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Response of Wheat and Wheat-Weeds to Allelopathic Effects of Sorghum Residues Under Varying Levels of Fertility

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Abstract

An experiment to evaluate the allelopathic effects of sorghum residues and fertilizer application on wheat and wheat-weeds was conducted at University of Agriculture, Faisalabad during 1990. Treatments included no fertilizer + weeds, fertilizer @ 56-56-56 kg NPK ha-1 + weeds, fertilizer @ 84-56-56 kg NPK ha-1 + weeds and fertilizer @ 114-84-56 kg NPK ha-1 + weeds. All these treatments were supplemented with sorghum roots and whole sorghum plants which were incorporated at maturity after proper chaffing. Control (no sorghum residue, no fertilizer) was also included. Sorghum generally promoted the density and biomass of Melilotus parviflora and Rumex dentatus, Phalaris minor, Convolvulus arvensis, Coronopus didymus, Cnenopodlum album, Cyperus rotundus and Anagallis arvensis was suppressed. Fertilizer application of 114-84-56 kg NPK ha-1 with sorghum roots was most effective combination for inhibiting the weed density, biomass and to increase the wheat yield by neutralizing the adverse allelopathic effects of sorghum residues.

Introduction

Wheat (*Triticum aestivum* L.) is staple food crop and mainstay of Pakistan's economy. It is grown on an area of 7877.6 thousand hectares with a total production of 15684.2 thousand tonnes. Average wheat yield per hectare (1990 kg ha-1) is far below its existing potential (anonymous, 1991-92). One of the major factors limiting the yield is the presence of weeds in wheat.

Cultivation of high yielding wheat varieties, with higher irrigation and fertilizer requirements has encouraged weed population and growth. Losses in wheat yield due to weed infestation may range between 17-25 (Shad, 1987). Considering 17% as a base, monetary losses are estimated to be around Rs. 5.0 billion per annum (Cheema, 1988). Theses losses can be minimized by adopting the appropriate weed control measures.

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Conventional means of weed control i.e; cultural and chemical weed control practices, are getting expensive and the use of chemicals is also creating pollution hazards. It is wiser to consider some other practices which may suppress the growth of weeds, without having ill-effects. Weed control with the help of plant allelochemicals provides an alternative for weed management. Purvis *et. al.* (1985) stated that residues from mature harvested crops of sorghum, wheat, sunflower, oilseed rape and field pea exhibited selective effects on weed germination and growth under field conditions. They also reported that the extent of germination inhibition was dependent was dependent on residue type. The presence of allelochemicals in the crop residues and their effects on subsequent crop and weed growth are recognized (Putanan *et. al.* 1983 Cheema, 1988). There are indications that

A. T1 Control (No sorghum residue, no fertilizer)

B. <u>Sorghum roots soil incorporated plus</u>

T2 No fertilizer, weeds removed
T3 No fertilizer, weeds present
T4 Fertilizer @ 56 : 56 : 56 kg NPK ha-1 + weeds
T5 Fertilizer @ 84 : 56 : 56 kg NPK ha-1 + weeds
T6 Fertilizer @ 114 : 84 : 56 kg NPK ha-1 + weeds

C. <u>Whole sorghum soil incorporated plus</u>

T7 No fertilizer, weeds removed
T8 No fertilizer, weeds present
T9 Fertilizer @ 56 : 56 : 56 kg NPK ha-1 + weeds
T10 Fertilizer @ 84 : 56 : 56 kg NPK ha-1 + weeds
T11 Fertilizer @ 114 : 84 : 56 kg NPK ha-1 + weeds

Residues of already sown mature sorghum were incorporated in the field one week before sowing wheat. Sorghum plants were harvested from ground level at maturity. Harvested material was weighed and chopped with a fodder cutter and the incorporated into respective plots with a cultivator. Soon after incorporation of sorghum, wheat was sown in all the plots. all of P205. K20 and half of N was applied at sowing and remaining half of N was applied with first irrigation. Weeds were removed from two plots in each replication while in other plots weeds were allowed to grow.

Weed population from a randomly selected unit area (1 m2) was recorded. Weeds were removed at maximum growth from selected area for weed biomass both fresh and dry. Data on individual weeds was also recorded. Growth and yield parameters like germination, number of fertile tillers per unit area (1 m2), number of grains per spike, 1000-grain weight (g), grain yield (kg) and harvest index were recorded. The data were subjected to Fisher's analysis of variance technique and Duncan's New Multiple Range Test was used to test the differences among treatment means at 5 percent probability (Steel and Torrie, 1980).

