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Effect of Mulching & non-mulching and Irrigation on growth characters in Barley (*Hordeum vulgare* L.)

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Abstract
An investigation was conducted in *rabi* season of 2013-14 at Genetics and Plant Breeding Research Farm of Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad to compare mulching and non-mulching treatments with respect of growth characters of barley and to study the effect of irrigation on growth characters of barley crop. The experiment was laid out in Split Plot design (SPD) with 9 treatment combinations *viz*. Under irrigation treatments; $\mathbf{I_0}$: No irrigation, $\mathbf{I_1}$: One irrigation and $\mathbf{I_2}$: Two irrigations and under mulching treatments; $\mathbf{M_0}$: No mulching, $\mathbf{M_1}$: 4t/ha mulch materials & $\mathbf{M_2}$: 6t/ha mulch materials with three replications. Irrigations management Treatments affects significantly with Treatment $\mathbf{I_2}$ (Two irrigations) was found best over control treatment and being at par with $\mathbf{I_1}$ (One irrigation) in all aspects of growth parameters *i.e.*
Plant height (86.0 cm), Number of shoots (393.66), Leaf area index (4.57) and Dry matter accumulation (696.50 g). Under Mulching management, Treatment $\mathbf{M_2}$ (6t/ha mulch materials) was found significantly superior with Plant height (85.33 cm), no. of shoots (386.33), dry matter accumulation (668.67 g) and leaf area index (4.54) as compared to other treatments.

Keywords: Mulching and Non-mulching, Irrigation, Growth characters, Barley.

Introduction
Barley (*Hordeum vulgare* L.) is the world's fourth most important cereal after wheat, rice and maize. In India, it is popularly known as "Jau" and it is grown from equator to 700 North, from humid region of Europe and Japan to Sahara and Oaces below sea level in Palestine to high up mountain of Himalayas, East Africa and South America. It is staple food of the people in Tibet, Nepal and Bhutan. The barley is grown all-round the year in the world and highest yield is obtained in Europe. India ranks 7th in world in respect to total area and production. In India barley crop is grown over an area of 0.695 m ha with a production of 1.74 mt and productivity of 25.1 q ha^{-1} (Anonymous, 2013) [1]. Uttar Pradesh is one of the most important barley growing sates of India, which produces nearly half of India's total production. In Uttar Pradesh, the area under cultivation of barley is about 168 thousand ha with a production of 441 thousand tones and productivity of 26.3 q ha^{-1} (Anonymous, 2013) [1]. Half of the total area under this crop is irrigated and rest remains rainfed. The priority researchable area in barley agronomy includes input management under resource poor conditions, fine-tuning of sowing date under changing climatic condition, investigation on dry/marginal lands, limited and brackish water resource, late sowing conditions, saline-alkali soils and resource poor farmer, malt barley under good management conditions and dual purpose barley in dry land. In spite of the fact that the crop is being grown mostly on marginal and problematic lands, there is an increasing trend in the average grain productivity per unit area during recent years. Evidence of the beginning of cultivation of barley goes back to the Middle East about nine thousand years ago. It is fifth largest cultivated cereal crop andan important winter cereal crop in the Northern Plains of India, comprising the states of Uttar Pradesh, Haryana, Rajasthan, Punjab, Madhya Pradesh, Himachal Pradesh and Uttarakhand.
Archeological evidence suggests that in the past, barley known as "Indra Jau" was more popular in every religious ceremony as sacred grain. Today barley is widely grown for animal feed and for making malt and beer and many health tonics like horlick, maltova and barley syrups. However, it is still an important staple food for the several peoples. Due to hardy and versatile nature, barley can be grown in various agro-climatic situations. It requires cool

weather during early growth and warm dry weather at maturity. The crop possesses very high degree of tolerance to drought and salt. Being a salt tolerant crop, its area can be increased by bringing more saline area under its cultivation.

