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EFFICACY OF BRASSICA SORGHUM AND SUNFLOWER AQUEOUS EXTRACTS TO CONTROL WHEAT WEEDS UNDER RAINFED CONDITIONS OF POTHWAR, PAKISTAN

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ABSTRACT

Allelopathy is an environment friendly technique in controlling weeds and helpful in reducing cost of herbicide. An experiment was conducted at PMAS Arid Agriculture University during Rabi 2007, to observe the allelopathic effect of water extracts of sorghum, sunflower and brassica to control weeds in wheat using cultivar GA-2002. Extracts were prepared by taking chopped dry sorghum, sunflower and brassica herbage separately in water for one day in the proportion of 1:10 (w/v). The treatments were control, hand weeding, sorghum, sunflower and brassica individually and combined as sorghum+ sunflower, sorghum+ brassica, sunflower+ brassica and sorghum+ sunflower+ brassica. The experiment was laid out in Randomized Complete Block Design with four replications. Size of each individual plot was 5 × 6 m. Results indicated that the highest weed density and biomass suppression was achieved with hand weeding among all the treatments. Among the foliar application of extracts, the highest weed control was recorded with the combined application of concentrated aqueous extracts of sorghum, sunflower and brassica at 45 and 75 days after sowing followed by both sorghum+ sunflower. In case of growth and yield components, highest increase was recorded in manual weeding and lowest in case control. Among extracts application treatments the highest increase in wheat biometry and yield attributes was found by combined application of sorghum, sunflower and brassica extracts compared to rest of the treatments.

Key words: *Allelopathy, sorghum, sunflower, brassica extracts, wheat (Triticum astivum L.), yield and weed control.*

INTRODUCTION

Wheat (*Triticum astivum* L.) being staple food, is the crop of significant importance in Pakistan. It is cultivated on an area of 9.042 million hectares with production of 23.864 million ton with an average yield of 2639 kilogram per hectare contributing 3 percent to GDP to economy of Pakistan. (Govt. of Pakistan, 2009-10). This yield is alarmingly low compared to other wheat growing countries of the world. Among the different factors limiting wheat yield, weed infestation is the most prevailing in reducing wheat yield in Pakistan. Memon and Bhatti (2003) reported twenty four weed species infesting the wheat crop in the wheat fields of Khairpur. A plentiful amount of Rs. 2.2 billion is invested on the import of herbicides for wheat which accounts 63 % of the total herbicide import (Ashiq *et al.*, 2006).

The negative and positive affects of chemical compounds produced from microorganisms, fungi, viruses and plants manipulate agricultural and biological ecosystems. (Martines, *et al*., 2009). Allelopathy is an environment friendly technique in controlling weeds and helpful in reducing cost of herbicide as herbicide create environmental pollution. Allelopathic plants may also be considered a potential source of new molecules with herbicidal action for the chemical industry, the necessity of which is due to the emergence of resistant weeds to older synthetic molecules (Albuquerque *et al.*, 2011).

Allelopethic potential in crop plants can be successfully utilized for weed management. Certain crops restrain growth of some weed species while phytotoxins releasing from their residues inhibit seed germination of weeds. Allelochemicals from several crops has been identified and their activities for weed management has also been established. (Bhadoria, 2011). Most of the exudates chemicals are toxic thus can be used as potential herbicides. (Troc *et al*., 2011). Sunflower is renowned for its allelopathic chemicals such as sesquiterpene, lactones and terpenes from crude leaf extract (Gao *et al*., 2008; Macias *et al.*, 2002). Sorghum roots exudes an allelochemical "Sorgoleone", which detrimentally affect performance of succeeding crops (Abdelkarim *et al*., 2010) and weeds (Czarnota *et al.* 2001). Allelopathic crops are considered as viable option to reduce the usage of synthetic herbicides (Fuji, 2001; Perry *et al*., 2009). Brassica species inhibit seed germination of several species such as wild oat by releasing glucosinolates (Turk and Tawaha, 2003). The herbicides use has raised serious concerns as it cause environmental pollution and develop resistance against herbicides in some weeds, so a new technique to control weeds by allelopathic suppression is attracting attention as a potential alternative weed control

(Lin *et al*.,2010).The use of water extracts of sorghum along with extracts of other crops provide an environmentally, cost effective and efficient weed control method (Mushtaq *et al*., 2010). Excessive and continuous use of herbicides has resulted in resistant weed populations and this phenomenon urged upon the exploitation of allelopathic potential of crop plants (Ferreira and Reinhardt, 2010). There is dire need to scrutinize the role of allelopathic crops and their incorporation in weed management system.

