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ANALYSIS OF WHEAT CROP PARAMETERS UNDER ALLELOPATHIC WITH REDUCED DOSE OF HERBICIDE APPLICATION.

Afza Tabassum[1,2]*, Ziaur Rahman[2], Aymen Saeed[3], Haleema Bibi[3], Baseer Muhammad[2]. Syed Azam Shah[4]

ABSTRACT

Water extracts from allelopathic plants like sorghum, sunflower and brassica having potential to control weeds effectively, especially when it is use in combination with reduced dose of herbicides. A field experiment was carried out to examine the feasibility of using sorghum water extract as a natural weedicide in rabi season crop (wheat) during 2015-2016 at Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan. Sorgaab sprays with three different concentration (1:3, 1:4,1:5) in combination with Weedicide (affinity) in three different levels (1/3,1/2 and 2/3 of the recommended dose), with three application timing (emergence, tillering, 50% at emergence and 50 % at tillering), were tested and compared with hand weeding, unweeded and with weedicide sole. Results of the study showed that the herbicide sole followed by hand weeded plots were more effective among all the treatments for controlling weed dry weight and increasing of the grain yield. Sorghum extract sprayed at 1:5 resulted in decreased dry weight (127.2 g m^{-2}), more leaf area $tiller^{-1}$ (101 cm^2), more leaf area index (3.0) and higher grain yield (3727 kg ha^{-1}). Herbicide (affinity) at the rate of 1317g ha^{-1} clearly decreased dry weight of weeds (133.3 g m^{-2}) and increased leaf area $tiller^{-1}$ (100 cm^2), leaf area index (2.9) and higher grain yield (3665 kg ha^{-1}). Sorghum extract concentration with combination of herbicide sprayed at tillering stage gave reduced dry weight (132), increased leaf area $tiller^{-1}$ (99 cm^2), more leaf area index (2.9) and grain yield (3727 kg ha^{-1}). It is concluded that sorghum extract concentration 1:5 with 1317g ha^{-1} of the herbicide affinity applied at tillering stage is recommended for higher yield and yield components of wheat crop.

Keywords: Wheat, Allelopathy, Affinity, Agriculture, Leaf area $tiller^{-1}$, Leaf area index, Grain yield.

1 - Department of Agronomy, The University of Agriculture Peshawar-Pakistan.
2 - Department of Agriculture, University of Swabi, Swabi-Pakistan.
3 - Department of Plant Breeding and Genetics,The University of Agriculture, Peshawar-Pakistan.
4 - Soil & Environmental Sciences Division. Nuclear Institute for Food and Agriculture Peshawar.
*Corresponding author's email: rayan@aup.edu.pk

