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Response of nutrient management, varieties and moisture conservation practices on growth and yield of barley (*Hordeum vulgare* L.) under rainfed condition

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Abstract
The present investigation was conducted 2015-16 and 2016-2017 at experiment farm Soil Conservation of Water Management in C.S. Azad University of Agriculture and Technology, Kanpur. The experiment was carried out in factorial complete randomized block design with three replications and three nutrient management i.e. N_1 (100% RDN), N_2 (75% RDN through chemical fertilizers + 25% RDN through vermicompost) and N_3 (75% RDN through chemical fertilizers + 25% RDN through vermicompost + Azotobacter) and two varieties i.e. V_1-Narmada (K- 603), V_2-Azad (K-125) and three level of moisture conservation practices i.e. M_1 -Control, M_2 -Dust mulch created by weeding and hoeing followed by hand hoe after 25 days of sowing, M_3-Herbicide (2,4-D, 35 days after sowing) . Results of the experiments indicated that the Barley variety Narmada (K-603)" proved better with 75% RDN through chemical fertilizers + 25% RDN through vermicompost + Azotobacter and moisture conservation practices of dust mulch created by weeding and hoeing followed by hand hoe.

Keywords: Management, varieties, growth, *Hordeum vulgare* L.

Introduction
Barley can be a successful cereal crop because of its short growing time and ability to survive in poor conditions. Barley possesses genetic yield stability and high levels of water and nutrient-use efficiency, traits that can reduce production risks for resource-poor dryland smallholders, especially in the face of climate change. This "climate-smart" crop also has a strong genetic tolerance for drought, high temperatures and soil salinity, as well as high levels of resistance to pests and disease. Drought is a major factor limiting crop production worldwide. Barley is a well-adapted cereal that is largely grown on dry marginal land where water and salinity are the most prevalent environmental stresses.
Major constraints in barley production are non availability of suitable varieties and high temperature stresses. In peninsular India, which is geographically located between 8^0 N and 21^0 latitude and between 73^0E and 85^0E longitude, maximum and minimum temperatures during the growing season are high (heat stress), thereby limiting the expression of full genetic potential of the crop.
Under North Indian conditions, recommended sowing time of barley is from middle of October to middle of November (Anonymous 2014) [1]. Maximum, minimum and optimum temperatures for germination of barley are 38 to 40, 3.5 to 5 and 20°C, respectively (Malik, 1980). These temperatures prevail from mid-October to end-November or early December in North India. The differences in production of timely sown and late sown crops may be attributed to the unfavorable temperature prevailing at different growth stages, such as low temperature at the time of germination which may delay crop emergence. Low temperature may also slow down the growth and development of the crop, thus, resulting in the accumulation of insufficient biomass and shortening of crop duration. On the other hand, too early sowing may also result in reduced germination due to higher temperature, even the plant may die after germination due to higher temperature as rate of respiration may exceed that of photosynthesis. The temperature during October is higher whereas towards end of November and early December, it is lower which may be congenial for disease incidence as it is known that high temperature is congenial for incidence of foliar blight, whereas, lower temperature favours stripe disease incidence. Moreover, the varieties developed much earlier, become susceptible to insect-pest and disease incidence. Timely sowing of barley i.e. from the mid of October to mid of November under Uttar Pradesh conditions may be conducive for high grain yield. However, sometimes due to non-availability of farm inputs at right time and

in desired quantities, the farmers have to sow part of their crop late. So, it is imperative to study the response of time of sowing on yield performance and reaction to diseases.