Keeping in view the importance of allelopathic potential of the crops a study was conducted to evaluate the efficacy of sole and combined application of sorghum, sunflower and brassica aqueous extracts on wheat weed management and its consequent effects on wheat yield.

MATERIALS AND METHODS

An experiment was carried out at university research farm, Chakwal road located at latitude 233°06'N and 73°00'E at an elevation 1702ft to evaluate the allelopathic effect of sorghum, sunflower and brassica aqueous extracts for weed control in wheat during winter (Rabi season) 2007-08. Extracts were prepared by soaking chopped dry sorghum, sunflower and brassica herbage separately in water for twenty four hours in the proportion of 1:10(w/v) by soaking one kilogram dry herbage in ten liters of water. Then these extracts were filtered and reduced the volume of respective filtrate twenty times by continuously boiling it. Wheat variety GA-2002 was sown in individual plot of size 5 × 6 m^{-2} in Randomized Block Design consisting four replications. The treatments were as follow.

T_0 = Weedy check (control),

T_1 = Hand weeding (HW) at 30 and 60 days after sowing (DAS)

T_2 = Sorghum water extract (SWE) @ 12 L ha^{-1} at 30 and 60 DAS

T_3 = Sunflower water extract (SFWE) @ 12 L ha^{-1} at 30 and 60 DAS

T_4 = Brassica water extract (BWE) @ 12 L ha^{-1} at 30 and 60 DAS

T_5 = Sorghum water extract (SWE) + sunflower water extract @ 6+6 L ha^{-1} at 30 and 60 DAS

T_6 = Sorghum water extract (SWE) + brassica water extract (BWE) @ 6+6 L ha^{-1} at 30 and 60 (DAS)

T_7 = Sunflower water extract (SFWE) + brassica water extract (BWE) @ 6+6 L ha^{-1} at 30 and 60 (DAS)

T_8 = sorghum water extract (SWE) + sunflower water extract(SFWE) + brassica water extrac (BWE) t @ 4+4+4 L ha^{-1} at 30and 60 (DAS).

Plant biometrical measurements: Weed density (m^{-2}) was recorded from randomly selected area of one meter square at 45 and 75 days after sowing (DAS). Samples were taken at twice from every plot and then an average was calculated. Weeds fresh weight (g m^{-2}) was taken from randomly selected areas of one meter square at two stages at 45 and 75 DAS and recording the fresh weight. For recording the weeds dry biomass (g m^{-2}) the samples taken for fresh weight were dried at 70^0C for 72 hour. Fertile tillers (m^{-2}) were recorded by counting from an area of one meter square from each plot at maturity. Spike length (cm) was measured at maturity from each plot by selecting 10 plants at random and number of spikelets per spike was also measured from those plants as well. Grains per spike were also counted from each plot selecting10 plants at random and average was taken. Five samples were taken from each plot to calculate 1000-seed weight (g). Aerial biological yield (Kg ha^{-1}) was determined by harvesting, whole plant material above ground in each plot manually. Sun dried samples were threshed manually and grain yield per plot was computed in Kg ha^{-1}. Difference between biological and grain yield was taken to calculate straw yield (Kg ha^{-1}). Harvest index was computed by formula

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

The data were analyzed by employing one way analysis of variance (ANOVA) procedure and the treatment means were compared by Least Significant Difference test (LSD) at 5 percent probability level (Montgomery, 2001).