I. Introduction

In Pakistan, weeds inflict 20- 30% losses in different crops on the average (Anonymous, 2005). Existing weed control methods are either expensive or hazardous. Heavy use of chemical herbicides in most integrated weed management systems is a most concern since, it causes serious threats to the environment, public health and increase cost of crop production. Small farmers cannot afford the cost of weed management practices for crop production. Thus weeds growing among crop plants adversely affect yield and quality of harvest and increase production costs, resulting in high economic losses. Some species of weed plants might be a serious threat to crop plants diversity, sharing nutrients, moisture, sunlight and space (Ozturk*et al.*, 2012). Weeds compete with crops for nutrients, solar radiation, water, carbon dioxide and space. Apart from competition, many other factors like lodging and harvesting problems are created by weeds. In Pakistan, weeds are accountable for 30 percent grain yield losses in wheat which amounts to Rs. 1150 million annually (Marwat *et al*., 2008). Weed decline yield and quality of crops and leads to higher cost in food production (Pandya *et al*., 2005). Therefore, weed control is one of the most important aspects of crop production in agricultural systems. In addition to the direct losses caused by the weeds competition with crops for water, mineral nutrients and light, quality of crop may also be compromised by the occurrence of weeds and or their seeds, which habitually causes a great economic loss to the crop. Therefore, alternative strategies against weed must be developed (Rice, 1983) defined allopathy as the effect of one plant on other plants through the release of chemical compounds in the soil environment. Allelopathy is a natural, inexpensive, environmentally safe and an organic approach to control weeds and increase crop yields while conserving the ecosystem. Ahmad *et al*. (1991) concluded that sorghum is highly allelopathic and sorghum residue could be effectively used to manage some of the important weeds in irrigated wheat crop without affecting crop in semi-arid environment. Mature sorghum plants possess nine water soluble chemicals which are phytotoxic to certain weeds such as *Phalaris minor* Retz. *Chenopodium album L*., *Rumex dentatus* L., and *Convolvulus arvensis L*. (Cheema, 1988). Water extract of matured sorghum plants was used by Cheema and Khaliq (2000) and reported that water extract spray reduced weed biomass by 35-40% and increased wheat yield by 10-21%. Sorghum roots exudates reduced growth of various weed species at very low concentration (Roth *et al.*, 2000). It has also been documented that production of allelochemicals in plants is influenced by environmental factors and greater quantities of allelochemicals have been found in plants grown under drought and mineral stress (Roth *et al*., 2000; Suthep*et al.*, 2001). In recent times, studies on unitization of allelopathic chemicals (allelochemicals) as natural substances from plants for weed control in crop production have been widely noticed (Iqbal *et al*., 2010; Elahi *et al*., 2011; Afridi *et al*., 2013; Ahmed *et al*., 2014). In general, allelochemicals from plants are considered to be safe and beneficial.

Most allelochemicals are classified as secondary metabolites of the plant (Kruse *et al.*, 2000). It is well documented that the production of secondary metabolites is characterized by the plant's genetic and environmental conditions during its growth (Quader *et al.,* 2001). However, these stimulatory and inhibitory effects depend on the concentration of the compounds (Bhowmik and Inderjiit, 2003). Sorghum residues release sorgoleone, cyanogenic glycosides-dhurrin, and a number of breakdown products of phenolics that bring about weed suppression (Guenzi and McCalla, 1966; Nicollier *et al.*, 1983; Putnam, 1988; Weston *et al.*, 1989 Sorghum allelopathy for weed management in wheat 259 Weston, 1996). Cheema and Khaliq (2000) performed a series of experiments in semiarid region of Punjab, Pakistan, to explore the use of allelopathic properties of sorghum for weed control in irrigated wheat. Allelochemicals of *P.hysterophorus*can be exploited as a source of natural herbicides to control other invasive species (Mulatu *et al.*, 2009). Earlier research (Khaliq *et al.,* 2002; Jabran *et al.,* 2008; Mahmood *et al.,* 2009; Razzaq *et al.*, 2010, 2012) findings have shown that the use of reduced doses of herbicides with allelopathic plant water extracts has increased the desirable characters of crops.

Keeping in view the losses due to weeds, resistance creating to herbicide application and the recognized importance of allelochemicals in weed management, a present field experiment were conducted under the agro climatic condition of Peshawar.

Material and methods

The experimental work was evaluated at Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan. The experiment was laid out in a randomized complete block design (RCBD) having three replications in plot of size 3 m x 1.8 m (L x W). Each plot consist of six rows having 30 cm row to row distance. Wheat variety (Atta Habib 2010) at the seed rate of 120 Kg ha^{-1} was sown on 21 November 2015 with the help of seed drill, and harvested on 2 June 2016 by hand sickle. Nitrogen and Phosphorous fertilizers were applied at the rate of 120-90 kg ha^{-1}, respectively, and source of N and P fertilizer were applied in the form of urea (46% N) and diammonium phosphate (46% P_2O_5 and 18% N). All phosphorous fertilizer and half of nitrogen were applied at the time of sowing, remaining nitrogen was applied at first irrigation. Irrigations were applied whenever required.

