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Herbicide and nitrogen application effects on weeds and yield of wheat

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ABSTRACT

A field experiments was conducted during winter seasons of 2010-12 at Banaras Hindu University, Varanasi to study the effect of herbicides, nitrogen rates and it's scheduling on associated weeds, crop growth and yield of wheat. Six weed species were common infesting wheat fields were *Phalaris minor, Cynodon dactylon,* C*henopodium album, Oxalis purpurea, Anagallis arvensis* and *Cyperus rotundus.* Among the herbicidal treatments, post-emergence application (30 DAS) of sulfosulfuron + metsulfuron [32 g/ha] with higher rates 160 kg N/ha and time of application (50% basal + 25% CRI + 25% flowering) performed significantly with respect to reduction in density and biomass of weeds; increased the LAI and SPAD value ultimately enhanced the production of grain yield of wheat. Scheduling of nitrogen (50% basal + 25% CRI + 25% flowering) enhanced the nitrogen uptake efficiency and total nutrient uptake by crop than other scheduling of nitrogen. However, application of herbicide mixtures as a post-emergence (30 DAS) with increased dose of nitrogen applied as 1/2 basal and topdressing 1/4 at CRI and 1/4 at flowering is most effective.

Key words: Herbicide mixture, LAI, N uptake efficiency, SPAD values

Wheat is the most important cereal crop which is badly infested with grassy as well as broad-leaf weeds. Since 1982 isoproturon is most widely used herbicide for management of *Phalaris minor* in wheat, particularly under rice-wheat cropping system (Walia *et al*. 2010). But, its efficacy has declined due to development of resistance in *P. minor* (Singh 2007). However, the sole dependence on herbicide of single mode of action is also not advisable as it has contributed to shift towards difficult to control weeds and rapid evolution of multiple herbicides resistance, which is a threat to wheat production (Singh 2007). Therefore, there is need to use mixture of herbicides in a way to lower the load on environment and improve weed control efficacy without any adverse effect on crop. Nitrogen (N) is the nutrient that most often limits crop production. Among major cereals, wheat requires 1 kg of N to produce 44 kg of wheat (Pathak *et al*. 2003). Generally, more than 50% of the N applied is not assimilated by plants (Dobermann and Cassman 2004). Furthermore, Kim *et al*. (2006) reported that there was often a significant interaction between herbicide and nitrogen, where increased nitrogen found to enhance the performance of herbicide as well as N-scheduling not only influences the crop growth but also influences weed density and biomass also. However, information in this regard is lacking. So, there is a greater need for new formulated herbicides with nitrogen rates and time of application to make out the effect of treatments on growth and yield of wheat.

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MATERIALS AND METHODS

Field study was carried out during winter (*Rabi*) seasons for two consecutive years of 2010-11 and 2011-12 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°18′ N, 83°03′ E and 128.93 m altitude). The soil of the experimental field was sandy clay loam in texture with slightly alkaline in reaction (pH 7.5) having low organic carbon (0.42%) and available nitrogen (195.3 kg/ha); and medium in available phosphorus (21.8 kg/ha) and potassium (232.2 kg/ha).

It was a factorial experiment conducted in a randomized complete block design and replicated thrice, having three factors. First factor comprised of three herbicides, *viz.* weedy check, sulfosulfuron + metsulfuron (32 g/ha) and carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha), whereas, second and third factors comprised of two nitrogen rates (120 kg N/ha and 160 kg N/ha) and three times of nitrogen application, *viz.* 50% basal + 50% CRI, 50% basal + 25% CRI + 25% flowering and 33.3% basal + 33.3% CRI + 33.3% flowering, respectively. Wheat variety *'PBW 343'* was sown on 26 November, 2010 and 30