RESULTS AND DISCUSSION

Weed Depression: Species as *Convolvulus arvensis* L., *Fumaria indica* L., *Phalaris minor* Retz., were the dominant weeds in the experimental area. Data recorded (Table 1) regarding weed density at 45 and 75 DAS revealed that application of conc. Sorghum, sunflower and brassica water extracts significantly suppressed the weed density. Hand weeding at 30 and 60 DAS reduced weed density over control by 47.68 and 52.95 %. However the minimum weed density was observed under hand weeding where 22.63 and 24.88 weeds were found at 45 and 75 DAS respectively while weed density (27.00 m^{-2} and 29.13 m^{-2}) at 45 and 75 DAS, respectively was achieved in plots where conc. SWE + SFWE + BWE @ 4 + 4 + 4 L ha^{-1} were applied. Whereas, the maximum weed density 43.25m^{-2} and 52.88m^{-2} was recorded under control treatment. These results showed that conc. SWE + SFWE + BWE if applied in combination are most effective for weed control whereas conc. SWE alone is less effective. Hand weeding was most effective among all treatments for controlling weeds but this method is labour intensive therefore it is an expensive method and economically not applicable. The results are in line with the findings of Farooq *et al.,* (2011) who reported significant decrease in weed density using allelopathic crop water extracts.

Data recorded (Table 1) regarding fresh and dry weights weeds at 45 and 75 DAS revealed that foliar spray of sole or combined application of conc. SWE + SFWE + BWE significantly reduced fresh and dry weights over the control. However, among the foliar spray treatments of different crop WE, the maximum fresh and dry weights reduction at 45 and 75 DAS was observed in combined treatments of conc. SWE + SFWE + BWE @4+4+4Lha-1 applied at 30 and 60DAS which was followed by conc. SWE + SFWE @ 6+6 Lha-1 applied at 30 and 60DAS with fresh weight (40.75g and 47.88g) and dry weight (4.74g and 9.25g). The other foliar treatments were lagging behind with the lowest reduction of fresh and dry weights with concentrated BWE application. These decreased dry weights might be because of the phytotoxic effects of alleleochemicals present in crop water extracts (Bhadoria, 2011). The result are confirmatory with Cheema *et al.,* (2003;2008) who observed reduced weed biomass with the foliar application of aqueous extracts of sorghum at different days after sowing in wheat crop.

Growth attributes: The height of a crop plant is a combined expression of genetic and environmental factors. The data (Table. 1) demonstrate that application of concentrated sunflower, sorghum, and brassica aqueous extracts exhibited suppressive effect on plant height of wheat when compared to weedy check (control). The maximum plant height (86.25 cm) was noted under hand weeding which was statistically at par with control (weedy check). Maximum reduction in plant height i.e. (74.89 cm) relative to control was observed when concentrated SWE+ concentrated SFWE @ 6 + 6 L ha^{-1} was applied at 30 &60 DAS. This reduced plant height under the treatments of concentrated sorghum, sunflower and brassica aqueous extracts may be attributed to the selective behavior of allelochemicals present in these extracts showed inhibitory effect on plant height in wheat plants as reported by Batish *et al.,* (2002;2006) observed reduced heights in different crops by soil amended with allelopathic plant residues. Also Shahid *et al.,* (2006) discovered that different allelopathic plant water extracts exhibited suppressive effects on wheat plant height.

Data (Table 2) showed that conc. SWE, SFWE and BWE @4+4+4 Lha^{-1} applied at 30 and 60DAS significantly increased fertile tillers compared to weedy check. The highest number of fertile tillers were (368.3) in the plots where two foliar sprays of conc. SWE , SFWE and BWE @ 4 + 4 + 4 L ha^{-1} and (349.3) in case of concentrated SWE + SFWE @ 6 + 6 L ha^{-1} applied at 30 &60 DAS. The number of tillers in concentrated SWE + BWE @ 6 + 6 L ha^{-1} applied at 30 &60 DAS were (326.3).Treatments showing increase in the number of fertile tillers may be due to relatively better weed control which ultimately facilitated relatively more translocation of photosynthates toward reproductive growth due to less weed wheat competition (Malik *et al.,* 2009). These results also validated the findings of Khan *et al.* (2000) who observed significantly affected fertile tillers m^{-2} by different weed control practices.

