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Research Article

The Study Explores the Impact of Nitrogen Fertilizer within the Framework of Balanced Fertilization on Food Barley Cultivation in the Basona Warana District, Located in the North Shewa Zone of the Amhara Region, Ethiopia

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ABSTRACT

The study explores the impact of nitrogen fertilizer application on food barley cultivation in the Basona Warana District, North Shewa Zone, Amhara Region, Ethiopia, over three consecutive years from the main rainy season of 2013 to 2016. Barley, a significant cereal crop in Ethiopia, faces various challenges such as poor soil fertility, water logging, drought, frost, acidity, diseases, pests, and weed competition, all of which contribute to reduced yields. The experiment applied different nitrogen (N) doses ranging from 0 to 222 kg N ha-1, along with uniform applications of 69 P2O5, 80 K2O, 30 S, 0.5 B, 2 Zn, and 2 Cu kg ha-1 across all plots. The treatments were organized in a completely randomized block design with three replications.

Results indicated significant impacts of nitrogen rates on barley growth and yield components compared to the control treatment. The highest grain and straw yields were observed with the application of 222 kg N ha-1. Economic analysis revealed that the addition of 222 kg N ha-1 resulted in the highest net return of

Birr 42,698.7 ha-1 and a marginal rate of return of 471.1%. While consistent yield increments were observed with increased nitrogen rates up to 222 kg N ha-1, practical adoption beyond 92 kg N ha-1 may pose challenges. Thus, farmers should focus on soil fertility management to enhance soil biophysical and chemical properties, particularly considering the low soil organic carbon content, which directly impacts the efficiency of applied nitrogen fertilizer.

Keywords: Balanced fertilization; Food barley; Nitrogen fertilizer.

INTRODUCTION

Barley (Hordeum Vulgare L.) stands as a vital food crop globally, ranking fourth in total cereal production following wheat, rice, and maize. Major barley-producing countries like Russia, Canada, Germany, Ukraine, and France contribute significantly to global production. In Ethiopia, barley holds prominence as a staple food crop, utilized in various culinary preparations such as Injera, Kolo, bread, as well as in local beverages like tela, borde, and beer. Its straw also serves as essential animal feed, especially during dry seasons, highlighting its multifaceted importance in Ethiopian agriculture. The increased recognition of barley's health and nutritional benefits has led to its amplified production and consumption worldwide [1].

Despite its significance, barley production in Ethiopia faces various challenges, resulting in a relatively low yield of 2.16 t ha-1 compared to its potential yield of over 6 t ha-1 on experimental plots. Several factors contribute to this disparity, including poor soil fertility, waterlogging, drought, frost, soil acidity, diseases, pests, and weed competition. Notably, inadequate soil fertility and low pH levels pose significant constraints to barley cultivation, exacerbated by severe soil erosion and historical neglect of soil management practices, particularly in highland regions where barley production is concentrated. Nitrogen and phosphorus deficiency, coupled with suboptimal crop management practices like monocropping, further impede barley productivity [2].

The strategic use of fertilizers plays a crucial role in enhancing crop productivity, with nitrogen fertilizer particularly known to increase grain yield and protein content in barley. However, despite existing studies on the response of barley to nitrogen fertilization, research specifically addressing optimal nitrogen fertilizer rates under balanced fertilization remains limited in the study area. Hence, this study aims to assess the impact of varying nitrogen fertilizer levels under balanced fertilizer application and determine the economically optimal nitrogen rate for barley production [3].

MATERIALS AND METHODS

The experiment took place in Goshe Bado and Gudo Beret areas of Basona Warana district, located in the North Shewa Zone of the Amhara Regional State, approximately 147 and 172 km northwest and east of Addis Ababa, respectively. The predominant soil type in the study area is classified as Vertisols, characterized by low organic matter content. Geographically, the experimental sites ranged from 090.43’.58.4” to 090.44’45.8” N and 0390.25’.39.1” to 0390.27’.29.4” E, with altitudes ranging from 2796 to 2990 m.a.s.l in Goshebado and 090.46’.21.2” to N 090.47’.06.5” and 0390.39’.37.3” to 0390.40’.08.5” E, with altitudes from 2914 to 3043 m.a.s.l in Gudo Beret. The area experiences an unimodal rainfall pattern, with peak rainfall occurring in July (maximum: 293.07 mm) and minimal rainfall in December (4.67 mm). The mean annual rainfall is 934.2 mm, with a mean annual maximum temperature of 19.82°C and monthly temperature fluctuations ranging from 18.4°C in August to 21.8°C in June. The mean annual minimum temperature is 6.4°C, with monthly values varying from 2.8°C in November to 8.8°C in June. November marks the coldest month, while May and June are the hottest months [4] (see Figure 1).

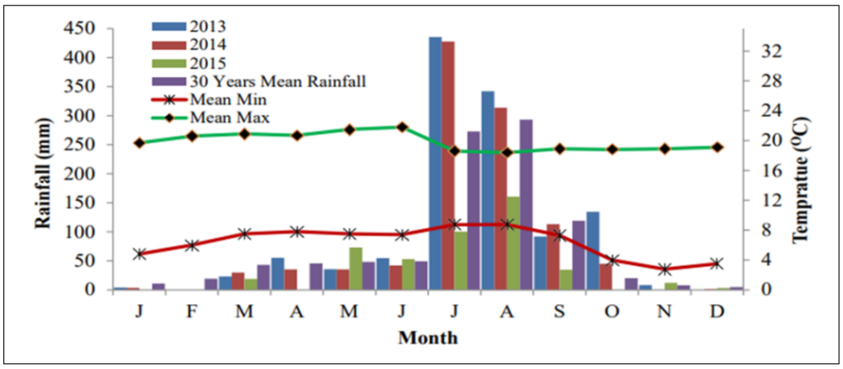

Figure 1: Mean and Monthly Rainfall, mean monthly minimum and maximum temperature of the study areas.

