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ALLELOPATHIC POTENTIAL OF SUNFLOWER EXTRACT ON WEEDS DENSITY AND WHEAT YIELD

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ABSTRACT

Synthetic herbicides contaminate environment, pollute underground water and cause health hazards and develop weed resistance. Conventional weed control techniques are backbreaking, tiresome and time consuming. Problems caused by commercial herbicides demand for exploring alternative weed control methods. A field experiment was conducted at Agronomy Research Farm, University of Agriculture Peshawar, Pakistan during 2014-15 to evaluate the allelopathic potential of sunflower (Gulshan-98) water extracts (SWE) on weeds density and yield of wheat cultivar 'Atta-Habib-2010'. Randomized complete block design having four replications was used. The experiment was consisted of four concentrations (1:3, 1:4, 1:5 and 1:6 kg L^{-1}) of sunflower extract and three application times (emergence (E), tillering (T) and half at E + half at T). Herbicides (H) application, hand weeding (HW) and control plots were also included for comparison. Herbicide application showed 45 % suppression of weeds density and increased plant height (12%), leaf area $tiller^{-1}$ (23%), spike length (16%) and grain yield (17%) over SWE. Likewise, HW plots showed 36% suppression of weeds, and increased plants height (11%), leaf area $tiller^{-1}$ (20%), spikes length (13.6%), and grain yield (15.6%) over SWE. While SWE resulted in 46% reduction in weeds density and increased plants height, leaf area, spike length and grain yield of wheat (14, 26, 17 and 76%) respectively over control. Application of 1:3 SWE resulted in lower weeds density, taller plants, more leaf area $tiller^{-1}$, longer spikes, and high grain yield of wheat. Among application times SWE applied at tillering resulted in lower weeds density, maximum leaf area $tiller^{-1}$, more spike length and high grain yield. It is concluded from the data that SWE with 1:3 concentration applied at tillering reduced weeds density by 52% and increased wheat yield by 100% over control and is recommended for suppressing weeds and enhancing wheat productivity in agro-climatic conditions of Peshawar valley.

Key words: Allelopathy, grain yield, sunflower, water extract, weeds density, wheat.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the leading cereal crops of family Poaceae grown all over the world. It is specifically cultivated for grains production in Asia and many other countries, because it is staple food for human consumption and provides the major nutritional requirements. It contains average diet protein and 60% of calories (Khalil and Jan, 2005). It is grown on 8.7 million hectares area with a production of 24.3 million tons and average yield of 2787 kg ha^{-1} while in Khyber Pakhtunkhwa, the area under its cultivation is 636.3 thousand hectares with grain production of 1149.9 thousand tons having an average yield of 1808 kg ha^{-1} (MNFSR, 2014).

The deficiency of food supply occurs in Pakistan due to problem in production of wheat such as high weeds attack, late sowing, and deficiency of water are the major reasons which reduce wheat yield (Jabran *et al*., 2011). Maximum yield losses occur when weeds are left unmanaged in field (Jabran *et al*., 2010). Weeds suppression through chemical use is a very effective and herbicides provide efficient weed control enhance in crop production (Santos, 2009). The over use of herbicides for rapid weed control might increase the incidence of crop damage, diseases in humans and animals, contamination of soils and water (Farooq *et al*., 2011). This increase also causes many environmental issues as well. Use of the same type of herbicides for many years may develop resistance in weed biotypes which is a serious issue to think about (Bhowmik and Inderjit, 2003). More than 295 biotypes of 177 weeds species have developed resistance to synthetic herbicides (Heap, 2005).

The possible way for reducing herbicides use is the use of natural products and exploitation of for weed control being the ecological approach for environmental safety (Farooq *et al*., 2008). To control the adverse effects of synthetic chemicals on environment and human and animal health, the importance of sustainable agriculture has increased. So, research awareness is now focused on dropping the reliance upon synthetic herbicides and finding alternative strategies for weed management.