November, 2011 with 100 kg seed/ha by keeping row to row spacing of 22.5 cm during both the years of investigations, respectively. Nitrogen applied as per treatment but full amount of P and K were applied at the time of sowing. Herbicides were dissolved in 600 liters water and applied at 30 days after sowing (DAS), using the knapsack sprayer fitted with flat-fan nozzle. Total weed density and biomass of weeds were recorded 60 DAS and at harvest using a quadrant of 0.5 x 0.5 m randomly selected at two places in each plot. Furthermore, all weeds from quadrant were cut at ground level, placed in a paper bag, and dried for 48 h in an oven at 60° C, and then were weighed to determine weed dry biomass. Leaf area index (LAI) is defined as the area of leaves per unit area of soil surface. LAI was quantified with the AccuPAR model LP-80 (Decagon Devices, Inc. instrument, which calculates LAI based on the above and below-canopy PAR measurements. Leaf chlorophyll content was estimated non-destructively by measuring leaf greenness using a portable SPAD (Soil Plant Analysis Development)-502 chlorophyll metre (Minolta Camera Co. Ltd., Japan). Grain yield recorded in kg/plot was finally converted into grain yield kg/ha. Nitrogen uptake efficiency (%) as the ratio of total plant N uptake to N supplies (Ortiz-Monasterio *et al.* 1997). Weed data (density and biomass) were subjected to square-root transformation $\sqrt{x + 0.5}$. Weed control efficiency (WCE) was computed on the basis of total weed density at harvest. All data were put to analysis of variance as described by Gomez and Gomez (1984). The mean assessment was accomplished by least significant difference (LSD) at 5% level of probability.

Nutrient uptake in grain and straw of the crops were calculated in kg/ha in relation to yield per ha by using the following formula:

$$\text{Uptake (kg/ha)} = \frac{\text{Nutrient (\%) in grain/straw x grain/straw yield (kg/ha)}}{100}$$

RESULTS AND DISCUSSION

Effect on density and biomass of weed

Experimental field was infested with weed flora of C*henopodium album*, *Oxalis purpurea* and *Anagallis arvensis,* among broad-leaf weeds whereas, *Phalaris minor* and *Cynodon dactylon* among grasses. Moreover, among sedges only one species *i.e. Cyperus rotundus* was observed. Herbicidal treatments significantly reduced the density and dry biomass of total weeds than weedy check. Pre-mix formulation of sulfosulfuron + metsulfuron (32 g/ha) proved the most effective herbicides against broad-leaf weeds and annual grasses, and recorded significantly lower density and dry biomass of these weeds than the tank-mixture of carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha), during both the year (Table 1). The highest weed-control efficiency was also recorded under pre-mix formulation (Total) of sulfosulfuron + metsulfuron (32 g/ha) than tank-mixture of carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha). The higher efficacy of sulfosulfuron + metsulfuron (32 g/ha) as compared to tank-mix of carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha can be attributed to its slow degradation in soil; it control weeds throughout crop growth period (Khokhar and Nepalia 2010). While, sulfosulfuron applied in wheat was found to persist even after 150 days after its application in wheat and its residues in the soil caused phytotoxicity to succeeding crop of sorghum (Brar *et al.* 2007). Carfentrazone-ethyl when tank mixed with fenoxaprop produced white speckling on the top wheat leaf, which disappeared within 10-12 days without any effect on yield attributes. The results are in line with the findings of (Singh *et al.* 2011).

Increased dose of nitrogen 160 kg/ha significantly reduced the density and biomass of weeds as compared to lower rates of nitrogen 120 kg/ha. It is worthwhile to mention that critical period of crop weed competition in wheat is between 30-50 DAS (Chaudhary *et al.* 2008). It means those nitrogen rates which provide competitive advantage to crop *vis-à-vis* suppressive effect on weeds up till 50 DAS would have positive influence on crop yield. In line with above-said facts, experimental findings also showed that during the critical period of crop-weed competition, application of higher rates of nitrogen (160 kg N/ha) shift the competitive advantage in favour of crop and also helps in smothering of weed. It appeared that vigorous crop stand and growth due to higher N levels asserted a strong smothering effect on growth and development of weeds (Patel *et al.* 2012).

Out of various N splits, nitrogen applied in three splits (50% basal + 25% CRI + 25% flowering) showed lower density and biomass of weeds, and higher weed control efficiency being at par with two splits (50% basal + 50% CRI) but significantly superior over three equal splits (33.3% basal + 33.3% CRI + 33.3% flowering). This might be due to improved crop growth as compared to other caused smothering effect on weed growth and development. These finding are in conformity to those of Yadav *et al.* (2005).