Many crop management factors affect the yield of this crop. It is grown in harsh environments, the potential for meeting growing demand by expanding the area sown is limited. Among the various management practices, the major non monetary inputs for enhancing the barley production is optimum time of sowing and optimum spacing which modifies the growth environment by way of regulating the natural endowments like light, temperature and moisture. Also owing to its hardy nature, it can be successfully cultivated in rainfed areas of Karnataka with appropriate land management practices. Criteria applied for selection of landform management depends on factors like rainfall of the region, soil type, field slope and intended crop for the season. There is a need for an improved *in-situ* soil and water conservation and proper drainage technology particularly in deep black soils that can protect the soil from erosion throughout the season and provide control at the place where the rain falls. Tillage, nitrogen levels and irrigation greatly influence the yield and malt quality of barley. Tillage methods have a major influence on aeration, moisture and temperature of soil which in turn affect the yield and quality of crop.

Nitrogen is a constituent of amino acids, required for proteins synthesis and other related compounds; it plays a role in almost all plant metabolic processes. It is an integral part of chlorophyll responsible for plant food manufacturing through photosynthesis. So it induces rapid growth, increases leaf size and improves quality, promotes fruit and seed development. Among the fertilizer nutrients, nitrogen is the nutrient that is absorbed in largest amount and is the most limiting factor for crop production (Dev and Chauhan 2009) [3]. The insufficient amount of nitrogen can reduce the quality below acceptable levels, while high nitrogen fertilizer rates can result in translocation of sufficient amount of nitrogen from vegetative organs to the grain, resulting in, high grain protein content.

A variety of any crop having good yield potential, resistance to insect-pest and disease sometimes becomes susceptible to such biotic factor and thus loses the yield potential. Over the time, they also start behaving differently to the applied nutrients. It is hence, desirable that varieties should be evaluated for staggered sowing and variable nutrients. Different varieties have different yield potential requiring variable nitrogen dose. All the varieties may not be suitable for timely as well as the late sowing. The information on the suitability of barley varieties for different periods is not available as in the case of other crops, such as wheat.

Materials AND methods

The present investigation was conducted at Soil Conservation and Water Management Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during *rabi* season of 2015-16 and 2016-17. The experimental farm falls under the Indo-gangetic alluvial tract of Central Uttar Pradesh.

Geographically, Kanpur is situated in the central part of U.P. and subtropical tract of North India between latitude ranging from 25^0 56’ to 28^0 58’ North and longitude 79^0 31’ to 80^0 34’ East and is located on an elevation of about 125.9 meters above mean sea level in gangetic plain. The seasonal rainfall of about 816 mm received mostly from II^{nd} fortnight of June or first fortnight of July to mid October with a few showers in winter season.

The experiment was carried out in factorial complete randomized block design with three replications and three nutrient management i.e. N_1 (100% RDN), N_2 (75% RDN through chemical fertilizers + 25% RDN through vermicompost) and N_3 (75% RDN through chemical fertilizers + 25% RDN through vermicompost + Azotobacter) and two varieties i.e. V_1-Narmada (K- 603), V_2-Azad (K-125) and three level of moisture conservation practices i.e. M_1 - Control, M_2 -Dust mulch created by weeding and hoeing followed by hand hoe after 25 days of sowing, M_3-Herbicide (2,4-D, 35 days after sowing)

Results and Discussion

Growth charecters

Plant population

The perusal of the results indicated that (Table 1) there was no much difference among treatments for the primary stand in both the years as well as in pooled results of two years under nutrient management practices. Further the treatments also failed to show much variation in regards to plant stand at initial and harvest stages in both the years under both the tested varieties. The different moisture conservation practices significantly influenced to the plant population at initial and harvest stages of the crop. The dust mulching indicated superiority over other two moisture conservation practices.

Plant height

The results that (Table 2) sowing of barley crop with 100% RDN through chemical fertilizer brought out the maximum height in both the years at 30 DAS. The 75% RDN through chemical fertilizer + 25% RDN through vermicompost reduced the plant height at 30 DAS and 60 DAS, 90 DAS and at harvest were maximum height found in75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter during both the years and pooled results of two years over other two nutrients management practices.

Cultivar *Narmada* displayed the maximum height of plant at all stages of observations over *Azad* in two years study and pooled results of two years.