In India, the productivity of barley is still below the world average because it is cultivated under minimum input management conditions. In recent years, the increasing demand of malting and brewing industries as well as the need for diversification of wheat cultivation has given some impetus to the barley cultivation under better managed conditions and it may be expected further rise in the productivity of barley. Internationally, China, Australia and Canada are the major exporters. Australia and Canada are far away located from the Asian markets of China, Japan and other high beer consuming countries which either grows less or no barley but need barley or malt or malt extract for beer making. There is an opportunity for export of malt or malt extract or barley from India at competitive price. The demand for the malt barley from industry is on the rise which is presently nearly 18-20 per cent of the total barley production in the country. However, even this much amount is not available with the desired malting quality and the industry is facing a lot of difficulty in processing as well as economy of the Indian malt with the international standards.

Irrigation and its scheduling is an important factor that governs the evapo-transpiration, water use efficiency and moisture extraction pattern of the crop in a particular environment. The irrigation requirement may be changed due to use of different type of mulching materials. The results of the study on the effect of different types of mulch and irrigation scheduling on yield, soil moisture status and water use efficiency of barley crop grown in winter season, reveal that application of surface mulch enhance the productivity significantly by improving soil moisture status over no mulch treatment. Application of mulch not only improves the productivity but also reduces the number of irrigations. It has been observed that due to the high price of synthetic mulch the economic gain was maximum under locally available mulch material i.e. straw and leaves of plants. The mulches of various materials have been shown to provide control of weeds and insect pests in various crops. Some mulches have been shown to hasten plant growth but increase of the yields through the alteration of soil moisture and temperature of soil. Exposed to heat, wind, and compacting forces, soil loses water through evaporation and is less able to absorb rainfall or irrigation as it becomes increasingly compressed. Weeds can increase evapotranspiration of soil moisture by 25% in a hot day. Mulches may increase soil water by increasing percolation and retention, reducing evaporation and reducing weeds. An early study demonstrated that a layer of straw only 3.8 cm thick reduced evaporation about 35%. The mulches may initially increase soil water retention since evaporation is reduced. Mulches protect soils from extreme temperatures and kept soils cooler in hot conditions and warmer in cold conditions. The impacts of mulches on soil temperature have been well documented and it is clear that some mulches heat the soil as a function of solar radiation during the winter. The irrigation requirement may be changed due to use of different type of mulching material. Mulching increases the infiltration of water in to the soil through run off control and increasing opportunity time to infiltration, reduces the evaporation loss. Keeping all above facts in view the present study was undertaken to compare mulching and non-mulching treatments with respect of growth characters of barley and to study the effect of irrigation on growth characters of barley crop.

Materials & Methods

The present investigation was under taken during *rabi* 2013-14 at the Genetics and Plant breeding Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The experimental site falls under subtropical climate in Indo-Gangetic plains having alluvial calcareous soil and lies between 26°47' North latitude and 82°12' East longitude at an altitude of 113 m from mean sea level. The region receives annual rainfall ranging from 1000-1200 mm and 90 per cent of which is received in Mid-June to end of September. The soil of the experimental field was silt loam, having pH 8.1, organic carbon 0.38, available N, P and K 203.0 kg ha^{-1}, 15.25 kg ha^{-1} and 265.0 kg ha^{-1} respectively. The seeds were sown at proper moisture on 25th December 2013 of variety JB-1. Sowing was done in rows 23 cm apart. A certified seed was used at the rate of 100 kg ha^{-1}. The experiment was laid out in Split Plot design (SPD) with 9 treatment combinations *viz*. Under Irrigation treatments; **I_0:** No irrigation, **I_1:** One irrigation & **I_2:** Two irrigations and under mulching treatments; **M_0:** No mulching, **M_1:** 4t/ha mulch materials, **M_2:** 6t/ha mulch materials with three replications.

