WATER PRODUCTIVITY OF BARLEY CULTIVARS IN RELATION TO ROW SPACING AND MOISTURE REGIMES PLANTED ON RAISED BEDS

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SUMMARY

A field experiment was conducted during **rabi** 2011-12 at Research Farm, CCS Haryana Agricultural University, Hisar, Haryana (India) in a semi-arid climate to study the water productivity of barley cultivars in relation to row spacing and moisture regimes planted on raised beds. The experiment was laid out in split plot design with three replications keeping three cultivars viz., BH 393, BH 902 and BH 885 and two rows spacing viz., 2 rows per bed and 3 rows per bed (70 cm wide with 40 cm top and 30 cm furrow) in main plots and three moisture regimes (irrigation at IW/CPE 0.3, 0.4 and 0.5) in sub-plots. The results revealed that maximum soil moisture depletion, ground water contribution and total water use were recorded in BH 902, followed by BH 393 and BH 885. Productivity of irrigation and total water use was highest under BH 902, followed by BH 393 and BH 885. Among two row spacing, soil moisture depletion, ground water contribution and total water use were recorded higher in 3 rows per bed than 2 rows per bed. Comparatively higher irrigation and total water productivity were achieved in barley planted on raised beds with 3 rows per bed than 2 rows per bed. Among three moisture regimes, the soil moisture depletion and ground water contribution at 60 DAS to maturity, decreased with increase in moisture regime from irrigation at IW/CPE 0.3, to irrigation at IW/CPE 0.4 or 0.5. But total water use was increased with increase in moisture regime, being similar with irrigation at IW/CPE 0.4 and 0.5. The irrigation water productivity decreased with increasing moisture regime. However, productivity of total water use increased with increase in moisture regimes.

Key words : Spacing, moisture regimes, raised bed planting, productivity, barley

Barley (*Hordeum vulgare* L.) is the fourth largest cereal crop in the world, with a share of 7 per cent of the global cereals production and 15 per cent of coarse grains consumption, used in animal feed, malting and food products. World over, barley is cultivated in about 54 million hectares area with production of 124 million tonnes (FAO, 2012). In India, barley is grown on 0.649 million hectares area with 1.608 million tonnes production and average yield of 2480 kg/ha and it is largely confined to North-West region (Anonymous, 2012). Although, production is low, the country is self sufficient in barley, besides annual export of 0.1-0.2 million tonnes.

Barley is commonly grown in India under restricted irrigation conditions, following conventional system of flat sowing and flooded irrigation, which is conducive to excessive irrigation water use, downward leaching of native and applied nutrients, periodic aeration stress and high mechanical resistance. The good quality water resources have started depleting, which has been continuing in agriculture for many years, resulting into fall in water table and this is likely to continue in the future. It is, therefore, imperative to carefully examine every potential solution that can contribute to savings in water use in modern agriculture. The research activities initiated about 30 years ago on bed and furrow system by the scientists of International Crop Research Institute for Semi-Arid Tropics (ICRISAT) showed that this system worked best in areas of dependable rainfall averaging 750-1250 mm per year. During recent years, furrow irrigated raised bed planting system (FIRBS) has proved to be one of the important components of low cost sustainable production system for crop production in several parts of the world, including India. Sowing of crops under FIRBS is a relatively new technology in

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India, in which the crop is sown in 2 rows or 3 rows on the top of raised beds (about 70 cm wide, with 40 cm top and 30 cm furrow). Soil moisture is also one of the most important factors which influences the availability of water and nutrients to plants. Interval of irrigation application greatly influences the soil moisture and hence, the grain yield of barley. Kumar and Agarwal (1991) reported that the increase in grain yield with 1 and 2 irrigations was 23.6 to 37.7 per cent and 17.1 to 28.6 per cent over the control, respectively. Further increase in irrigation frequency to 3 irrigations could not result in yield increase. Gupta *et al*. (1999) reported that progressive increase in irrigation regimes from IW/CPE 0.2 to 0.6 significantly improved grain yield of barley. However, the differences in grain yield between IW/CPE 0.4 and 0.6 were not significant. Since, barley is grown in limited irrigation condition in semi-arid region of Haryana, it is important to quantify the level of moisture regime under FIRBS planting to maximize the yield and water productivity.