The following factors and their levels were studied:

Concentration of sorghum plant having three levels as factor A, C1=1:3, C2=1:4 and C3= 1:5 (i.e 1kg sorghum plant herbage+3, 4 and 5 liters of water). Herbicide ratio as factor B with three levels: R1=1/3, R2=1/2 and R=2/3 of the recommended dose of affinity (post emergence herbicide). Application times as factor C: AT1= Full at emergence (E), AT2=Full at tillering stage (T) and AT3 = Half at E + half at T. Different concentration (1:3), (1:4) and (1:5) i.e. (1 kg sorghum and 3, 4 and 5 liters of water) of sorghum extract were sprayed at three stages full at emergence, full tillering and half at emergence plus half at tillering. Experiments were also including control (without weed), hand weeding (HW) and herbicides application. Herbicide “Affinity” was applied at three different ratios i.e. one third (1/3) of the recommended dose (670 g ha^{-1}), half (1/2) of the recommended dose (988 g ha^{-1}) and two third (2/3) of the recommended dose (1317 g.ha^{-1}). All other agronomic practices were applied uniformly.

Preparation of sorghum water extracts concentrations

Mature sorghum was collected from Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan. Then chopped into small pieces with the help of fodder cutting machine and soaked in tubs for 48 hours by maintaining (1:3,1:4,1:5) i.e. (1 kg plant herbage and 3, 4 and 5 liters of water) for preparation of different concentrations. Then sieved the mixture through muslin cloth to remove sorghum crop herbage and to obtain extract of sorghum. Data were recorded for dry weeds weight (g m^{-2}) (40 and 60 days after sowing), Leaf area $tiller^{-1}$ (cm^2), Leaf area index (LAI) and Grain yield (Kg ha^{-1}) according to the recommended methods.

Statistical analysis

The data recorded were analyzed statistically using analysis of variance techniques appropriate for randomized complete block design. Means will be compared using LSD test at 0.05 level of probability, when the F-values was significant (Jan *et al.*, 2009).

RESULTS AND DISCUSSION

Weed dry weight (g m^{-2})

Weeds dry weight (g m^{-2}) was significantly influenced by sorghum concentration (SC), affinity ratio (AR), application time (AT), control vs rest, hand weeding vs herbicide, herbicide sole vs ratio, and R x T interaction, whereas herbicide sole, C x R, C x T, C x R x T interaction were found non-significant (Table 1). More weeds dry weight recorded 40 DAS compared to 60 DAS. Maximum weeds dry weight (149.1g m^{-2}) was obtained from sorghum concentration 1:3 (1kg sorghum and 3 liter water). Thereafter, weeds dry weight decreased with decreased of sorghum concentration. Minimum weeds dry weight (127.2g m^{-2}) were recorded from 1:5 (1kg sorghum and 5 liters water). Lower affinity dose 670 g resulted in higher weeds dry weight (143.5g m^{-2}). Higher affinity ratio (1317 g) resulted in lower weeds dry weight (133.3g m^{-2}). Sorghum herbage applied at tillering produced lower weeds dry weight (132g m^{-2}), while the higher weeds dry weight (143,142g m^{-2}) were obtained from sorghum herbage applied at emergence or 50 at emergence + 50 at tillering stage. R x T interaction indicated that minimum weeds dry weight were recorded from emergence time x 670 g affinity, while maximum weeds weight were observed at tillering and 1317g herbicide applied. Control vs rest contrast indicated that reduced weeds dry weight (134.28g m^{-2}) were obtained from rest (treated plot), while control plot resulted in higher weeds dry weight (164.80g m^{-2}). Hand weeded plots produced minimum weeds dry weight (111.77g m^{-2}) compared with herbicide treated plots (135.01g m^{-2}). In herbicide vs ratio contrast the lowest weeds dry weight was obtained from ratios (138.92g m^{-2}), while herbicide treated plots gave maximum weeds dry weight (144.75g m^{-2}).These results are supported by Khan *et al*. (2015), Arif *et al*. (2015), Awan *et al*. (2012), Shahid *et al*. (2007), Hussain *et al*. (2014) who recorded significant decreased in weed dry weight with water extract obtained from different allelopathic crops.

