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Journal of Fertilization: In vitro - IVF-Worldwide, Reproductive Medicine, Genetics & Stem Cell Biology

Research Article

Effect of Nitrogen Fertilizer under Balanced Fertilization on Food Barley at Basona Warana District of North Shewa Zone of Amhara Region, Ethiopia

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ABSTRACT

Utilization of fertilizers is an integral part of improved crop production technology and their proper management to crops is important for maximum yield production. Nitrogen is the most limiting nutrient for production of cereal crops in Ethiopia. In Ethiopia, barley ranks both in area coverage and production among cereals. The most important factors that reduce yield of barley in Ethiopia include poor soil fertility, water logging, drought, frost, soil acidity, diseases and insect pests, and weed competition. The present experiment was conducted on main rainy season of 2013 to 2016 for three consecutive years to determine the effect of application of different doses of nitrogen (N) on yield and yield attributes of food barley (var. HRo713).The treatments included the control (0), 46, 92, 138,176 and 222 kg N $ha^{-1}$and 69 P205, 80 K20, 30 S, 0.5 B, 2 Zn and 2 Cu kg ha-1 were applied uniformly to all plots. The treatments were laid out in a completely randomized block design with three replications. Results indicated that nitrogen rates significantly affected growth and yield component of barley as compared to the control treatment. The highest grain and straw yields of barley were recorded from the application of nitrogen at the rate of 222 kg ha^{-1}. The economic analysis revealed that the highest net return of Birr 42,698.7ha^{-1} and marginal rate of return 471.1% were obtained from the addition of 222 kg N ha^{-1}. In fact, consistent yield increments were observed with increased N rates up to 222 kg N ha^{-1}, but the rate beyond 92 kg N ha^{-1} will be practicability difficult for adoption. Rather, it would be advisable the farmer to invest soil fertility management to improve overall soil biophysical and chemical properties because soil organic carbon content is very low, which has direct implication on the efficiency of applied N fertilizer.

Keywords: Balanced fertilization, Food barley, Nitrogen fertilizer

INTRODUCTION

Barely (*Hordeum Vulgare* L.) is one of the most important food crops produced in the world. It ranks the fourth in the total cereal production in the world after wheat, rice and maize. Many countries grow barley as a commercial crop; Russia, Canada, Germany, Ukraine and France are the major barley producers, accounting for nearly half of the total world production. It is also one of the most important staple food crops produced in the highland areas of Ethiopia. Its grain is used for the preparation of different foodstuffs, such as *Injera, Kolo, bread*, and local drinks, such as *tela, borde and* beer. Currently, the production and consumption of barley has increased all over the world due to its health and nutritional value in human diets. The straw is also used as animal feed, especially during the dry season [1].

In Ethiopia, barley ranks both in area coverage and production among cereals. The yield of barley is 2.16 t ha^{-1}which is very low compared to its potential yield of over 6 t ha^{-1} on experimental plots. Despite the importance of barely, there are several factors affecting its yield and production. The most important factors that reduce yield of barley in Ethiopia include poor soil fertility, water logging, drought, frost, soil acidity, diseases and insect pests, and weed competition. Poor soil fertility and low pH are among the most important constraints that threaten barley production in Ethiopia. Since the major barley producing areas of the country are mainly located in the highlands, severe soil erosion and lack of appropriate soil management practices in the past have resulted low fertility. Particularly, deficiency of nitrogen and phosphorus is the main factor that severely reduces the yield of barely. Poor crop management practices including monocropping practices are also

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Received date: June 17, 2021; **Accepted date:** July 06, 2021; **Published date:** July 13, 2021

Citation: Kassie K, Shewangizaw B, Assefa S, Shegaw G, Taye G, Abe A (2021) Effect Of Nitrogen Fertilizer Under Balanced Fertilization On Food Barley At Basona Warana District Of North Shewa Zone Of Amhara Region, Ethiopia. J Fertil In vitro IVF Worldw Reprod Med Genet Stem Cell Biol. 9:4.

among the major production constraints affecting the productivity of barley [2].

Utilization of fertilizers is an integral part of improved crop production technology and their proper management to crops is important for maximum yield production. Results of several studies also have shown that nitrogen fertilizer increases grain yield and its protein content. Although some trials were conducted on the response of barley to N fertilizer, the studies undertaken so far on the determination of optimum nitrogen fertilizer rates for barley were not under balanced fertilization in the study area. The present study was, therefore, carried out to find out the effect of different levels of applied nitrogen fertilizer under balanced fertilizer application and to determine economically optimum N arte for barley production [3].

