International Journal of Agricultural Sciences
Volume **14** | Issue 2 | June, 2018 | 278-282 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/14.2/278-282
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RESEARCH PAPER

Yield performance and nutrient content, uptake as influenced by herbicides and row spacing in wheat crop (*Triticum aestivum* L.)

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Abstract : A field experiment was conducted during *Rabi* season of 2011-12 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur. The experiment consisted of six weed control treatments (pinoxaden 40 g ha^{-1}, isoproturon 750 g ha^{-1}, metribuzin 400 g ha^{-1}, sulfosulfuron 25 g ha^{-1}, idosulfuron 25 g ha^{-1} and weedy check) and three row spacings (17.5 cm, 20.0 cm and 22.5 cm) making eighteen combinations. These treatments were evaluated in Factorial Randomized Block Design with three replications. All the herbicide significantly increased N, P and K content and uptake by wheat grain as well as straw over weedy check. The maximum N, P and K uptake by crop was recorded with the application of isoproturon which was significantly superior over all other treatments. Row spacing did not differ significantly with nutrient content in grain and straw but nutrient uptake varied with row spacing. Row spacing of 17.5 cm recorded maximum N, P and K uptake by wheat grain and found superior to 20.0 and 22.5 cm row spacing in this respect while, uptake by straw did not differ significantly with each other.

Key Words : Wheat, Metribuzin, Isoproturon, Sulfosulfuron, Row spacing, Herbicides, Content, Uptake

View Point Article : Yadav, Mukesh Kumar, Choudhary, Jagdish and Yadav, Kiran (2018). Yield performance and nutrient content, uptake as influenced by herbicides and row spacing in wheat crop (*Triticum aestivum* L.). *Internat. J. agric. Sci.*, **14** (2) : 278-282, **DOI:10.15740/ HAS/IJAS/14.2/278-282.**

Article History : Received : 24.03.2018; **Revised :** 15.04.2018; **Accepted :** 01.05.2018

INTRODUCTION

Wheat is important crops of India. For millennia, wheat has provided dietary sustenance for large proportion of world's population. It is produced in wide range of climatic environments and geographic regions (Dixon *et al*., 2009). It provides 21 per cent of the food calories and 20 per cent protein for more than 4.5 billion people in 94 developing countries (Braun *et al*., 2010). Our country has witnessed spectacular growth in production and productivity which has made country self-sufficient. However, there is need to further increase production to fulfill requirement of exploding population, maintenance of adequate buffer stock and to meet out demand for processing industries.

Since very little scope exists for horizontal growth, the alternative is to achieve vertical growth through

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increasing productivity. Rajasthan shares nearly 10 per cent of the acreage and 9 per cent of the total production of wheat in India. Weed interference is one of the most important but less noticed factor, contributing towards lowering the yields of wheat. Due to industrialization, labour constraints at peak growth period, small family size and under specific situations where weeds are very difficult to be removed manually, the herbicide use becomes inevitable. The chemical control of weeds in general has been realized to be more cost effective and easy compared to manual weeding (Yadav and Malik, 2005; Garcia-Martin *et al*., 2007). Herbicides form potent tool to check the mixed flora of weeds in close row crops like wheat where manual or mechanical weeding is difficult and certain grassy weeds evade farmers hoe because of botanical mimicry at early growth stage (Yasin *et al*., 2010).

Among various agronomic factors, the row spacing of wheat is very important for proper distribution of plants over cultivated area for better utilization of available soil and atmospheric resources. Wheat is generally sown in straight unidirectional rows at 22.5 cm apart. At this row spacing, the space between the crop rows is so much that the plants are not able to fully utilize the available solar radiation and mineral nutrients due to which plants are not able to make sufficient use of available resources. Apart from this reduced row spacing also has a shading effect on interior zone which is capable of suppressing the weeds photosynthesis (Reddy and Reddi, 2002). Similarly, it suppresses weed density and weed dry weight substantially through manipulation in crop geometry (Johari and Singh, 1991). Research carried out on the wheat spacing have indicated that reduction in spacing of wheat from normal 22.5 cm has given higher yield and better use of available resources for photosynthesis. Nanda and Patro (1996) found that 15.0 cm row spacing recorded significantly lower weed population, weed dry weight and higher wheat grain yield over 20.0 cm row spacing.

