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Effect of nitrogen and zinc levels on growth and yield of barley" (*Hordeum vulgare* L.)

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Abstract
The field experiment was on the Effect of nitrogen and zinc levels in the growth and yield of barley (*Hordeum vulgare* L.) and it was conducted in Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during the Rabi season of 2024 2025. The soil type was sandy loam with pH of 6.5, organic carbon content of 0.4 and 250, 135 and 344 kg of available nitrogen, phosphorus and potassium resp. A Randomized Block Design experiment was done in which ten treatments with different combinations of zinc (20, 25, and 30 kg/ha), and nitrogen (50, 75, and 100 kg/ha) were established. A control (RDF: 80:30:30 NPK kg/ha) was involved too, and the experiment was replicated thrice. Treatment of (T_9) yielded the best results of all the treatment using 100 kg/ha of nitrogen and 30 kg/ha of zinc. Maximum height of plants (121.79 cm), effective tillers/m^2 (201.33), grains per spike (57.27), test weight (38.71 g), grain yield (4.35 t/ha), straw yield (7.21 t/ha) and economic returns (₹2,21,755.45/ha gross return, ₹160,145.00/ha net return, 2.60 benefit cost ratio). Findings of the study indicate that the optimal level of growing barley in agroclimatic conditions of Prayagraj region is to use 100 kg/ha of nitrogen and 30 kg/ha of zinc to increase its growth, yield, and profitability.

Keywords: Barley, nitrogen, zinc, growth, yield and economics

Introduction

Barley (*Hordeum vulgare* L.) is amongst the most ancient crops contracted of cereal crops that have been cultivated due to the ability to perform well in marginal soils and under adverse weather conditions like drought, saline and frost. It is considered as a poor man crop, meaning that it does well in low input situations, therefore able to support rainfed and semi-arid lands. Barley is locally grown in India mainly in the Rabi season It serves as food, animal food, and beverage purposes. Historically, the barley has been classified in the following ways: 75 per cent is utilized as fodder, 20 per cent on a malting and brewing program, and 5 per cent (or less) is employed in direct human consumption (GOI, 2021). It has become an important part of the economy as demand of its products such as malt-based products to industrial consumers has been on the rise.

In nutritional value, barley contains a lot of dietary fibre, especially β- glucans, as well as proteins, carbohydrates, vitamins, and minerals that are healthy to humans and domesticated animals (Dundigala *et al.*, 2021) [1]. It is the fourth cereal crop in the whole world and the leading producers are Russia, China, France, the USA and Spain. In India, it is cultivated on 23.83mh with the annual production of 5.15 Mt with the state of Uttar Pradesh leading the crop.

Although it is resistant to stresses, the barley performance is usually encumbered by nutrient shortages especially nitrogen (N) and zinc (Zn). Nitrogen plays an important role in the growth of plants, cell division and photosynthesis but deficiency and excessive use of nitrogen may adversely impact on produce and crop yield. Zinc is necessary with enzyme activity, protein synthesis, and reproductive growth. Zinc deficiency occurs in close to 50 percent of soils in India and may actually cause grain size to be small and of low grade as well as being depleted in human micronutrients.

To overcome these predicaments, optimum nutrient application particularly the application of nitrogen and zinc has thus become necessary to enhance barley yield and quality.

Thus, the trial named as influence of nitrogen and zinc on growth and yield of barley (*Hordeum vulgare* L.) was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) in the Rabi season-2024-25 with an aim of studying the interaction of nitrogen and zinc on the performance of barley in the local environment.

Material and Methods

A field experiment known as experiment evaluation field experiment was done in Rabi season of 2024-2025 at Crop Research Farm (CRF) of department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P) to undertake the evaluation of the effect of nitrogen and zinc levels about the growth and yield of Barley (*Hordeum vulgare* L.). It had a pH of 6.5 and organic carbon of 0.4% on sandy loam and the available nitrogen, phosphorus and potassium level in the soil was 250, 135 and 344 kg/ha respectively. The experiment was set in Randomized Block Design (RBD) consisting of Ten treatments in three replications. The combinations being used as the treatments will be as follows., (T_9) Nitrogen at 50kg/ ha coupled with Zinc at 20 kg/ha, and (T_2) Nitrogen at 50kg/ ha coupled with Zinc at 25 kg/ha, and (T_3) Nitrogen at 50kg/ ha coupled with Zinc at 30 kg/ha, and (T_4) Nitrogen at 75kg/ ha coupled with Zinc at 20 kg/ha, (T_5) Nitrogen at 75kg/ ha along with Zinc at 25 kg/ha, (T_6) Nitrogen at 75kg/ ha along with Zinc at 30 kg/ha, (T_7) Nitrogen at 100 kg/ ha along with Zinc at 20 kg/ha, (T_8) Nitrogen at 100 kg/ ha along with Zinc at 25 kg/ha, (T_9) Nitrogen at 100 kg/ ha along with Zinc at 300 kg/ha and (T_{10}) RDF: 80:30:30 NPK kg/ha as control.

