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Effect of herbicides and row spacing on weed dynamics and productivity of bread wheat (*Triticum aestivum* L.)

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ABSTRACT : Application of herbicides caused significant reduction in weed density and weed dry matter. The maximum reduction in weed density and weed dry matter was recorded in the plots treated with metribuzin followed by isoproturon and sulfosulfuron at 45 DAS and at harvest. Herbicidal treatments significantly increased number of tillers 45 DAS and plant height at 90 DAS and at harvest. The dry matter accumulation by crop at all the growth stages was significantly higher under isoproturon which was closely followed by sulfosulfuron.The maximum value of effective tillers, ear length, number of grains ear^{-1} and test weight were observed with isoproturon followed by sulfosulfuron. Consequently, isoproturon produced significantly higher grain (5.72 t ha^{-1}) and biological yield (12.64 t ha^{-1}) and also net return (83753 Rs. ha^{-1}) compared to other treatments. The effect of row spacing was significant on density and dry matter of weeds at 45 DAS and at harvest. The minimum density of weeds was observed under row spacing of 17.5 cm which was closely followed by 20.0 cm and both these had significantly lower than 22.5 cm in this respect. Row spacings did not have significant impact on plant height. The maximum number of effective tillers was recorded under 20.0 cm whereas dry matter accumulation was under 22.5 cm row spacing. Sowing at 17.5 cm row spacing produced significantly higher grain (4.94 t ha^{-1}) and biological yield (11.94 t ha^{-1}) also net return (71314 Rs. ha^{-1}) compared to other row spacing.

KEY WORDS : Bread wheat, Metribuzin, Isoproturon, Sulfosulfuron, Row spacing, Herbicides, Grain yield

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Wheat is one of the most important cereal crops of India, not only in terms of hectares, but also in terms of its versatility for adoption under wide range of agro- climatic conditions and crop growing situations. Among several constraints of wheat production, weed infestation is a major one (Zimdahl, 2004). Weed interference is one of the most important but less noticed factors, contributing towards lowering the yields of wheat. Weeds not only reduce the crop yield, deteriorate the quality of farm produce but also trim down the market value of crop (Hussain *et al.,* 2012). They mainly compete with crop for nutrients, moisture, space and solar radiation. Due to industrialization, labour constrains 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). To control mixed population of weeds and also to avoid herbicides resistance by continuous use of single herbicide, compatible mixtures can be employed to widen the spectrum of weed control (Das and Yaduraju, 2012).

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). Row spacing of 15.0 cm recorded significantly lower weed population, weed dry weight and higher wheat grain yield over 20.0 cm row spacing (Nanda and Patro, 1996).

RESEARCH PROCEDURE

The experiment was laid out at the Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan). 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. Soil of experimental site was clay loam in texture, having alkaline reaction (pH 8.1). 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 sowing of crop was done on November 23rd 2011 using recommended seed rate of 100 kg ha^{-1} using 120 kg N + 60 kg P_2O_5 ha^{-1} were applied through urea and DAP. One third of N and full dose of P were applied as a basal dose. Remaining N were applied through urea in two equal splits at the time of first irrigation and second irrigation.The data pertaining to weed study, growth characters, yield attributes, yield and economics of the crop were evaluated.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of herbicides:

Data presented in Table 1 indicate that application of herbicides caused marked reduction in density and dry matter of weeds. Before spray of herbicides, the variations in weed density and weed dry matter were not statistically significant. Post-emergence application of herbicides

Table 1 : Effect of herbicides and row spacing on weed density and weed dry matter

Treatments	Weed density (m^2)			Weed dry matter (g)		
	Before spray	45 DAS	At harvest	Before spray	45 DAS	At harvest
Herbicides						
Pinoxaden 40 ml ha^{-1}	11.55 (133.33)	8.32 (70.44)	5.52 (30.56)	253.89	160.89	171.56
Isoproturon 750 g ha^{-1}	11.43 (130.44)	6.06 (36.33)	5.30 (28.00)	250.78	109.33	150.11
Metribuzin 400 g ha^{-1}	11.41 (130.22)	5.99 (35.56)	5.15 (26.56)	254.56	64.00	137.44
Sulfosulfuron 25 g ha^{-1}	11.53 (132.89)	7.24 (53.44)	5.38 (28.78)	251.44	159.56	163.78
Idosulfuron 25 g ha^{-1}	11.38 (129.78)	8.72 (78.44)	5.74 (32.89)	251.22	166.29	183.33
Weedy check	11.58 (133.78)	12.06 (145.11)	8.20 (66.89)	253.89	359.78	577.22
S.E. ±	1.51	0.730	0.478	2.723	1.909	1.36
C.D. (P = 0.05)	NS	2.098	1.375	NS	5.486	3.89
Row spacing (cm)						
17.5	11.23 (126.11)	7.06 (54.06)	5.24 (28.44)	244.00	148.70	198.72
20.0	11.49 (131.67)	7.98 (67.22)	5.85 (34.94)	253.33	164.44	234.61
22.5	11.73 (137.44)	9.15 (88.39)	6.56 (43.44)	260.56	196.78	258.39
S.E. ±	0.76	0.365	0.239	1.362	0.954	3.89
C.D. (P = 0.05)	NS	1.049	0.688	NS	2.743	7.79

