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EFFECTS OF IRRIGATION AND HERBICIDES ON THE GROWTH, YIELD AND YIELD ATTRIBUTES OF WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

A field experiment was conducted during the winter (*rabi*) seasons of 2012-13 at Varanasi, Uttar Pradesh, to study the effect of irrigation and herbicides on the growth, yield and yield attributes of wheat under zero-tillage system. Results revealed that the highest density and dry weight of weeds and the maximum growth parameters, 1000-grain weight, protein yield, straw and grain yield and biological yield were recorded with the application of irrigation at 40 mm CPE over irrigation at 60 and 80 mm CPE. Among herbicidal treatments, application of sulfosulfuron (25 g/ha) resulted the lowest density and dry weight of weeds, the highest weed control efficiency and the lowest weed index thereby increased plant growth and yield attributes which produced the highest straw and grain yield, biological yield, protein content and protein yield over metribuzin and these were at par with metsulfuron methyl. None of the herbicidal treatments was found effective as weed free with respect to weeds, crop growth and yield.

Introduction

Wheat (*Triticum durum* L.) is the most important cereal among the food grain crops in the world. Wheat is the second most important cereal crop in India after rice (Pradhan *et al*. 2014), covering an area of 29 million ha with the production of 92.46 million ton during 2012-13. It is produced in wide range of climatic environments and geographic regions (Dixon *et al*. 2009). In north Indian plains wheat occupies large areas under rice-wheat cropping system. Studies in the past decade indicate that sustainability of rice-wheat system in the northern plains has been at risk mainly due to declining groundwater levels, soil organic matter content and nutrient availability, increased soil salinization, incidence of pests and diseases. However, water availability may become a major limiting factor for sustained productivity of wheat crop grown in the dry winter season and are dependent on supplemental irrigation either by canal or underground water (Kumar *et al*. 2010). Among several constraints of wheat production, one of the main problems that agricultural production faces is weeds that interfere with crop growth and production. These weeds compete with plant species for water, light, nutrients and space (Najwa *et al*. 2012) and causing yield losses to the extent of 50% (Azad 2003). Weeds growing in association with irrigated and heavy fertilized crop decline its yield besides lowering down the quality of produce by way of weed seed contamination. The crop is infested with heavy population of common broad-leaf weeds and annual grassy weeds like *Phalaris minor*, *Avena fatua*, *Avena leudoviciana*, *Poa annua* etc. of which *Phalaris minor* is considered most damaging (Inderjit and Kaushik 2009). Thus the heavy infestation with complex weed flora in wheat has become a serious problem in increasing the productivity. It has been proved that continuous use of single herbicide has developed the resistance and problem in increasing the productivity. Continuous use of herbicides like isoproturon not only resulted into herbicidal resistant in *Phalaris minor* but also created weed shifts. Secondly, 2,4-D has been found very effective for the control of broad-leaved weeds in

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wheat but its defective use led to ear deformation (Tiwari *et al*. 2005). Recently, new compounds like sulfosulfuron, metsulfuron-methyl, fenoxaprop, clodinafop and metribuzin have been reported to be very effective against associated weed species in wheat crop. This was routes testing of new molecules and their mixtures to develop an alternative of existing recommendation for weed control in wheat crop (Verma *et al*. 2008). Both poor irrigation schedule (Maurya and Singh 2008) and improper weed management (Azad 2003) are the major causes of yield reduction in wheat. The judicious application of water need immediate attention and this is possible only by application of water to the crop with efficient water practices. The number of approaches has been investigated for scheduling irrigation in wheat; however, irrigation based on climatological approach has been most widely accepted. Therefore, research efforts are urgently needed to develop and promote new technologies to enhance the herbicide efficiency and productivity of water and its judicious use. Keeping the above facts in view, a field experiment was conducted to assess the effect of irrigation and herbicides on the growth, yield and yield attributes of wheat under conventional tillage system.