Chemical analysis of soil

In order to determine what the first soil characteristics are, prior to the experimental design; a composite soil sample was taken. This soil sample was obtained at depth 0-15 cm, dried in shade, pulverised with the help of wooden pestel and motor, and filtered through 2mm filter to be used in the analysis. Available organic carbon and black p technique by (Jackson 1973) [4], available nitrogen by alkaline permanganate method by Subbaih and Asija (1956) [8], available phosphorus by Olsen colorimeter method as explained by Oslen *et al.*, (1954) [7] and available potassium by flame photometer technique by Jackson (1973; Toth and Prince, (1949) [4, 10].

Statistical analysis

The statistical analysis of variance (ANOVA) was then applied on experimental data collected as how it was outlined by Gamez and Gomez (2010). The values of Critical Difference (CD) were calculated and the F test was significantly at 5% level.

Result and Discussion

Growth and Yield attributes

1. Plant height (cm)

There were considerable variations between the treatments. Application of nitrogen to the barley cultivated and zinc separately resulted in an increase in plant height with growth stage (20, 40, 60, 80 DAS, and at harvest) with significant difference at DAS 40 and above. Treatment T_9 (100 kg/ha Nitrogen + 30 kg/ha Zinc) also registered the highest plant height at every stage and attained plant height at harvest of 121.79 cm, followed closely by T_8 and T_7 which were at par with T_9 hence statistically similar later on. The differences at the early stages (20 DAS) were not significant but still, the highest value was at T_9 (20.69 cm). The effect of increased plant height at the increased level of nitrogen stage is due to the better absorbing level of nitrogen which leads to protein synthesis, cell division and elongation whereas zinc added its value through enzyme action and chlorophyll synthesis. The results of the study concur with those of Dundgiala *et al.*, (2021) and Muhammad *et al.*, (2017) [6] in the case of wheat.

2. Number of tillers/hills

The number of tillers per plant in barley was greatly influenced by the addition of nitrogen and zinc in different growth stage (40, 60, 80 DAS and at harvest). Treatment T_9 (100 kg/ha Nitrogen + 30 kg/ha Zinc) had the significant highest tiller count at all times and achieved 5.67 tillers/plant at harvest that could only be closely matched with treatment T_8 and T_7 which are destined to be statistically equal at most stages. Tiller number of 40 DAS was the greatest in T_9 (3.20), and T_8 (3.10), and T_7 (2.87) were close to each other. This was maintained even at 60 DAS T_9 (4.67 tillers), 80 DAS T_9: (5.93 tillers) and during harvest. This was due to improved soil conditions and equal distribution of nutrients by nitrogen and zinc which stimulated production of protein, cell division and the activity of metabolites showing the improved tillering. Dundigala *et al.*, (2021) [1] and Muhammad *et al.*, (2017) [6] also reported these results since their studies concluded that application of nitrogen and zinc had a positive impact on tiller development in barley and wheat.

3. Plant dry weight (g)

The dry weight of the barley plants significantly grew throughout all the stages of growth (20, 40, 60, 80 DAS, and at harvest) and was affected by the use of nitrogen and zinc significantly. Treatment T_9 (100kg/ha Nitrogen + 30kg/ha Zinc) was recorded to have the highest dry weight that in harvest was found to weigh 24.77g. Although the differences at 20 DAS were statistically not significant, T_9 posted the highest value (0.39g) followed by T_6 and T_7 that was equated. The T_9 demonstrated a signification increase in dry weights than other treatments especially of 40 DAS onwards, but T_6 (75 kg/ha N + 30 kg/ha Zn) and T_8 (100 kg/ha N + 25 kg/ha Zn) remained statistically comparable in most events. Increased growth and photosynthesis leading to increased nutrient uptake and accumulation of biomass attributed to increased dry weight with increasing nitrogen can be explained by reason that the higher the concentration of nitrogen, the better the plants grew as more energy, which synthesize organic matter is released during photosynthesis. Zinc also played an important role since it enhanced some of the critical physiological and biochemical processes. These findings are supported by the study of Jadon *et al.*, (2015) and Muhammad *et al.*, (2017) [5, 6], which have obtained the same trends in barley and wheat, respectively.