In Haryana, planting of barley on beds is a recent technology and information on the response of barley cultivars for their suitability under FIRBS in respect to grain yield and water use efficiency is lacking. Keeping this in view, the present investigation was carried out during **rabi** season of 2011-12 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar.

MATERIALS AND METHODS

The experiment was conducted during **rabi** 2011-12 at Research Farm of CCS Haryana Agricultural University, Hisar, Haryana (India) situated at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level in a semi-arid climate. The experimental treatments consisted of combination of three cultivars viz., BH 393, BH 902 and BH 885 and two rows spacing viz., 2 rows per bed and 3 rows per bed (70 cm wide with 40 cm top and 30 cm furrow) in main plots and three moisture regimes (irrigation at IW/CPE 0.3, 0.4 and 0.5) in sub-plots. Experiment was laid out in split plot design with three replications. The experiment was sown on 11 December 2011 with the help of bed planter using recommended seed rate. The size of the bed was 70 cm with 40 cm top and 30 cm furrow. Two rows of barley were sown on top of beds by maintaining 20 cm spacing between the two rows and 10 cm on both sides of the top, while three rows of barley were sown on top of beds by maintaining a row to row spacing of 10 cm and 10 cm on both sides of the top. Irrigations were applied as per treatments based on IW/CPE in individual plots and the depth was measured with the help of current meter. The IW/CPE ratios were calculated based on depth of irrigation water and the cumulative pan evaporation during the particular period. Only one pot-sown irrigation (64 mm) was applied in the treatments IW/CPE 0.3 but two irrigations were applied in each treatment IW/CPE 0.4 (116 mm) and IW/CPE 0.5 (117 mm).

RESULTS AND DISCUSSION

Soil Moisture Depletion

Among cultivars, BH 902 had maximum soil moisture depletion followed by BH 393 due to increased evapotranspiration demand owing to higher growth and LAI (Table 1 and Fig. 1). The cultivar BH 885 depleted minimum soil moisture due to lower growth habit of the crop. Planting of barley on raised beds with 3 rows per bed had higher soil moisture depletion than 2 rows per bed. This was due to higher crop water requirement owing to increased LAI and hence increased ET demand.

Among moisture regimes, the depletion of soil moisture was higher with irrigation at IW/CPE 0.3 which decreased with increasing moisture regime to irrigation at IW/CPE 0.4 and 0.5. Under deficit irrigation moisture regime (IW/CPE 0.3) relatively less amount of irrigation water was applied and the crop extracted more water from the soil profile to meet its metabolic requirement. These results are in corroboration with those of Kumar and Dhindwal (2009) and Bandyopadhyay and Mallick (2003).

Ground Water Contribution

Among cultivars, BH 902 used maximum ground water followed by BH 393 and BH 885 due to high ET demand for higher crop growth (Table 1 and Fig. 1). Planting of barley on raised beds with 3 rows per bed resulted in higher ground water contribution than 2 rows per bed. Higher depletion of ground water in 3 rows per bed may be to meet out the higher ET demand to achieve higher growth and yield.

Among moisture regimes, the ground water contribution was higher with irrigation at IW/CPE 0.3 and decrease with increase in moisture regime to IW/CPE 0.4 or 0.5. This was due to compensate the low water supply through irrigations under deficit irrigations (IW/CPE 0.3), the roots of plants penetrate deeper to meet out the ET demand for growth. These results were supported by Kumar and Dhindwal (2009).

