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Influence of row orientation, row spacing and weed-control methods on physiological performance of irrigated wheat (*Triticum aestivum*)

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ABSTRACT

An experiment was laid out in split-plot design with 3 replications to study the effect of combinations of 3 row directions (north–south, south–west and bi-directional) and 2 spacings (15 cm and 20 cm) + broadcast sowing and 4 weed-control treatments (unweeded check, isoproturon 0.75 kg/ha, isoproturon 1.50 kg/ha and hand-weeding twice 30 and 60 days after sowing) on performance of wheat (*Triticum aestivum* L. emend. Fiori & Paol.). Bi-directional row orientation increased the yield due to increased leaf-area index (LAI), crop-growth rate (CGR), yield attributes and reduced the weed growth rate, followed by north–south row direction. Closer row spacing of 15 cm reduced the weed dry matter and thus increased the LAI, CGR, yield and yield attributes of wheat over wider row spacing of 20 cm. All the weed-control treatments increased the yield, yield attributes and decreased the weed biomass significantly over the unweeded check. Isoproturon 1.5 kg/ha was the best among weed-control treatments.

Infestation of weeds has posed a serious threat under the modified microclimate created after introduction of high-yielding, dwarf varieties of wheat (*Triticum aestivum* L. emend. Fiori & Paol.). For sustainable agriculture, there is need to integrate the non-monetary or low-cost inputs with weed-control methods to favour the physiological performance of crop over associated weeds.

The present investigation was therefore conducted to study the effect of integrating the row orientations, row spacings and weed-control methods on physiological performance of wheat by effective control of weeds in wheat.

MATERIALS AND METHODS

The field experiment was conducted during winter (*rabi*) season of 1988–89 and 1989–90 at Himachal Pradesh Krishi Vishvavidyalaya, Palampur, in split-plot design with 3 replications keeping combinations of 3 row orientations (N–S, E–W and bi-directional) and 2 row spacings (15 and 20 cm) + broadcast sowing in main plots and 4 weed-control treatments [unweeded check, isoproturon 0.75 kg/ha, isoproturon 1.50 kg/ha and hand-weeding twice at 30 and 60 days after sowing (DAS)] in sub-plots. The soil was silty-clay loam (Alfisols) in texture and acidic in reaction (pH 5.5). The fertility of the soil was low in available N, medium in available P and high in available K.

Wheat 'S 308' was sown on 11 November 1988 and 15 Novemebr 1989 by using 120 kg seed/ha. Fertilizer, irrigation and other cultural practices were applied as per the recommended practices. For bidirectional sowing the seed and fertilizer were divided into 2 halves and seed was sown in equal quantity in both directions. The N–S and E–W sowing was done with recommended seed rate and fertilizers. The isoproturon was sprayed in 600 litres water/ha at 35 DAS using knapsack sprayer. Dry-matter accumulation and growth rate of *Avena fatua* L. and *Vicia sativa* L were subjected to $\sqrt{x+1}$ transformation before statistical analysis. Leaf area of the crop was estimated by leaf-area meter.

The crop-growth rate (CGR), weed-growth rate (WGR) and net assimilation rate (NAR) were worked out by the formulae given by Radford (1967).

RESULTS AND DISCUSSION

Weed dry matter

The dry matter of *Lolium temulentum* L. and *Phalaris minor* Retz. was almost similar during both the years, while that of *Avena fatua* L. and *Vicia sativa* L. increased during the second year over the first year. The lower dry matter of these 2 weeds during the first year might be because the experimental field was under rice–flax rotation before the experiment.

The dry matter of all the weeds at 150 DAS was significantly lowest in bi-directional row orientation, followed by N–S row orientation in both the years (Table 1). However, the effect of row orientations on *A. fatua* and *V. sativa* was not significant during the first year. But during the second year, N–S and E–W row orientations remaining statistically at par reduced the dry matter of *V. sativa* significantly over bi-directional sowing. The decreased dry matter of grassy weeds due to bi-directional sowing might be attributed to early development of the crop canopy cover, which might have reduced the radiation reaching the weed plants. Malik *et al.* (1988) reported similar results. Due to its shading effect, the closer row spacing of 15 cm reduced the dry matter in all the grassy weeds compared with wider spacing of 20 cm.