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

Data analyzed statistically showed that leaf area tiller^{-1} (cm^2) was significantly influenced by sorghum concentration (SC), affinity ratio (R), application time (AT), control vs rest, hand weeding vs herbicide, herbicide sole vs ratio, and C x R whereas, C x T, R x T, C x R x T interaction were found non-significant (Table 2). Minimum leaf area tiller^{-1} (93 cm^2) was obtained from sorghum concentration 1:3 (1kg sorghum and 3 liter water). Maximum leaf area tiller^{-1} (101 cm^2) were recorded from 1:5 (1kg sorghum and 5 liters water) which was statistically similar with sorghum concentration 1:4 (1kg sorghum and 4 liters water).). Lower affinity dose (670 g) resulted in lower leaf area tiller^{-1} (95 cm^2). Leaf area tiller^{-1} increased with each increments of herbicide and maximum leaf area tiller^{-1} (100 cm^2) was recorded from affinity applied at 1317g which was statistically at par with herbicide applied at the rate of 988g. Sorghum herbage applied either at tillering or at emergence stage produced higher leaf area tiller^{-1} (99 cm^2) than sorghum applied 50 at emergence + 50 at tillering stage (96 cm^2). R x T interaction revealed that minimum leaf area tiller^{-1} (93.4 cm^2) was recorded from sorghum concentration (1:3) x 670g affinity, while maximum leaf area tiller^{-1} (101.5cm^2) was noted at 1:5 sorghum concentration and 1317 g herbicide applied. The control vs rest comparison indicated that higher leaf area tiller^{-1} (97.76cm^2) were obtained from treated plots while control plots (no treatments) give less leaf area tiller^{-1} (89.35 cm^2). Hand weeded plots produced higher leaf area tiller^{-1} (112.9 cm^2) compared with herbicide treated plots (97.3 cm^2). Herbicide vs ratio contrast that maximum leaf area tiller^{-1}(97.87 cm^2) was obtained from ratio while herbicide treated plots gave less leaf area tiller^{-1} (91.68 cm^2). Our results are in line with Anwar *et al*., (2003) who reported highest leaf area with herbicides application followed by hand weeding. Combination of grassy and broad leaf herbicides was superior to their separate application for weed control in wheat as reported by Cheema and Akhtar (2005). Similar results were reported by Cheema *et al*., (2000), Anwar *et al*., (2003) who observed that concentrated sorghum water extract applied at various timing significantly increased leaf area.

Leaf area index (LAI)

Leaf area index was significantly influenced by sorghum concentration, affinity ratio, application timing, control vs. rest, hand weeding vs. herbicide, herbicide sole vs. ratio, C x R interaction, whereas, herbicide sole, C x T, R x T, C x R x T interaction were found non-significant (Table 3). Minimum leaf area index (2.5) was obtained from sorghum concentration 1:3 (1kg sorghum and 3 liter water), leaf area increased with decrease of sorghum concentration. Maximum leaf area index (3.0) was recorded from 1:5 (1kg sorghum and 5 liter water). Lower affinity dose (670 g) resulted in lower leaf area index (2.6). Higher affinity ratio (1317 g) resulted in maximum leaf area index (2.9) which was statistically at par with herbicide ratio (988g). Sorghum herbage applied at tillering stage produced higher leaf area index (2.9) which was statistically similar when applied at emergence (2.8) than sorghum applied 50 at emergence + 50 at tillering stage (2.6). C x R interaction revealed that minimum leaf area index was recorded from sorghum concentration (1:3) x 670 g affinity, while maximum leaf area index (3.0) was noted at 1:5 sorghum concentration and 1317 g herbicide applied. Control vs rest contrast indicated that maximum leaf area index (2.7) were obtained from rest (treated plot), while control plot (no treatment) resulted in minimum leaf area index (2.1). Hand weeded plots produced higher leaf area index (3.5) compared with herbicide treated plots (2.7). In herbicide vs ratio contrast the maximum leaf area index (2.7) was obtained from ratios, while herbicide treated plots gives lowest leaf area index (2.5). Similar results were reported by Mubeen *et al*. Jamil *et al*. (2009) who reported higher LAI with herbicides application followed by hand hoeing.