Materials and Methods

A field study was conducted during the winter seasons of 2012-13 at Agronomy Farm, BHU, Varanasi (23^o.20' N, 83^o .03' E and 128.93 m above mean sea-level). The experimental soil was sandy clay loam with pH 7.8. The soil was low in available nitrogen (240.45 kg/ha), medium in available phosphorus (25.0 kg/ha) and high in available potassium (225 kg/ha). The experiment was conducted in split plot design having 15 treatments with 3 replications. Irrigation in main plot treatments comprised *viz.* 40, 60 and 80 mm CPE and weed management practices in sub-plots comprised 5 treatments, *viz.* weedy check, weed free [Hand weeding (HW) at 20 and 40 DAS], sulfosulfuron (25 g/ha), metsulfuron-methyl (4 g/ha) and metribuzin (210 g/ha). The wheat variety 'HUW 234' was sown with the help of ferti-seed drill at 22 cm row spacing using 100 kg seed/ha on 1st December, 2012 in 4.6 × 5.5m^2 gross plot size. All the herbicides were applied with the help of flat fan nozzle attached to the foot sprayer using volume of spray 500 litres/ha, at 30 days after sowing. Urea, diammonium phosphate and muriate of potash were used as sources of nitrogen, phosphorus and potassium, respectively. An uniform dose of 40: 60: 40, N:P: K kg/ha was applied uniformly at the time of sowing and remaining 80 kg N was top-dressed in two equal splits, each after first irrigation and flowering time. As per the treatment, 6 cm water was applied per irrigation by fixing Parshal flume in irrigation channel. Density, dry weight and weed control efficiency of weeds were observed at 40 days after sowing of crop. Weed control efficiency (WCE) was calculated as follows:

WCE (%) = Weed population in control plot – weed population in treated plot/ weed population in control plot × 100. Data on weed density was recorded from an area enclosed in the quadrate of 0.25/m^2 randomly selected at three places in each plot. Weed counted from each sample and their density was recorded as average number/m^2. Oven dry weight of weeds was recorded at 70^0C for 48 hrs and expressed as dry matter production/m^2. Data on growth parameters were recorded at 80 DAS and yield contributing characters, straw, grain and biological yield, protein content and protein yield at harvest were studied. N content in straw and grain was determined by modified Micro Kjeldahl method (Jackson 1973) and P content was determined by Vandomolybdo-phosphoric acid yellow color method using the Barton's reagent as suggested by Jackson (1973). The K content was estimated with the help of Flame-photometer (Jackson 1973). Protein content in wheat grain was determined by multiplying the N content of respective samples with the factor 6.25. The crop was harvested on 8th April, 2013. Data collected on various parameters were analyzed statistically for valid conclusion.

Results and Discussion

Weather condition was fairly good for growth and development of wheat crop during investigation (Table 1). During crop season total rainfall (86.80 mm) occurred during February to April. In general, there was a gradual drop in temperature from December to January which favoured the growth and development of crop. Maximum and minimum temperature were also favourable for the growth and development of crop. The relative humidity although optimum in the beginning showed an increase as the crop advanced in age from December to March. There was gradual drop in relative humidity from March to April due to rise in maximum temperature. Period of bright sunshine hours during investigation was normal with slight fluctuation due to cloudy weather or rainfall occurrence.

Table 1. Weather parameters on monthly basis during crop season.

Weather parameter	December	January	February	March	April
Rainfall (mm)	0.0	0.0	66.8	9.6	10.4
Evaporation (mm)	49.5	46.6	56.9	128.3	176.6
Max. temp (^oC)	27.7	30.6	28.2	35.0	42.0
Min. temp (^oC)	4.2	2.0	7.4	12.0	17.0
Mean RH (max)	85.0	87.1	86.3	70.4	56.1
Mean RH (min)	47.6	46.4	53.7	35.8	29.7
Mean sunshine (hrs)	5.5	5.82	6.33	9.1	9.07

Source: Meteorological observatory of All India Co-ordinated Research Project for Dryland Agriculture, situated at Research farm of BHU, Varanasi, UP, India.

The field was infested with grassy weeds which constituted 64.6% comprising *Phalaris minor* L.(20.3%), *Avena leudoviciana* (3.8%), *Cynodon dactylon* (25.3%), and *Cyperus rotundus* (15.2%). Whereas, broad leaved weeds *Chenopodium albu*m (8.9%), *Melilotus indica* (5.1%), *Vicia sativa* (3.8%), *Anagallis arvensis* (5.1%), *Fumaria parviflora* (2.5%), *Euphorbia hirta* (3.8%) and *Solanum nigrum* (6.3%) accounted for 26.74% of total weed species at 40 DAS (Table 2). Results are corroborated with research findings of Verma *et al*. (2008).

The density and dry weight of weeds were recorded under irrigation and weed management practices were significantly reduced as compare to weedy check (Table 3). Significantly the highest density and dry weight of weed were recorded with application of irrigation at 40 mm CPE as compared to irrigation at 60 and 80 mm CPE. The increase in density and dry weight of weed at higher rate of irrigation resulted from the greater availability of moisture.