Table1. Effect of herbicides, rates and time of nitrogen application on total weed density and biomass

Treatment	Total weed density (number/m^2)*				Total weed biomass (g/m^2)*				WCE (%)
	60 DAS		At harvest		60 DAS		At harvest		
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	Mean
Herbicides									
Sulfosulfuron + metsulfuron (Total)	7.34c	9.03c	2.65c	4.18c	6.63c	7.02c	3.30c	3.58c	83.0
32 g/ha	(53.6)	(81.4)	(6.75)	(17.1)	(43.6)	(49.2)	(10.6)	(12.6)	
Carfentrazone 10 g/ha + fenoxaprop	8.25b	9.91b	3.50b	5.04b	7.44b	7.89b	4.30b	4.61b	72.4
100 g/ha	(67.8)	(98.1)	(11.9)	(25.0)	(55.17)	(62.2)	(18.2)	(21.1)	
Weedy check control	10.3a	12.8a	6.25a	10.2a	9.54a	10.4a	7.66a	8.53a	-
	(106.4)	(165.8)	(38.9)	(103.1)	(90.87)	(107.7)	(58.5)	(72.7)	
LSD(P=0.05)	0.33	0.30	0.18	0.14	0.30	0.34	0.21	0.24	
Nitrogen rates									
120 kg/ha	9.08a	11.0a	4.54a	6.77a	8.26a	8.83a	5.49a	6.01a	45.6
	(83.7)	(123.2)	(22.6)	(52.18)	(69.3)	(79.5)	(33.2)	(40.2)	
160 kg/ha	8.18b	10.2b	3.73b	6.15b	7.48b	8.04b	4.69b	5.13b	58.0
	(68.2)	(107.0)	(15.8)	(44.68)	(57.11)	(66.6)	(25.04)	(30.7)	
LSD (P=0.05)	0.27	0.25	0.15	0.11	0.25	0.28	0.17	0.20	
Time of nitrogen application									
50% basal + 50 % crown root	8.67ab	10.6 ab	4.09b	6.41b	7.85ab	8.43ab	5.05b	5.48b	52.6
initiation	(76.6)	(115.7)	(18.8)	(47.6)	(62.9)	(72.9)	(28.7)	(34.3)	
50% basal + 25 % crown root	8.40 bc	10.4 bc	3.92 bc	6.26c	7.63bc	8.18bc	4.86bc	5.31bc	55.2
initiation + 25% flowering	(71.9)	(111.0)	(17.4)	(46.1)	(59.6)	(68.8)	(26.90)	(32.6)	
33.3% basal + 33.3% crown root	8.83 a	10.7 a	4.39a	6.72a	8.12a	8.70a	5.36a	5.94a	47.6
initiation + 33.3% flowering	(79.3)	(118.5)	(21.3)	(51.5)	(67.12)	(77.3)	(31.8)	(39.4)	
LSD (P=0.05)	0.33	0.30	0.18	0.14	0.30	0.34	0.21	0.24	

*Data subjected to square root ($\sqrt{x+0.5}$) transformation and original data presented in parenthesis, NS- Not NS- not significant, Number followed by same letter are not statistically different at 5% level of significance.

Effect on crop

The highest leaf area index (LAI) and SPAD value was found in the pre-mix application of sulfosulfuron + metsulfuron (32 g/ha) *fb* by tank mix application of carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha) as compared to weedy check during both the year.

Increasing nitrogen rates gradually increased the LAI and SPAD having the significantly highest values at 160 kg N/ha during both the years. However, application of nitrogen as 50% basal + 25% CRI + 25% flowering brought the significantly higher LAI and SPAD followed 50% basal + 50% CRI being at par with 33.3% basal + 33.3% CRI + 33.3% flowering during both the years (Table 2). The increased in leaf area index with higher nitrogen levels might be due to more leaf area on account of more accumulation of assimilates. Ullah *et al.* (2013) reported enhanced leaf area index by applying higher level of nitrogen.