4. Number of Effective Tillers per m²

The mean and a maximum amount of effective tillers per square meter (201. 33) was significantly observed with treatment T_9 (100 kg/ha Nitrogen + 30 kg/ha Zinc) and was better compared to others. Nevertheless, the treatment T_6 (75 kg/ha N + 30 kg/ha Zn), T_3 (50 kg/ha N + 30 kg/ha Zn), and T_2 (50 kg/ha N + 25 kg/ha Zn) were found to be statistically at par with T_9. An increase in number of effective tillers could be explained by appropriate nitrogen provision that provides the solid development of the roots and effective nutrient translocation and zinc that is critical to activate growth enzymes controlling tiller commencement. These findings correspond to the observations made by Dubey *et al.*, (2018) [2].

5. Number of Grain per Spike

Significant and maximum number of grains/spike (57.27) was recorded with T_9 (100 kg/ha Nitrogen along with 30 kg/ha Zinc) which was superior over all other treatments. However, T_8 (100 kg/ha Nitrogen along with 25 kg/ha Zinc) was found to be statistically at par with T_9. Higher grains/spike may be attributed to better nitrogen uptake and effective photosynthate translocation to the spike during grain filling stage. Similar findings were also reported by Saha *et al.*, (2017) and Muhammad *et al.*, (2017) [6, 9].

6. Test Weight

Test weight (38.71 g) was significantly superior in T_9 (100 kg/ ha Nitrogen plus 30 kg/ha Zinc) then in T_8 (100 kg/ha Nitrogen plus 25 kg/ha Zinc) as well as T_7 (100 kg/ha Nitrogen plus 20 kg/ha Zinc). These modalities were to be statistically equal with T_9. Better test weight could be attributed to increased enzyme activities because of zinc that have been involved in the grain filling and starch and protein accumulation. Muhammad *et al.*, (2017) [6] also reported similar results.

7. Grain Yield

Grain yields Significant and maximum (4.35 t/ha) was obtained with T_9 (100 kg/ha Nitrogen along with 30 kg/ha Zinc), which was statistically superior over all other treatments. Higher grain yield could be due to improved plant growth, tillering, spike length and seed setting.

9. Straw Yield

Significantly higher straw yield (7.21 t/ha) was recorded with T_9 (100 kg/ha Nitrogen along with 30 kg/ha Zinc), which might be due to increased vegetative growth and plant height due to optimum nutrient availability.

10. Harvest Index

Maximum harvest index (38.40%) was observed not significant with T_2 (50 kg/ha Nitrogen along with 25 kg/ha Zinc), which was statistically at par with T_1 (50 kg/ha Nitrogen along with 20 kg/ha Zinc) and T_3 (50 kg/ha Nitrogen along with 30 kg/ha Zinc). This might be due to efficient partitioning of dry matter towards reproductive structures.

Economic Analysis

Economical analysis of barley growing with varying amounts of nitrogen and zinc was that the treatment T_9 (100 kg/ha Nitrogen + 30 kg/ha Zinc) turned out to be most beneficial. T_9 returned the maximum gross (₹ 2,21,755.45/ha), net (₹ 1,60,145/ha) returns and benefit-cost ratio (2.60), and also it was most expensive to cultivate (₹ 61,610.45/ha), which is quite significant compared to any other treatment. Contrastingly, T_{10} (control) recorded the lowest economic returns in terms of gross returns of (₹1,80,866.20/ha), net returns of (₹ 1,21,130/ha), and the narrowest B:C ratio of 2.03. This is because T_9 has better economic performance which was contributed by better yields on grain and straw produced due to the optimum supply of nutrients. These results agree with Muhammad *et al.*, (2017) [6], who stated that the higher rations of B:C can be realized due to better enzymatic activities, better absorption, and simply more production in crops with the sufficient amount of nitrogen and zinc.

Conclusion

The conclusion is that the treatment T_9, which implied the use of 100 kg/ha Nitrogen and 30 kg/ha Zinc, turned out to be the most effective. The highest values were realized in grain and straw yield, test weight, effective tillers and grains per spike in this treatment. It also attained the highest gross return, net return and benefit cost ration.