Among herbicidal treatments, application of sulfosulfuron caused significant reduction in density and dry weight of weeds than metribuzin and it was at par with metsulfuron-methyl. These results are found consistent with findings of Singh *et al.* (2013). However, two hand weedings (HW) at 20 and 40 DAS (weed free) was found more effective than the herbicides, due to slow pace of growth of first flush of weeds, 20 days after sowing thereafter the emergence of new flushes of weeds could not attain full growth under the shade of crop plants. These results are in close conformity with those of Faisal *et al.* (2012). Sulfosulfuron obtained the highest weed control efficiency (65%) followed by the WCE with metsulfuron-methyl and metribuzin, respectively. The maximum weed index (17.9%) was obtained with metribuzin followed by metsulfuron-methyl and sulfosulfuron, respectively. The highest weed control efficiency and the lowest weed index of sulfosulfuron indicate its relative performance of particular set of treatment (Pandey *et al*. 2006).

Table 2. Relative composition of narrow and broad leaves weeds in weedy check at 40 DAS.

Weed type	Scientific name	Weeds/m^2	Composition (%)
Narrow leaves	*Phalaris minor* Retz.	16	20.3
	Avena leudoviciana L.	3	3.8
	Cynodon dactylon Pers	20	25.3
	Cyprus rotundus L.	12	15.2
	Sub-total	51	64.6
Broad leaves	*Chenopodium album* L.	7	8.9
	Melitotus indica Dresr	4	5.1
	Vicia sativa L.	3	3.8
	Anagallis arvensis L.	4	5.1
	Fumaria parviflora L.	2	2.5
	Euphorbia hirta L.	3	3.8
	Solanum nigrum L.	5	6.3
	Sub-total	28	35.4
	Total	79	100

Irrigation at 40 mm CPE significantly increased the average plant height, number of green leaves, number of tillers and crop dry weight. Significant increase in growth attributes was obtained with higher irrigation frequencies as Jat *et al.* (2008). An application of sulfosulfuron resulted the maximum average plant height, number of green leaves, number of tillers and dry weight of crop followed by metsulfuron-methyl and metribuzin, respectively. The reason for higher values on growth parameter can be discussed in the light of fact that crop under this treatment had comparatively less weed competition. The reduction in weed competition in wheat by the use of herbicides or hand weeding not only favoured the crop growth with abundant availability of moisture, nutrients, light and space, but also reduced over all weed interference, facilitating vigorous growth and development of crop plants.

Yield contributing characters and yield were significantly influenced by the irrigation regimes and weed management practices (Tables 3 and 4). Among the irrigation regimes, irrigation at 40 mm CPE recorded the highest number of effective tillers/running meter, number of grains/ear head, 1000-grain weight, protein content, protein yield, grain yield, straw yield and biological yield as compared to irrigation at 60 and 80 mm CPE, respectively. The better development of crop under irrigated treatments was a result of yield attributes, protein content and yield, better moisture availability, which maintained the internal water balance of the plant. Increase in crop yield is due to the better crop growth agrees with the increase in the yield attributes of wheat reported by Rahim *et al.* (2010) due to irrigation.

Among herbicidal treatments, application of sulfosulfuron recorded significantly the highest yield attributes, grain and straw yield, protein content and yield of wheat over metribuzin and these were statistically at par with metsulfuron-methyl. Higher yield attributes under these treatments may be due to lesser crop-weed competition, which gave better environment for crop growth and development of crop. Because in these treatments weed population and their growth was abstracted due to broad spectrum activity of mentioned herbicide. The minimum straw and

Table 3. Effect of irrigation regimes and weed management practices on weeds, crop growth, yield attributes, protein content and yield of wheat.

