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Effect of Mulch and Irrigation Levels on Yield and Quality of Barley (*Hardeum vulgare* L.)

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A field study was carried out at the Banaras Hindu University's Agricultural Research Farm during the *rabi* (dry) seasons of 2013-14 in a Randomized block design (RBD) with three replications, consisting of 9 treatments, namely, T_{1} (6 t/ha mulching + No irrigation), T_2 (6 t/ha mulching + One irrigation at 35 DAS), T_{3} (6 t/ha mulching + Two irrigation at 35 DAS & 85 DAS), T_4 (4 t/ha mulching + No irrigation), T_5 (4 t/ha mulching + One irrigation at 35 DAS), T_6 (4 t/ha mulching + Two irrigation at 35 DAS & 85 DAS), T_7 (No mulching + No irrigation), T_8 (No mulching + One irrigation at 35 DAS) and T_9 (No mulching + Two irrigation at 35 DAS & 85 DAS). The research results indicated that amongst different mulching and irrigation levels, the treatment T_3 recorded expressively higher grain yield, straw yield, quality parameters and nutrient uptake. This in turn resulted in significant improvement in grain, straw yield, biological yield and nutrient uptake in T_3 over remaining mulching and irrigation levels.

Keywords: mulching; irrigation; yield; nutrient content; quality parameter.

Barley (*Hordeum vulgare L.*) is a primitive cereal grain, which upon domestication has evolved largely a food grain to a feed and malting grain. It is frequently being described as the most sophisticated of the crops and also well thought-out, as poor man's crop because of the low input requirement and better adaptability to drought, salinity, and alkalinity and marginal lands. It is fourth important cereal crop in the world after maize, wheat and rice with a share of 7% global cereal production. During 2012-13, globally barley was cultivated on nearly 49 million hectare area with a production of 132 million tones. In India, during 2013-14, barley was cultivated on about 671.1 lakhs hectare area with production of 1752 lakhs tons and productivity of 2580 kg/ha (Anonymous, 2014).

Agriculture production being an integrated interaction effect of soil, water, fertilizer, climate continuum, a wise scientific management of the complex system is essential for enhancing crop productivity on sustained basis without any loss to the environmental ecology. Therefore, the major goal of the present day agriculture is to maximize land and crop productivity without aggressive the environment and the natural resources.

Although, efforts have been made to quantify rates of mulches to conserve moisture and control weeds in many crops, but literature is both scare and limited in respect to its integration with irrigation, especially in barley. Therefore, it is justifiable to quantify the amount of straw mulch in barley with different levels of irrigation.

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MATERIALS AND METHODS

The field experiment was conducted at the Agricultural Research Farm of Banaras Hindu University, Varanasi (83°03' E and 25°18' N; 81.71 m above mean sea level) during *rabi* seasons (November–April) of 2013. The soil of the experimental field was 'sandy clay loam', neutral in reaction (pH 7.2), having 0.34% organic carbon (Walkley and Black method, 1965; Jackson, 1973), 174.6 kg ha^{-1} available N (Alkaline permanganate method, A.O.A.C.,1967), medium levels of available phosphorus (22.6kgha^{-1}, Olsen's method, Jackson,1973) and available potassium (191.5kgha^{-1}, Flame Photometer method, Jackson, 1973) in 0–15 cm soil depth at the start of the experiment. The experiment was laid out in a Randomized block design with three replications. The different treatments (9) were allocated in plots randomly. In all treatments phosphorus (P_2O_5) as DAP, a complex fertilizer containing 46% P_2O_5 and 18% N and potassium (K_2O) as muriate of potash (contains 60% K_2O) were applied at the rate of 30 kg ha^{-1} and 20 kg ha^{-1}, respectively as basal dose in each plot. The nitrogen as urea, an organic fertilizer containing 46% N at rate of 60kg/ha was applied in splits: 1/3 at sowing and 1/3 at first and second irrigation, respectively in irrigation treatments. Entire amount of N was applied at sowing in no irrigation treatment. The crop was irrigated as per treatments. In each irrigation 6 cm of irrigation water was uniformly applied in each plot. Irrigation was applied at 35 DAS and 85 Days after sowing. The variety RD 2552 was taken which is a drought and saline resistant variety of Barley. It has good malting quality with high recovery, desirable protein levels and feed for human being and cattle. It is developed by K.V.K. Durgapur (Rajasthan). This is a six rows cultivar, released for general cultivation in north-eastern and western plain zones. Barley seeds were sown on 29 November 2013 at the rate of 100 kg ha^{-1} in lines; at a row to row distance 20cm. Seeds were sown in furrows opened by the '*kudal'* by manual labor. Crop was harvested when all the ear head turned yellow on 3 April 2014. The net plots were harvested after removing the border rows and were tied, numbered and left out in the field to dry for a 4-5 days. After proper cleaning and winnowing the grain weight of each plot at 12% moisture was recorded. Grain and straw yield were recorded at harvest. Similarly, quality parameters such as N, P and K content and their uptake by grain and straw were estimated. Protein content in grain was estimated by multiplying N content with 6.25.