Pre-mixed application of sulfosulfuron + metsulfuron (32 g/ha) had brought about significant increment 37.7 and 39.2% in grain yield over weedy check during first and second years respectively. Tank mix application of carfentrazone (10 g/ha) + fenoxaprop-p-ethyl (100 g/ha) produced 29.1 and 30.6% higher grain yield over weedy check during first and second year, respectively. This was perhaps due to reduced crop weed competition as the effectively suppressed predominant weeds (both on density and biomass) throughout crop growth period.

Enhanced nitrogen application from 120 to 160 kg/ha resulted in significant increase in grain yield during both the years (Table 2). Application of 160 kg N/ha produced significantly 12.8 and 12.8% higher grain yield over 120 kg N/ha during first and second years, respectively. These results were in conformity with the findings of Bhat *et al.* (2006). However, split application of nitrogen also found significantly increased the grain yield of wheat. Three split application of nitrogen 50% basal + 25% CRI + 25% flowering recorded more yield followed by two split application of nitrogen 50% basal + 50% CRI and three equal splits 33.3% basal + 33.3% CRI + 33.3% flowering. Whereas, three split application of nitrogen 50% basal + 25% CRI + 25% flowering were recorded 13.4 and 16.4 percent higher grain yield over 50% basal + 50% CRI during first and second years, respectively.

Table 2. Effect of herbicides, rates and time of nitrogen application on LAI, SPAD value, grain yield and nitrogen uptake efficiency

Treatment	LAI[a]		SPAD value[a]		Grain yield (t/ha)		N uptake efficiency (%)	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
Herbicides								
Sulfosulfuron + metsulfuron (Total) (32 g/ha)	3.86a	4.16a	43.3a	44.6a	4.76a	4.85a	83.8a	87.8a
Carfentrazone (10 g/ha) + fenoxaprop (100 g/ha)	3.61b	3.82b	41.6b	42.8b	4.46b	4.55b	75.5b	79.2b
Weedy check control	3.45c	3.53c	40.0c	40.7c	3.46c	3.49c	56.8c	59.0c
LSD (P=0.05)	0.13	0.14	1.50	1.54	0.14	0.14	7.60	7.91
Nitrogen rates								
120 kg/ha	3.39b	3.60b	40.2b	41.6b	3.97b	4.04b	78.1a	81.5a
160 kg/ha	3.90a	4.07a	43.1a	43.9a	4.48a	4.56a	66.0b	69.2b
LSD (P=0.05)	0.10	0.11	1.23	1.26	0.12	0.11	6.21	6.46
Time of nitrogen application								
50% Basal + 50% crown root initiation	3.59b	3.81b	41.2b	42.9b	4.27b	4.34b	74.1b	77.4b
50% Basal + 25% crown root initiation + 25% flowering	3.81a	3.99a	42.8a	43.7a	4.42a	4.50a	83.1a	86.6a
33.3% Basal + 33.3% crown root initiation + 33.3% flowering	3.52bc	3.72bc	40.8bc	41.6bc	3.99c	4.05c	59.0c	62.1c
LSD (P=0.05)	0.13	0.14	1.50	1.54	0.14	0.14	7.60	7.91

observation recorded at 90 DAS; LAI= Leaf area index

Interaction effect

Significant interaction effect of herbicides and nitrogen rate was observed on wheat productivity during both the years (Table 3). Pre-mix application of sulfosulfuron + metsulfuron with higher level of nitrogen 160 kg/ha produced significantly highest grain yield (5045.52 and 5142.97 kg/ha) and as compared to tank-mix of carfentrazone + fenoxaprop-p-ethyl during both the year, respectively. Also nitrogen rate and time of nitrogen application was observed significantly on grain yield during both the year. Application of nitrogen at 160 kg/ha applied as three split (50% basal + 25% CRI + 25% flowering) recorded significantly highest wheat productivity compared to all other combinations except at the same nitrogen level applied as (50% basal + 50% CRI) during both the year.