MATERIAL AND METHODS

An experiment was conducted at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) during *Rabi* 2011-12. The experiment consisted of six weed control treatments (pinoxaden 40 g ha^{-1}, isoproturon 750 g ha^{-1}, metribuzin 400 g ha^{-1}, sulfosulfuron 25 g ha^{-1}, idosulfuron 25 g ha^{-1} and weedy check) and three row spacings (17.5 cm, 20.0 cm and 22.5 cm) making eighteen combinations. These treatments were evaluated in Factorial Randomized Block Design with three replications. Wheat variety Raj 4037 was used as a test crop. The soil was medium in available nitrogen (249.26 kg ha^{-1}) and available phosphorus (19.41 kg ha^{-1}) but high in available potassium (371.82 kg ha^{-1}). The data pertaining to yield, content (%) and uptake of the crop were evaluated.

Plant analysis :

Nutrient content (N, P and K) :

The plant samples collected at harvest from each net plot were dried in oven at 65^{o}C for 72 hrs, and were ground separately to pass through 40 mesh size. From each sample, the required quantity was weighed separately for chemical analysis to determine nitrogen, phosphorus and potash by adopting following standard methods (Table A).

Table A : Methods for determination of nutrients content

Nutrients	Method of analysis	Reference
Nitrogen	Nesseler's reagents colorimetric method	Lindner (1944)
Phosphorus	Ammonium vanadomolybdo phosphoric acid yellow color method	Richards (1968)
Potassium	Flame photometer method	Jackson (1973)

Nutrient uptake :

The uptake of N, P and K at harvest was calculated by using the following formula:

$$\text{Nutrient uptake by grain/straw (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in grain/straw (\%)} \times \text{Grain/straw yield (kg ha}^{-1}\text{)}}{100}$$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of herbicides :

Effect on yield :

An examination of data (Table 1) clearly showed that all the herbicide treatments gave significant increases in grain yield over weedy check. The highest grain yield was obtained under application of isoproturon (5.72 t ha^{-1}) which was closely followed by sulfosulfuron (5.30 t ha^{-1}) and both these herbicides recorded significantly higher grain yield over rest of the treatments. Further, herbicide isoproturon exhibited 14.40, 28.25, 7.92, 16.02 and 71.77 per cent higher grain yield as compared to pinoxaden, metribuzin, sulfosulfuron, idosulfuron and weedy check, respectively. The better expression of yield attributes in these plants might be due to poor resurgence frequency and growth of weeds as evident from weed dry matter studies in these plots. Hence, weeds were unable to compete with the crop plants for different growth factors. Several workers have also reported improvement in yield attributes with reduced weed density and dry matter (Singh, 2012 and Dev *et al.*, 2013).

Effect on nutrient content and uptake :

The results indicated that application of herbicides significantly enhanced nutrient content and uptake by grain and straw over weedy check (Table 1 and 2). These significant improvements in nutrient content and uptake by wheat grain and straw due to application of different herbicides compared to weedy check could be ascribed mainly to weed free environment at early growth stage of the crop, wherein the major portion of the basal dose of fertilizers applied to the soil was available for crop in contrast to weedy check where weeds might have used up major part of the applied nutrients. Similarly, at later stages the applied nutrients under weedy check were taken up mainly by weeds due to their greater competitiveness and probably better root system. More availability of nutrients for the crop under comparatively weed free situation due to herbicide application might have increased its concentration in the plants which resulted in greater translocation towards ultimate sink (grain). In the present experiment the highest uptakes of 111.87 kg N, 24.66 kg P ha^{-1} were obtained with isoproturon treatment while the maximum K uptake was observed with sulfosulfuron (106.98 kg ha^{-1}). This resulted in higher biomass production by wheat crop, yielded into greater uptake of nutrients. The higher uptakes of nutrients by wheat with the application of herbicides have also been reported by Kumar *et al.* (1998) and Kanojia and Nepalia (2006).

Effect of row spacing:

Effect on yield :

A perusal of data presented in Table 1 reveals that row spacing of 17.5 cm registered the maximum grain yield (4.94 t ha^{-1}) closely followed by row spacing of 20.0 cm (4.83 t ha^{-1}) and both these row spacings gave significantly higher grain yield over 22.5 cm spacing. Further, 17.5 cm spacing increased grain yield to the tune of 2.28 and 7.39 per cent over 20.0 and 22.5 cm row spacings, respectively. Grain and biological yield depend upon many factors such as effective tillers, spacing, test weight, ear length etc. The greater tiller numbers at the narrow row spacing was likely due to more uniform spatial distribution and less plant to plant competition compared with the wider row spacing (Auld *et al*., 1983), because at the same seeding rate plants in wide rows were more concentrated in narrow bands with less

Table 1 : Effect of herbicides and row spacing on yield and nutrient content (%)

