Research Article

Nutrient Uptake, Quality and Yield of Wheat as Influenced by Different Herbicides

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Abstract

A field experiment was conducted to study the nutrient uptake, quality and yield of wheat as influenced by different herbicides on clay loam soil at Instructional Farm of Rajasthan College of Agriculture, Udaipur during the *rabi* season of 2016-17. The experiment was laid out in randomize block design has replicated thrice. The experiment consisted of eleven treatments viz. halauxifen methyl ester + florasulam + polyglycol at 12.76 g ha^{-1} (T_1), metsulfuron + surfactant at 4 g ha^{-1} (T_2), carfentrazone at 20 g ha^{-1} (T_3), 2, 4-D Na Salt at 500 g ha^{-1} (T_4), 2, 4-D Ester at 500 g ha^{-1} (T_5), metsulfuron + carfentrazone + surfactant at 4 g + 20 g ha^{-1} (T_6), 2, 4-D Na + carfentrazone at 400 g + 20 g ha^{-1} (T_7), 2, 4-D E + carfentrazone at 400 g+ 20 g ha^{-1} (T_8), halauxifen + florasulam + carfentrazone + surfactant at 10.21 g + 20 g ha^{-1} (T_9), weedy check (T_{10}) and weedy free (T_{11}). Among the herbicidal treatments, application of halauxifen + florasulam + polyglycol at 12.76 g ha^{-1} recorded significantly maximum N, P and K uptake, protein content and yield over rest of the weed control treatments.

Keywords: Herbicides, Nutrient, Wheat, Yield

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Introduction

Wheat stands second to rice under food grain with a production of 99.70 million tonnes from an area of 29.576 million ha with a productivity of 3.37 tonnes ha^{-1} during 2016-17 [1]. The five major wheat growing states of Uttar Pradesh, Punjab, Madhya Pradesh, Haryana and Rajasthan contributed nearly 86.0 per cent of the total production in the country. Punjab has the highest average productivity of 4.70 t ha^{-1} followed by Haryana (4.40 t ha^{-1}). Rajasthan accounted for about 10.71 per cent (3.31 m ha) of the national area and 11.10 per cent (12.18 m t) of grain production with average productivity of 3.67 t ha^{-1} [2]. Weeds competing with crops for limiting resources such as light, water and nutrients resulting adversely affect the crop growth and yield by [3] The intensity and duration of the crop-weed competition determines the magnitude of crop yield losses [4]. Avoiding or reducing crop yield losses due to weed competition requires the utilization of diverse and effective weed management programs [5]. Among several constraints of wheat production, weed infestation is a major one [6]. Weed interference is one of the most important but less noticed factor, contributing towards lowering the yield of wheat. Weeds not only reduce the crop yield, deteriorate the quality of farm produce but also trim down the market value of crop [7]. Uncontrolled growth of weeds on an average caused about 48 per cent reduction in grain yield of wheat when compared with weed free condition [8].

Materials and Methods

The experiment was conducted at the Instructional Farm, Department of Agromomy, Rajasthan College of Agriculture, Udaipur which is situated at $24^0$35' N latitude and $74^0$42' E longitude. The region falls under the Agro Climatic Zone IVa of Rajasthan (*i.e*. Sub-Humid Southern Plain and Aravalli Hills). The average rainfall of Udaipur is 637 mm, most of which (80-85 %) is received through south-west monsoon during July to early September. The mean maximum and minimum humidity at Udaipur fluctuate in between 46.0 to 92.14 per cent and 10.86 to 47.0 per cent, respectively. Maximum and minimum temperature during the experimental period ranged between 20.91 º C to 38.14 º C and 5.64 º C and 19.74 ºC, respectively (**Figure 1**). There was 3.0 mm rainfall received during the crop season. The soil of the experimental site was clay loam in texture and slightly alkaline in reaction. It is low in