Grain yield (kg ha^{-1})

Statistical analysis of the data showed that grain yield (kg ha^{-1}) was significantly influenced by sorghum concentration (SC), affinity ratio (AR), application time (AT), control vs rest, hand weeding vs herbicide and R x T interaction (Table 4) whereas, herbicide sole vs ratio, herbicide sole, C x R, C x T, C x R x T interaction were found non-significant. Minimum grain yield (3384 kg ha^{-1}) was obtained from sorghum concentration 1:3 (1kg sorghum and 3 liter water) which was statistically at par with sorghum concentration 1:4 (1kg sorghum and 4 liter water). Maximum grain yield (3727 kg ha^{-1}) were recorded from 1:5 (1kg sorghum and 5 liters water). Lower affinity dose (670 g) resulted in lower grain yield (3379 kgha^{-1}). Higher affinity ratio (1317 g) resulted in higher grain yield (3665 kg ha^{-1}). Sorghum herbage applied at tillering stage produced higher grain yield (3616 kg ha^{-1}), while the lowest grain yield (3420 kgha^{-1}) were obtained from sorghum herbage applied at emergence. R x T interaction indicated that minimum grain yield (3420.1kg ha^{-1}) was recorded from emergence time x 670g affinity, while maximum grain yield (3616.3kg ha^{-1}) was noted at tillering and 1317g herbicide applied. The herbicide vs. hand weeding contrast revealed that hand weeding resulted in higher grain yield (4016.0 kg ha^{-1}) compared to herbicide treated plots (3520.4 kg ha^{-1}). The control vs. rest contrast indicated that treated plots resulted in higher grain yield (3536.35 kg ha^{-1}) over control plots (2917.33 kg ha^{-1}). These findings are in line with Ahmad *et al.* (1993), Singh and Singh (1996) and Subhan *et al.* (2003) who concluded that herbicide application and hand weeding increased grain yield of wheat compared to weedy check. Similarly the results are also in conformity with the findings of Awan *et al*., (1990), Hassan *et al*. (2003) and Tunio *et al*. (2004) who reiterated the efficacy of herbicide applications having been influential in raising the grain yield of wheat. It has been noted that grassy weeds like *A. fatua* and broadleaf weeds like *R. dentatus*are harmful for all the winter crops including wheat. Due to strong competitive ability of these weeds with wheat crops, the management of these weeds need to be addressed to avoid the grain yield losses (Tauseef *et al.*, 2013).

Table 1. Weed dry weight (g m^{-2}) in wheat as affected by allelopathic and chemical with different application time.

Treatments	Sampling intervals (days after sowing)		Mean
Concentration of sorghum (kg) L^{-1} water	40 days	60 days	
1:3	193.7	104.6	149.1a
1:4	188.4	92.4	140.4 b
1:5	173.2	81.3	127.2 c
Affinity (1976 g ha^{-1})†			
670	189.1	97.9	143.5 a
988	187.3	92.6	140.0 a
1317	178.8	87.7	133.3 b
Application time			
Emergence (E)	189	97	143 a
Tillering (T)	175	89	132 b
1/2at E +1/2 at T	192	92	142 a
Planned Mean Comparison			
Control	213.25	116.36	164.80 a
Rest of treatment	178.44	90.12	134.28 b
Hand weeding	155.96	67.59	111.77 b
Herbicide	179.16	90.85	135.01 a
Herbicide sole	185.58	103.92	144.75 a
Ratio	185.08	92.76	138.92 b

† Affinity recommended dose

$LSD_{0.05}$ for concentration	=	4.69
$LSD_{0.05}$ for application time	=	4.69
$LSD_{0.05}$ for ratio	=	4.69

Means within the same category followed by different letters are significantly different at P ≤ 0.05 using LSD test.

Table 2. Leaf area tiller^{-1}(cm^2) in wheat as affected by allelopathic and chemical with different application timing.