The allelopathy consists of two Greek words, allelon meaning 'mutual' and pathos meaning 'to suffer', damaging effects on other plant growing near them (Chon and Nelson, 2012). It is one of the cheapest and environment friendly approaches for weeds management (Iqbal and Cheema, 2009). . Weed control through allelopathy can be practically utilized in the form of either intercropping or spraying of plant water extracts (Farooq *et al*., 2011). Sunflower (*Helianthus annuus* L.) has been broadly studied with respect to its allelopathic nature (Kamal, 2011) and as part of a strategy for sustainable weed management (Jabran *et al*., 2015)

Sunflower being an important allelopathic crop (Kamal, 2009) releases many allelopathic compounds such as Sorgoleone, Glycosides, alkaloids, flavonoids, phenolics and terpeniods which actively influence the growth of nearby plants because of its high allelopathic nature (Anjum and Bajwa, 2008) and they affect germination of seeds (Kamal and Bano, 2008, Hozayn *et al.*, 2011.). Weed density and biomass is reduced ranging from 19 to 49 %, by using allopathic plants (Cheema and Khaliq, 2000). Allelopathy has been successfully used against weeds in cotton, sunflower and mungbean fields. Weeds control through extract of allelopathic plant increase yield from 15 to 25 % (Cheema *et al.*, 2012). Combined used of extracts allelopathic plants (sorghum, sunflower and rice) is more useful for controlling weeds than alone (Cheema *et al*., 2003). The present research was therefore conducted to evaluate allelopathic effect of sunflower extract on weeds suppression and productivity of wheat.

MATERIALS AND METHODS

In order to study the impact of sunflower water extracts on weeds density and yield of wheat a field experiment was conducted at Agronomy Research Farm, University of Agriculture Peshawar, Pakistan during 2014-15. The experiment was performed in randomized complete block design replicated four times. A plot size of 5.4 m^2 was used. Each plot contained six rows having 30 cm row to row distance and three meter row length. Wheat cultivar 'Atta Habib 2010' was sown with seed rate of 120 kg ha^{-1} on 30th November, 2014. The crop was harvested on 25th May 2015. Fertilizers nitrogen (N) and phosphorus (P) were applied at the rate of 120 and 90 kg ha^{-1} respectively and sources of fertilizer were urea (46% N) and DAP (46% P_2O_5 and 18% N). All phosphorus fertilizer and half of nitrogen were applied at sowing while remaining half of nitrogen was applied at tillering stage. The experiment comprised of four concentrations (1:3, 1:4, 1:5 and 1:6 kg L^{-1}) of sunflower extracts and three application times (emergence (E), tillering (T) and half at E + half at T). Herbicides application, hand weeding and control (no spray and no weeds check) plots were included for comparison. Sunflower water extracts were applied as foliar spray with knapsack hand sprayer over weeds. No weed control was performed in control plots. Manual hand weeding was carried out by uprooting the weeds in hand weeded plots. Post emergence herbicides Buctril super 60EC (bromoxynil+MCPA) @

1.5 L a.i ha^{-1} and Puma Super 75EW (fenoxaprop-P-ethyl) @ 1.25 L a.i ha^{-1} were applied 45 days after sowing in herbicides treated. Sunflower stem water extracts were prepared following the method of Rab *et al.* (2016). Ttreatments were combined and applied in the following manner.

Treatment	Treatment Details
T1	Control (No weeds check and no spray)
T2	Sunflower water extract with 1:3 concentration sprayed at emergence (E)
T3	Sunflower water extract with 1:3 concentration sprayed at tillering (T)
T4	Sunflower water extract with 1:3 concentration sprayed half at E + half T
T5	Sunflower water extract with 1:4 concentration sprayed at emergence (E)
T6	Sunflower water extract with 1:4 concentration sprayed at tillering (T)
T7	Sunflower water extract with 1:4 concentration sprayed half at E + half T
T8	Sunflower water extract with 1:5 concentration sprayed at emergence (E)
T9	Sunflower water extract with 1:5 concentration sprayed at tillering (T)
T10	Sunflower water extract with 1:5 concentration sprayed half at E + half at T
T11	Sunflower water extract with 1:6 concentration sprayed at emergence (E)
T12	Sunflower water extract with 1:6 concentration sprayed at tillering (T)
T13	Sunflower water extract with 1:6 concentration sprayed half at E + half at T
T14	Hand weeding
T15	Herbicides applications

Data Recording

Data were recorded on weed density, plant height, leaf area $tiller^{-1}$, spike length and grain yield using standard procedures. For weeds density data, weeds were counted in one meter row at two different places in each plot. Weeds density m^{-2} was then calculated by using the given equation. Weeds density data were recorded two times (i.e. 70 and 90 days after sowing) in each plot.

$$\text{Weed density } (m^{-2}) = \frac{\text{Number of weeds in one meter row}}{0.3 \text{ m x } 1 \text{ m x } 1}$$