Observations were recorded at different growth stages of barley. For Initial plant population counting number of shoots a 0.92 cm x 100 cm quadrate was placed in each plot at 20^{th} days after sowing and finally average number of shots were calculated. Five plants were selected randomly in each plot and tagged for measuring height at different intervals. Height was measured at 30, 60, 90,120 days after sowing and at harvest stage with the help of meter scale from ground surface to the tip of the top most leaf before heading and up to the base of ear head after heading. The average was taken and finally plant height (cm) was expressed. The number of tillers were counted per meter row length from three places selected randomly in each plot at 30, 60, 90,120 days after sowing and at harvest stage. Then average value was worked out. Dry matter accumulation at 30^{th}, 60^{th}, 90^{th}, 120^{th} days after sowing and at harvest stage was recorded. For this purpose, the plant shoots per metre row length were cut close to the ground level and put in the paper bags. After sun drying, the samples were dried into hot air oven at 70 ± 1 0C till the constant weight attained. The values of dry weight of plant were computed in g m^{-1}. The leaf area was measured at 30, 60, 90, and 120 days after sowing stage to calculated the leaf area index. The plants of 0.25 m row length were taken and green leaves were separated. All the leaves were grouped into three viz. small, medium and large. Five leaves from each group were taken and their surface area was measured by automatic leaf area meter. Area of leaves was multiplied with respective leaf number of a group and sum of all three gave the total leaf area. For obtaining leaf area index, leaf area was divided by ground area. Ground area calculated in 0.25m X 0.23m square meter.

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}$$

Results and Discussion

The data on plant height, no. of shoots, leaf area index (LAI) and dry matter accumulation increased significantly with Treatments **I_2** (two irrigations) under irrigation management treatments and Treatment **M_2** (6t/ha mulch materials) under mulch management treatments during course of investigation.