Data in Table 2 indicated foliar sprays of brassica, sorghum and sunflower aqueous extracts significantly decreased the number of unfertile tillers compared to control. SWE + SFWE applied twice @ 6 + 6 L ha^{-1} and SWE + SFWE + BWE @ 4 + 4 + 4 L ha^{-1} applied at 30 &60 DAS showed almost similar results which appeared to be the most effective treatments in decreasing the number of unfertile tillers. Whereas, SWE @ 12 L ha^{-1} decreased the number of unfertile tillers compared to control. SWE + BWE @ 6 + 6 L ha^{-1} applied at 30 and 60 DAS is also effective in decreasing the number of unfertile tillers of wheat i.e. 39.00. Decrease in unfertile tillers due to application of allelopathic extracts may be contributed either due to allelopathic influences of the extracts applied which promoted the fertility of wheat tillers resulting in reduced unfertile tillers compared to control, or due to high wheat weed competition in weedy check plots as compared to the plots where allelopathic treatments were applied. Findings of this study indicated that suppression in the number of unfertile tillers due to the foliar spray of concentrated sorghum, sunflower and brassica aqueous extracts promoted wheat tillers fertility resulting in decrease in unfertile tillers m^{-2}, which confirmed the findings of Khan *et al.,* 2000 who stated various weed control practices promote fertile tillers m^{-2}.Increased unfertility of wheat tillers as a result of more weed infestation was also suggested by Reeves (2006) who reported that a weed (annual rye grass) decreased fertile tillers and fertile spike production.

Yield Components: Spike length in wheat may influence grains per spike and crop yield. Data in Table 2 indicated stimulatory effect of sole and combined application of sorghum, brassica and sunflower aqueous extracts on spike length compared to control. Significantly longer spikelets (11.23 cm) over control (8.830 cm) were recorded where SWE + SFW + BWE @ 4 + 4 + 4 L ha^{-1} was applied at 30 & 60 DAS. Other treatments also showed increase in spike length compared to weedy check. These results indicated increase in the spike length may be due to the short plant height and suppressed weed biomass under foliar application of allelopathic crop water extracts. This suppressed vegetative growth resulted in more translocation and assimilation of photosynthates toward reproductive growth (Borras *et al.* 2004).

Increased spikelets per spike compared to control in all treatments except BWE @ 12 L ha^{-1} applied at 30 and 60 DAS which showed non significant difference in spikelet number per spike compared to weedy check. However an increase in spikelet number per spike was highest 16.25 in plots where two sprays of SWE + SWE was applied @ 6 + 6 L ha^{-1} which was almost same 16.24 where SWE + SWE + BWE @ 4 + 4 + 4 L ha^{-1} were applied at 30 &60 DAS. Although other treatments cause an increase in the number of spikelets per spike of wheat compared to control. This increase in spikelets per spike was perhaps due to better weed control in plots. These findings were also supported by (Naseem *et al* (2009) who stated SFWE promoted the number of spikelets per spike in wheat.

Grain number per spike could affect final crop yield. Significant increase in grains per spike in all treatments was noted except concentrated brassica water extract @ 12 L ha^{-1} applied at 30 &60 DAS. On the other hand two sprays of SWE + SFWE @ 6 + 6 L ha^{-1} applied at 30 &60 DAS showed the maximum (51.70) grains per spike. The difference in grain number per spike of wheat was probably due to smothering of weeds resulted in more translocation and assimilation of photosynthates toward grain formulation (Borras *et al.* 2004). These findings are also in conformity with the results of Malik *et al.,* (2009) who observed that grain number per spike was affected due to weed infestation.

Wheat Yield: It was obvious from the data presented in Table 3 that all the treatments significantly influenced wheat grain weight compared to control. Maximum grain weight (43.67 g) compared to control was found in plots where two foliar applications of SWE + SFWE @ 6 + 6 L ha^{-1} at 30 &60 DAS was applied, other treatments also showed increase in grain weight which might be a result of better weed control resulting better crop yield. Grain weight was negatively associated with plant height these results are in conformity with the findings of Mushtaq *et al.* (2010) who found increase in 1000-grain weight with reduced weed infestation.

Data regarding aerial biological yield showed that all the treatments increased biological yield of wheat. Sole application of SFWE @12 L ha^{-1} and BWE @12 L ha^{-1} improve biological yield by 9394 kg ha^{-1} and 9207kg ha^{-1} respectively. The maximum aerial biological yield 9.96 percent over control was recorded in the plot where SWE + SFWE @ 6 + 6 L ha^{-1} applied at 30 and 60 DAS. These results confirmed the work of (Cheema and Khaliq, 2000) who reported increase in biological yield by controlling weeds applying Sorgaab (Sorghum water extract) treatments.