All the data recorded were statistically analyzed by means of the standard procedures of Randomized block design (Gomez and Gomez, 1984). For determining the significant of difference in between the treatments and to draw valid conclusions, the data obtained were subjected to statistical analysis by 'Analysis of variance' (ANOVA). Once F ratio was significant, a multiple

Table 1. Effect of mulch and irrigation levels on yield characters grain yield, straw yield, biological yield and harvest index on barley

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
6 t/ha mulching + no irrigation	3056.67	7766.67	10823.33	28.24
6 t/ha mulching + one irrigation at 35 DAS	3463.33	8803.33	12266.67	28.23
6 t/ha mulching + two irrigation at 35 DAS & 85 DAS	3580.00	9570.00	13150.00	27.22
4 t /ha mulching + no irrigation	2923.33	7576.67	10500.00	27.85
4 t/ha mulching + one irrigation at 35 DAS	3246.67	8656.67	11903.33	28.37
4 t/ha mulching + two irrigation at 35 DAS & 85 DAS	3383.33	8900.00	12283.33	27.55
No mulching + no irrigation	2666.67	6816.67	9483.33	28.13
No mulching + one irrigation at 35 DAS	2783.33	7340.00	10123.33	27.33
No mulching + two irrigation at 35 DAS & 85 DAS	3260.00	8403.33	11663.33	27.95
SEm±	51.64	183.62	225.39	0.42
CD (P=0.05)	154.81	550.47	675.70	NS

mean comparison was performed using Fisher's Least Significance Difference Test (0.05 probability level).

RESULTS

Yield characters

Grain yield

Critical appraisal of data showed that highest grain yields (3580.00 kg/ha) was obtained in6 t/ha mulching + two irrigation at 35DAS & 85DAS (T_3) which was at par with 6t/ha mulching + one irrigation at 35 DAS (T_2). It was significantly superior to rest of treatments (Table 1). Significantly minimum grain yield (2666.67 kg/ha) recorded under No mulching + no irrigation treatment (T_7). It is also evident from data that under no irrigation treatment significantly higher grain yield was recorded with 6 t/ha mulching than no mulching treatment whereas, it remained at par with 4 t/ha mulching.

Straw yield

Perusals of data reveals that maximum straw yield (9570.00kg/ha) was obtained in 6t/ha mulching with two irrigation at 35DAS & 85DAS (T_3) which was at par with 6 t/ha mulching + one

Table 2. Effect of mulching and irrigation levels on nutrients content in grains and straw on barley

Treatment	Nutrients content in grains (%)			Nutrients content in straw (%)		
	N	P	K	N	P	K
6 t/ha mulching+ no irrigation	1.55	0.37	0.42	0.46	0.036	0.887
6 t/ha mulching+ one irrigation at 35 DAS	1.64	0.38	0.53	0.58	0.038	1.010
6 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	1.76	0.44	0.56	0.63	0.039	1.079
4 t /ha mulching+ no irrigation	1.54	0.35	0.42	0.45	0.035	0.868
4t/ha mulching+ one irrigation at 35 DAS	1.58	0.36	0.52	0.57	0.037	0.995
4 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	1.66	0.39	0.54	0.60	0.039	1.057
No mulching+ no irrigation	1.48	0.33	0.40	0.45	0.029	0.865
No mulching+ one irrigation at 35 DAS	1.57	0.34	0.47	0.54	0.033	0.973
No mulching+ two irrigation at 35 DAS & 85 DAS	1.60	0.35	0.50	0.56	0.036	0.998
SEm±	0.05	0.02	0.02	0.04	0.00	0.05
CD (P=0.05)	0.16	0.07	0.07	0.11	NS	NS

Table 2.1 Effect of mulching and irrigation levels on nutrients uptake in grains and straw on barley