Treatments	Yield (t ha^{-1})		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Herbicides								
Pinoxaden 40 ml ha^{-1}	5.00	7.10	1.5311	0.3748	0.2851	0.1149	0.4424	1.1804
Isoproturon 750 g ha^{-1}	5.72	6.92	1.5152	0.3643	0.2914	0.1153	0.4390	1.1775
Metribuzin 400 g ha^{-1}	4.46	6.99	1.5296	0.3695	0.2902	0.1149	0.4369	1.1823
Sulfosulfuron 25 g ha^{-1}	5.30	7.07	1.5215	0.3784	0.2907	0.1149	0.4428	1.1810
Idosulfuron 25 g ha^{-1}	4.93	7.12	1.5165	0.3721	0.2878	0.1149	0.4373	1.1822
Weedy check	3.33	5.89	1.2680	0.3318	0.2634	0.0968	0.4114	1.1227
S.E. ±	0.03	0.09	0.004	0.002	0.002	0.0005	0.002	0.0042
C.D. (P = 0.05)	0.07	0.25	0.010	0.006	0.005	0.0016	0.006	0.0121
Row spacing (cm)								
17.5	4.94	7.00	1.4767	0.3695	0.2856	0.1118	0.4361	1.1727
20.0	4.83	6.92	1.4757	0.3618	0.2822	0.1116	0.4334	1.1667
22.5	4.60	6.62	1.4885	0.3641	0.2865	0.1124	0.4355	1.1736
S.E. ±	0.01	0.04	0.002	0.001	0.001	0.0003	0.001	0.0021
C.D. (P = 0.05)	0.04	0.12	NS	NS	NS	NS	NS	NS

NS=Non-significant

Table 2 : Effect of herbicides and row spacing on nutrient uptake

Treatments	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Herbicides									
Pinoxaden 40 ml ha^{-1}	76.42	26.50	102.92	14.22	8.15	22.37	22.11	83.71	105.82
Isoproturon 750 g ha^{-1}	86.65	25.22	111.87	16.70	7.96	24.66	25.20	81.56	106.76
Metribuzin 400 g ha^{-1}	68.22	25.85	94.07	12.96	8.05	21.01	19.51	82.82	102.33
Sulfosulfuron 25 g ha^{-1}	80.51	26.72	107.23	15.39	8.13	23.52	23.43	83.55	106.98
Idosulfuron 25 g ha^{-1}	74.79	26.58	101.37	14.21	8.18	22.38	21.58	84.24	105.82
Weedy check	42.27	19.59	61.86	8.78	5.72	14.49	13.69	66.20	79.89
S.E. ±	0.413	0.35	0.45	0.12	0.11	0.14	0.16	1.05	0.98
C.D. (P = 0.05)	1.19	0.99	1.29	0.35	0.30	0.41	0.46	3.01	2.83
Row spacing (cm)									
17.5	73.40	25.97	99.37	14.24	7.86	22.10	21.75	82.36	104.11
20.0	71.77	25.08	96.85	13.65	7.74	21.39	20.89	80.89	101.78
22.5	69.26	24.19	93.45	13.24	7.49	20.73	20.12	77.79	97.90
S.E. ±	0.21	0.17	0.22	0.06	0.05	0.071	0.08	0.52	0.49
C.D. (P = 0.05)	0.59	NS	0.64	0.18	NS	0.21	0.23	NS	NS

NS=Non-significant

available space plant^{-1} than plants in narrow rows. In this study, more biomass was produced at the narrower spacing (17.5 cm) than 20.0 and 22.5 cm spacing indicating better resource utilization in narrow rows than wider rows. Increased light capture by a canopy has been reported in wheat with narrow row spacing configurations (Andrade *et al*., 2002).

Effect on nutrient content and uptake :

Sowing of wheat under different row spacings did not affect the N, P and K content in grain and straw but uptake of N (73.40 kg ha^{-1} and 25.97 kg ha^{-1}), P (14.24 kg ha^{-1} and 7.86 kg ha^{-1}) and K (21.75 kg ha^{-1} and 82.36 kg ha^{-1}) by grains and straw were significantly higher at 17.5 cm row spacing (except K uptake by straw) over the remaining row spacings. This situation could be due to the highest production of biological yield at row spacing of 17.5 cm. C1oser row spacing (15.0 cm) significantly decreased the nutrient removal by the *Phalaris minor* compared to wider row spacing (22.5 cm) thus resulted in higher nutrient uptake by the crop due to lesser dry matter production of *Phalaris minor* (Mahajan and Sardana, 2003).

The positive correlation was obtained between nitrogen uptake and grain yield (0.992**) and phosphorus uptake and grain yield (0.998**). Almost similar trends were obtained in respect of nitrogen and phosphorus uptake by grain and straw yield.

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