Under moisture conservation practices dust mulching exhibited maximum height of plant closely followed by herbicide in both the years and pooled results of two years. The minimum plant height was measured under control in the study of two years and in pooled results of two years at all stages of observations. These results are in conformity with findings of Awasthi *et al.* (2017) [2].

No. of tillers M^{-1} per row meter

It is clear from the results presented in Table 3 that 100% RDN through chemical fertilizer produced the maximum number of tillers per running meter at 30 DAS but 60 DAS, 90 DAS and at harvest are found maximum number of tillers in 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter to both the years and pooled results of two years. The minimum number of tillers per running meter was noted in 100% RDN at all the stages of observations except 30 DAS.

Perusal of data make it clear that cultivar *Narmada* displayed the higher number of tillers m^{-1} row length over cv. *Azad* in both the years and pooled results of two years at 60 DAS, 90 DAS and at harvest, but at 30 DAS, the cultivar *Azad* gave higher tiller m^{-1} row length over *Narmada* (K-605) in both the years and pooled years.

Dust mulching practices of moisture management exhibited maximum number of tiller m^{-1} row length while control produced minimum tillers m^{-1} row length in comparison to other two tested practices of moisture management during both the years and pooled results of two years at all the stages of observations. Shantveerayya *et al.* (2015) [4] also reported similar results.

Yield

grain yield (q/ha)

It is clear from the results given in (table 3) that the 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter gave highest grain yield, which was higher than all other nutrients management practices in both the years of study. The pooled results of two years under 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter established its significantly superiority over all other nutrients management practices. Therefore, the order of performance of nutrients management practices 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter was (26.61 q/ha), 75% RDN through chemical fertilizer + 25% RDN through vermicompost (25.73 q/ha) > (24.04 q/ha) 100% RDN through chemical fertilizer. 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter treatment 10.70 per cent more grain yield over 100% RDN through chemical fertilizer.

Under tested varieties, cultivar *Narmada* (K-603) produced significantly highest grain yield as compared to *Azad (K-125)* in both the experimental seasons and in pooled results of two years. Therefore, the order of performance of varieties was *Narmada* (16.66 q/ha) > *Azad* (24.25 q/ha). The 9.94 per cent more yield obtained from cultivar *Narmada* over *Azad*.

Among the moisture conservation practices, dust mulching gave significantly highest grain yield in both the experimental seasons and in pooled results of two years. The order of moisture conservation practices was dust mulching (27.49 q/ha) > herbicide (25.76 q/ha) > control (23.00 q/ha). The dust mulching gave 6.72 per cent and 19.52 per cent more yield over herbicide and control moisture conservation practices, respectively. These results confirm the findings of Solanki *et al.* (1987) [5] and Tiwari *et al.* (2008) [6].

Straw yield (q/ha)

It is clear from the results that (Table 3)the significantly highest straw yield was noted in 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter over other two nutrients management practices in both the years. The trend of results in pooled data was also in favour of chemical. The minimum straw yield was weighed in 100% RDN through fertilizer in both the experimental seasons and in pooled results of two years.

The cultivar *Namrada* produced significantly higher straw yield as compared to *Azad* in both the years and pooled results of two years. The minimum straw yield was weighed under tested cv. *Azad* during two years of experimentation and pooled results of two years.

Perusal of data make it clear that dust mulching gave higher straw yield by 38.37 q/ha over other two tested moisture conservation practices. The minimum straw yield was recorded under control.