The other methods of sowing decreased the biomass production of all the grassy weeds significantly only during second year, whereas that of *V. sativa* during both the years over broadcast sowing.

The weed-control methods decreased the dry matter of all the weeds significantly over the unweeded check. Isoproturon 1.50 kg/ha was the best treatment in reducing the dry matter of all the grassy weeds, whereas hand-weeding twice and isoproturon 0.75 kg/ha remianed invariably at next place. In reducing the dry matter of *V. sativa*, hand-weeding twice was significantly superior among all the weed-control treatments. These results are in line with those of Malik *et al.* (1988).

Weed-growth rate

The N–S and bi-directional row orientations being statistically at par reduced the growth rate of *Lolium temulentum* and *Phalaris minor* significantly between 120 and 150 DAS (Table 2), whereas the bi-directional row orientation being at par with E-W orientation reduced the growth rate of *Avena fatua* significantly. The growth rate of *Vicia sativa* was not influenced significantly by the row orientations.

Row spacings did not influence the growth rate of all the weed species. However, numerically the closer row spacing of 15 cm reduced the growth rate of all the grassy weeds.

Broadcast sowing did not differ significantly from other methods of sowing in influencing the growth rate of different weed

Table 1. Effect of row orientation, row spacing and weed-control method on species-wise dry matter (g/m^2) of weeds at 150 days after sowing

Treatment	*Lolium temulentum*		*Phalaris minor*		*Avena fatua*		*Vicia sativa*	
	1989	1990	1989	1990	1989	1990	1989	1990
Row orientation								
N—S	91.35	70.93	68.14	61.17	3.30 (14.6)	64.80	4.69 (23.0)	19.47
E—W	115.51	80.18	76.90	69.80	3.20 (14.0)	72.72	4.55 (22.3)	21.42
Bi-directional	80.28	60.77	57.11	45.97	2.23 (6.6)	54.03	4.53 (24.6)	23.56
CD (P = 0.05)	3.71	3.38	7.88	5.67	NS	3.77	NS	2.99
Row spacing								
15 cm	90.51	65.34	60.59	53.34	2.77 (10.8)	60.10	4.50 (23.1)	20.44
20 cm	100.91	75.92	74.18	64.61	3.05 (12.6)	67.59	4.68 (23.4)	22.53
CD (P = 0.05)	3.03	2.75	6.43	4.62	NS	3.07	NS	NS
Broadcast vs others								
Broadcast	95.73	84.10	72.80	77.98	2.80 (11.9)	75.19	5.50 (31.4)	28.35
Others	95.71	70.63	67.38	58.98	2.91 (11.7)	63.85	4.49 (23.3)	21.48
CD (P = 0.05)	NS	5.14	NS	8.65	NS	5.75	1.01	4.55
Weed-control method								
Unweeded check	141.15	108.72	134.01	120.60	5.50 (31.4)	111.44	5.07 (26.3)	26.62
Isoproturon 0.75 kg/ha	83.62	64.77	44.75	47.62	2.28 (6.2)	52.66	5.07 (27.5)	24.01
Isoproturon 1.50 kg/ha	76.17	56.37	31.82	30.00	1.78 (4.1)	41.94	5.17 (29.9)	23.82
Hand-weeding twice	81.92	60.35	62.03	48.54	2.01 (5.4)	55.84	3.57 (14.2)	15.40
CD (P = 0.05)	8.60	3.95	8.40	4.54	0.83 4.45	0.82	1.88	

Values in the parentheses are the means of the original values

Isop, Isoproturon

Table 2. Effect of row orientation, row spacing and weed-control method on growth rate of different weed species between 120 and 150 days after sowing