The data pertaining to initial plant population per m^{-2} as influenced by different treatments have been summarized in Table 1. It is revealed from the data given table that different irrigation treatments did not influence the initial plant population per m^{-2}. The different mulching treatments also non-significantly affected the initial plant population per m^{-2} of barley at initial stage. Various irrigations did not differ the initial plant population but slightly more population was observed with two irrigations, whereas, mulching had distinct effect on initial plant population. Increasing quantity from 4t mulch/ha to 6t mulch/ha increased the plant population primarily because of more quantity of mulch per unit area. The data pertaining to number of shoots m^{-2} at successive stages of crop growth as affected by irrigation and mulching are presented in Table 2. In general, number of shoots m^{-2} was increased progressively up to 90 DAS and thereafter it was decreased. It is evident from the data given in table 2 that the effect of irrigation was found invisible on number of shoot m^{-2} at 30 DAS, after this, irrigation exhibited significant effect on number of shoot m^{-2}. At 60 DAS, 90 DAS and at harvest stages the higher number of shoot m^{-2} was counted under two irrigations (I_2) which was at par with one irrigation (I_1) and was found significant superior over control (I_0). Mulching had the significant effect on number of shoots m^{-2} after 30 days stage and 6t mulch ha^{-1} gave higher number of shoots m^{-2} which was at par with the application of 4t mulch/ha (M_1) and significantly superior over no mulch (M_0). The lower number of shoots m^{-2} was recorded with the no mulch at all the stages of crop growth. Number of shoots per meter square increased with irrigations up to 90 DAS after that a slight reduction was noticed but significant effect of irrigations was observed at 60 and 90 DAS and at harvest. The higher number of shoots associated with increasing irrigations at later stages might be due to enhanced cell expansion and various metabolic processes in the presence of abundant irrigations which resulted into increased tillering and thus number of shoots per meter square. However, at initial stage these activities were very slow and had a little effect on number of shoots under various irrigations. The result conform the findings of Chaturvedi *et al.* (1981) [2]. The mulching had the profound effect on number of shoots per meter square. The higher number of shoots m^{-2} as affected by the various mulch was observed at 90 DAS stage of the crop but the magnitude of difference between 6t mulch/ha and 4t mulch/ha decrease with later stage while it was enhanced beyond 30 DAS stage and established up to maturity in between the 6t mulch/ha and 4t mulch/ha. Higher number of shoots m^{-2} was observed under each increased quantity of mulch, it was because of the fact that higher initial plant population was maintained by soil moisture longer time caused more quantity of mulch per unit area. Vigorous growth of individual shoots under 6t mulch on account due to the improve moisture conservation, water use efficiency, higher photosynthetic activities and increased the temperature of soil due to covering the soil surface led to better development of plants up to maturity of crop. The beneficial effect of mulch, number of shoots is inconformity with the findings of Mishra (1996) [4], Pal *et al.* (2000) [6] and Thakuria *et al.* (2004) [8]. Data on plant height at the successive stages of crop growth as influenced by various irrigation and mulch treatments have been summarized in Table 3. In general, plant height was increased successfully up to 90 DAS stage. It is evident from the data that the effect of irrigation was not visible at 30 DAS stage, after this, irrigation had the significant effect on plant height. The higher plant height was recorded under two irrigations (I_2) which was at par with one irrigation (I_1) and significantly superior over control (I_0) at all the stages of crop growth. It is evident from the data given in Table 2 that the increasing trend in plant height was recorded with the increasing levels of mulch at all the stages of plant growth. The tallest plants were measured at all the stages of plant growth when 6t mulch/ha and 4t mulch/ha were applied these treatments have statistical superiority over the control (M_0) treatment. Irrigation profoundly affected the plant height with the age of the crop. The less difference in plant height at initial age of the crop was due to less time available for growth and development of plants. On the other hand increased cell division due to proper availability of water, increased the plant height may be attributed to better availability of moisture in soil profile. This finding is supported by Soleymani and Shahrajabian (2013) [7] and Saren *et al.* (2004). Mulching may be attributed to better availability of conserved moisture in soil profile to influence plant height. However, increasing plants height was noted under increased quantity of mulch. The results are in agreement with the findings of Mondal *et al.* (2007) [5] and Mishra (1996) [4]. Plant height increased with increasing number of irrigations at all the stages of growth. The higher plant height was recorded under I_2 (two irrigations) and being at par with I_1 (one irrigations). The lowest plant height was recorded under I_0 (no irrigation). Dry matter production was affected significantly due to various irrigations. The higher dry matter was accumulated under 6t mulch/ha being at par with 4t mulch/ha and significantly superior over all the rest of the treatment growth stages. Plant height increased with increase the quantity of straw mulch from 4t mulch/ha to 6t mulch/ha at all the stages of growth. The higher plant height was recorded under 6t mulch/ha and being at par with 4t mulch/ha. The lowest plant heights were recorded under no mulching treatments. Data on leaf area index at the successive stages of crop growth as influenced by various treatments of irrigation and mulching have been summarized in Table 4. In general, leaf area index (LAI) was increased up to 60 DAS stage. It is evident from the data given in table that the effect of irrigation was not visible at 30 DAS stage, after this, irrigation treatments have the significant effect on leaf area index at 60 and 90 DAS stage. The higher leaf area index was recorded under two irrigations (I_2) which was at par with one irrigation (I_1) and two irrigations (I_2) and one irrigation (I_1) treatments have the significant superiority over no irrigation (I_0) treatment at all the stages of crop growth. An increasing trend of leaf area index was observed with the increasing levels of mulching treatments at all stages of plant growth. The higher leaf area index was recorded at all the stages of crop growth when 6t mulch/ha (M_2) was applied which was at par with 4t mulch/ha (M_1) and these treatments have statistical superiority over the control (M_0) treatment. The data recorded on dry matter accumulation (gm^{-2}) as showed by different levels of irrigation and mulching has been presented in Table 5. Dry matter accumulation of barley was significantly affected by different levels of irrigation and mulching. After this, it exhibited significant effect on dry matter accumulation. The higher dry matter accumulation was recorded under two irrigations (I_2) which was at par with one irrigation (I_1) and both were significant superior over the control (I_0). An increasing trend in dry matter accumulation was observed with the increasing levels of mulching at all stages of crop growth. At 60, 90 DAS and at harvest stage, the higher dry matter accumulation was recorded when 6t mulch/ha (M_2) and it was at par with 4t mulch ha^{-1} and it significantly superior over the control (M_0). Irrigations to bring out a significant difference on dry matter accumulation at 30 DAS stage of the crop, but at onward stages dry matter was affected profoundly. The higher dry matter is substantiated precisely and perceptible from the contribution of growth and yield attributes at later stages of the crop. The dry matter accumulation increased slowly in the initial stage of the crop because of the fact that leaves being unable to manufacture sufficient food materials and plant had to depend principally on the stored food in the seed along with little food manufactured by young leaves, which did not increased the dry matter accumulation to the significance level. Beneficial effects of irrigations were reported by Hossain and Akhtar (2014) [3]. Mulching also influence the dry matter accumulation at all the stages of crop growth. Higher values of dry matter were recorded with higher quantity of mulch. This was mainly due to improved vegetative characters *viz.*, plant height and number of tiller per unit area. The results are in line with these obtained by Thakuria *et al.* (2004) [8]. Dry matter production was affected significantly due to various mulching. The mulching of 6t mulch ha^{-1} maintained highest dry matter followed by 4t mulch ha^{-1} and no mulching at 30 DAS stage of crop growth. At 60, 90 DAS and at harvest stages the mulching of 6t mulch ha^{-1} and 4t mulch ha^{-1} remained at par and significantly superior over the no mulch treatments.