* Data subjected to $\sqrt{x + 0.5}$ transformation and figures in parenthesis are original weed count m^{-2} NS=Non-significant

brought about significant reductions in density and dry matter of weeds in comparison to weedy check at 45 DAS and at harvest. The minimum weed density and dry matter were recorded with metribuzin, closely followed by isoproturon and both these herbicides were statistically at par to each other. However, application of metribuzin proved phytotoxic to wheat crop as evident from its effect on crop growth characteristics. Metribuzin, as selective and systemic herbicide, is absorbed predominantly by the roots, but also by the leaves, with translocation acropetally in the xylem. Metribuzin, is PS II inhibiting herbicide was found effective against *Phalaris minor* and other grassy and broad- leaf weeds (Malik *et al.*, 2005 and Punia *et al.*, 2005) but application of metribuzin beyond 210 g ha^{-1} also has been found to adversely affect wheat growth and tillering (Singh *et al.*,

Table 2 : Effect of row spacing and varieties on growth characters of wheat crop

Treatments	Plant height (cm)		DMA (g)		RGR		CGR		NAR	
	60 DAS	At harvest	60 DAS	At harvest	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
Herbicides										
Pinoxaden 40 ml ha^{-1}	87.67	88.69	33.94	168.33	0.0335	0.0500	1.5604	8.5667	16.7213	100.6559
Isoproturon 750 g ha^{-1}	89.90	91.58	35.67	174.11	0.0357	0.0495	1.6896	8.7481	17.8140	101.2516
Metribuzin 400 g ha^{-1}	82.22	84.49	28.94	162.89	0.0317	0.0498	1.4156	7.9296	14.9298	93.0319
Sulfosulfuron 25 g ha^{-1}	89.24	90.76	34.67	173.89	0.0349	0.0501	1.6285	8.7556	17.2855	102.0665
Idosulfuron 25 g ha^{-1}	85.83	88.33	32.56	165.33	0.0332	0.0502	1.4896	8.2963	15.7492	96.0227
Weedy check	85.67	86.97	26.89	154.00	0.0273	0.0490	1.1533	6.8741	11.4092	75.5588
S.E. ±	0.36	0.37	0.298	1.101	0.0005	0.0003	0.0237	0.0618	0.2784	0.7825
C.D. (P = 0.05)	1.03	1.07	0.857	3.166	0.0013	NS	0.0681	0.1775	0.8001	2.2489
Row spacing (cm)										
17.5	87.07	89.23	29.14	161.92	0.0310	0.0516	1.3241	8.0759	15.6854	103.5035
20.0	86.91	88.17	33.39	166.50	0.0342	0.0487	1.5772	8.1704	16.2279	92.3087
22.5	82.29	88.00	33.81	170.86	0.0329	0.0490	1.5672	8.3389	15.0411	88.4814
S.E. ±	0.18	0.19	0.149	0.551	0.0002	0.0002	0.0119	0.0309	0.1392	0.3912
C.D. (P = 0.05)	NS	NS	0.429	1.583	NS	0.0004	0.0341	NS	NS	1.1244

NS=Non-significant

Table 3 : Effect of row spacing and varieties on yield attributes, yield and economics of wheat crop