Treatment	Weed-growth rate (g/day/m^2)			
	Lolium temulentum	*Phalaris minor*	*Avena fatua*	*Vicia sativa*
Row orientation				
N–S	1.2659	0.7775	1.096 (0.208)	1.054 (0.12)
E–W	1.6341	1.0793	1.053 (0.108)	1.037 (0.10)
Bidirectional	1.4034	0.7746	1.036 (0.066)	1.075 (0.16)
CD (P = 0.05)	0.1861	0.2142	0.037	NS
Row spacing				
15 cm	1.4224	0.8225	1.057 (0.116)	1.060 (0.13)
20 cm	1.4465	0.9218	1.066 (0.139)	1.052 (0.12)
CD (P = 0.05)	NS	NS	NS	NS
Broadcast vs others				
Broadcast	1.2018	0.9917	1.078 (0.172)	1.123 (0.27)
Others	1.4645	0.8771	1.062 (0.127)	1.056 (0.13)
CD (P = 0.05)	NS	NS	NS	NS
Weed-control method				
Unweeded check	1.7694	1.7246	1.171 (0.370)	1.050 (0.12)
Isop. 0.75 kg/ha	1.2879	0.5121	1.034 (0.067)	1.106 (0.23)
Isop. 1.50 kg/ha	1.1853	0.4149	1.019 (0.035)	1.100 (0.22)
Hand-weeding twice	1.3681	0.9223	1.032 (0.064)	1.007 (0.02)
CD (P = 0.05)	0.2467	0.2328	0.035	NS

Values in the parentheses are the means of original values
Isop, Isoproturon

species.

All the weed-control treatments being statistically at par reduced the growth rate of *L. temulentum* and *A. fatua* significantly over the unweeded check. The growth rate of *P. minor* was significantly reduced by isoproturon at both the doses over hand-weeding twice. However, growth rate of *V. sativa* was not influenced significantly by weed-control treatments.

Crop-growth analysis

Due to uniform plant distribution, bidirectional sowing resulted in significantly highest LAI and CGR, followed by N-S row orientation, whereas E–W and bi-directional row orientations remaining statistically at par resulted in significantly higher NAR over N–S row direction (Table 3). These results are in conformity with those of Kurchania *et al.* (1990).

Due to higher plant stand 15 cm row spacing increased the LAI and CGR singificantly over 20 cm row spacing; however, the effect of row spacings on NAR was not significant.

Other methods of sowing increased the LAI and CGR significantly over broadcast

Table 3. Effect of row orientation, row spacing and weed-control methods on leaf-area index (120 DAS), crop-growth rate and net assimilation rate (90–120 DAS)

Treatment	Leaf-area index	Crop-growth rate (g/m^2/day)	Net assimilation rate (g/m^2 leaf area/day)
Row orientation			
N–S	2.3404	11.7450	6.83
E–W	2.1158	11.6404	7.54
Bi-directional	2.9137	15.4035	7.43
CD (P = 0.05)	0.0567	0.1636	0.22
Row spacing			
15 cm	2.5308	13.3553	7.23
20 cm	2.3825	12.5033	7.30
CD (P = 0.05)	0.0462	0.1336	NS
Broadcast vs others			
Broadcast	2.1838	11.4633	7.57
Others	2.4566	12.9293	7.26
CD (P = 0.05)	0.0865	0.2499	0.29
Weed-control method			
Unweeded	1.6754	11.5690	8.70
Isop. 0.75 kg/ha	2.5289	12.9448	7.07
Isop. 1.50 kg/ha	2.8000	13.2057	6.56
Hand-weeding twice	2.0664	13.1600	6.91
CD (P = 0.05)	0.0424	0.2267	0.16

Isop., Isoproturon

sowing, whereas reverse trend was observed for NAR.

Among the weed-control treatments, isoproturon 1.50 kg/ha increased the LAI and CGR, but was statistically at par with hand-weeding twice. However, the reverse trend was observed in case of NAR.