Grain yield is the product of genetic and environmental expression any variation in the environmental factors affects significantly on grain yield. Increase in grain yield was recorded in the plots where SWE + SFWE was applied at 30 and 60 DAS and in plots where SWE + SFWE + BWE was applied @ 4+4+4 L ha^{-1} at 30 and 60 DAS. Concentrated sorghum water extract and hand weeding increased the wheat grain yield. This increase in grain yield probably as the result of weed suppression and might be the effect of allelochemicals present in crop water extracts applied, which influenced grain yield. Similar results were found by Cheema *et al.* (2008) who observed increased grain yield of wheat due to sorghum extract application. These results also confirmed the findings of (Ashraf and Naeem, 2005) who reported significant gains in wheat grain yield as a consequence of sorghum and sunflower extract application.

Results given in Table 3 showed all treatments have significant effects on straw yield compared to control but SFWE @ 12L ha^{-1} applied at 30 &60 DAS produced maximum straw yield 6608 kg ha^{-1}, while rest of the treatments produced similar yields. This increase in the straw yield due to application of water extracts may be the result of better weed control or result of allelopathic chemicals present in the allelopathic crop water extracts applied or due to more availability of nutrients available in soil, because as weed infestation decreased in the plots where weed control treatments were applied weed wheat competition for the resources ultimately decreases which cause better growth of crop plants and result in an increase in crop yield components. These results verified the observations of Reeves (2006) that weeds infestation decreased dry matter production in wheat. Similarly Anwar *et al.* (2003) and Marwat (2005) reported the crop water extracts influenced the wheat yield components.

Harvest index reflects the relationship between economic and biological yield. Data pertaining to harvest index in Table 3 revealed that all the treatments and hand weeding showed significant effects on harvest index of wheat. Sole application of concentrated sorghum water extract @ 12 L ha^{-1} and hand weeding increased harvest index by 8 percent approximately whereas concentrated sunflower water extract @ 12 L ha^{-1} showed only 2.91 percent and concentrated brassica water extract @12 L ha^{-1} showed 2.67 percent increase in harvest index compared to control. On the other hand increase in harvest index was the highest 10 percent approximately in plots where SWE + SFWE @ 6 + 6 L ha^{-1} and SWE + SFWE + BWE @ 4 + 4 + 4 L ha^{-1} applied at 30 &60 DAS. It was observed that plots having better weed control showed significant differences for harvest index relative to control. These results showed that harvest index increased with the efficient weed control which might be possible because of more nutrients availability in the plot where there is less weed wheat competition. These observations are in line with findings of Marwat *et al.* (2005) who revealed that harvest index increased due to better weed control.

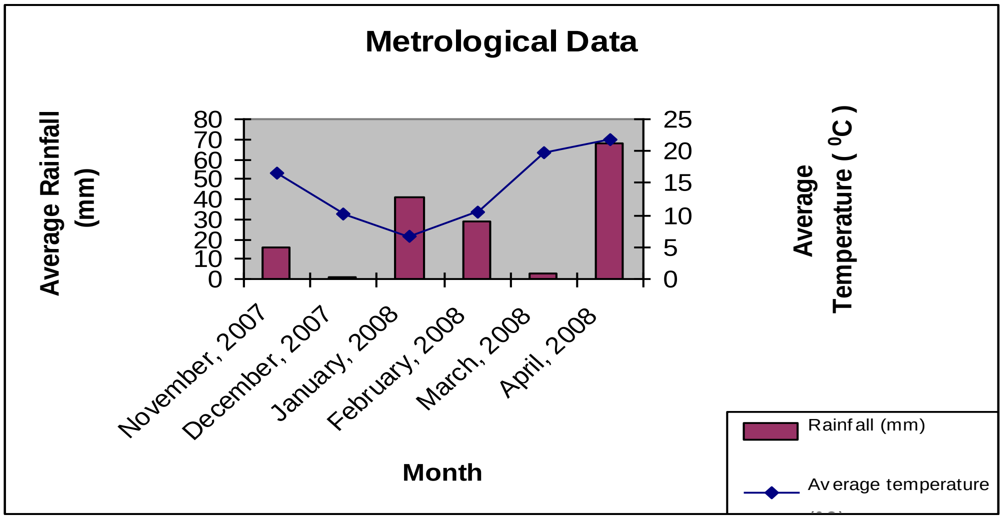

Fig 1. Metrological data (Rainfall and average temperature) for Chakwal during the growth period of wheat (Nov. 2007 to April. 2008)