On the basis of result of the experiment, it may be concluded that the application of 6t mulch ha^{-1} may be instrumental to increase the yield of barley. The combination of **M_2:** 6t straw mulch + **I_2:** two irrigations were found remunerative and feasible for the growth characters of late sown barley.

Table 1: Initial plant population of barley as influenced by different irrigation and mulching treatments:

Treatment	Initial plant population at 20 DAS (m^{-2})
Irrigations	
I_0	130.00
I1	132.00
I_2	131.00
SEm±	4.21
C.D. (P=0.05)	NS
Mulching	
M0	131.20
M_1	131.33
M_2	130.47
SEm±	3.69
C.D. (P=0.05)	NS

Table 2: Number of shoots (m^{-2}) of barley as influenced by different irrigation and mulch treatments at different stages of crop growth.

Treatment		Number of shoots (m^{-2})		
	30 DAS	60 DAS	90 DAS	At harvest
Irrigations				
I0	152.66	322.37	337.33	331.33
I_1	172.00	369.44	386.33	379.00
I_2	170.33	385.99	401.00	393.66
SEm±	5.48	12.23	11.86	11.64
C.D. (P=0.05)	NS	48.00	46.57	45.72
Mulching				
M0	168.67	337.26	352.33	345.67
M_1	171.00	364.66	378.67	372.00
M_2	172.00	375.88	393.67	386.33
SEm±	4.80	5.93	10.45	10.25
C.D. (P=0.05)	NS	18.26	32.20	31.60

Table 3: Plant height (cm) of barley as influenced by irrigation and mulch treatments at different growth stages.

Treatment			Plant height (cm)		
	20 DAS	30 DAS	60 DAS	90 DAS	At harvest
Irrigations					
I_0	13.52	22.5	51.66	76.00	75.30
I1	13.88	24.6	56.50	82.77	82.20
I_2	13.90	25.8	59.26	86.99	86.00
SEm±	0.37	0.31	1.16	1.24	2.34
C.D. (P=0.05)	NS	1.25	4.55	4.85	7.68
Mulching					
M_0	13.85	22.70	52.17	76.55	75.90
M_1	13.77	24.60	56.50	83.00	82.27
M_2	13.70	25.60	58.77	86.22	85.33
SEm±	0.33	0.61	1.16	2.40	2.27
C.D. (P=0.05)	NS	1.89	3.59	7.38	7.00

Table 4: Leaf area index (LAI) of barley crop as influenced by Irrigation and mulch treatments at different stages of crop growth.

Treatment		Leaf area index	
	30 DAS	60 DAS	90 DAS
Irrigation			
I_0	1.07	4.53	3.96
I_1	1.11	4.95	4.36
I2	1.15	5.21	4.57
SEm±	0.03	0.12	0.11
C.D. (P=0.05)	NS	0.49	0.44
Mulching			
M_0	1.07	4.58	4.03
M_1	1.12	4.96	4.33
M_2	1.15	5.16	4.54
SEm±	0.03	0.12	0.10
C.D. (P=0.05)	NS	0.38	0.32

Table 5: Dry matter accumulation of barley as influenced by different levels of irrigation and mulching at different stages.

Treatment	Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest
Irrigation				
I_0	84.0	280.10	466.93	583.66
I1	95.8	316.03	532.26	665.33
I_2	100.3	334.30	557.20	696.50
SEm±	2.28	7.34	16.22	13.55
C.D. (P=0.05)	8.95	28.83	63.70	53.21
Mulching				
M0	90.80	296.03	493.33	616.67
M_1	93.63	313.97	528.13	660.17
M2	95.70	320.43	534.93	668.67
SEm±	2.56	6.26	9.26	13.18
C.D. (P=0.05)	NS	19.29	28.55	40.61

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