available nitrogen (287.5 kg ha^{-1}), medium in organic carbon (0.62%) and phosphorus (23.6 kg ha^{-1}) and high in available potassium (366.1 kg ha^{-1}). The experiment was laid out in Randomize Block Design and replicated thrice. Wheat variety Raj.- 4079 was used as test crop. The experiment consisted of eleven treatments *viz*. halauxifen methyl ester + florasulam + polyglycol at 12.76 g ha^{-1} (T_1); metsulfuron + surfactant at 4 g ha^{-1} (T_2); carfentrazone at 20 g ha^{-1} (T_3); 2, 4-D Na Saltat 500 g ha^{-1} (T_4); 2, 4-D Esterat 500 g ha^{-1} (T_5); metsulfuron + carfentrazone + surfactantat 4 g + 20 g ha^{-1} (T_6); 2, 4-D Na + carfentrazone at 400 g + 20 g ha^{-1} (T_7); 2, 4-D E + carfentrazone at 400 g+ 20 g ha^{-1} (T_8); halauxifen + florasulam + carfentrazone + surfactant at 10.21 g + 20 g ha^{-1} (T_9); weedy check (T_{10}); weedy free (T_{11}). A blanket dose of clodinafop 60 g ha^{-1} was applied 7 days before application of herbicidal treatments to control grassy weeds. Weed free plots were completely weed free from crop germination to harvest by manual weeding. All the herbicides were applied as post-emergence at 32 days after sowing. Ready mix herbicides were applied as per treatment through knapsack sprayer fitted with flat fan nozzle using spray volume of 500 litre ha^{-1} after calibration. Wheat variety Raj 4079 was drilled at 20.0 cm row spacing on 11th November, 2016 using 100 kg ha^{-1} seed rate. The crop was supplied 120 kg N ha^{-1} half of which was drilled in crop rows at sowing while remaining half was top dressed in two equal splits at the time of first and second irrigation. Protein content in wheat grain was calculated by Lowery *et al*., 1951 method [16]. For estimation of nitrogen, phosphorus and potassium contents, representative plant samples were collected at harvest, oven dried and grind to fine powder and nutrient contents in grain and straw were estimated as per the method adopted for determination of nutrients content (**Table 1**). After threshing and winnowing the grain weight from net plot was recorded and expressed as kg ha^{-1}. The straw yield was calculated by subtracting grain yield from respective biological yield of each treatment and expressed as kg ha^{-1}. The ratio of economic yield (grain yield) to the biological yield was worked out and expressed in percentage [9].