Table 1: Effect of nutrients management, varieties and moisture conservation practices on plant stand (per running meter) of barley

Treatment		Plant population per running meter					
		Initial plant population			Final plant population		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
A. Nutrient management							
N_1-	100% RDN through chemical fertilizer	26.88	26.99	26.91	25.49	24.83	25.16
N_2-	75% RDN through chemical fertilizer + 25% RDN through vermicompost	26.99	26.99	26.99	25.66	24.83	25.24
N_3-	75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter	27.66	27.66	27.66	26.33	25.66	25.99
	S.E. (d±)	0.50	0.57	0.37	0.48	0.56	0.37
	C.D. 5%	N.S.	N.S.	N.S.	N.S.	N.S.	0.75
B. Varieties							
V_1-	*Narmada* (K- 603)	27.42	27.62	27.63	26.29	25.51	25.90
V_2-	*Azad* (K- 125)	26.90	26.70	26.70	25.37	24.70	25.03
	S.E. (d±)	0.41	0.46	0.30	0.39	0.45	0.30
	C.D. 5%	N.S.	N.S.	0.61	0.88	N.S.	0.61
C. Moisture conservation practices							
M_1-	Control	27.05	26.55	26.55	25.22	24.38	24.80
M_2-	Dust mulching	27.33	27.83	27.83	26.29	25.83	26.16
M_3-	Herbicide	27.11	27.11	27.11	25.77	25.11	25.44
	S.E. (d±)	0.50	0.57	0.37	0.48	0.56	0.37
	C.D. 5%	N.S.	N.S.	0.75	1.08	1.25	0.75

Table 4.2: Plant height (cm) of barley at different interval under different treatments

Treatment	At 30 DAS			At 60 DAS			At 90 DAS			At harvest		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
A. Nutrient management												
N_1- 100% RDN through chemical fertilizer	16.23	16.48	16.35	44.70	45.00	44.85	57.01	57.81	57.16	63.90	64.08	63.99
N_2- 75% RDN through chemical fertilizer + 25% RDN through vermicompost	15.31	15.66	15.48	46.76	45.56	46.16	59.71	60.01	59.86	66.45	66.98	66.71
N_3- 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter	15.81	16.11	15.96	47.25	47.53	47.39	63.36	63.38	63.37	70.40	69.73	70.06
S.E. (d±)	0.24	0.26	0.18	0.76	0.72	0.52	0.87	1.0	0.66	0.95	0.88	0.65
C.D. 5%	0.54	n.s.	0.35	1.71	1.61	1.05	1.95	2.23	1.33	2.12	1.98	1.30
B. Varieties												

V1-	*Narmada* (K- 603)	15.73	16.03	15.88	46.70	47.00	46.85	61.18	61.48	61.33	67.61	67.47	67.54
V2-	*Azad* (K- 125)	15.84	16.14	15.99	45.44	45.73	45.58	58.87	59.18	59.02	66.22	66.38	66.30
	S.E. (d±)	0.19	0.21	0.14	0.62	0.59	0.43	0.71	0.81	0.54	0.77	0.72	0.53
	C.D. 5%	N.S.	N.S.	N.S.	N.S.	1.31	0.86	1.59	1.82	1.08	N.S.	N.S.	N.S.
C. Moisture conservation practices													
M1-	Control	14.96	15.28	15.12	44.55	44.80	44.67	58.50	58.80	58.65	64.50	64.70	64.60
M2-	Dust mulching	16.51	16.78	16.64	47.43	47.73	47.58	61.95	62.25	62.10	69.95	69.28	69.61
M3-	Herbicide	15.88	16.20	16.04	46.23	46.56	46.39	59.65	59.96	59.80	66.30	66.81	66.55
	S.E. (d±)	0.24	0.26	0.18	0.76	0.72	0.52	.87	1.00	0.66	0.95	0.88	0.65
	C.D. 5%	0.54	0.59	0.35	1.71	1.61	1.05	1.95	2.23	1.33	2.12	1.98	1.30

Table 3: Tillers m^{-1} row length under nutrient management, varieties and moisture conservation practices at different DAS