Treatment	Nutrients content in grains (%)			Nutrients content in straw (%)		
	N	P	K	N	P	K
6 t/ha mulching+ no irrigation	47.38	11.31	12.84	35.73	2.80	68.89
6 t/ha mulching+ one irrigation at 35 DAS	56.80	13.16	18.36	51.06	3.35	88.91
6 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	63.01	15.75	20.05	60.29	3.73	103.26
4 t /ha mulching+ no irrigation	45.02	10.23	12.28	34.10	2.65	65.77
4t/ha mulching+ one irrigation at 35 DAS	51.30	11.69	16.88	49.34	3.20	86.13
4 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	56.16	13.19	18.27	53.40	3.47	94.07
No mulching+ no irrigation	39.47	8.80	10.67	30.68	1.98	58.96
No mulching+ one irrigation at 35 DAS	43.70	9.46	13.08	39.64	2.42	71.42
No mulching+ two irrigation at 35 DAS & 85 DAS	52.16	11.41	16.30	47.06	3.03	83.87
SEm±	2.04	0.64	0.78	3.27	0.21	5.44
CD (P=0.05)	6.12	1.92	2.33	9.79	0.63	16.32

Table 3. Effect of mulching and irrigation levels on grain protein content and protein yield on barley

Treatment	Protein content (%)	Protein yield (kg/ha)
6 t/ha mulching+ no irrigation	9.69	296.19
6 t/ha mulching+ one irrigation at 35 DAS	10.25	354.99
6 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	11.00	393.80
4 t /ha mulching+ no irrigation	9.63	281.52
4t/ha mulching+ one irrigation at 35 DAS	9.88	320.77
4 t/ha mulching+ two irrigation at 35 DAS & 85 DAS	10.38	351.19
No mulching+ no irrigation	9.25	246.67
No mulching+ one irrigation at 35 DAS	9.81	273.04
No mulching+ two irrigation at 35 DAS & 85 DAS	10.00	326.00
SEm±	0.47	16.54
CD (P=0.05)	1.41	49.60

irrigation at 35 DAS (T_2). It was significantly superior to rest of treatments (Table 3). Significantly minimum grain yield (6816.67 kg/ha) recorded under No mulching +no irrigation treatment (T_7). Further data indicate that highest straw yield was recorded in 6 t/ha mulching than no mulching treatment whereas, it was remained at par with 4 t/ha mulching.

Biological yield and harvest index

It is evident from the data that maximum biological yield (13150.00kg/ha) was recorded in6 t/ha mulching + two irrigation (T_3) which was at par with 6 t/ha mulching + one irrigation (T_2). It was significantly superior to rest of treatments (Table 1). Significantly minimum biological yield (9483.33kg/ha) was recorded under No mulching + no irrigation treatment. It is apparent from the data that the irrigation and mulching levels failed to cause significant variation in harvest index.

Nutrients content and nutrient uptake by crop

Data related to N, P, K content (%) in grain and straw and their uptakes by crop (kg ha^{-1}) at harvest are presented in (Table 2 and 2.1).

The nitrogen content in grains and straw and its uptake as affected by different mulching treatments was found to be significantly highest with 6 t/ha mulching+ two irrigation (T_3) which was at par with 4 t/ha mulching + two irrigation (T_6) and 6 t/ha mulching + one irrigation (T_2) and was significantly superior with rest of treatments. However, lowest N content in grain (%) was recorded in No mulching + no irrigation (T_7) treatment.

Similarly, N uptake by grain (kg ha^{-1}) was found to be in maximum with 6 t/ha mulching + two irrigation which was at par with 6 t/ha mulching + one irrigation (T_2). It was significantly superior to rest of treatments. However, lowest N uptake by grain was recorded in no mulching + one irrigation (T_7).

Perusal of data indicate that significantly highest P content in grain (%) was recorded with 6 t/ha mulching + two irrigation (T_3) which is at par with 4 t/ha mulching + two irrigation at 35 (T_6) and 6 t/ha mulching + one irrigation (T_2). It was significantly superior to rest of treatments. However, lowest P content was recorded in No mulching with no irrigation (T_7) treatment. Data further indicate that P content in straw was not affected by treatments under study.

In case of P uptake (kg ha^{-1}) by grain and straw, significantly highest P uptake was recorded with 6 t/ha mulching with two irrigation (T_3) which is at par with 4 t/ha mulching + two irrigation (T_6) and 6 t/ha mulching + one irrigation at 35 DAS (T_2). It was significantly superior to rest of treatments. However, lowest P uptake by grain was recorded in no mulching + no irrigation treatment (T_7).