Results and Discussion

Weed population of experimental site comprised *Melilotus parviflora* L. (Yellow sweet clover). *Medicago hispida* L. (Bur clover), *Rumex dentatus* L. (Duck), *Convolvulus arvensis* L. (Bind weed), *Chenopodium album* L. (Lambs quarter), *Anagallis arvensis* L.(Blue pimfernal), *Phalaris minor* Retz. (Canary grass and *Cyperus rotundus* L. (purple nutsedge).

Melilotus was the most prominent weed in the area and formed major component of weed population (Table-1). Incorporation of sorghum residue showed selective allelopathic effects on different weed species. Generally sorghum treatments promoted Melitotus and Medicago density (Table-1) while the density of other weeds reduced. Weed population was higher where sorghum roots or whole sorghum was added without fertilizer application. Total weed population decreased with increasing rate of fertilizer.

Population of Melilotus and Medicago increased with sorghum roots or whole sorghum incorporation. It appears that with incorporation of sorghum residues the growth of Melilotus was stimulated. Cheema (1988) while working with sorghum residues reported similar findings. The data further shows, that with increasing rate of fertilizer, the population decreased, probably promoting effects of allelochemicals were nullified with the addition of fertilizer.

Generally population of other weeds was lower. Weedy check had more weeds, but where sorghum roots or whole sorghum was added without fertilizer lesser number of weeds was noted particularly, the population of *Cyperus* and *Anagallis* spp was the lowest. This observation is supported by the work of Cheema (1988) and Kalair (1989). It was noted that as the fertilizer rates increased, the inhibitory effects of sorghum allelochemicals decreased and weed population was promoted. This finds support from the work of Kalair (1988).

Incorporation of sorghum roots or whole sorghum significantly affected the total and individual weed biomass (Table-2). The effect of sorghum treatments on fresh and dry weight of weeds with and without fertilizer was different. Generally total fresh and dry weed biomass was less in weedy check than sorghum treatments. This was probably due to relatively more share of Melilotus and Medicago.

Fertilizer application again changed the response pattern of weeds to sorghum residues (Table-2). Total fresh and dry matter accumulation in *sorghum*-root treatments was considerably reduced with increasing rates of fertilizer but on the other hand with whole sorghum, the total weed fresh and dry biomass remained more than control with increasing rate of fertilizer. Fresh and dry weight of *Melilotus*, *Medicago*, *Convolvulus* and *Cyprus* decreased with increasing rates of fertilizer while fresh and dry weight of Rumex, *Coronopus*, *Chenopodium*, *Anagallis* and *Phalaris* increased in all the treatments with increasing rates of fertilizer. It may be suggested that sorghum roots incorporation with higher fertilizer rates was more effective because sorghum roots contain certain water soluble allelochemicals which generally inhibit weed density and weed biomass of most species except *Melilotus* and *Medicago*. This confirms the finding of Cheema (1988) and Kalair (1989). It appears that the response of weed to sorghum residues varies from species to species and changes with change in fertility status of soil. Changing behavior of weeds under different fertility conditions (with and without fertilizer) may help in development of better weed management strategies. Purvus *et al.* (1985) also reported similar findings. Incorporation of sorghum roots generally suppressed wheat germination (Table-3). Incorporation of sorghum roots, probably with smaller amounts of allelochemicals resulted in stimulation of germination, while suppression of germination in whole sorghum treatment could be attributed to relatively higher amounts of allelochemicals released into the soil. The results are in line with the work of Guenzi and MeCalla (1962) where sorghum roots or whole sorghum was incorporated without fertilizer application and weeds were allowed to grow, germination of wheat decreased considerably.

Incorporation of sorghum roots with addition of higher fertilizer rate was the most effective treatment (Table-3) because sorghum roots contain allelochemicals in lower quantities and fertilizer application neutralized the adverse allelopathic effects of sorghum on wheat. This confirms the finding of Kalair (1989).

Maximum reduction in plant height occurred where whole sorghum was incorporated. The reduction in height was comparatively less where sorghum roots were incorporated. Where sorghum roots and whole sorghum was incorporated without fertilizer application and weeds were allowed to grow, the height of wheat decreased considerably.

Sorghum roots incorporation with addition of higher fertilizer rate was the most effective treatment to minimize the allelochemical effects of sorghum residues on wheat. This confirms the findings of Kalair (1989).

Maximum reduction in fertile tillers occurred where whole sorghum was incorporated followed by treatments where sorghum roots were incorporated. Where sorghum roots and whole sorghum was incorporated without fertilizer application and weeds were allowed to grow, the fertile tillers decreased considerably. This suppressive effect on number of fertile tillers was possibly due to release od allelopathics from sorghum. This confirms the findings of Guenzi and MeCalla (1962).