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Table 1: Influence of Nitrogen and Zinc on growth attributes of Barley.

S. no	Treatment combination	Pre Harvest Observation		
		Plant Height (cm)	Number of Tillers/Plant	Plant dry Weight(g)
	50 kg/h Nitrogen + 20 kg/h Zinc	108.04	4.67	18.70
	50 kg/h Nitrogen + 25 kg/h Zinc	109.09	5.07	19.43
	50 kg/h Nitrogen + 30 kg/ Zinc	111.38	5.20	18.48
	75 kg/h Nitrogen + 20 kg/h Zinc	115.29	5.13	19.89
	75 kg/h Nitrogen + 25 kg/h Zinc	116.43	5.13	18.86
	75 kg/h Nitrogen + 30 kg/h Zinc	116.23	5.13	20.03
	100 kg/h Nitrogen + 20kg/h Zinc	116.77	5.20	19.91
	100 kg/h Nitrogen + 25 kg/h Zinc	120.28	4.93	20.95
	100 kg/h Nitrogen + 30 kg/h Zinc	121.79	5.67	24.77
	Control N-P-K (80:30:30)	113.61	5.27	18.43
	F - Test	S	S	S
	S.Em (±)	2.84	0.19	0.52
	CD (p = 0.05)	8.45	0.56	1.50

Table 2: Influence of Nitrogen and Zinc on Post-Harvest Observation of Barley.

S. no	Treatment combination	Post - Harvest Observations					
		No. of Effective Tillers /m^2	No. of grains/ Spike	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1.	50 kg/h Nitrogen + 20 kg/h Zinc	177.00	56.47	34.58	3.72	6.05	38.06
2.	50 kg/h Nitrogen + 25 kg/h Zinc	191.33	56.60	33.72	3.83	6.14	38.40
3.	50 kg/h Nitrogen + 30 kg/ Zinc	187.67	56.73	35.09	3.90	6.63	37.07
4.	75 kg/h Nitrogen + 20 kg/h Zinc	182.00	56.53	36.63	3.86	6.45	37.46
5.	75 kg/h Nitrogen + 25 kg/h Zinc	190.33	55.87	36.27	3.84	7.05	35.23
6.	75 kg/h Nitrogen + 30 kg/h Zinc	196.00	56.80	37.85	3.99	6.97	36.39
7.	100 kg/h Nitrogen + 20kg/h Zinc	192.33	56.13	35.81	3.95	6.97	36.25
8.	100 kg/h Nitrogen + 25 kg/h Zinc	191.33	56.60	36.53	4.01	7.03	36.37
9.	100 kg/h Nitrogen + 30 kg/h Zinc	201.33	57.27	38.71	4.35	7.21	37.58
10.	Control N-P-K (80:30:30)	185.00	56.53	35.00	3.26	5.96	35.40
	F - Test	S	S	NS	S	S	NS
	S.Em (±)	4.42	0.22	1.37	0.10	0.24	0.97
	CD (p = 0.05)	13.12	0.66	-	0.29	0.71	-

Table 3: Influence of Nitrogen and Zinc on economic of Barley.

S. no	Treatment combination	Economics			
		Cost of cultivation (INR/ha)	**Gross return (INR/ha)**	**Net return (INR/ha)**	**B:C ratio**
1	50 kg/h Nitrogen + 20 kg/h Zinc	57862.25	194585.03	136722.78	2.36
2	50 kg/h Nitrogen + 25 kg/h Zinc	59301.50	199885.24	140583.74	2.37
3	50 kg/h Nitrogen + 30 kg/ Zinc	60740.75	204647.08	143906.33	2.37
4	75 kg/h Nitrogen + 20 kg/h Zinc	58297.05	200510.58	142213.53	2.44
5	75 kg/h Nitrogen + 25 kg/h Zinc	59736.30	202483.56	142747.26	2.39
6	75 kg/h Nitrogen + 30 kg/h Zinc	61175.55	208784.63	147609.08	2.41
7	100 kg/h Nitrogen + 20kg/h Zinc	58731.85	205002.89	146271.04	2.49
8	100 kg/h Nitrogen + 25 kg/h Zinc	60171.10	208556.36	148385.26	2.47
9	100 kg/h Nitrogen + 30 kg/h Zinc	61610.35	221756.99	160146.64	2.60
10	Control N-P-K (80:30:30)	50800.00	171928.66	121128.66	2.38

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