influence of Sorghum and Sunflower Powders and Water Extracts

Treatments	Seed germination (%)	Root length (cm)	Shoot length (cm)	Fresh weight seedling^{-1} (g)	Dry weight seedling^{-1} (g)
Control (Untreated)	91.7 a	11.9 a	10.4 a	6.0 a	3.0 a
Sorghum root powder (10 g kg^{-1} soil)	80.0 c (-11.7)	7.7 e (-35.3)	6.2 ef (-40.4)	4.4 bc (-26.7)	2.3 bc (-23.3)
Sorghum shoot powder (10 g kg^{-1} soil)	80.0 c (-12.8)	6.5 f (-45.4)	5.0 g (-51.9)	3.5 d (-41.7)	1.9 e (-36.7)
Sorghum root water extract (10 ml kg^{-1} soil)	85.0 b (-7.3)	8.8 c (-26.1)	7.4 c (-28.8)	4.6 b (-23.3)	2.3 b (-23.3)
Sorghum shoot water extract (10 ml kg^{-1} soil)	81.7 c (-9.8)	7.9 de (-33.6)	6.4 de (-38.5)	3.9 cd (-35.0)	2.1 cd (-30.0)
Sunflower root powder (10 g kg^{-1} soil)	85.0 b (-7.3)	8.5 cd (-28.6)	7.0 cd (-32.7)	4.6 b (-23.3)	2.4 b (-20.0)
Sunflower shoot powder (10 g kg^{-1} soil)	81.7 c (-12.0)	6.9 f (-42.0)	5.6 fg (-46.2)	3.6 d (-40.0)	2.0 de (-33.3)
Sunflower root water extract (10 ml kg^{-1} soil)	86.7 b (-5.5)	9.9 b (-16.8)	8.5 b (-18.3)	4.5 b (-25.0)	2.4 b (-20.0)
Sunflower shoot water extract (10 ml kg^{-1} soil)	85.0 b (-7.3)	8.9 c (-25.2)	7.4 c (-28.8)	4.2 bc (-30.0)	2.1 cd (-30.0)
S.E ±	1.57	0.34	0.33	0.25	0.09
$HSD_{0.05}$	3.30	0.71	0.69	0.53	0.19

Means not sharing same letter differ significantly at p=0.05; values in parenthesis show percent decrease (-) of control.

42.0%, shoot length by 46.2%, fresh weight seedling^{-1} by 40.0% and dry weight seedling^{-1} by 33.3% as compared to control (untreated). Similarly, sorghum shoot water extract (10 ml kg^{-1} soil) also exerted substantial suppressing effects and decreased seed germination of cotton by 9.8%, seedling root length by 33.6%, shoot length by 38.5%, fresh weight seedling^{-1} by 35.0% and dry weight seedling^{-1} by 30.0%. Sunflower shoot water extract (10 ml kg^{-1} soil) also caused marked inhibitory effects and depressed seed germination by 7.3%, root length by 25.2%, shoot length by 28.8%, fresh weight seedling^{-1} by 30.0% and dry weight seedling^{-1} by 30.0% against control (untreated). The results further illustrated that sorghum proved higher in allelopathic activity over sunflower. It is also obvious from the trend of results that sorghum and sunflower possess many water soluble allelopathic compounds in their underground and above ground plant parts and inhibition in the germinability and subsequent growth and weight of cotton seedlings may be ascribed to phytotoxic compounds with inhibitory effect in both sorghum and sunflower. Sorghum and sunflower both are known as plants with high allelopathic potential against weeds and crop plants. In present study, the inhibition of germination and subsequent growth of cotton seedlings showed that allelochemicals possessed by sorghum and sunflower perhaps directly affected to the cotton roots and leaves curling reduced water transpiration and stoma regulation. In earlier literature the allelopathic effect of sorghum and sunflower with inhibition of germination and growth of cotton [13], wheat [14], rice [15] and mungbean [16] in the laboratory, pot and field experiments and weeds [20] has been well documented in laboratory bioassays as well as pot and field experiments. The allelopathic compounds hamper cell division, seed germination, leaf expansion, stomatal movement, respiration and internode elongation, and alter the biomass partitioning into the leaves [8]. **S**orghum [10] and sunflower [11] possess many allelochemicals with known phytotoxic action against many crop plants and weeds. Germination of plants is suppressed when exposed to allelopathic compounds [24]. Plant parts vary in allelopathic properties where shoot caused more negative effects as compared to root [14] Sunflower plant material suppressed germination, decreased chlorophyll content as well as root and shoot length [25]. The suppression in fresh and dry weight of cotton was possibly due to decreased root and shoot length of seedlings which was as a result of allelopathic compounds found in sorghum and sunflower. The phytotoxins decrease water and minerals uptake through roots eventually negative effects on plant processes and functions such as cell division, photosynthesis, roots thickness, respiration and protein synthesis [26]. At par results have also been reported by [21] who found that sunflower reduced chlorophyll contents, seedling length, and finally seedlings biomass. The reduction in germination (%), delayed germination, decrease in radical and plumule growth and dry matter weight of maize and wheat seedlings may be linked to suppressive influences of allelopathic compounds present in sunflower which possibly modified cell division, physiological functions and absorption capacity of test plants seedlings [5]. It could be inferred from the results of present study that allelopathic compounds in the substratum might exerted adverse influences on water uptake, photosynthesis, respiration and root proliferation, resultantly reduced cotton seedling length and biomass. Suppression in root and shoot growth of cotton seedlings by phytotoxins is probably due to decline in cell division and the amount of auxins. These findings support the suggestions of earlier researchers that the decrease in root length and fresh biomass may be due to adverse impact of allelopathic compounds in the powder and water extract of sorghum [27] and sunflower [28] on the growth processes of cotton root or the decrease in uptake of nutrients by the roots. Hence, further studies are suggested to evaluate the possible allelopathic effects of sorghum and sunflower on cotton under field conditions.