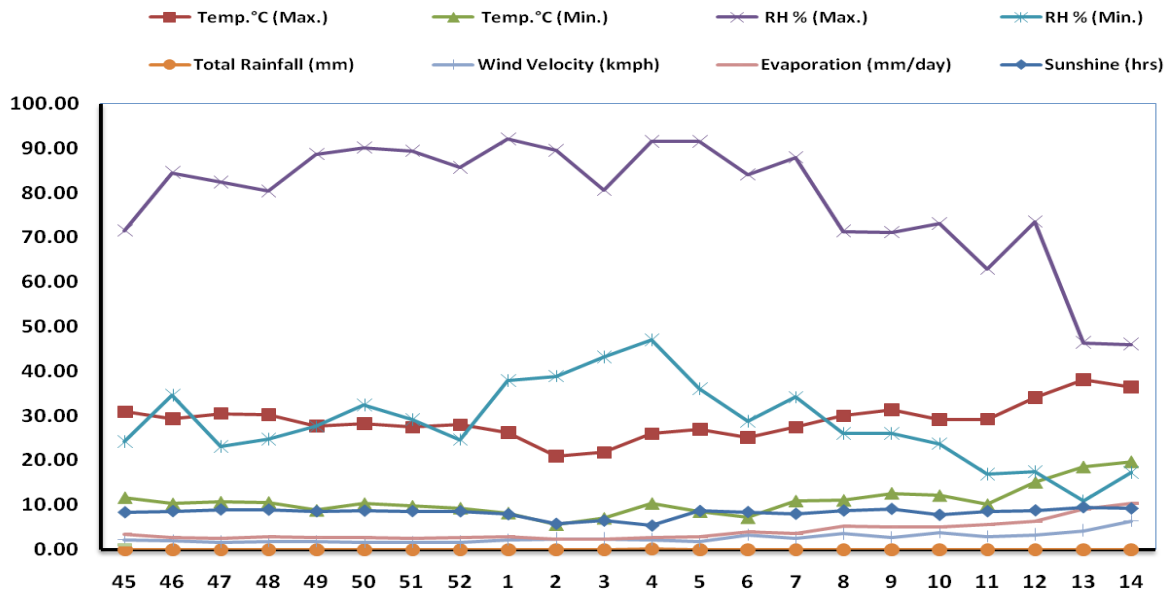

Figure 1 Mean weekly weather parameter during the crop growth period of *Rabi* 2016-17

Table 1 Methods for determination of nutrients content

Nutrients	Method of analysis	Reference
Nitrogen	Nesseler's reagents colorimetric method	[10]
Phosphorus	Ammonium vanadomolybdo phosphoric acid yellow colour method	[11]
Potassium	Flame photometer method	[12]

Results and Discussion

Nitrogen, Phosphorus and Potassium content and uptake in grain and straw

All the weed control measures tended to improve the nitrogen, phosphorus and potassium by grain and stover compared to weedy check (**Table 2**). Nutrient uptake by crop is primarily a function of yield and nutrient content. The highest NPK uptake was recorded halauxifen + florasulam + polyglycol at 12.76 g ha^{-1} which might be due to decreased crop weed competition had concurrently increased in nutrient availability, better crop growth and higher crop biomass production coupled with more nutrient content. The data reveal that maximum nitrogen, phosphorus and

potassium content were recorded in the plot weed free (2.10, 0.317 and 0.365 %) followed by halauxifen + florasulam + polyglycol (2.085, 0.313and 0.359 %), halauxifen + florasulam + carfentrazone+ surfactant (2.05, 0.313 and 0.357 %) and 2, 4-D E + carfentrazone (2.040, 0.307 and 0.347 %). The statistical analysis revealed that the effect of all these three treatments were at par. The N content recorded under weedy check was significantly lower than rest of the weed control treatments (Table 2). A weedy crop resulted in least nutrient uptake. Application of weed control measures tended to enhance nitrogen, phosphorus and potassium uptake significantly weed free accounted for highest gains in nitrogen, phosphorus and potassium uptake (55.4, 76.8 and 67.8 %) followed by halauxifen + florasulam + polyglycol (50.0, 70.4 and 61.0 %), the results of two being at par. Next in the succession were halauxifen + florasulam + carfentrazone + surfactant (46.8, 69.5and 58.8) and 2, 4-D E + carfentrazone (45.6, 65.9 and 54.6 %) over weedy check (Table 2). Variation in nitrogen content of wheat straw was registered under the influence of various weed control treatments. However, the test of significance revealed significant increase over weedy check was achieved only by three treatments namely weed free (0.35, 0.25 and 1.4 %) halauxifen + florasulam + polyglycol (0.34, 0.25and 1.42 %) and halauxifen + florasulam + carfentrazone+ surfactant (0.34, 0.24 and 1.4 %) (Table 2). The increased uptake of N, P and K by crop in herbicide treated plots has also been reported by Devi *et al*., 2017 [13]. Mitra *et al*.(2019) [17] reported that lowest weed index and maximum herbicides efficiency index was recorded by metsulfuron + carfentrazone + surfactant treatment (6%)which was closely followed by halauxifen-methyl + florasulam+ carfentrazone + surfactant treatment (9.3%). Superiority of this combination in suppressing the weed flora leading to less competition for nutrients resulting higher uptake of nutrients by wheat.