Treatment		At 30 DAS			At 60 DAS			At 90 DAS			At harvest		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
A. Nutrient management													
N1-	100% RDN through chemical fertilizer	31.83	32.16	31.99	65.94	66.60	66.27	77.44	78.66	78.05	77.94	78.27	79.10
N2-	75% RDN through chemical fertilizer + 25% RDN through vermicompost	30.16	30.49	30.32	66.99	67.66	67.32	79.44	79.93	79.68	82.66	82.99	82.82
N3-	75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter	30.38	30.77	30.57	68.27	68.94	68.60	80.64	80.88	80.66	84.60	84.94	84.77
	S.E. (d±)	0.50	0.47	0.34	0.57	0.69	0.44	0.89	0.93	0.64	1.00	1.13	0.75
	C.D. 5%	1.11	1.06	0.69	1.27	1.54	0.89	2.00	2.08	1.29	2.23	2.53	1.51
B. Varieties													
V1-	*Narmada* (K- 603)	30.74	31.10	30.92	67.70	68.36	68.03	79.95	80.83	80.39	81.92	82.25	82.08
V2-	*Azad* (K- 125)	30.85	31.18	31.01	66.44	67.10	66.77	78.14	79.17	78.65	81.55	81.88	81.71
	S.E. (d±)	0.40	0.38	0.28	0.46	0.56	0.36	0.73	0.76	0.52	0.81	0.92	0.61
	C.D. 5%	N.S.	N.S.	N.S.	1.04	1.25	0.73	1.63	N.S.	1.05	N.S.	N.S.	N.S.
C. Moisture conservation practices													
M1-	Control	29.99	30.38	30.18	64.27	64.94	64.60	76.82	78.10	77.46	79.55	79.88	79.71
M2-	Dust mulching	31.39	31.72	31.55	69.33	70.00	69.66	81.05	81.49	81.27	84.44	84.77	84.60
M3-	Herbicide	30.99	31.32	31.15	67.61	68.27	67.94	79.27	79.82	79.54	81.21	81.55	81.38
	S.E. (d±)	0.50	0.47	0.34	0.57	0.69	0.44	0.89	0.93	0.64	1.00	1.73	0.75
	C.D. 5%	1.11	1.06	0.69	1.27	1.54	0.89	2.00	2.08	1.29	2.23	2.53	1.51

Table 4: Effect of different treatments on grain and straw yield (q/ha) of barley

Treatment		Grain yield (q/ha)			Straw yield (q/ha)		
		2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
A. Nutrient management							
N1-	100% RDN through chemical fertilizer	23.15	24.94	24.04	33.69	33.90	33.79
N2-	75% RDN through chemical fertilizer + 25% RDN through vermicompost	24.68	26.79	25.73	35.20	36.07	35.63
N3-	75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter	25.82	27.40	26.61	37.23	37.99	37.61
	S.E. (d±)	0.83	0.96	0.63	1.09	1.20	0.87
	C.D. 5%	1.70	1.93	1.26	2.20	2.43	1.74
B. Varieties							
V1-	*Narmada* (K- 603)	25.45	27.88	26.66	36.63	37.70	37.16
V2-	*Azad* (K- 125)	23.65	24.86	24.25	34.24	34.27	34.25
	S.E. (d±)	0.68	0.78	0.51	0.89	0.98	0.71
	C.D. 5%	1.38	1.58	1.02	1.80	1.99	1.42
C. Moisture conservation practices							
M1-	Control	22.82	23.18	23.00	22.74	32.48	33.11
M2-	Dust mulching	26.44	28.55	27.49	37.89	38.86	38.37
M3-	Herbicide	24.39	27.14	25.76	85.07	36.62	35.88
	S.E. (d±)	0.83	0.96	0.63	1.09	1.20	0.87
	C.D. 5%	1.70	1.93	1.26	2.20	2.43	1.74

Conclusion

On the basis of two years field investigation made during *Rabi* season of 2015-16 and 2016-17 at Soil Conservation and Water Management Farm. C.S. Azad university of Agriculture and technology, Kanpur. The experiments concluded that the Barley variety Narmada (K-603)" proved better with 75% RDN through chemical fertilizer + 25% RDN through vermicompost + Azotobacter and moisture conservation practices of dust mulch created by weeding and hoeing followed by hand hoe.

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