Source = Meteorology department: Soil and Water Conservation Research Institute (SAWCRI) Chakwal

Table 1. Allelopathic effect of sorghum, sunflower and brassica water extracts on weed density and biomass

Treatments	Weed density (#of weeds m^{-2})		Weed fresh wt. (gm^{-2})		Weed dry wt. (gm^{-2})	
	45DAS	75DAS	45DAS	75DAS	45DAS	75DAS
Control (unweeded check)	43.25^{a}	52.88^{a}	53.62^{a}	65.72^{a}	6.300^{a}	12.8^{a}
HW at 30 & 60DAS	22.63^{h}	24.88^{h}	28.76^{h}	33.70^{g}	3.34^{g}	6.56^{g}
SWE@12Lha^{-1}	34.13^{de}	37.13^{ef}	45.75de	59.02^{b}	5.36^{cd}	11.44^{b}
SFWE@12Lha^{-1}	36.50^{cd}	42.50^{d}	48.12^{bc}	57.42^{bc}	5.61^{bc}	11.12^{bc}
BWE@12 Lha^{-1}	39.25^{b}	46.38^{b}	49.72^{b}	59.30^{b}	5.78^{b}	11.60^{b}
SWE + SFWE @6+6 Lha^{-1}	30.00^{f}	34.75^{f}	40.75^{f}	47.88^{e}	4.74^{e}	9.25^{e}
SWE + BWE@6+6 L ha^{-1}	33.63^{e}	39.50^{de}	44.26^{e}	52.22^{d}	5.17^{d}	10.05^{d}
BWE+ SFWE @ 12 Lha^{-1}	38.13^{bc}	45.00^{bc}	47.37^{cd}	55.98^{c}	5.52^{bc}	10.86^{c}
SWE + SFWE + BWE @4+4+4 Lha^{-1}	27.00^{g}	29.13^{g}	37.25^{g}	43.21^{f}	4.35^{f}	8.35^{f}
LSD	2.59	3.58	2.05	2.32	0.28	0.52

Any two means not sharing a letter in common differ significantly at 5 % probability level.
LSD = Least significant difference at 5 % probability level.
DAS = Days after sowing. LSD = Least significant difference at 5 % probability level.

Table 2. Allelopathic effect of sorghum, sunflower and brassica water extracts on growth parameters of wheat

Treatments	Fertile Tillers	Unfertile Tillers	Spike length(cm)	spikelets per spike	grains per spike
Control (unweeded check)	248.8 ^{h}	42.92 ^{a}	8.83^{h}	14.15^{d}	46.60^{d}
HW at 30 & 60 DAS	268.8^{fg}	39.81^{cd}	10.24^{cd}	14.65^{c}	48.67^{c}
SWE@12Lha^{-1}	294.5^{de}	36.00^{e}	10.05 ^{de}	15.75^{b}	50.64^{ab}
SFWE@12Lha^{-1}	280.8 ^{ef}	40.25^{bcd}	9.76^{f}	14.61^{cd}	50.20^{b}
BWE@12 Lha^{-1}	255.5^{gh}	42.01^{ab}	9.28 ^{g}	14.18^{d}	47.55^{d}
SWE + SFWE @6+6 Lha^{-1}	349.3^{b}	32.75^{f}	10.86^{b}	16.25^{a}	51.70^{a}
SWE + BWE@6+6 L ha^{-1}	326.3^{c}	39.00^{d}	10.40^{c}	15.94^{ab}	50.93^{ab}
BWE+ SFWE @ 12 Lha^{-1}	303.3^{d}	41.70^{abc}	9.93^{ef}	14.88^{c}	50.41^{b}
SWE + SFWE + BWE @4+4+4 Lha^{-1}	368.3^{a}	33.75 f	11.23^{a}	16.24^{a}	51.15^{ab}
LSD	18.95	1.91	0.23	0.44	1.04

Any two means not sharing a letter in common differ significantly at 5 % probability level.
LSD = Least significant difference at 5 % probability level. DAS = Days after sowing.
LSD = Least significant difference at 5 % probability level. All the treatments were applied at 30 and 60DAS

Table 3. Allelopathic effect of sorghum, sunflower and brassica water extracts on yield parameters of wheat