For plant height data, ten representative plants from each plot were selected randomly and their height was measured with help of a meter rod and then averaged to record individual plant height for further analysis. For leaf area tiller^{-1} data on five representative tillers were randomly selected from each plot. The length and width of each tiller's leaves were measured with ruler and then average leaf length (A.L.L) and average leaf width (A.L.W) was recorded. The number of leaves of all the five tillers was also counted. Leaf area tiller^{-1} was then calculated using the given equation. The correction factor (C.F) used was 0.75 according to Khalil *et al.* (2002).

$$\text{Leaf area tiller}^{-1} = \frac{\text{Total number of leaves x A.L.L (cm) x A.L.W (cm) x C.F}}{\text{Number of tillers}}$$

For recording spike length data ten representative spikes were selected at random from each plot and their length was measured with the help of ruler from the initial joint to the spike tip excluding awn. Spike length data was then averaged to record individual spike length for further analysis. For grain yield data three central rows were harvested manually from each plot and then bundled and placed in field for sun drying for some days. Each bundle was threshed separately with electronic wheat thresher machine. Grains of each threshed bundle were collected and weighed with digital balance. Grain yield was then converted into kg ha^{-1} using the given equation.

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Three middle rows grain yield (kg) x 10000}}{\text{0.3 m x 3m x 3}}$$

Statistical analysis

The data were statistically analyzed for randomized complete block design. When F-value was significant then LSD test were carried out at 5% level of probability (Jan *et al*., 2009).

RESULTS AND DISCUSSION

Weeds density (m^{-2})

Statistical analysis of the data revealed that sunflower water extract (SWE) concentration (C), application time (AT), control vs. SWE, hand weeding (HW) vs. SWE and herbicides application (HA) vs. SWE significantly affected weeds density of wheat, whereas C and AT interaction was non significant (Table-1). HA resulted in lower number of weeds (29.4 m^{-2}) than SWE sprayed plots (53.6 m^{-2}). Similarly, HW plots produced fewer weeds (34.1 m^{-2}) compared with SWE sprayed plots (53.6 m^{-2}). Likewise, SWE plots resulted in fewer weeds (53.6 m^{-2}) over control (98.6 m^{-2}). More weeds were recorded in 90 days after sowing (DAS) (57.9 m^{-2}) compared to 70 DAS (49.3 m^{-2}). Mean values of concentration showed that less weeds (49.0 m^{-2}) were noted with 1:3 concentration, which was statistically at par with 1:4 concentration (51.5 m^{-2}). Weeds density decreased with increase in concentration and more weeds (57.4 m^{-2}) were recorded with 1:6 concentration. AT mean values showed that SWE applied at tillering gave fewer weeds (50.8 m^{-2}), whereas SWE sprayed at emergence resulted in more weeds (56.3 m^{-2}). SWE applied as ½ at E + ½ at T gave more (53.8 m^{-2}) weeds, which is statistically at par when SWE applied at emergence and tillering. Weeds suppression in herbicides treated plots might be due to the selective nature and of herbicides. These results are in line with (Santos, 2009) who reported that weeds were effectively controlled with herbicides. HW is very effective but labour intensive and costly. Our results are in line with Farooq *et al*. (2011) who reported fewer weeds with HW over water extract sprayed plots. SWEC have strong effect on weeds suppression and these effect increases with the increase of extract concentration. Our results are also in line with Afridi *et al.* (2013) who reported that extract concentrations have strong effect on weeds density and these effect increases with the increased of extract concentration. These results are also similar with Cheema (1988), Hall *et al.* (1982) and Naseem (1997) who reported that when concentration increases inhibitory effect of weeds also increases due to increase in the phenolic compound which suppressed weeds density.

Plant height (cm)

Statistical analysis of the data revealed that SWEC, AT, control vs. SWE, HW vs. SWE and HA vs. SWE significantly ($P \leq 0.05$) affected plant height of wheat, whereas C and AT interaction was non significant (Table-2). HA resulted in taller plants (96.0 cm) compared with SWE sprayed plots (85.6 cm). Similarly, HW plots produced longer plants (95.0 cm) compared with SWE sprayed plots (85.6 cm). Likewise, SWE sprayed plots gave taller plants (85.6 cm) compared with control (75.0 cm). Mean values for C showed that smaller plants (81.3 cm) were noted for 1:6 concentration. Plant height increased with increase in concentration and taller plants (92.2 cm) were recorded with 1:3 concentration. AT mean values showed that SWE at tillering gave longer plants (87.5 cm), while SWE applied at emergence gave smaller plants (84.2 cm). HA and HW produced taller plant compared with SWEC. Taller plants in HA and HW may be due to fewer weeds recorded in HA and HW and hence less competition between crops and weeds due to which plant height is maximum. Our results are in contrast with Shahid *et al*. (2006) who reported that different allelopathic plant water extracts exhibited suppressive effects on wheat plant height.