Yield and yield attributes

Because of reduced weed biomass (Table 1) and increased LAI and CGR of wheat (Table 3), bi-directional row orientation increased the yield-contributing characters, viz. effective tillers, spike length and spikelets/spike, significantly and ultimately the grain yield, followed by N–S row orientation (Table 4). However, the effect of row orientations on grains/spike and 1,000-grain weight was not significant. The N–S row orientation resulted in 8.5 and 9.9% higher grain yield than E–W row orientation in 1989–89 and 1989–90 respectively. Bi-directional sowing showed further increase of 14.1 and 11.6% over N–S direction during respective years. These results are inline with those of Walia and Cheema (1986).

The effect of row spacings was significant on grain yield only during 1988–89, and on effective tillers during both the years. The closer spacing of 15 cm increased these parameters significantly over 20 cm spacing (Table 4), because of its influence in reducing the weed biomass and weed growth rate (Tables 1,2) and increasing LAI and CGR (Table 3) of crop.

The other methods of sowing increased the grain yield significantly over broadcast sowing due to their influence in decreasing the weed biomass and increasing the effective tillers, LAI and CGR of the crop. These results are in direct agreement with those of Chatha and Nazir (1985).

The better physiology performance (Table 3) of the crop in weed-control methods due to effective reduction in growth rate of weeds (Table 2), increased the yield and yield-contributing characters of wheat significantly over the unweeded check (Table 4). Significantly highest grain yield was recorded with isoproturon 1.50 kg/ha, followed by hand-weeding twice during both the years, however, the latter was statistically at par with isoproturon 0.75 kg/ha during second year. Weeds in unweeded check reduced the grain yield of wheat by 42.2 and

Table 4. Effect of row orientation, row spacing and weed-control method on grain yield and yield-contributing characters of wheat

Treatments	Grain yield (q/ha)		Effective tillers/m^2		Spike length (cm)		Spikelets/ spike		Grains/ spike		1,000-grain weight (g)	
	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90
Row orientation												
N–S	31.81	29.53	402.1	400.1	10.69	10.38	13.59	12.97	28.51	26.71	49.28	48.17
E–W	29.33	26.88	375.1	372.7	10.55	9.83	13.48	12.50	30.23	26.68	48.45	47.04
Bidirectional	36.32	32.95	486.5	480.9	10.74	10.23	13.87	13.05	29.98	27.00	49.20	47.92
CD (P = 0.05)	1.15	2.35	2.00	4.2	NS	0.39	NS	0.41	NS	NS	NS	NS
Row spacing												
15 cm	33.30	30.74	446.5	438.5	10.66	10.22	13.67	12.87	29.22	26.90	48.94	47.95
20 cm	31.68	28.83	396.0	397.3	10.66	10.07	13.62	12.81	29.93	26.70	49.01	47.47
CD (P = 0.05)	0.94	NS	1.6	3.4	NS	NS	NS	NS	NS	NS	NS	NS
Broadcast vs others												
Broadcast	28.43	23.67	389.6	377.3	11.04	9.69	13.75	12.34	30.44	25.36	48.98	46.79
Others	32.48	29.79	421.2	417.9	10.66	10.15	13.65	12.84	29.57	26.80	48.98	47.71
CD (P = 0.05)	1.76	3.60	3.1	6.4	NS	NS	NS	NS	NS	NS	NS	NS
Weed-control method												
Unweeded check	22.18	13.73	386.5	357.4	9.81	7.12	12.30	9.51	25.19	17.80	45.61	39.52
Isop. 0.75 kg/ha	32.62	30.53	423.4	427.8	10.82	10.88	13.90	13.80	29.48	28.23	49.94	50.00
Isop. 1.50 kg/ha	38.40	40.29	431.3	436.5	11.26	11.46	14.29	13.98	32.54	30.85	50.74	50.66
Hand-weeding twice	34.43	31.09	425.6	426.6	10.96	10.87	14.15	13.77	31.58	28.92	49.61	48.98
CD (P = 0.05)	1.15	2.34	2.1	5.3	0.51	0.33	0.54	0.33	2.27	1.05	0.73	0.69

Isop., Isoproturon

65.9% over isoproturon 1.5 kg/ha during 1988–89 and 1989–90 respectively.

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