Total Water Use

Among barley cultivars planted on raised beds, total water use was maximum (28.1 cm) in BH 902 followed by BH 393 (27.0 cm) and minimum in BH 885 (25.5 cm). This increase in total water was higher owing to increased depletion of soil moisture and ground water use. Planting of barley on raised beds with 3 rows per bed used 27.2 cm total water, which was 2.3 per cent higher than 2 rows per bed (26.6 cm). The increased demand for total water was met out by soil moisture depletion and ground water use. The increase in total water use was achieved through increased depletion of soil moisture and ground water from shallow water table to compensate the higher water losses with increased ET due to higher growth of the crop (Table 1 and Fig. 1).

Among moisture regimes, irrigation at IW/CPE 0.4 and 0.5 had higher total water use than irrigation at IW/CPE 0.3. This was due to difference in frequency of irrigation application. Two irrigations were given on the basis of IW/CPE at 0.4 and 0.5, as compared to single irrigation in IW/CPE at 0.3. However, soil moisture depletion and ground water contribution were higher under IW/CPE at 0.3, to compensate short supply of water through irrigation. These results were corroborated with results of Singh *et al.* (2012) in barley. Chavan and Pawar (1988), Maurya and Singh (2008) and Kumar and Dhindwal (2009) also reported similar findings in wheat.

Grain Yield

The grain yield of barley was significantly influenced by cultivars (Table 2). BH 902 produced maximum grain yield which was marked superior to BH 393 and BH 885. This increase can be ascribed to higher number of productive tillers and 1000-grain weight in

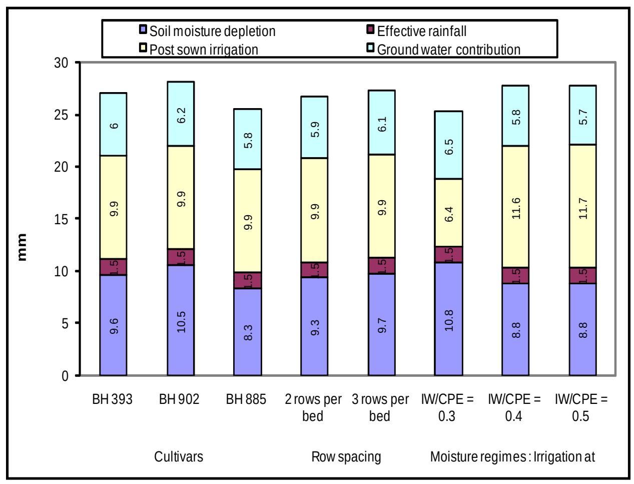

Fig. 1. Water use from different sources in barley as influenced by different treatments.

TABLE 1

Water use in bed planted barley under different treatments

Treatment	Amount of water use (cm)				
	Soil moisture depletion	Effective rainfall	Post-sown irrigation	Ground water contribution	Total water use
Cultivars					
BH 393	9.6	1.5	9.9	6.0	27.0
BH 902	10.5	1.5	9.9	6.2	28.1
BH 885	8.3	1.5	9.9	5.8	25.5
Row spacings					
2 rows per bed	9.3	1.5	9.9	5.9	26.6
3 rows per bed	9.7	1.5	9.9	6.1	27.2
Moisture regimes : Irrigation at					
IW/CPE=0.3	10.8	1.5	6.4	6.5	25.2
IW/CPE=0.4	8.8	1.5	11.6	5.8	27.7
IW/CPE=0.5	8.8	1.5	11.7	5.7	27.7
S. Em±	141	-	-		
C. D. (P=0.05)	412	-	-		

BH 902. The cv. BH 393 also proved superior to BH 885 in grain yield due to higher number of grains per spike. Planting of barley on raised beds with 3 rows per bed produced significantly higher grain yield than 2 rows per bed. The increase in grain yield can be attributed to higher number of productive tillers. Similar results have been reported by Chauhan *et al.* (2000), Yadav *et al.* (2002), Virdi (2003), Rinwa (2003), Kumar *et al.* (2005) and Kumar *et al.* (2010).