Affinity (1976 g ha^{-1})†	Concentration of sorghum (kg) L^{-1} water	Application Time			Mean
		Emergence (E)	Tillering (T)	1/2 at E +1/2 at T	
670	1:3	95	98	90	94
	1:4	95	93	98	95
	1:5	98	96	94	96
988	1:3	95	98	89	94
	1:4	106	103	97	102
	1:5	100	98	101	100
1317	1:3	95	88	91	91
	1:4	100	101	97	99
	1:5	110	113	104	109
670		96	96	94	95 b
988		100	100	96	98 a
1317		102	101	97	100 a
	1:3	95	95	90	93 b
	1:4	100	99	97	99 a
	1:5	103	102	100	101 a
Mean		99 a	99 a	96 b	
Control					89.35 b
Rest of treatments					97.76 a
Hand weeding					112.9a
Herbicide					97.3 b
Herbicide sole					91.68 b
Ratio					97.87 a

† Affinity recommended dose

$LSD_{0.05}$ for concentration	=	2.86
$LSD_{0.05}$ for application time	=	2.86
$LSD_{0.05}$ for ratio	=	2.86

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test.

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Table 3. Leaf area index (LAI) in wheat as affected by allelopathic and chemical with different application timing.

Affinity (1976 g ha^{-1})†	Concentration of sorghum (kg) L^{-1} water	Application Time			
		Emergence (E)	Tillering (T)	1/2at E +1/2 at T	Mean
670	1:3	2.3	2.7	2.3	2.4
	1:4	2.5	2.6	2.7	2.6
	1:5	2.8	2.8	2.5	2.7
988	1:3	2.8	2.8	2.2	2.6
	1:4	3.5	3.0	2.5	3.0
	1:5	2.9	2.8	2.8	2.8
1317	1:3	2.6	2.5	2.7	2.6
	1:4	2.9	2.9	2.6	2.8
	1:5	3.5	3.5	3.0	3.3
670		2.5	2.7	2.5	2.6 b
988		3.1	2.9	2.5	2.8 a
1317		3.0	3.0	2.8	2.9 a
	1:3	2.6	2.7	2.4	2.5 c
	1:4	2.9	2.8	2.6	2.8 b
	1:5	3.0	3.1	2.8	3.0 a
Mean		2.8 a	2.9 a	2.6 b	
Control					2.10 a
Rest of treatments					2.76 b
Hand weeding					3.5 a
Herbicide					2.7 b
herbicide sole					2.52 b
Ratio					2.76 a

† Affinity recommended dose

$LSD_{0.05}$ for concentration	=	0.14
$LSD_{0.05}$ for application time	=	0.14
$LSD_{0.05}$ for ratio	=	0.14

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test.

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Table 4. Grain yield (kg ha^{-1}) in wheat as affected by allelopathic and chemical with different application timing.

Affinity (1976 g ha^{-1})[†]	Concentration of sorghum (kg) L^{-1} water	Application time			Mean
		Emergence (E)	Tillering (T)	1/2at E +1/2 at T	
670	1:3	3214	3235	3466	3305
	1:4	3442	3115	3280	3279
	1:5	3516	3662	3486	3555
988	1:3	3188	3380	3452	3340
	1:4	3207	3472	3580	3420
	1:5	3650	3998	3610	3753
1317	1:3	3504	3660	3360	3508
	1:4	3333	3905	3606	3615
	1:5	3727	4120	3773	3873
670		3391	3337	3411	3379 c
988		3348	3617	3547	3504 b
1317		3521	3895	3580	3665 a
	1:3	3302	3425	3426	3384 b
	1:4	3328	3497	3489	3438 b
	1:5	3631	3927	3623	3727 a
Mean		3420 b	3616 a	3513 ab	
Control					2917.33b
Rest of treatments					3536.35 a
Hand weeding					4016.0a
Herbicide					3520.4 b
herbicide sole					3556.65
Ratio					3516.33

[†] Affinity recommended dose

$LSD_{0.05}$ for concentration	=	114.91
$LSD_{0.05}$ for application time	=	114.91
$LSD_{0.05}$ for ratio	=	114.91

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test.

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