Treatments	1000 Grain weight (g)	Biological yield (Kg ha-1)	Grain yield (kgha1)	Straw yield(kg ha -1)	Harvest index (%)
Control (unweeded check)	40.54 g	8632 f	2487 f	6145 c	28.81 e
HW at 30 & 60 DAS	40.95 f	9351 c	2899 b	6452 b	31.00 b
SWE@12Lha-1	42.82 c	9447 a	2935 b	6512 b	31.06 b
SFWE@12Lha-1	42.34 d	9394 b	2786 cd	6608 a	29.65 d
BWE@12 Lha-1	41.14 f	9207 e	2724 e	6487 b	29.58 d
SWE + SFWE @6+6 Lha-1	43.67 a	9491 a	3014 a	6477 b	31.75 a
SWE + BWE@6+6 L ha-1	42.59 cd	9314 cd	2814 c	6500 b	30.21 c
BWE+ SFWE @ 12 Lha-1	41.65 e	9274 d	2752 de	6522 b	29.67 d
SWE + SFWE + BWE @4+4+4 Lha-1	43.25 b	9480 a	3005 a	6475 b	31.69 a
LSD	0.33	42.30	47.80	63.08	0.52

Any two means not sharing a letter in common differ significantly at 5 % probability level.
Figures given in parenthesis show percentage decrease over control.
LSD = Least significant difference at 5 % probability level.
Conc. = Concentrated.
DAS = Days after sowing.
LSD = Least significant difference at 5 % probability level.

REFERANCES

Abdelkarim, M., R. J. Gualandi, K. D. Gwinn, and B. H. Ownley (2010) Impact of mycorrhizal infection on sensitivity of wheat to sorghum Allelopathy. Phytopathology. 100:52

Albuquerque, M., R. Santos, L. Lima, P. Filho, R. Nogueira,C. Camara, and A. Ramos (2011). Allelopathy, an alternative tool to improve cropping systems. A review. Agron. Sustain. Dev., 31: 379-395

Anwar, S., W. A. Shah, M. Shafi, J. Bakht, and M. A. Khan (2003). Efficacy of sorgaab (sorghum water extract) and herbicide for weed control in wheat (*Trtticum aestivum* L.) crop. Pakistan J. Weed Sci. Res. 9: 161-170.

Ashiq, M., N. Muhammad, and N. Ahmed (2006). Comparative efficacy of different herbicides -to control grassy weeds in wheat. Pakistan J. Weed Sci. Res. 12: 157-161.

Ashraf, M. and M. S. Naeem (2005). Allelopathic effects of sunflower and sorghum water extracts on wheat-weeds under rain fed conditions of Pothowar. Pakistan J. Arid Agric. 8: 43-47.

Bhadoria, P. B. S. (2011). Allelopathy a natural way towards weed management. American J. Experimental Agri. 1: 7-20.

Batish, D. R., H. P. Singh, S. Kaur, and R. K. Kohli (2006). Phytotoxicity of Ageratum conyzoides residues towards growth and nodulation of Cicer arietinum. Agri. Eco Sys. And Env.113: 399-401.

Batish, D. R., P. Tung, H. P. Singh, and R. K. Kohi (2002). Phytotoxicity of sunflower residues against some summer season crops. J. Agron. 188: 19-24.

Borras, L., G. A. Slafer, and M. E. Otegui (2004). Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal. Field Crop Research. 86: 131-146.

Cheema Z. A. and A. Khaliq (2000). Use of sorghum allelopathic properties to control weeds in irrigated wheat in a semi arid region of Punjab. Agri. Eco Sys. and Envi. 79: 105-112.

Cheema Z. A, A. Khaliq, and M. Farooq (2008). Sorghum allelopathy for weed management in wheat. In: Zeng R.S, A. Mallik and S. M. Luo (eds) Allelopathy in sustainable agriculture and forestry, Springer, New York, pp. 255-270

Cheema, Z. A., A. Khaliq and R. Farooq (2003). Effect of concentrated sorgaab aloneand in combination with herbicides and a surfactant in wheat. J. Animal Plant Sci. 13: 10-13.

Cheema, Z. A., H. M. I. Sadiq and A. Khaliq (2000). Efficacy of sorgaab (sorghum water extracts) as a natural weed inhibitor in wheat. Int. J. Agri. Biol. 2: 144-146.