Among the moisture regimes, the increase in moisture regime from irrigation at IW/CPE 0.3 to IW/CPE 0.4 or 0.5 resulted in significant increase in grain yield. This can be ascribed to higher number of effective tillers, grains per spike and 1000-grain weight due to better micro environmental conditions for growth and development of barley crop under irrigation at IW/CPE 0.4 and 0.5 (two irrigations). Singh *et al.* (2012) also reported significant increase in grain yield with increased IW/CPE. These results are in conformity with the results of Garg and Saraswat (1973), Warsi and Lal (1979), Gupta *et al.* (1999) and Mammnouie *et al.* (2006).

Water Productivity

Water productivity showed negative relationship with water use i. e. higher water productivity with low water use and vice-versa (Table 2 and Fig. 2). Among the cultivars, BH 902 had comparatively higher productivity for irrigation and total water than BH 393 and BH 885. This can be ascribed to the higher yield potential of BH 902 and increased use of soil moisture and ground water to meet out water requirement. Planting of barley on raised beds with 3 rows per bed resulted in higher irrigation and total water productivity than 2 rows per bed.

This increase in water productivity can be attributed to more efficient use of soil moisture and ground water under 3 rows per bed resulting in improved yield.

Irrigation at IW/CPE 0.3 resulted in higher irrigation water productivity than irrigation at IW/CPE 0.4 and 0.5. But, Maximum total water productivity was achieved with irrigation at IW/CPE 0.5, which was slightly higher than irrigation at IW/CPE 0.4, but considerably higher than irrigation at IW/CPE 0.3. This was obviously due to more grain yield in irrigation at IW/CPE 0.5 followed by irrigation at IW/CPE 0.4 and 0.3. Singh *et al.* (2012) also reported significant increase in total water productivity with increased moisture regime. Kumar and Dhindwal (2009) also reported decrease in irrigation water productivity and increase in total water productivity with increase in moisture regimes in wheat.

TABLE 2
Water productivity of bed planted barley under different treatments

Treatment	Grain yield (kg/ha)	Water productivity (kg/ha-mm)	
		Irrigation	Total
Cultivars			
BH 393	4305	43.5	15.9
BH 902	5058	51.1	18.0
BH 885	3338	33.7	13.1
S. Em±	68	-	-
C. D. (P=0.05)	213	-	-
Row spacings			
2 rows per bed	4117	41.6	15.5
3 rows per bed	4351	43.9	16.0
S. Em±	55	-	-
C. D. (P=0.05)	174	-	-
Moisture regimes : Irrigation at			
IW/CPE=0.3	3363	52.5	13.3
IW/CPE=0.4	4589	39.6	16.6
IW/CPE=0.5	4750	40.6	17.1

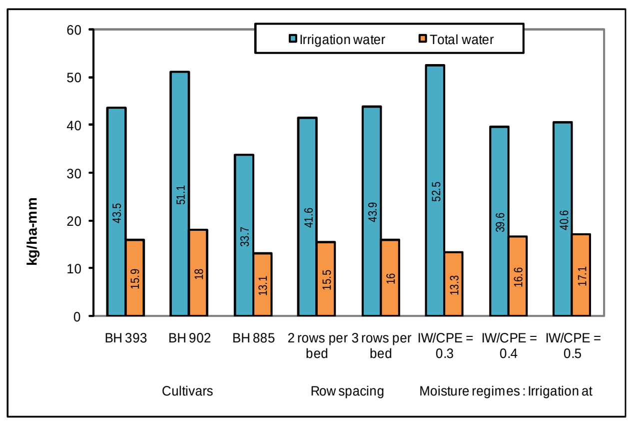

Fig. 2. Water productivity of barley as influenced by cultivars, row spacings and moisture regimes under raised bed planting.

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