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Research Paper

Root characteristics and performance of different wheat (*Triticum aestivum*) genotypes under restricted irrigations in alluvial soil

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ABSTRACT

A field experiment was conducted during the winter season of 2010–11 and 2011–12 at Gwalior, Madhya Pradesh, to evaluate performance of different cultivars of wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] under restricted irrigations on alluvial soils. The treatments were 18 combinations of 3 irrigation levels (no irrigation, 1 irrigation and 2 irrigations) and 6 wheat genotypes ('HI 1572', 'HI 1500', 'Lok 1', 'MP 3288', 'A 9-30-1' and 'HI 8627'). A significant increase was observed in chlorophyll content index, root-development parameters (length, volume and diameter), yield attributes and grain yield in all the varieties with first irrigation. The increase in these characters owing to second irrigation was also significant, but the magnitude was relatively low. Among the different genotypes, 'HI 1572' responded more to irrigation than the others and it was closely followed by 'MP 3288'. Significant decrease in the water-use efficiency was recorded with the increase in water application and highest water-use efficiency was recorded in variety 'HI 1572', which was closely followed by 'MP 3288'.

Key words : Restricted irrigation, Root development, Water-use efficiency, Wheat genotypes

It is well established fact that water stress reduces wheat grain yield. In general, water requirement of semi-dwarf varieties of wheat is about 45 cm in the form of 4–6 irrigations with a depth of 4–7 cm. Root is the main organ of the plant in contact with the soil for absorbing water and nutrients. Successful growth of roots and their functions as absorbing surface depends on many factors of soil environment. The principal soil physical factors are soil-moisture status, mechanical strength (resistance to root extension), temperature and soil aeration. In the field, soil water appears to be of greater importance since it acts both directly on plant growth and function, and indirectly by affecting other related factors such as aeration, soil impedance and soil temperature prevailing in the root zone (Sharma, 2005).

Water scarcity affects root growth, nutrient availability and nutrient uptake by wheat. Therefore there is a need for efficient utilization of water through appropriate irrigation scheduling for achieving higher water and nutrients-use efficiency, productivity and crop yield. Wheat genotypes have different water requirements in different ecosystems of northern part of Madhya Pradesh. The rainfall pattern and environmental conditions are not consistent for the last 2 decades and there is limited irrigation water to meet out the requirement of wheat crop. The paucity of irrigation during critical stages of growth period, has forced the scientists to find out its solution under the limited irrigation for remunerative production of wheat.

MATERIALS AND METHODS

A field experiment was conducted during the winter season (*rabi*) 2010–11 and 2011–12 at the research farm, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior. The experimental soil was sandy clay loam, with pH 7.82, electrical conductivity (EC) 0.36 dS/m, organic carbon 0.42% with available N (196 kg/ha), avialable P (11.6 kg/ha) and available K (256 kg/ha). The experiment was laid out in split-plot design with 3 replications. Three irrigation schedules, viz. no irrigation (I_0), 1 irrigation at CRI stage (I_1) and 2 irrigation at CRI and late tillering stage (I_2) were main-plot treatments and 6 new wheat genotypes ('HI 1572', 'HI 1500', 'LOK 1', 'MP 3288', 'A 9-30-1' and 'HD 8627') were in subplots. Wheat genotypes as per treatment were sown on 15 and 18 November in 2010 and 2011 respectively. All other cultivation practices were adopted as per recommendations. The rainfall

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received 68.6 and 27.6 mm during the crop season of 2010–11 and 2011–12 respectively.

The chlorophyll content index was measured by chlorophyll meter (Opti-sciencesmodel- CCM-200) at maximum foliage stage (i.e. 65 days after sowing) of the crop. The roots of crop were collected after excavating a soil column (50 cm length × 22.5 cm width ×100 cm depth) and displacing soil by water through a jet nozzle. The roots on per plant basis were computed by dividing it by number of plants in 50 cm row length. Root volume was estimated by water displacement method using a measuring cylinder. Mean root diameter was measured by a screw gauge and roots length was measured by spreading roots over transparent paper after blotting excess water. Water-use efficiency (WUE) was calculated by dividing yield with total consumptive use of water (cm) by all components (Sinclair *et al*., 1984).

RESULTS AND DISCUSSION

Chlorophyll content and root characteristics

Irrigation: There was a significant increase in the chlorophyll index recorded at maximum growth stage due to increase in number of irrigations during both the years (Table 1) The maximum pooled chlorophyll index was recorded in 'HI 8627' followed by 'HI 1572'; it was lowest in 'Lok 1'. The root characteristics of all the varieties showed drastic changes due to application of irrigation water. The root length was significantly higher due to application of single irrigation over no irrigation to the crop, but further increase in number of irrigation (2 irrigations) did not produce any substantial increase in root length. This indicated that root development due to first irrigation exploited water from increased soil volume. The result indicates that at least 1 irrigation should be applied to wheat under dryland conditions. The root volume of crop also showed similar effect of irrigation but there was a significant increase in root diameter due to increased numbers of irrigations. These findings indicate that application of irrigation to wheat crop always favours root development and promotes crop growth. These results are in conformity with earlier observation by Xue *et al*. (2003) and Zhang *et al.* (2004).

Variety: Wheat varieties differed significantly in root length, diameter and volume. Wheat variety 'HI 8627' had the longest roots, while 'MP 3288' had the shortest roots. As regards, root diameter 'HI 1500' and 'A 9-30-1' had the thickest roots, while 'HI 1572' had the thinnest roots. Root volume was the most in 'HI 1500' and least in 'HI 1572'.

Table 1. Chlorophyll content and root parameter of different varieties of wheat as influenced by irrigation (pooled data of 2 years).