Czarnota, M. A., R. N. Paul, F. E. Dayan, C. I. Nimbal, and L. A. Weston (2001). Mode of action, localization of production, chemical nature and activity of sorgoleone: a potent PSII inhibitor in sorghum spp. Root exudates. Weed Technology. 15: 813 - 825.

Farooq, M., K. J. Zahid A. Cheema, A. Wahid and K. H. M. Siddiquec (2011). The role of allelopathy in agricultural pest management. Pest Manag. Sci., 67: 493–506

Ferreira, M. I and C. F. Reinhardt (2010). Field Assessment of Crop Residues for Allelopathic Effects on Both Crops and Weeds. Agronomy J. 102 (6): 1593-1600.

Fuji, Y. (2001). Screening and future exploitation of allelopathic plants as alternative herbicides with special reference to hairy vetch. 4: 257-275.

Gao, Y., C. Zheng, Y. Li, C. Fan, G. Tu and J. Gao (2008). Chemical constituents from leaves of allelopathic cultivar sunflower in china. Chem. Natu. Comp. 44(6): 773-775.

G.O.P. (2009). Economic Survey of Pakistan. Economic Division. pp. 13.

Khan, M. B., M. Asif, N. Hussain and M. Iqbal (2000). Agro economic impact of different weed control strategies in wheat. J. Res. Sci. B.Z.U., Multan. 11: 46-49.

Lin, W., C. Fang, T. Chen, R. Lin, J. Xiong and H. Wang (2010). Rice allelopathy and its properties of molecular ecology. Frontiers in Biology, 5(3): 255-262

Macias F. A., T. Ascension, J. L. G. Galindo, M. Rosa, A. J. Varela and J. M. G. Molinillo (2002). Bioactive terpinoids from sunflower leaves cv. Peredovick. Phytochemistry 61: 687-692.

Malik, A. U., I. Hussain, M. A. Alias, H. A. Baksh, M. A. Haji and M. Ali (2009). Demonstration and evaluation of effect of weedicides on broad leaved weeds on wheat yield. The J. Animal Plant Sci. 19: 193-196.

Martines, I. P., H. V. Kojouharov and J. P. Grover (2009). A chemostat model of resource competition and allelopathy. Applied Mathematics and Computation, 215 : 573–582

Marwat, K. B., Z. Hussain, M. Saeed, B. Gul and S. Noor (2005). Chemical weed management in wheat at higher altitudes. Pakistan J. Weed Sci. Res. 11: 102 -107.

Memon, R. A. and G. R. Bhatti (2003). Weed diversity of wheat crop in Khaipur district, Sindh (Pakistan). Pakistan J. Weed Sci. Res. 9: 99-103.

Montgomery, D. C. (2001). Design and Analysis of Experiments. 5th ed. John Willy and Sons, New York. P. 64-65.

Mushtaq M. N, Z. A. Cheema, A. Khaliq and M. R. Naveed (2010). A 75% reduction in herbicide use through integration with Sorghum+sunflower extracts for weed management in wheat J. Sci. Food Agric., 90: 1897–1904

Naseem, M., M. Aslam, M. Ansar and M. Azhar (2009). Allelopathic extracts of sunflower water extract on weed control and wheat productivity. Pakistan J. Weed Sci. Res. 15: 107-116.

Perry, L.G., S. A. Cronin and M. W. Paschke (2009). Native cover crops suppress exotic annuals and favor native perennials in a greenhouse competition experiment. Plant Ecol., 204:247–259

Reeves, T. G. (2006). Effect of annual ryegrass (Lolium rigidum Gaud.) on yield of wheat. Weed Res. 16: 57 – 63.

Shahid, M., B. Ahmad, R. A. Khattak and M. Arif (2006). Integration of herbicides with aqueous allelopathic extracts for weeds control in wheat. African Crop Science Conference Proceedings. 8. pp. 209-212.

Troc, M., D. Saja, A. Kornas, A. Zuraw and A. Skoczowsk (2011). J. Therm. Anal. Calorim.104:141–148

Turk, M. A. and A. M. Tawaha (2003). Allelopathic effect of black mustard (Brassica nigra L.) on germination and growth of wild oat (Avena fatua L.). Crop Protec. 22: 673-677.