Effect on nutrient

The difference in the total uptake of N, P and K by the crop under herbicidal treatments was also a function of the total plant biomass production by any particular treatments. Herbicides application brought about significant reduction in N, P and K uptake by weeds and enhanced nutrient uptake by crop. Amongst herbicides, pre-mix application of sulfosulfuron + metsulfuron increased the availability of nutrients by reducing crop weed competition and resulted into more dry matter accumulation in the crop, which ultimately reflected in more nutrient uptake and nitrogen uptake efficiency as compared to weedy check. The results were in close conformity with the finding of and Chopra *et al.* (2008).

The total uptake of N, P and K in wheat grain and straw was increased significantly with an increased nitrogen rates (160 kg/ha) while, significant decline in nitrogen uptake efficiency. The low uptake of these nutrients under lower level of nitrogen may be attributed to less plant biomass (grain and straw). Sinebo *et al.* (2004) also reported that N uptake efficiency was higher at lower rates of N application but drastically decreased with further increases in the rate of the nutrient. Whereas, application of N in three splits *i.e.* 50% basal + 25% CRI + 25% flowering coinciding with crop requirements might have reduced rapid mineralization and losses through different pathways and their by increased nutrient contents in wheat grain and straw. As a result, higher total uptake of N, P and K with an increased plant biomass (grain and straw).

Scheduling of nitrogen indicated that higher N uptake efficiency by the crop when nitrogen was applied in three splits 50% basal + 25% CRI + 25% flowering regardless of the amount of the dose at each time. Thus, compared to the two split N applications at 50% basal + 50% CRI, the three split applications resulted in significantly higher uptake efficiencies. Corroborating these results, Tran and Tremblay (2000) also indicated lower N uptake

Table 3. Effect of herbicides, rates and time of nitrogen application on total nutrient uptake by crop (grain + straw) of wheat

Treatment	Total nutrient uptake by crop (kg/ha)					
	N		P		K	
	I Year	II Year	I Year	II Year	I Year	II Year
Herbicides						
Sulfosulfuron + metsulfuron (Total) (32 g/ha)	115.9a	121.5a	21.3a	22.7a	107.7a	120.3a
Carfentrazone (10 g/ha) + fenoxaprop (100 g/ha)	104.7b	109.9b	19.4b	20.6b	94.9ab	106.8ab
Weedy check control	78.4c	81.5c	14.5c	15.4c	71.0c	78.5c
LSD (P = 0.05)	10.07	10.37	1.53	1.58	14.8	16.2
Nitrogen rates						
120 kg/ha	93.7b	97.8b	17.3b	18.37b	86.46	95.4
160 kg/ha	105.6a	110.7a	19.5a	20.83a	96.10	108.2
LSD (P = 0.05)	8.22	8.47	1.25	1.29	NS	NS
Time of nitrogen application						
50% basal + 50% crown root initiation	102.3b	106.9b	18.8b	20.0b	94.8b	105.6b
50% basal + 25% crown root initiation+ 25% flowering	114.7a	119.6a	20.8a	22.0a	111.2a	123.2a
33.3% basal + 33.3% crown root initiation+ 33.3% flowering	82.1c	86.4c	15.6c	16.7c	67.8c	76.7c
LSD (P=0.05)	10.07	10.4	1.53	1.58	14.8	16.2

Table 4. Interaction effects of herbicides, nitrogen rate and time of nitrogen application on grain yield of wheat

Treatment	Grain yield (t/ha)											
	I year			II year			I year			II year		
	H_1	H_2	H_3	H_1	H_2	H_3	T_1	T_2	T_3	T_1	T_2	T_3
120 kg/ha	3.31	4.48	4.12	3.34	4.57	4.21	4.07	4.23	3.61	4.14	4.30	3.67
160 kg/ha	3.60	5.04	4.81	3.63	5.14	4.90	4.47	4.61	4.37	4.54	4.69	4.44
LSD (P = 0.05)		0.21			0.20			0.25			0.25	

efficiency in the early applications of N fertilizer at planting and tillering compared to applications in the later stage of crop growth.

It was concluded that pre-mix application of sulfosulfuron + metsulfuron (32 g/ha) along with 160 kg N/ha applied at 50 % basal + 25 % CRI + 25 % flowering showed best treatment for control of weeds in wheat.

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