Table 2 Effect of herbicides on nutrient content in wheat grain and straw

Treatments	**Nutrient content (%)**					
	Grain			**Straw**		
	Nitrogen	**Phosphorus**	**Potassium**	**Nitrogen**	**Phosphorus**	**Potassium**
Halauxifen+ Florasulam+ Polyglycol	2.085	0.313	0.359	0.348	0.250	1.427
Metsulfuron+ Surfactant	2.016	0.287	0.330	0.300	0.200	1.347
Carfentrazone	1.907	0.250	0.317	0.280	0.180	1.333
2,4-D Na Salt	1.911	0.243	0.310	0.273	0.177	1.333
2,4-D Ester	1.962	0.250	0.330	0.283	0.193	1.347
Metsulfuron+ Carfentrazone + Surfactant	2.037	0.290	0.340	0.317	0.203	1.353
2,4-D Na+ Carfentrazone	2.020	0.287	0.337	0.313	0.203	1.350
2,4-D E+ Carfentrazone	2.040	0.307	0.347	0.327	0.230	1.353
Halauxifen+ Florasulam+ Carfentrazone + Surfactant	2.059	0.313	0.357	0.345	0.240	1.400
Weedy check	1.751	0.231	0.280	0.243	0.143	1.267
Weed free	2.108	0.317	0.365	0.356	0.250	1.433
SEm±	0.024	0.005	0.008	0.004	0.004	0.020
CD (P=0.5)	0.070	0.014	0.022	0.013	0.011	0.060

Total nutrient uptake by crop and protein content

The increase uptake of nutrients by crop under the influence of herbicidal treatments was due to the fact that these treatments effectively suppressed the growth of both categories of weeds which ultimately lead to increase availability of nutrients to the crop and their more transaction towards sink i.e. grain. Thus higher nutrient content coupled with higher crop yield whereas in undisturbed environment of weedy plots, applied nutrient were shared by weeds because of their competiveness and better root system, thus crop was derived of these nutrients. The data revealed that maximum total nutrient uptake by weed free plot and it statistically at par with halauxifen + florasulam + polyglycol and halauxifen + florasulam + carfentrazne + surfactant. Compared to weedy check these treatments increase the N uptake by 58.2, 52.3 and 49.5 percent, 89.9, 84.9 and 80.0 per cent increase in P uptake and 36.3, 32.9 and 29.8 per cent increase in P uptake over weedy check, respectively (**Table 3** and **Figure 2**). Compared to weedy check, weed control through all means under experimentation increased protein content by wheat grain. While highest protein content was accounted by weed free (13.17 %), its effect was statistically at par withhalauxifen + florasulam + polyglycol (13.03 %), halauxifen + florasulam + carfentrazone + surfactant(12.87 %) and 2, 4-D E + carfentrazone(12.75 %) and metsulfuron + carfentrazone+ surfactant (12.73 %) (**Table 4**). The results are closely related with findings of Mahmoud *et al*., (2016) [14].

Table 3 Effect of herbicides on nutrient uptake by wheat crop

Treatments	Nutrient uptake (kg ha^{-1})								
	Grain			Straw			Total		
	N	P	K	N	P	K	N	P	K
Halauxifen+ Florasulam+ Polyglycol	107.37	16.14	18.48	25.27	18.16	103.67	132.64	34.29	122.14
Metsulfuron+ Surfactant	99.39	14.17	16.28	20.46	13.65	91.98	119.85	27.82	108.26
Carfentrazone	87.48	11.47	14.54	18.72	12.05	89.18	106.20	23.52	103.72
2,4-D Na Salt	88.04	11.20	14.28	18.40	11.95	89.84	106.44	23.15	104.12
2,4-D Ester	90.76	11.58	15.26	19.02	12.98	90.49	109.79	24.56	105.76
Metsulfuron+ Carfentrazone + Surfactant	102.26	14.57	17.07	22.39	14.34	95.56	124.65	28.91	112.62
2,4-D Na+ Carfentrazone	101.31	14.40	16.89	21.81	14.14	94.11	123.12	28.54	111.01
2,4-D E+ Carfentrazone	104.40	15.71	17.75	23.05	16.21	95.39	127.45	31.92	113.14
Halauxifen+ Florasulam+ Carfentrazone + Surfactant	105.29	16.05	18.23	24.89	17.33	101.07	130.18	33.38	119.31
Weedy check	71.70	9.47	11.48	15.39	9.08	80.43	87.10	18.55	91.91
Weed free	111.43	16.75	19.26	26.35	18.49	105.98	137.79	35.23	125.24
SEm±	3.42	0.71	0.59	0.39	0.42	2.55	3.50	0.83	2.60
CD (P=0.5)	10.09	2.09	1.75	1.16	1.23	7.51	10.32	2.46	7.67