Treatments	Yield attributes				Yield (t ha^{-1})			Economics	
	Effective tillers (0.5 m row length)	Ear length (cm)	No. of grains ear^{-1}	Test weight (g)	Grain	Straw	Biological	Net returns (Rs. ha^{-1})	BC ratio
Herbicides									
Pinoxaden 40 ml ha^{-1}	65.29	10.19	42.63	40.30	5.00	7.10	12.09	72316	3.49
Isoproturon 750 g ha^{-1}	69.53	10.36	43.73	41.42	5.72	6.92	12.64	83753	4.07
Metribuzin 400 g ha^{-1}	59.40	9.35	41.95	39.51	4.46	6.99	11.46	63200	2.99
Sulfosulfuron 25 g ha^{-1}	66.60	10.24	43.10	40.53	5.30	7.07	12.37	77129	3.73
Idosulfuron 25 g ha^{-1}	64.29	9.71	41.92	40.20	4.93	7.12	12.05	71405	3.46
Weedy check	54.67	9.26	40.68	39.17	3.33	5.89	9.22	44020	2.18
S.E. ±	0.32	0.05	0.15	0.12	0.03	0.09	0.08	395	0.02
C.D. (P = 0.05)	0.92	0.14	0.42	0.35	0.07	0.25	0. 23	1134	0.05
Row spacing (cm)									
17.5	63.50	9.80	42.05	39.68	4.94	7.00	11.94	71314	3.45
20.0	64.41	9.91	42.32	40.42	4.83	6.92	11.76	69485	3.36
22.5	61.99	9.85	42.64	40.47	4.60	6.62	11.22	65112	3.15
S.E. ±	0.16	0.02	0.07	0.062	0.01	0.04	0.04	197	0.01
C.D. (P = 0.05)	NS	NS	NS	NS	0.04	0.12	0.12	567	0.03

NS=Non-significant

1999). In present investigation metribuzin gave the highest reduction in weed density 75.49 and 60.26 per cent at 45 DAS and at harvest, respectively. In respect of weed dry matter accumulation, 82.21 and 76.19 per cent reduction at 45 DAS and at harvest, respectively. The findings of present investigation are in close conformity with those of Sharma *et al*. (2002) and Pandey *et al.* (2006).

It is evident from data (Table 2) that application of different herbicides provided noticeable improvement in growth characters of wheat crop. The maximum value of plant height, dry matter accumulation, RGR, CGR and NAR was observed under the application of isoproturon and which was statistically superior over weedy check. Data presented in Table 3 show that application of herbicides improved yield attributes and yield compared to weedy check. The maximum effective tillers, ear length, number of grains ear^{-1} and test weight were observed with isoproturon followed by sulfosulfuron. Consequently, isoproturon produced significantly higher grain (5.72 t ha^{-1}), biological yield (12.64 t ha^{-1}), monetary returns (83753 Rs. ha^{-1}) and B : C ratio (4.07) which was significantly superior over rest of treatments. Greater dry matter accumulation and higher tillers under weed control treatments is an indirect effect on account of least competition for plant growth inputs *viz.*, light, space, water and nutrients. Under reduced density and dry matter of weeds, plants get sufficient space for the optimum expansion of leaves and branches as early as possible (Gupta, 2012). Thus, under least crop-weed competition, adequate availability of light, optimum temperature, space along with improvement in physiological and morphological characters of the plants can be reasoned for greater photosynthetic rate thereby more accumulation of dry matter (Duncon, 1971 and Korpff, 1993). Similar findings were obtained by Brar and Walia (2009) and Singh *et al.* (2009).

Effect of row spacing :

Generally speaking, a more dense plant- stand, allows the crop to compete better with weeds. There is considerable evidence that narrower row spacing reduce overall weed competition. Manipulating row spacing in crops that are generally planted as row crops also has potential to affect weed control. The lowest weeds found in narrow row spacing might be due to more competition of wheat crop for development resources. In present investigation significantly the lowest weed density and weed dry matter observed with row spacing of 17.5 cm 30, 45 DAS and at harvest. These findings are in line with those of Jat *et al.* (2003) and Hada (2006).

Under close row spacing (17.5 and 20.0 cm) competition for light and other resources was greater which was compensated with increasing crop height. Narrower spacing had greater height due to competition for light than wider spacing. Among all three row spacings, 17.5 cm had the maximum height over rest of treatments. These findings are in close conformity with those of Suthar (2006) and Patel *et al*. (1986). The branching or tillering habit is commonly observed and is probably one of the most extensively studied phenomena on an individual plant basis in wheat. Number of effective tillers unit^{-1} area is one of the limiting factors of grain yield (Kakar *et al*., 2001).

A perusal of data (Table 3) reveals that the maximum grain yield (4.94 t ha^{-1}) and biological yield (11.94 t ha^{-1}) was recorded under narrower row spacing *i.e.* 17.5 cm which was highly significant over 20.0 and 22.5 cm row spacing. 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 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 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). Further, data indicate that narrower row spacing 17.5 cm gave maximum net returns (71314 Rs. ha^{-1}) and B : C ratio (3.45) and exhibited 9.53 and 9.52 per cent over row spacing 22.5 cm, respectively.

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