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Effect of fertility levels on growth and yield of barley (*Hordeum vulgare* L.) varieties in central plain zone of Uttar Pradesh

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Abstract
A field experiment was conducted during rabi seasons of 2023-24 as carried out at agricultural farm of Rama University, Kanpur to find out effect of fertility levels on growth and yield of barley (*Hordeum vulgare*) varieties in central plain zone. The treatment comprised 9 combination of 3 varieties V_1-Haritma (K-560), V_2 -Narmada (K-603) and V_3-Lakhan (K-226) and 3 fertility level F_1 (N, P_2O_5& K_2O)- 40;20;20, F_2 -60;30;30 & F_3- 80;40;40 tested in Split plot design (SPD). In which variety 'Haritma' (29.51 q/ha) and 'Narmada' (29.40 q/ha) being at par produced higher grain yield than 'Lakhan' (26.43 q/ha). Among fertility level, N-80, P-40, K-40 recorded significantly higher grain yield (31.22 q/ha) followed by N-60, P-30, K-30 (29.27 q/ha) and lowest yield recorded in N-40, P-20, K-20 (24.85 q/ha).

Keywords: Varieties, fertility, grain yield

Introduction
Barley is one of the significant cereal crops, followed by wheat, rice, and maize. Barley is one of the ancient crop cultivated since 10,000 years during Pre-Harrapan era. In the past century, barley was primarily cultivated and utilized for human food supply, whereas nowadays it is largely grown for animal feed, malt products, and human consumption, respectively. Nowadays, Globally 30 per cent of barley production is used for malting purpose and 70 per cent feed use.
Barley is one of the important cereal in the World. It is grown in an area of 70 million hectares with 160 mt grain production. The major barley growing countries are Russia, China, Canada, USA, Spain, France, Australia, UK and India. In India, Barley cultivation is done in area of 6.28 lakh ha with a production of barley is 1.91 million tonnes (DA&FW- 2022-23).It is cultivated on large scale in case in Uttar Pradesh, and Rajasthan. It is also commonly grown in MP, Punjab, Haryana and Bihar. It is also cultivated for malting and brewing purposes in Haryana, Western U.P., Punjab and Rajasthan with relatively better management to get good grain quality.
Fertilizer play an important role in crop production. Fertilizers, whether artificial or natural, are vital components that enhance plant productivity and development. They help plants become more resilient against harmful pathogens, pests, and weeds, consequently increasing the value of the harvest by effectively eliminating diseases. It also enhance the water holding capacity of plants and promote deeper root growth. Potassium within fertilizers strengthens plant straws and stalks. Phosphorus facilitates quicker root development and seed formation. Nitrogen in fertilizers boosts plant growth, evident in the vibrant green coloration of plants.
Unbalanced and indiscriminate use of plant nutrients, often few below their removal by growing crop led to continuous minimizing of nutrient from native reserves. As a result, not only the number of deficient nutrients increased but also the extent of nutrient deficiencies in soil became larger and larger. The problem is more pronounced in Indo Gangetic plains, indicated that cultivars are using excessive fertilizer to get higher yields (Dwivedi -2017).
The ability of soil to support crop growth for optimum crop yields is one of the important factor of soil fertility that determines the production potential. Several processes which influence the soil fertility and productivity are controlled by the different characteristics of soil.

The proper understanding of physical, chemical and biological properties of the soil will go to insight in the dynamics of such light textured alluvial soil. Soil fertility is one of the important deciding factor which affect the crop yields.

Materials and Methods

An experiment was conducted during rabi season of 2023-24 agricultural farm of Rama University, Kanpur in alluvial soil. The soil of experimental field was sandy loam in texture and slightly calcareous having organic carbon 0.35%, total nitrogen 0.04%, Available P_2O_5 17.2 kg/ha, Available K_2O172.3 kg/ha, pH-7.6, electrical conductivity 0.38 dS m^{-1}, field capacity 19.70%, Bulk density 1.48 Mg m^{-1} Particle density 2.64 Mg m^{-1} and porosity 43.9%.The field experiment was conducted in split plot design with three replication, keeping variety in main plot and fertility in sub plot.