Treatment	Weed density (m^2) at 40 ADS	Weed dry wt. (g/m^2) at 40 ADS	Weed control efficiency (%)	Weed index	Av. plant height at 80 DAS (cm)	No. of tillers/ running meter at 80 DAS	No. of green leaf/ running meter at 80 DAS	Crop dry weight/ running meter at 80 DAS (g)	No. of effective tillers/ running meters at harvest	No. of grains/ ear head	1000-grain weight (g)	Protein content (%)	Protein yield (kg/ha)
Irrigation													
40 mm CPE	34.2	6.1	-		90.2	114.0	271.2	183.3	112.3	44.6	43.8	12.00	609
60 "	32.6	5.6	-		89.5	111.7	263.3	172.8	110.1	43.9	42.7	12.03	498
80 "	32.0	5.5	-		88.9	110.3	261.4	160.1	107.6	43.8	42.0	12.27	451
SEm±	0.37	0.06			0.23	0.70	1.95	2.64	0.77	0.15	0.27	0.05	13.1
CD (p = 0.05)	1.07	0.19			0.92	2.75	7.65	10.4	3.02	0.58	1.04	0.14	51.4
Weed management practices													
Weedy check	78.3	11.3	0.0	37.0	83.1	97.5	245.0	150.9	96.1	40.0	36.9	11.67	339
Weed free (HW at 20 and 40 DAS)	0.0	0.0	100.0	0.0	93.0	120.3	276.5	187.3	118.5	46.0	45.4	12.46	536
Sulfosulfuron 25 g/ha (post-em)	27.4	5.5	65.0	5.0	91.4	115.5	270.9	180.5	113.7	45.7	44.5	12.43	491
Metribuzin 210 g/ha (post-em)	30.0	6.1	61.7	17.9	88.6	111.8	263.1	163.7	109.2	43.3	42.9	12.37	402
Metsulfuron-methyl 6 g/ha (post-em)	29.0	5.7	63.0	9.5	91.5	115.0	270.8	177.9	112.5	45.5	44.3	12.41	484
SEm±	0.03	0.04	-	-	0.21	0.36	1.37	0.33	0.72	0.14	0.25	0.03	6.4
CD (p = 0.05)	0.13	0.17	-	-	0.63	1.06	4.01	0.97	2.09	0.40	0.72	0.09	18.7

grain yield was recorded in weedy check because of more weed growth and poor performance of yield attributing characters. Similar results were in conformity with the findings of Pandey *et al*. (2006). Relative weed free situation under herbicidal treatments reduced the crop weed competition and thus lead to higher vegetative growth and yield attributes significantly affected the grain and straw yield wheat (Verma *et al*. 2008).

Table 4. Interaction effect of irrigation regimes and weed management practices on straw, grain and biological yield of wheat.

Treatment herbicides	Irrigation			Mean
	40 mm CPE	60 mm CPE	80 mm CPE	
		Straw yield (t/ha)		
Weedy check	5.55	4.70	4.50	4.91
Weed free	9.83	8.04	7.14	8.34
Sulfosulfuron 25 g/ha	9.58	7.47	6.50	7.85
Metribuzin 210 g/ha	8.25	6.52	5.25	6.67
Metsulfuron-methyl 6 g/ha	8.80	7.05	6.35	7.40
Mean	8.40	6.76	5.95	
SEm±		0.15		
CD (p = 0.05)		0.44		
		Grain yield (t/ha)		
Weedy check	3.50	3.00	2.90	3.13
Weed free	5.80	4.80	4.30	4.97
Sulfosulfuron 25 g/ha	5.70	4.50	3.95	4.72
Metribuzin 210 g/ha	5.00	4.00	3.25	4.08
Metsulfuron-methyl 6 g/ha	5.30	4.30	3.90	4.50
Mean	5.06	4.12	3.66	
SEm±		0.16		
CD (p = 0.05)		0.46		
		Biological yield (t/ha)		
Weedy check	9.05	7.70	7.40	8.05
Weed free	15.63	12.84	11.44	13.30
Sulfosulfuron 25 g/ha	15.28	11.97	10.45	12.56
Metribuzin 210 g/ha	13.25	10.52	8.50	10.76
Metsulfuron-methyl 6 g/ha	14.10	11.35	10.21	11.89
Mean	13.46	10.88	9.60	
SEm±		0.27		
CD (p = 0.05)		0.79		

Interaction effect of irrigation regimes and weed management practices on straw yield, grain yield and biological yield was significant (Table 4). Irrigation at 40 mm CPE recorded significantly the highest straw yield (9.83 t/ha), grain yield (5.80 t/ha) and biological yield (15.63 t/ha) with weed free followed by the straw, grain and biological yield under 40 CPE with sulfosulfuron, metsulfuron-methyl and metribuzin, respectively. The lowest straw, grain and biological yield was with irrigation at 80 mm CPE along with the post-em application of metribuzin. It was concluded that under the presence of mix weed flora, the crop irrigated at 40

CPE along with an application of sulfosulfuron 25 g/ha (post-em) can be recommended for higher productivity of wheat.

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