CONCLUSIONS AND RECOMMENDATIONS

The results of present study concluded that all the powders and water extracts of sorghum or sunflower showed allelopathic influence and inhibited cotton seed germination, seedling growth and weight as compared to control (untreated). Soil incorporation of sorghum shoot powder demonstrated superiority in inhibitory efficacy over rest of the allelopathic treatments. Sunflower shoot powder followed in phytotoxic action. Powder was found more allelopathic in contrast to water extract. Shoot surpassed root in allelopathic potential. Hence, it could be inferred from the results that sorghum and sunflower possess allelopathic compounds with inhibitory efficacy and further studies should be conducted under field conditions to evaluate the possible phytotoxic effects of allelopathic plants on crops. The material of such plants for controlling weeds should be applied in such a way that there may be minimum negative effect on crop plants.

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REFERENCES

[1] GOP. Economic Survey of Pakistan, 2012-13. Government of Pakistan, Ministry of Food, Agriculture and Livestock, Agriculture & Livestock Division (Economic Wing), Islamabad 2013.

[2] Bhoi SK, Lakpale R, Jangre A, Mishra S. Studies on the effect of weed control methods on growth and yield attributes of hybrid cotton. Res J Agri Sci 2010; 1(4): 434-437.

[3] Iqbal N, Cheema ZA, Khaliq A, Iqbal J. Possible reduction of S-metolachlor dose in combination with allelopathic crop water extracts in cotton. Abst, 1st Int Weed Sci Conf 23-26 October 2003; Weed Sci Soci Pak.

[4] Bhowmik PC, Inderjit. Challenges and opportunities in implementing allelopathy for natural weed management. Crop Prot 2003; 22: 661-671. http://dx.doi.org/10.1016/S0261-2194(02)00242-9

[5] Muhammad Z, Majeed A. Allelopathic effects of aqueous extracts of sunflower on wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.). Pak J Bot 2014; 46(5): 1715-1718.

[6] Bashir U, Javaid A, Bajwa R. Allelopathic effects of sunflower residue on growth of rice and subsequent wheat crop. Chilean J Agri Res 2012; 72(3): 326-331. http://dx.doi.org/10.4067/S0718-58392012000300004

[7] Mahmood K, Khaliq A, Cheema ZA, Arshad M. Allelopathic activity of Pakistani wheat genotypes against wild oat (*Avena fatua* L.). Pak J Agri Sci 2013; 50:169-176.

[8] Hozayn M, Lateef EMA, Sharar FF, Monem AAA. Potential uses of sorghum and sunflower residues for weed control and to improve lentil yields. Allelopathy J 2011a; 27 (1): 15-22.

[9] Iqbal J, Cheema ZA. Purple nutsedge (*Cyperus rotundus* L.) management in cotton with combined application of Sorgaab and S-metolachlor. Pak J Bot 2008; 40(6): 2383-2391.