The requisite amount of urea, single super phosphate and muriate of potash fertilizer was applied in furrow below the seed at time of seed sowing. Sowing of barley varieties was done @ 100 kg ha $^{-1}$ behind country plough in furrow 22.5 cm apart on 30 october 2023. The amount and distribution of rainfall received during cropping season was 89.2 mm in 2023-24 against the average annual rainfall of about 800 mm

Cost of cultivation was calculated by taking in to account the prevailing price of input and price of grain and straw. B: C (Benifit cost ratio) was calculated by dividing the gross return of each treatment by total cultivation cost of respective treatment.

Results and Discussion

Growth and yield attributes

The variety Lakhan (V_3) produced tallest plants at different growth stages, whereas shortest plant height was recorded in variety Narmada (V_2). The fertility levels significantly influenced the plant height considerably. The F_3 level of fertility which received 80:40:40 kg NPK/ha showed tallest plants. The shortest corresponding value were recorded at F_1 level of fertility.

The different varieties of barley had influence on effective tillers significantly during the crop growth at different stages of growth. The maximum corresponding values were observed in variety V_1 (Haritma), while lowest in variety V_2 (Narmada). Moreover, the highest numbers of effective tillers were observed in F_3 level when 80:40:40 NPK kg/ha was applied. Whereas, the lowest number of tillers were recorded at F_1 level of fertilizer application.

The barley variety Haritma (K-560) showed maximum earhead count per square meter followed by V_2 Narmada (K-603). Conversely, the lowest earhead count of 235 was observed in V_3 (K-226) Narmada. Increasing fertility levels had to a significance enhancement in the number of spike per square meter, upto the highest level of fertilizer application at F_3 level. (Neelam *et al*. 2019) [6].

Variety V_1: K-560 showed superiority with ear weight exceeding over both variety of V_2: K-603 and V_3 (Lakhan).The F_3 level of fertility produced maximum ear weight and minimum under F_1 level of fertilizer application.

Maximum 1000 grain weight of 45.20gm was recorded with variety Lakhan (K-226) whereas, lowest under variety Haritma (K-560). Regarding fertility levels maximum 1000 grain weight of 45.0gm was observed at F_3 level, however the minimum values was recorded at the fertility level of F_1 (43.23g).

Leaf Area Index (LAI) increased with increasing DAS and maximum values were found at 90 DAS and then it declined considerable. The highest LAI was recorded in variety Lakhan (V_3) corresponding values were recorded in variett Narmada (V_2). As regards the fertility level, highest LAI was observed at F_3 level with and lowest values with F_1 level of application.

Dry matter accumulation increases progressively upto maturity across various growth stages. Fertility level also influenced the dry matter accumulation and maximum value recorded at F_3 level of fertility, which received 80:40:40 kg NPK /ha during the experimentation. The lowest values were observed in F_1 level of fertility at different growth stages. (Choudhary *et al*. 2017 and Singh *et al*. 2021) [3, 14].

Table 1: Effect of varieties and fertility levels on plant height (cm) of barley crop

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Varieties				
V_1	24.9	73.60	90.11	92.10
V_2	23.16	71.76	88.73	91.46
V_3	26.23	74.50	93.03	97.93
SE (d)	0.632	0.769	0.301	0.784
CD(P=0.05)	1.802	N.S.	0.859	2.234
Fertility				
F_1	22.16	71.50	88.45	90.36
F_2	24.93	73.20	90.01	93.73
F3	27.2	75.16	93.41	97.40
Mean	24.763	73.28	90.62	93.83
SE(d)	0.548	0.783	0.560	0.501
CD(P=0.05)	1.208	1.725	1.234	1.103

Table 2: Effect of varieties and fertility levels on number of productive/ effective tillers

	No. of productive/effective tillers			
Treatment	30 DAS	60 DAS	90 DAS	At harvest
Varieties				
V_1	2.7	6.4	7.6	6.6
V_2	2.4	5.6	7.4	5.9
V_3	3.0	6.9	8.1	7.0
SE(d)	0.083	0.072	0.112	0.152
CD (P=0.005)	0.237	0.205	0.319	0.434
Fertility				
F_1	2.3	5.4	7.0	5.8
F_2	2.6	6.3	7.8	6.4
F_3	3.2	7.2	8.3	7.3
SE(d)	0.103	0.152	0.158	0.142
CD (P=0.05)	0.227	0.335	0.347	0.313

Table 3: Effect of varieties and fertility levels on number of earhead/m², ear weight and 1000-grain weight.