Leaf area tiller^{-1} (cm^{2})

Statistical analysis of the data revealed that SWEC, AT, control vs. SWE, HW vs. SWE and HA vs. SWE significantly ($P \leq 0.05$) affected leaf area tiller^{-1} of wheat, whereas C and AT interaction was non significant (Table-3). HA resulted in higher leaf area tiller^{-1} (108.3 cm^{2})

compared with SWE sprayed plots (87.9 cm^2). Similarly, HW plots produced higher leaf area $tiller^{-1}$ (105.5 cm^2) compared with SWE sprayed plots (87.9 cm^2). Likewise, SWE plots gave higher leaf area $tiller^{-1}$ (87.9 cm^2) compared with control (69.5 cm^2). Mean values for SWE showed that less leaf area $tiller^{-1}$ (79.25cm^2) was noted with 1:6 concentration. Leaf area $tiller^{-1}$ increased with increase in concentration and higher leaf area $tiller^{-1}$ (99.3 cm^2) was record with 1:3 concentration. Mean values for AT showed that SWE applied at T gave higher leaf area $tiller^{-1}$ (90.5 cm^2), while SWE applied as 1/2 at E + 1/2 at T gave smaller leaf area $tiller^{-1}$ (86.1 cm^2) which was statistically similar SWE applied at E (87.2 cm^2). Our finding are in line with Elahi et al., (2011) who evaluated the allelopathic effect of sunflower, sorghum, rice and brassica water extract for weeds control in wheat crop and resulted in maximum weeds suppression due to which plant grow higher and produced maximum leaf area $tiller^{-1}$.

Spike length (cm)

Statistical analysis of the data revealed that SWEC, control vs. SWE, HW vs. SWE and HA vs. SWE significantly ($P \leq 0.05$) affected spike length of wheat, whereas AT and C and AT interaction was non significant (Table-4). HA sprayed plots produced longer spikes (10.20 cm) compared with SWE sprayed plots (8.79cm). Similarly, HW plots produced taller spikes (9.95cm) compared with SWE sprayed plots (8.79cm). Likewise, SWE sprayed plots resulted in taller spikes (8.97cm) compared with control (7.45cm). Mean values for C showed that smaller spikes (8.23cm) were noted with 1:6 concentration, which was statistically similar to 1:5 (8.33cm) and 1:4 (8.75cm) concentration. Spike length increased with increase in concentration and longer spikes (9.84cm) were recorded with 1:3 concentration. Longer spikes in HA and HW plots may be due to the less weeds in these plots due to which all the photo assimilate were transferred to wheat and thus produced maximum spike length. Our results are in line with Borras *et al.* (2004) who reported that by controlling weeds in crops all the photoassimilate transfers to the major crops.

Grain yield (kg ha^{-1})

Statistical analysis of the data revealed that SWEC, AT, control vs. SWE, HW vs. SWE and HA vs. SWE significantly ($P \leq 0.05$) affected grain yield of wheat, whereas C and AT interaction was non significant (Table-5). HA resulted in maximum grain yield (4291.3) compared with SWE sprayed plots (3672). Similarly, HW plots produced maximum grain yield (4208.2 kg ha^{-1}) compared with SWE sprayed plots (3672.6). Likewise SWE treated plots resulted in maximum grain yield (3672.7) compared with control (2091.4). Mean values for concentration showed that minimum grain yield (2926.5) was noted with 1:6 concentration. Maximum grain yield (4111.9) was recorded with 1:3 concentration. AT showed that SWE at tillering gave maximum grain yield (3768.2) which was statistically at par when SWE applied as 1/2 at E + 1/2 at T (3663.2). While SWE applied at emergence gave minimum (3586.7) grain yield. More grain yield may be due to effective weed control due to which all the nutrients, moisture and sunlight were easily available and utilized by crop that accelerate crop growth, consequently enhanced grain yield. These results are in line with Muhammad *et al*. (2013) who also reported suppressed weed density and higher crop yield in sunflower and sorghum water extract treatments than control plots.