Application of fertilizer with increasing rates resulted in a significant increase in the number of fertile tillers per unit area in sorghum roots treatments but in case of whole sorghum treatments, fertile tillers were less than control even with the maximum fertilizer application (Table-3). It appears that sorghum roots incorporation with addition of higher fertilizer rate minimized the allelochemic effects of sorghum roots. This is supported by the work of Kalair (1989). Suppressive effects of sorghum allelochemicals on tiller formation were overcome with addition of fertilizer. Similar results were reported by Stowe and OSborn (1980).

The decrease in grain weight due to incorporation of sorghum was more pronounced where sorghum residue was added without fertilizer application and whether the weeds were eradicated or not. Grain weight increased with the increase in level of fertilizer. The form of residue (roots or whole sorghum) did not make much difference towards grain weight. Ameliorative effects of fertilizer application on suppressive influence of sorghum allelochemicals on wheat grain weight was also reported by Kalair (1989).

Wheat yield was considerably reduced with the incorporation of sorghum residues without addition of fertilizer. The grain in yield was much mire conspicuous where weeds were allowed to grow and the drop in yield was to the extent of 58.3 to 82.0% in treatments where sorghum roots or whole sorghum was incorporated without the control of weeds (Table-3).

With the application of fertilizer at lower rate, the level of yield was comparable to weed free and without fertilizer application plots. As the rate of fertilizer application increased, the yield increased by 23.4 and 17.7% in sorghum root and whole sorghum incorporation, respectively. It may be concluded although incorporation of both root and whole plant residues decreased the general population of weeds but *Melilotus* density, fresh and dry weight was increased. Whole plant residue was more suppressive to weeds and wheat compared with roots. The addition of fertilizer particularly at higher rates mitigated the adverse effects of sorghum allelochemicals. This confirms the findings of Cheema (1988) and Kalair (1989).

Wheat straw yield without fertilizer was similar to grain yield with sorghum residues. A significant decrease in straw yield (Table-3) was observed in the sorghum treatment without fertilizer even weeds were removed. When sorghum roots and whole sorghum was incorporated without fertilizer application and weeds were allowed in straw yield decreased considerably. Maximum reduction in straw yield occurred where whole sorghum was incorporated without fertilizer.

Wheat straw yield statistically increased in all the sorghum treatments with the increasing rates of fertilizer. Maximum straw yield was obtained where higher rate of fertilizer was applied with sorghum roots incorporation. The addition of fertilizer particularly at higher rates mitigated the adverse effects of sorghum allelochemicals. This in line with the finding of Kalair (1989).

Table-1. Effect of sorghum residues on weed density (m^{-2}) under varying levels of soil fertility

	Treatments	A. arvensis	C. album	C. arvensis	C. didymus	M. hispida	M. parviflora	R. dentatus	P. minor	C. rotudus	Others	Total weeds
A.	1 Control (No sorghum residue no fertilizer)	5.25	7.25	3.00	0.00	6.25	417.00	13.50	5.50	6.75	41.00	505.50
B.	*Sorghum roots soil incorporated plus*											
	2 No fertilizer weeds removed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3 No fertilizer weeds present	0.50	5.25	1.00	2.25	18.75	510.00	8.50	5.25	1.00	26.75	579.25
	4 Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	0.75	6.50	1.25	3.25	11.50	256.75	9.75	6.50	4.25	31.00	331.50
	5 Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	1.00	7.75	1.75	3.25	6.00	98.50	11.00	7.75	7.00	34.00	178.00
	6 Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	1.50	8.75	2.25	4.25	2.25	18.00	12.75	9.25	11.75	37.75	108.50
C.	*Whole sorghum soil incorporated plus*											
	7 No fertilizer weeds removed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8 No fertilizer weeds present	0.00	0.00	9.5	0.00	36.25	436.50	1.75	0.00	1.00	14.75	499.75
	9 Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	2.50	2.25	10.50	11.50	22.00	284.50	6.00	7.25	3.00	37.50	387.00
	10 Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	3.50	3.25	11.25	18.50	14.50	167.75	12.25	11.00	5.00	52.00	299.25
	11 Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	4.75	4.00	12.50	24.50	5.00	83.25	18.00	13.25	8.00	73.00	246.25

Table 2. Effect of sorghum residues on fresh and dry weight (g) of weed biomass under varying levels of soil fertility (dry weight in paran-thesis)