The experiment spanned the main rainy seasons for three consecutive years (2013-2016) and was conducted on farmers' fields. Prior to commencing the experiment, composite soil samples (0-20 cm depth) were collected annually from the experimental plots using a zigzag sampling method. The experiment employed a randomized complete block design (RCBD) with three replications, and each plot measured 3.6 x 3.4 m (12.24 m2), with a 1 m alley between replications and 0.5 m separation between plots [5].

Following local farming practices, the experimental fields were initially prepared using oxen-drawn implements known as Maresha. The treatment involved six nitrogen levels (0, 46, 92, 138, 176, and 222 kg ha-1) combined with 69 P205, 80 K20, 30 S, 0.5 B, 2 Zn, and 2 kg Cu ha-1 fertilizers. At planting, the full amounts of P, K, S, and half of N were applied using triple superphosphate (TSP), muriate of potash (KCl), gypsum (CaSO4), and urea, respectively. The remaining half of the nitrogen was top-dressed 45 days after sowing (at tiller development stage). Micronutrients (Zn, B, and Cu) in the form of ZnSO4, Borax, and CuSO4 were foliarly applied twice at the tiller development stage. Barley seeds (var. HB1307) were drilled in rows spaced 20 cm apart at a seeding rate of 138 kg ha-1 [6].

Data Analysis

Agronomic and yield data were analyzed using the general linear model (GLM) procedures of SAS statistical software to assess the effect of different nitrogen fertilizer rates under balanced fertilization. The Least Significant Difference (LSD) test at P ? 0.05 was utilized to separate means when significant differences were observed among treatments [7].

Economic Analysis

Variable costs associated with barley production and local market prices of barley were recorded for partial budget analysis to evaluate the impact of balanced nutrient application on barley yield. To account for potential yield overestimation from the experimental plot, mean grain and straw yields were adjusted downward by 10% to reflect actual field conditions, following CIMMYT guidelines [8].

RESULTS AND DISCUSSION

Soil Physicochemical Properties

The pre-experiment analysis of selected soil physical and chemical properties in the study area is presented in Table 1. Soil pH ranged from 5.87 to 6.88 for Goshe Bado and 6.20 to 6.41 for Gudo Beret, indicating slightly acidic to neutral soil conditions. According to Landon's classification, soils were categorized as low to medium in total nitrogen (TN), very low to high in available phosphorus (Av. P), and low in organic carbon (OC) (Table 1).

Parameters	2013/14	2014/15	2015/16	Soil test interpretation
pH (1:2.5)	6.59	6.08	6.14	Slightly acidic to acidic
Total nitrogen (%)	0.12	0.09	0.09	Very low to medium
Organic carbon (%)	1.31	0.89	0.86	Low
Av. P (ppm)	9.98	9.09	8.34	Low
Sand (%)	22.4	32.0	29.0	-
Clay (%)	49.6	37.0	47.0	-
Silt (%)	28.0	31.0	24.0	-
Soil Texture	Clay	Clay loam	Clay	-

Table 1: Selected physicochemical properties of experimental soils before planting of barley.

Effect of Nitrogen on Growth and Yield of Barley

The results indicated that plant height was significantly ($P < 0.01$) influenced by nitrogen fertilizer rates. The highest plant height was observed with the application of 222 kg N ha-1, while the lowest was from the control across three years. Nitrogen, being a major component of chlorophyll and proteins, likely enhanced the growth and development of plants. Higher nitrogen rates with balanced fertilization had a pronounced effect on increasing the vegetative growth of crop plants, consistent with other studies [9,10].

Analysis of variance revealed that grain and straw yields of barley at both locations were significantly ($P < 0.01$) influenced by different rates of nitrogen fertilizer. Barley grain and straw yields consistently increased with the increase in nitrogen application rate. The maximum grain and straw yields were obtained from the addition of 222 kg N ha-1, resulting in substantial yield increments compared to the control without nitrogen application. The increase in grain yield as a result of increased nitrogen fertilizer application could be attributed to enhanced development of yield components of barley, leading to increased grain yield and total biomass.

Nitrogen fertilizer rates significantly correlated with barley grain yield, following a quadratic equation relationship. Grain yield increased rapidly as nitrogen application rate increased from 0 to 222 kg ha-1, indicating the potential for significantly higher grain yield at higher nitrogen application rates. Similar findings have been reported in other studies.

Partial Budget Analysis

Partial budget analysis of nitrogen fertilizer on food barley revealed that the highest net benefit was obtained from the application of 222 kg N ha-1, with a maximum net benefit of 42,698.7 ETB ha-1 and optimum marginal rate of return. The rate of 92 kg N ha-1 showed the highest marginal rate of return, aligning with CIMMYT recommendations. However, investing in additional nitrogen fertilizer rates beyond 92 kg ha-1 resulted in lower marginal rates of return, suggesting that the 92 kg ha-1 rate is recommended for food barley production.

CONCLUSION

The study findings suggest that the application of 92 kg N ha-1 resulted in improved barley grain yield and economic benefits compared to yields obtained without nitrogen application over three cropping seasons. Based on these results, the combined application of 92 kg N ha-1 with 69 P205, 80 K20, 30 S, 0.5 B, 2 Zn, and 2 kg Cu ha-1 fertilizers is recommended for food barley production in the study areas and similar agro-ecologies.

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