Table-1. Weeds density (m^{-2}) of wheat as affected by sunflower water extract concentration and application time

Concentration (C) kg L^{-1}	Stages		Mean
	70 DAS	90 DAS	
C_1 = 1:3	45.2	52.8	49.0 b
C_2 = 1:4	46.4	56.7	51.5 b
C_3 = 1:5	52.3	61.0	56.6 a
C_4 = 1:6	53.5	61.3	57.4 a
Application time (AT)			
Emergence (E)	51.1	61.4	56.3 a
Tillering	47.0	54.6	50.8 b
1/2 at E + 1/2 at T	49.9	57.8	53.8 b
Mean	49.3	57.9	
Planned Mean Comparison			
Control	98.6		
Sunflower Water Extract	53.6		
Hand Weeding	34.1		
Herbicides Application	29.4		

Means of the same category having similar letter (s) are non significant at P ≤ 0.05 level using LSD test.
LSD (0.05) for concentration = 4.5, LSD (0.05) for application time = 3.9

Table-2. Plant height (cm) of wheat as affected by sunflower water extract concentration and application time.

Conc. (C) kg L^{-1}	Application Time (AT)			Mean
	Emergence (E)	Tillering (T)	½ at E + ½ at T	
C_1 = 1:3	92.4	94.0	90.2	92.2 a
C_2 = 1:4	82.8	88.1	86.2	85.7 b
C_3 = 1:5	81.3	84.3	83.5	83.0 c
C_4 = 1:6	80.5	83.5	80.1	81.3 d
Mean	84.2 b	87.5 a	85.0 b	

Planned Mean Comparison	
Control	75.0
Sunflower Water Extracts	85.6
Hand Weeding	95.0
Herbicides Application	96.0

Means of same category with similar letter(s) are non significant at P≤0.05 level using LSD test. LSD (0.05) for concentration = 2.2, LSD (0.05) for application time = 1.9

Table-3. Leaf area tiller^{-1} (cm^2) of wheat as affected by sunflower water extract concentration and application time

Conc. (C)	Application Time (AT)			
(kg: L^{-1})	Emergence (E)	Tillering (T)	½ at E + ½ at T	Mean
C1 = 1:3	98.5	101.3	98.3	99.3 a
C2 = 1:4	91.8	97.0	89.0	92.6 b
C3 = 1:5	79.5	83.3	78.8	80.5 c
C4 = 1:6	79.0	80.3	78.5	79.3 c
Mean	87.2 b	90.4 a	86.1 b	
Planned Mean Comparison				
Control	69.5			
Sunflower Water Extract	87.9			
Hand Weeding	105.5			
Herbicides Application	108.3			

Means of same category with similar letter(s) are non significant at P≤0.05 level using LSD test. LSD (0.05) for concentration = 2.9, LSD (0.05) for application time = 2.5

Table-4. Spike length (cm) of wheat as affected by sunflower water extract concentration and application time.

Conc.	Application Time			
(kg:L^{-1})	Emergence	Tillering	½ at E + ½ at T	Mean
C_1 = 1:3	9.5	10.1	10.0	9.8 a
C_2 = 1:4	8.6	8.9	8.8	8.8 b
C_3 = 1:5	8.0	8.6	8.4	8.3 b
C_4 = 1:6	8.0	8.4	8.3	8.2 b
Mean	8.5	9.0	8.8	
Planned Mean Comparison				
Control	7.5			
Sunflower water extract	8.8			
Hand weeding	10.0			
Herbicide Application	10.2			

Means of the same category having similar letter (s) are non significant at P ≤ 0.05 level using LSD test.
LSD (0.05) for concentration = 0.82, LSD (0.05) for application time = 0.71

Table-5. Grain yield (kg ha^{-1}) of wheat as affected by sunflower water extract concentration and application time.

Conc. (kg :L^{-1})	Application Time			Mean
	Emergence	Tillering	½ at E + ½ at T	
C_1 = 1:3	4055.5	4182.0	4098.2	4111.9 a
C_2 = 1:4	3842.6	4039.9	3949.5	3944.0 b
C_3 = 1:5	3677.3	3743.5	3704.7	3708.5 c
C_4 = 1:6	2771.6	3107.5	2900.5	2926.5 b
Mean	3586.7 b	3768.2 a	3663.2 a	
Planned Mean Comparison				
Control	2091.4			
Sunflower water extract	3672.7			
Hand weeding	4208.2			
Herbicide Application	4291.3			

Means of the same category having similar letter (s) are non significant at P ≤ 0.05 level using LSD test.
LSD (0.05) for concentration = 119.8, LSD (0.05) for application time = 103.8

CONCLUSION

It is concluded from the results that SWE with 1:3 concentration applied at tillering reduced weeds density by 52% and increased wheat yield by 100% over control and is recommended for suppressing weeds and enhancing wheat productivity in agro-climatic conditions of Peshawar valley, Pakistan.

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