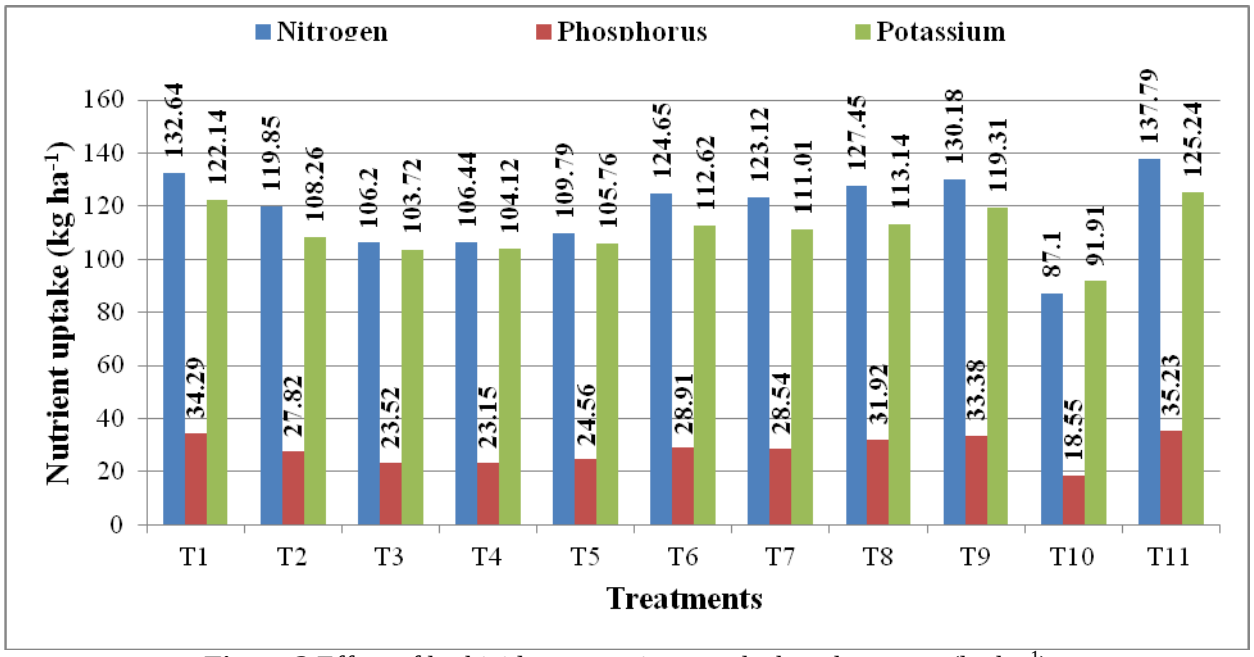

Figure 2 Effect of herbicides on nutrient uptake by wheat crop (kg ha^{-1})

Table 4 Effects of herbicides on protein content of grain

Treatments	Percent
Halauxifen+ Florasulam+ Polyglycol	13.03
Metsulfuron+ Surfactant	12.60
Carfentrazone	11.92
2,4-D Na Salt	11.94
2,4-D Ester	12.26
Metsulfuron+ Carfentrazone + Surfactant	12.73
2,4-D Na+ Carfentrazone	12.63
2,4-D E+ Carfentrazone	12.75
Halauxifen+ Florasulam+ Carfentrazone + Surfactant	12.87
Weedy check	10.94
Weed free	13.17
SEm±	0.15
CD (P=0.5)	0.44