Treatment	Chlorophyll content index	Root length (cm)	Root diameter (mm)	Root volume (cm^3/ plant)
Irrigation schedules				
No irrigation (I_0)	25.8	16.2	1.5	0.27
1 irrigation at CRI stage (I_1)	29.7	23.0	1.9	0.46
2 irrigations at CRI and late tillering stages (I_2)	33.8	22.6	2.7	0.47
SEm±	0.21	0.33	0.15	0.01
CD (P=0.05)	0.82	1.09	0.48	0.03
Genotypes				
'HI 1572'	31.2	20.9	1.6	0.30
'HI 1500'	26.5	21.6	2.2	0.42
'Lok 1'	24.7	20.9	2.1	0.34
'MP 3288'	30.0	17.3	2.1	0.40
'A 9-30-1'	29.9	18.7	2.2	0.33
'HI 8627'	36.3	24.0	2.0	0.63
SEm±	0.57	0.26	0.09	0.02
CD (P=0.05)	1.63	0.74	0.27	0.06

CRI, Crown-root initiation

Yield attributes, yield, WUE, and economics

Irrigation: Spikes/m and spike length were significantly increased by the first irrigation only, there being no further significant increase, when 2 irrigations were given (Table 2). On the other hand, grains/spike of wheat significantly increased with each successive irrigation, showing the importance of water in grain formation. An increase in harvest index was recorded only when 2 irrigations were applied. However, 1,000-grain weight of wheat and water-use efficiency were the highest when irrigation was not applied. The lower WUE associated with higher soil moisture status was due to proportionately increase in evapotranspiration than the increase in seed yield. The results are in line with the findings of Thakral *et al.* (1997) and Ahmad *et al.* (2005). Bolder grains and low yield of wheat are characteristic of dryland agriculture. However the benefit: cost ratio was the highest with 2 irrigations. These results confirm those of Behera *et al.* (2002) and Kibe and Singh (2003).

Variety: Wheat varieties differed significantly in their yield attributes. Spikes/m were maximum in 'HI 1572' and 'HI 15000', which were at par and had significantly more spikes/m than 'Lok1' and 'MP 3288', which had in turn significantly more than 'A 9-30-1' and 'HI 8627' (Table 2). As regards grains/spike, wheat varieties 'HI 1572', 'HI 1500', 'Lok 1' and 'MP 3288' were at par and had significantly more grains/spike than 'A 9-30-1' and 'HI 8627'. 'MP 3288' had the longest spikes, significantly longer than 'HI 1572' and 'Lok 1', which were at par and had

Table 2. Yield attributes, grain yield, water use efficiency (WUE) and economics of wheat cultivars as influenced by irrigations

Treatment	Spike/m	Grains/ spike	Spike length (cm)	1,000-grain weight (g)	Grain yield (tonnes/ ha)	Harvest index (%)	WUE (kg/ha/ cm)	Net returns (₹/ha)	Benefit: cost ratio
Irrigation schedules									
No irrigation (I_0)	225	41.2	7.9	36.7	2.11	33.0	367	26,090	2.5
1 irrigation at CRI stage(I_1)	256	42.8	8.2	34.7	3.10	34.6	273	45,420	3.5
2 irrigations at CRI and late tillering stages (I_2)	263	44.4	8.3	34.2	3.65	36.7	137	55,710	4.0
SEm±	8.7	0.44	0.08	0.28	0.02	0.8	10.8	-	-
CD (P=0.05)	34.1	1.45	0.27	0.92	0.09	2.6	31.3	-	-
Genotypes									
'HI 1572'	292	43.8	8.6	30.4	3.40	37.8	305	51,720	3.9
'HI 1500'	260	42.3	8.2	32.3	2.44	31.2	215	31,720	2.8
'Lok 1'	244	43.0	8.5	39.9	3.04	33.2	265	44,200	3.5
'MP 3288'	258	44.1	9.3	37.1	3.25	35.7	279	48,510	3.7
'A 9-30-1'	214	41.3	7.2	35.1	2.47	36.4	216	32,410	2.8
'HI 8627'	220	42.1	7.0	34.8	3.14	34.4	276	46,140	3.6
SEm±	11.4	0.66	0.09	0.42	0.05	1.0	5.7	-	-
CD (P=0.05)	32.9	1.91	0.26	1.35	0.13	3.0	17.9	-	-

significantly longer spikes than 'A 9-30-1' and 'HI 8627'. 'LOK 1' had the highest 1,000-grain weight, while 'HI 1572' had the lowest 1,000-grain weight. 'HI 1572' recorded the highest-grain yield, significantly more than 'MP 3288' and 'HI 8627', which were at par. The lowest grain yield was recorded was recorded for 'HI 1500', which was at par with 'A 9-30-1'. Water use efficiency (WUE), net return and benefit: cost ratio followed the same pattern as grain yield and the top 3 varieties were in order of: 'HI 1572' > 'MP 3288' 'HI 8627'. A close examination of the yield attributes shows the main yield contributing character for 'HI 1572' was spikes/m, while the main contributing factor for 'MP 3288' was spike length. On the other hand 'HI 8627' had the highest root volume and chlorophyll content (Table 1).

I irrigation at crown-root initiation can contribute considerably towards chlorophyll content, root development and grain yield in wheat in Madhya Pradesh. Wheat varieties differed considerably in chlorophyll content, root characteristics and yield attributes. In wheat variety 'HI 8627', increased root volume and chlorophyll content could be the major contributor towards an increase in grain yield, on the other hand spikes/m could be mainly responsible for increased yield in 'HI 1572'. Spike length could be the major contributor towards high yield in 'MP 3288'.

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