[10] Duke SO, Baerson SR, Rimando AM, Pan Z, Dayan FE, Belz RG. Biocontrol of weeds with allelopathy: conventional and transgenic approaches. Outlook Pest Manage 2007; 18: 54-58. http://dx.doi.org/10.1007/978-1-4020-5799-1_4

[11] Anjum T, Bajwa R. Screening of sunflower varieties for their herbicidal potential against common weeds of wheat. J Sustain Agri 2008; 32(2): 213-229. http://dx.doi.org/10.1080/10440040802170756

[12] Hozayn M, Monem AAA, Lateef EMA. Crop residues, an effective tool for improving growth of wheat and suppression of some associated weeds. Allelopathy J 2011b; 27(2): 237-344.

[13] Narwal SS, Palaniraj R, Sati SC. Role of allelopathy in crop production. Herbologia 2005; 6(2): 1-69.

[14] Nouri H, Talab ZA, Tavassoli A. Effect of weed allelopathic of sorghum (*Sorghum halepense*) on germination and seedling growth of wheat, Alvand cultivar. Ann Biol Res 2012; 3(3): 1283-1293.

[15] Khaliq A, Matloob A, Cheema ZA, Farooq M. Allelopathic activity of crop residue incorporation alone or mixed against rice and its associated grass weed jungle rice (*Echinochloa colonum* L.). Chilean J Agri Res 2011a; 71(3): 418-423. http://dx.doi.org/10.4067/S0718-58392011000300012

[16] Moosavi A, Afshari RT, Asadi A, Gharineh MH. Allelopathic effects of aqueous extract of leaf, stem and root of *Sorghum bicolor* on seed germination and seedling growth of *Vigna radiata* (L.). Not Sci Biol 2011; 3(2): 114-118.

[17] Yarnia M, Benam MBK, Tabrizi EFM. Allelopathic effects of sorghum extracts on *Amaranthus retroflexus* seed germination and growth. J Food Agri Environ 2009; 7 (3&4): 770-774.

[18] Kim SY, Datta SK, Robles RP, Kim KU. Lee SC Shin DH. Allelopathic effect of sorghum extract and residues on selected crops and weeds. Korean J Weed Sci 1993 ;14:34-41. http://dx.doi.org/10.3346/jkms.1993.8.1.34

[19] Cheema ZA, Luqman A, Khaliq A. Use of allelopathic extracts of sorghum and sunflower herbage for weed control in wheat. J Animal Plant Sci 1997; 7(3/4): 91-93.

[20] Randhawa MA, Cheema ZA, Ali MA. Allelopathic effect of sorghum water extract on the germination and seedling growth of *Trianthema portulacastrum*. Int J Agri Biol 2002; 4(3): 383-384.

[21] Anjum T, Bajwa R. The effect of sunflower leaf extracts on *Chenopodium album* in wheat fields in Pakistan. Crop Prot 2007; 26(9): 1390-1394. http://dx.doi.org/10.1016/j.cropro.2006.11.012

[22] Khaliq A, Matloob A, Farooq A, Mushtaq MN, Khan MB. Effect of crop residues applied isolated or in combination on the germination and seedling growth of horse purslane (*Trianthema portulacastrum*). Planta Daninha 2011b; 29(1): 418-423. http://dx.doi.org/10.1590/S0100-83582011000100014

[23] Matloob, A, Khaliq A, Farooq M, Cheema ZA. Quantification of allelopathic potential of different crop residues for the purple nutsedge suppression. Pak J Weed Sci Res 2010; 16(1): 1-12.

[24] Asgharipour MR. Inhibitory effects of sunflower root and leaf extracts on germination and early seedling growth of amaranth and purple nutsedge. Adv Environ Biol 2011; 5(11): 3550-3555.

[25] Sadeghi S, Rahnavard A, Ashrafi ZY. Allelopathic effect of *Helianthus annuus* (sunflower) on *Solarium nigrum* (black nightshade) seed germination and growth in laboratory condition. J Hort Sci Ornamen Plants 2010; 2(1): 32-37.

[26] Tesio F, Ferrero A. Allelopathy, a chance for sustainable weed management. Int J Sustain Develop World Ecol 2010; 17(5): 377-389. http://dx.doi.org/10.1080/13504509.2010.507402

[27] Jamil M, Cheema ZA, Mushtaq MN, Farooq M, Cheema M.A. Alternative control of wild oat and canary grass in wheat fields by allelopathic plant water extracts. Agron Sustainable Dev 2009; 29(3): 472-482. http://dx.doi.org/10.1051/agro/2009007

[28] Alsaadawi IS, Khaliq A, Al-Temimi AA, Matloob A. Integration of sunflower (*Helianthus annuus*) residues with a pre-plant herbicide enhances weed suppression in broad bean (*Vicia faba*). Planta Daninha 2011; 29(4): 849-859. http://dx.doi.org/10.1590/S0100-83582011000400015

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