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Goshe bado and Gudo beret areas of Basona Warana district, North Shewa Zone of the Amhara Regional State, 147 and 172 km northwest, and East of Addis Ababa, respectively. The dominant soil type of the study area is classified as Vertisols having low organic matter. Geographically, the experimental siteswere located at a range of 090.43'.58.4" to 090.44'45.8" N and 0390.25'.39.1"to 0390.27'.29.4" E and an altitude of 2796 to 2990 m.a.s.l at Goshebado and 090.46'.21.2" to N 090.47'.06.5" and 0390.39'.37.3" to 0390.40'.08.5" E and an altitude of 2914 to 3043 m.a.s.l at Gudo beret. It has unimodal rainfall pattern, with a maximum and minimum rainfall of 293.07 mm and 4.67 mm, which peaks in July and December, respectively. The mean annual rainfall is 934.2 mm. The mean annual maximum temperature is 19.82°C and monthly values range between 18.4°C in August and 21.8 °C in June. The mean annual minimum temperature is 6.4 °C and monthly values range between 2.8 °C in November and 8.8 °C in June. The coldest month occurs in November while the hottest months are May and June (Figure 1) [4].

Experimental design and procedure

The experiment was carried out on farmers' fields during the main rainy seasons for three consecutive years (2013-16). Before starting the experiment, initial composite soil samples (0-20 cm depth) were collected from the experimental plots in a zigzag method each year. The experiment was laid out in randomized complete block design (RCBD) with three replications and a unit plot size was 3.6 x 3.4 m (12.24 m^2), with 1m alley between each replication and the plots were separated by 0.5 m [5].

According to farmers' conventional practices, the experimental field was first prepared by using oxen-drawn implement (locally known as *Maresha*). The treatment consisted of six levels of nitrogen (0, 46, 92, 138, 176 and 222 kg ha^{-1}) with combination of 69 P_20_5, 80 K_20 30 S, 0.5 B, 2 Zn and 2 kg Cu ha^{-1}fertilizers. The full amount of P, K, S and half of N from each level were applied at the time of planting in the forms of triple superphosphate (TSP), muriate of potash (KCl), gypsum ($CaS0_4$) and are respectively. The remaining half urea for N was applied as top dressing 45 days after sowing (at tillers development stage). Micronutrients (Zn, B, and Cu) in the form of $ZnS0_4$, Borax and $CuS0_4$ respectively were applied as foliar two times at tillers developments stage of the crop. Barley (*var. HB1307*) seed was drilled in row with 20 cm apart between rows at the rate of 138 kg ha^{-1} [6].

Data Analysis

The agronomic and yield data were analysed using the general linear model (GLM) procedures of the SAS statistical software to evaluate the effect of different rates of N fertilizer under balanced fertilization. Least Significant Difference (LSD) test at $P \leq 0.05$ was used to separate means whenever there were significant differences among different treatments [7].

Economic analysis

Variable costs incurred for the production of barley and local market price of barley were recorded for partial budget analysis to examine the effect of application of balanced nutrient on barley yield. To minimize overestimation of yield from the experimental plot, mean grain and straw yield were adjusted downward by 10% to actual filed condition according to CIMMYT [8].

RESULTS AND DISCUSSION

Soil physicochemical properties

The pre-experiment analysis of selected soil physical and chemical properties used in the study area is presented in (Table 1). The pH of the soil ranged from 5.87 to 6.88 for Goshe bado and 6.20 to 6.41 for Gudo beret which showed that the soil of the study area was slightly acidic to neutral. According to Landon, the soils were low to medium in in total nitrogen (TN), very low and high in available phosphorus (Av.P), and low in organic carbon (OC) (Table 1).