Grain and Straw Yield

The data revealed (**Table 5**) that minimum gain was recorded by weedy check (4097 kg ha^{-1}). Amongst treatments, highest yield (5287 kg ha^{-1}) was obtained in weed free plot which statistically at par with halauxifen + florasulam + polyglycol (5151kg ha^{-1}), halauxifen + florasulam + carfentrazone + surfactant (5117 kg ha^{-1}), 2, 4-D E + carfentrazone, metsulfuron + carfentrazone + surfactant, 2, 4-D Na + carfentrazone and metsulfuron + surfactant. The array of increase ranged from 5.5 (under carfentrazone) to 16.6 per cent (under weed free) over weedy check. The maximum straw produced by weed free plot (7395 kg ha^{-1}) which statistically at par with halauxifen + florasulam + polyglycol, halauxifen + florasulam + carfentrazone + surfactant, 2, 4-D E + carfentrazone, metsulfuron+ carfentrazone + surfactant, 2, 4-D Na + carfentrazone and metsulfuron + surfactant. It is well established fact that least crop weed competition during critical phases of crop growth exerts an important regulation function on complex process of yield formation due to better availability of water, space and nutrient. The results corroborate the findings of Mahmoud *et al.,* (2016) [14], [15], Chhokar *et al.,*2015 [18]

Correlation study

In present study, high positive and significant correlation was documented between grain yield and N, P and K uptake by grain with the corresponding 'r' values as 0.96, 0.91 and 0.92, respectively. Similarly, high positive and significant correlation was also found between stover yield and N, P and K uptake by stover with the corresponding 'r' values as 0.97, 0.97and 0.99, respectively (**Table 6**).

Table 5 Effect of herbicides on yield and harvest index

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Grain	Straw	Biological	
Halauxifen+ Florasulam+ Polyglycol	5151	7264	12415	41.49
Metsulfuron+ Surfactant	4930	6821	11751	41.96
Carfentrazone	4587	6689	11277	40.69
2,4-D Na Salt	4606	6743	11350	40.61
2,4-D Ester	4630	6726	11356	40.76
Metsulfuron+ Carfentrazone + Surfactant	5021	7063	12085	41.55
2,4-D Na+ Carfentrazone	5015	6967	11982	41.85
2,4-D E+ Carfentrazone	5117	7050	12167	42.06
Halauxifen+ Florasulam+ Carfentrazone + Surfactant	5117	7220	12337	41.31
Weedy check	4097	6341	10438	39.30
Weed free	5287	7395	12682	41.68
SEm±	174.70	207.99	252.44	1.18
CD (P=0.5)	515.38	613.56	744.70	3.47

Table 6 Correlation coefficient (r) and regression equation (Y = a + bX) between various weed and crop parameters

Grain yield	Total N uptake by crop	0.960**	Y= 2083.88+23.47X
Grain yield	Total P uptake by crop	0.914**	Y= 3072.46+63.77X
Grain yield	Total K uptake by crop	0.928**	Y= 988.18+35.06X
Straw Yield	Total N uptake by crop	0.977**	Y= 4544.04+20.14X
Straw Yield	Total P uptake by crop	0.977**	Y= 5344.50+56.44X
Straw Yield	Total K uptake by crop	0.993**	Y= 3388.01+32.04X
Biological yield	Total N uptake by crop	0.997**	Y= 6629.20+43.60X
Biological yield	Total P uptake by crop	0.981**	Y= 8418.13+120.18X
Biological yield	Total K uptake by crop	0.980**	Y= 4377.88+67.10X

Conclusion

The highest grain yield (5151 kg ha^{-1}) was obtained by halauxifen + florasulam +polyglycol, which was followed by halauxifen + florasulam + carfentrazone + surfactant (5117 kg ha^{-1}). Maximum biological yield (12415kg ha^{-1}) was recorded by controlling weeds through halauxifen + florasulam + polyglycol while maximum straw yield was also obtained by application by halauxifen + florasulam + polyglycol (7264 kg ha^{-1}). The maximum harvest index (42.06 %) was achieved through 2, 4-D E + carfentrazone. The highest protein content (13.03 %) was achieved through halauxifen + florasulam + polyglycol. The maximum N, P and K uptake (132.64, 34.29 and 122.14 kg ha^{-1},

respectively) was observed by controlling weeds through halauxifen + florasulam + polyglycol, which was found significantly superior over rest of the weed control treatments.

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