It is also evident from data that under no irrigation treatment significantly higher P content and uptake by grain was recorded with 6 t/ha mulching than no mulching treatment. Whereas, it remained at par with 4 t/ha mulching.

The data on potassium content and uptake by crop indicate that significantly highest

K content in grain was also recorded in 6 t/ha mulching + two irrigation (T_3) which is at par with 6 t/ha mulching + one irrigation (T_2) and 4 t/ha mulching, one irrigation (T_5). It was at par to rest of treatments. However, lowest K content in grain was found in No mulching + no irrigation (T_7) treatment. It is also clear from the data that treatments failed to cause significant variation in K content in straw.

The K uptake (kg ha^{-1}) by grain and straw was maximum in 6 t/ha mulching+ two irrigation (T_3) which was significantly superior to mulching + no irrigation treatments, but at par with rest of the treatments. However, lowest K uptake by grain was in No mulching + no irrigation (T_7) treatment.

A perusal of data presented in (Table 3) indicates that protein content in grains did not differ significantly due to mulching levels. However, significant effect of mulching and irrigation levels was recorded on grains protein yield. The maximum protein yield was obtained with 6 t/ha mulching + two irrigation (T_3) which was at par 6 t/ha mulching + one irrigation (T_2) and 4 t/ha mulching+ two irrigation at (T_6). It is also evident from data that under no irrigation treatment significantly higher protein content and uptake by grain was recorded with 6 t/ha mulching than no mulching treatment.

DISCUSSION

Yield characters

The development of yield is dependent on the dry matter production and its translocation for the formation of yield contributing parameters in crop plants. Mulching at 6 t/ha + two irrigation (T_3) recorded higher grain yield than 6 t/ha mulching + one irrigation (T_2), 6 t/ha mulching + no irrigation (T_1) and 4 t/ha mulching + one irrigation (T_5). The minimum grain yield was obtained in no mulching + no irrigation (T_7). These results can be positively correlated with the value of yield attributing characters in different treatments. Thus, treatments with relatively more number of ear heads/plant, grains/ear head and 1000, grains weight produced higher grain yield than those having lower value of yield attributes. These results are in line with those of Khurshid *et al*. (2006), who reported that mulch increases the soil moisture and nutrients availability to plant roots, in turn, leading to higher grain yield. Similar to grain yield, straw yield was also significantly more in mulching at 6 t/ha + two irrigation (T_3) than 6 t/ha mulching + one irrigation (T_2), 6 t/ha mulching + no irrigation (T_1) and 4 t/ha mulching + one irrigation at (T_5). The minimum grain yield was obtained in no mulching + no irrigation (T_7). The higher straw yield in the T_3 than other treatment might be due to taller plants, more number of tillers, higher LAI and consequently maximum dry matter accumulation than treatments with relatively low straw yield. Several researchers (Din *et al*., 2013 and Rajput *et al*., 2014) have also reported increase in grain and straw yield in crops due to mulching.

Nutrient content uptake by grain and straw

Significantly higher content and uptake of N, P and K in grain and N content and N, P and K uptake in straw was recorded with 6 t/ha mulching + two irrigation at 35 DAS & 85 DAS (T_3) when compared with other treatments, except its application with one irrigation and 4 t/ha mulching + two irrigation Whereas, it was lowest in no mulching + no irrigation. The significant increase in nutrient content in T_3 as compare to rest of treatments can be discussed in light of fact that plants absorb most of nutrients from soil solution and water act as solvent for nutrients. Therefore, treatments having higher and continuous water availability resulted in higher uptake of nutrients as expressed in nutrient content in grains and straw. These findings are in agreement with Acharya and Sharma (1994) who reported that mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding un-mulched treatments.

Protein content and protein yield

Protein content and its uptake by grains were also significantly maximum in 6 t/ha mulching + two irrigations than treatments where irrigation was not applied either with or without mulching. This can be attributed to higher N content and grain yield in treatments where irrigation was applied with mulch in comparison to 6 t/ha mulching + two irrigation at 35 DAS & 85 DAS (T_3) un irrigated crop.

CONCLUSION

Mulching at 6 t /ha + two irrigation at 35 DAS and 85 DAS has been found most effective

in improving grain, straw and biological yield of barley in Varanasi region of Eastern Uttar Pradesh. Significantly increase in nitrogen, phosphorus and potassium content and uptake by grain and straw and also the protein yield in grain was recorded in mulching at 6 t/ha + two irrigation.

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