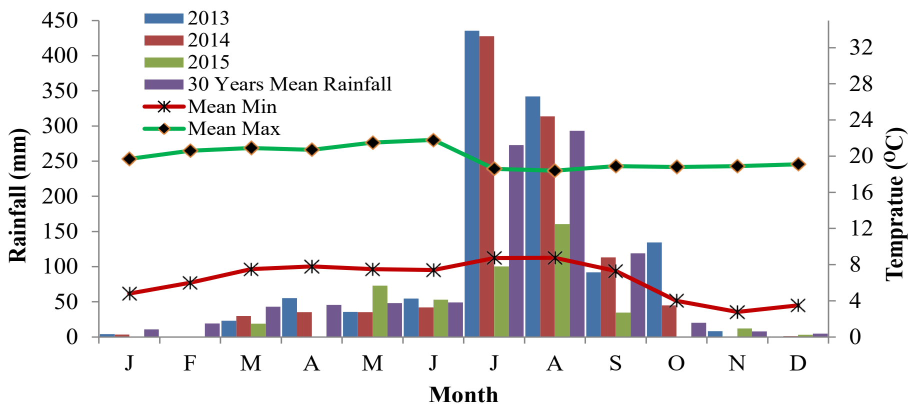

Figure 1: Mean and Monthly Rainfall, mean monthly minimum and maximum temperature of the study areas.

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

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	-

Effect of nitrogen on growth and yield of barley

The result showed that plant height was significantly (P<0.01) affected by N fertilizer rates. The highest plant height was recorded with application of 222 kg N ha^{-1} and the lowest value was from the control across three years. The possible reason for attaining maximum values of growth parameters of barely with application of 222 kg N ha^{-1} might be that nitrogen is the major component of chlorophyll and proteins which enhanced growth and development of plants. The other reason might be that the application of higher nitrogen rates with balanced fertilization had a pronounced effect on increasing the vegetative growth of crop plants. In consistent with the present study, other research findings also indicated that nitrogenous fertilizer significantly increased plant height.

The analysis of variance showed that grain and straw yields of barley at both locations were significantly (P<0.01) influenced by the application of different rates of N fertilizer. Barley grain and straw yields consistently increased with the increase in the rate of nitrogen application. The maximum grain and straw yields of 5224.1 and 6785.7 kg ha^{-1} were obtained from the addition of 222 kg N ha^{-1}, respectively. The application of 222 kg ha^{-1} N under balanced fertilization resulted in barley grain and straw yield increments of 172% (3499.8 kg) and 207% (4574.4 kg) compared to the control without nitrogen application under balanced fertilization. The increase in grain yield ha^{-1} as a result of increased nitrogen fertilizer application could be attributed to the enhanced development of yield components of barley which ultimately increased grain yield and total biomass of barley. Overall, the results of the study exhibited a significant effect of nitrogen fertilizer on growth and yield of barley, which agrees with the findings of other studies [9].

Nitrogen fertilizer rates significantly correlated with barley grain yield. The relationship of nitrogen fertilizer application and barley grain yield was fitted to quadratic equation. Grain yield increased rapidly as N application rate increased significantly from 0 to 222 kg ha^{-1},which implies that significantly higher grain yield could be attained at the highest N application rate at the study sites. Similarly, reported that yield and yield components of barley were significantly correlated with N rates.

Partial Budget Analysis

According to CIMMYT, the partial budget analysis of N-fertilizer on food barley revealed that the highest net benefit was obtained from the application of 222 N kg ha^{-1}. The maximum net benefit of 42698.7 ETB ha^{-1} with the optimum marginal rate of return was recorded at the rate of 222 kg N ha^{-1}, followed by nitrogen application rate of 176 kg N ha^{-1}. MRR of Nitrogen at all rates including 92 kg ha^{-1}rate was above the 100% minimum and this in line with CIMMT. But investing on additional nitrogen fertilizer rate above 92 kg ha^{-1}gave less MRR. Therefore, the treatments that have highest Marginal rate of return (MRR %), is Nitrogen at 92 kg ha^{-1} rate for food barley production is recommended [10].

CONCLUSION

The results of the study revealed that the application of 92 kg N ha^{-1} gave better barley grain yield and economic benefit than yields obtained without N application over three cropping seasons. Based on the findings of this study, the combined application of 92 kg N ha^{-1} with 69 $P_2 0_5$, 80 $K_2 0$ 30 S, 0.5 B, 2 Zn and 2 kg Cu ha^{-1} fertilizers could be recommended for food barley production for the study areas and similar agro-ecologies.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Amhara Agricultural Research Institute (ARARI) and Africa Rising Project for the financial support for the research work. We also appreciate staff members of Debre Birhan Agricultural Research Centre (DBARC) who participated in the realization of this research.

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