	Treatments	A. arvensis	C. album	C. arvensis	C. didymus	M. hispida	M. parviflora	R. dentatus	P. minor	C. rotudus	Others	Total weeds
A.	1. Control (No sorghum residue no fertilizer)	0.70 (0.18)	3.53 (1.00)	3.75 (0.63)	0.00 (0.00)	4.50 (1.45)	141.75 (31.00)	3.20 (0.60)	1.95 (0.68)	0.93 (0.23)	13.25 (3.00)	173.55 (38.75)
B.	*Sorghum roots soil incorporated plus*											
	2. No fertilizer weeds removed	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	3. No fertilizer weeds present	0.25 (0.28)	2.50 (0.25)	6.00 (1.20)	0.25 (0.28)	96.00 (19.15)	855.75 (168.00)	2.18 (0.68)	5.10 (1.92)	2.35 (0.48)	17.50 (4.00)	987.75 (195.75)
	4. Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	0.30 (0.09)	3.38 (0.47)	4.25 (0.99)	0.37 (0.09)	56.75 (9.50)	356.50 (74.00)	3.95 (0.75)	6.63 (2.40)	1.15 (0.27)	26.50 (4.75)	459.75 (93.00)
	5. Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	0.32 (0.09)	4.18 (0.73)	3.50 (0.85)	0.43 (0.09)	34.50 (5.75)	176.75 (21.50)	4.65 (0.85)	7.85 (3.10)	0.70 (0.19)	31.75 (5.50)	264.50 (38.25)
	6. Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	0.33 (0.10)	4.30 (0.95)	2.50 (0.72)	0.48 (0.10)	1.25 (0.38)	5.75 (1.50)	6.35 (0.95)	9.50 (3.70)	0.13 (0.05)	37.50 (6.00)	68.00 (14.25)
C.	*Whole sorghum soil incorporated plus*											
	7. No fertilizer weeds removed	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	8. No fertilizer weeds present	0.00 (0.00)	0.00 (0.00)	42.50 (10.13)	0.00 (0.00)	74.25 (14.50)	1180.00 (231.75)	0.00 (0.00)	0.00 (0.00)	0.63 (0.15)	42.25 (6.25)	1339.62 (262.77)
	9. Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	0.53 (0.13)	1.10 (0.24)	37.00 (8.40)	1.90 (0.41)	44.75 (7.50)	469.50 (96.50)	9.75 (0.95)	6.13 (1.97)	0.44 (0.12)	51.50 (8.75)	622.58 (124.90)
	10. Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	0.85 (0.21)	1.55 (0.34)	31.50 (17.10)	2.75 (0.53)	21.50 (4.75)	342.50 (48.00)	14.50 (1.43)	9.18 (3.10)	0.24 (0.09)	57.7 (10.50)	482.31 (76.03)
	11. Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	1.15 (0.28)	2.20 (0.48)	26.00 (5.80)	4.00 (0.73)	6.00 (1.23)	100.37 (7.50)	19.00 (2.10)	13.90 (4.05)	0.13 (0.05)	64.25 (12.00)	236.99 (34.00)

Table 3. Effect of Sorghum Residues on Yield And Yield Components of Wheat Under Varying Levels of Fertility

		Germination Count (m^{-2})	Plant height (cm)	No. of fertile Tillers (m^{-2})	1000 grain weight (g)	Grain yield $q.ha^{-1}$	Increase or decrease over control %	Harvest index
A.	1. Control (No sorghum residue no fertilizer)	332.50 cd	90.2 a	385.75 b	40.20 ab	35.0 b	(-)	59.7 c
B.	*Sorghum roots soil incorporated plus*							
	2. No fertilizer weeds removed	336.25 bc	71.4 ef	305.00 d	42.35 de	20.1 cd	-(42.6)	45.3 c
	3. No fertilizer weeds present	330.00 cd	67.9 fg	285.50 e	40.93 e	14.6 e	-(58.3)	37.26 g
	4. Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	338.25 bc	80.9 c	314.00 d	42.97 cde	22.9 c	-(34.6)	41.1 ef
	5. Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	344.50 ab	87.9 ab	344.75 c	44.88 bc	35.9 b	+(2.9)	52.3 d
	6. Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	352.75 a	90.0 a	450.25 a	47.18 a	45.2 a	+(23.4)	74.6 a
C.	*Whole sorghum soil incorporated plus*							
	7. No fertilizer weeds removed	318.75 e	63.5 gh	210.50 b	41.80 ef	17.45 de	-(50.00)	31.5 g
	8. No fertilizer weeds present	316.00 e	59.9 gh	176.00 g	39.53 f	6.25 f	-(82.0)	17.8 h
	9. Fertilizer @ 56:56:56 kg NPK ha^{-1} + weeds	318.75 de	75.5 de	222.75 f	42.25 de	22.5 de	-(35.7)	33.2 g
	10. Fertilizer @ 84:56:56 kg NPK ha^{-1} + weeds	323.75 de	79.6 cd	268.75 e	44.05 cd	32.0 b	-(8.6)	47.6 de
	11. Fertilizer @ 114:84:56 kg NPK ha^{-1} + weeds	229.25 cd	83.7 bc	243.00 c	46.53 ab	41.2 a	+(17.7)	67.2 b

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