Treatment	No. of ear head /m²	Ear weight	1000 grain weight
Varieties			
V1	261	2.20	43.26
V2	254	2.12	44.06
V3	235	2.04	45.20
SE	0.385	0.022	0.737
CD (P=0.05)	1.097	0.063	N.S.
Fertility			
F1	221	2.04	43.23
F2	253	2.12	44.30
F3	276	2.20	45.00
SE	1.544	0.014	0.855
CD (P=0.05)	3.400	0.032	N.S.

Table 4: Effect of varieties and fertility levels on Leaf area index.

Treatment	Leaf area index		
	30 DAS	60 DAS	90 DAS
Varieties			
V_1	1.10	2.25	3.17
V_2	1.03	2.13	3.14
V_3	1.17	2.28	3.20
SE (d)	0.022	0.019	0.011
CD(P=0.05)	0.063	0.054	0.031
Fertility			
F_1	0.98	2.11	3.08
F_2	1.12	2.23	3.19
F3	1.20	2.32	3.24
SE(d)	0.024	0.011	0.014
CD(P=0.05)	0.052	0.024	0.031

Table 5: Effect of varieties and fertility levels on dry matter accumulation (g/m²)

Treatment	Dry matter accumulation (g/m²)			
	30 DAS	60 DAS	90 DAS	At harvest
Varieties				
V_1	37.4	235	641	1110
V_2	36.3	226	626	1105
V_3	39.2	241	659	1148
SE (d)	0.427	1.186	2.009	1.449
CD(P=0.05)	1.218	3.382	5.728	4.130
Fertility				
F_1	34.8	219	617	1088
F_2	36.9	236	647	1124
F3	41.2	247	662	1151
SE(d)	1.010	1.392	1.419	2.664
CD(P=0.05)	2.224	3.067	3.125	5.869

Crop yield

Maximum grain yield of 29.51 q/ha was obtained in Haritma (V_1) followed by Narmada (V_2) while Lakhan (V_3) produce minimum grain yield of 26.43 q/ha. Grain yield showed significant increase with increasing fertility levels reaching at its peak at the highest fertility level of F_3 level with a yield of 31.22 q/ha. Conversely, the lowest was recorded with F_1 level at 24.85 q/ha. The highest yield was found in 'Haritma' might be possible due to ear length, productive tillers and no. grain straw yield also followed the similar trend with different varieties and fertility level.

Table 6: Effect of varieties and fertility level on yield

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)
Varieties			
V_1	29.5	55.0	84.5
V_2	29.4	54.3	83.7
V_3	26.4	50.8	77.2
SE	0.856	0.257	0.5
CD (P=0.05)	2.441	0.733	1.499
Fertility			
F_1	24.8	47.4	72.2
F_2	29.2	54.8	84.0
F_3	31.2	58.0	89.2
SE	1.044	0.871	0.903
CD (P=0.05)	2.299	1.918	1.988

Economic

The treatment combination V_2F_3 resulted in the highest net profit and return among all treatments tested. Barley variety K-560 demonstrated its economic superiority with a net return, while variety K-226 yielded the lowest net return. Additionally, increasing levels of fertility led to higher gross profit and net return, peaking at the F_3 level and lowest at the F_1 level.

Table 7: Shows the cost of cultivation and Gross Return, Net return

Varieties		Common cost of cultivation	Variable cost of cultivation	Total cost of cultivation	Gross Return	Net return	B:C ratio
V_1 (K-560)	V_1F_1	25126	2509	27635	67512	39877	1.44
	V_1F_2	25126	3754	28880	82585	53705	1.85
	V_1F_3	25126	5000	30126	86103	55977	1.85
V_2 (K-603)	V_2F_1	25126	2509	27635	67276	39641	1.43
	V_2F_2	25126	3754	28880	80297	51417	1.78
	V_2F_3	25126	5000	30126	87021	56895	1.88
V_3 (K-226)	V_3F_1	25126	2509	27635	65656	38021	1.37
	V_3F_2	25126	3754	28880	71686	42806	1.48
	V_3F_3	25126	5000	30126	76511	46385	1.53

These results may be concluded that barely varieties 'Haritma' and 'Narmada' along with 80 kg/ha N, 40 kg/ha P_2O_5 and 40 kg/ha K_2O are effective for higher Profitiblity and productivity.

Conclusion

The study concludes that barley varieties 'Haritma' and 'Narmada', combined with the highest fertility level of 80:40:40 kg NPK/ha, are most effective for achieving higher profitability and productivity in barley cultivation.

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