American-Eurasian Journal of Agronomy 16 (1): 01-09, 2023
ISSN 1995-896X

DOI: 10.5829/idosi.aeja.2023.01.09

Evaluation of Yield and Economic Analysis of Food Barley (*Hordeum vulgare* L.) as Affected by Varieties and Blended NPSB Fertilizer Rates in Central Highland of Ethiopia

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Abstract: Food barley is an important cereal crop in the central highland of Ethiopia; however its yield was low due to lack of improved varieties and a decline in soil fertility due to nutrient depletion. A field experiment was conducted to evaluate the yield and economic analysis of food barley as affected by varieties and blended NPSB fertilizer rates at Walmera District, Central Highland of Ethiopia. The experiment was laid out in Randomized Complete Block Design with three replications. The treatments consisted of factorial combinations of six fertilizer levels (control (0), 100, 150, 200 and 250 kg NPSB ha^{-1}) and recommended NP (60 N & 69 P_2O_5) kg ha^{-1} and three food barley varieties (HB1966, EH1493 and HB-1307). The analysis of variance revealed that grain yield was highly significantly ($p<0.01$) affected due to blended NPSB fertilizer levels, varieties and their interactions. The variety EH1493 gave the highest mean grain yield (4.71 t ha^{-1}) at 200 kg NPSB ha^{-1}. As compared to the recommended NP fertilizers, the grain yield (4.71t ha^{-1}) was increased by 28.99% with the application of 200kg NPSB ha^{-1} blended fertilizer with EH1493 variety. Similarly, application of 200kg NPSB ha^{-1} blended fertilizer with HB1966 variety increased grain yield by 4.28% than the recommended NP fertilizers level with the same variety. The economic analysis revealed that the highest net benefit (69558.42 birr ha^{-1}) with marginal rate of return of 1475.41% was recorded from the application of 200kg NPSB ha^{-1} with EH1493 variety. Therefore, application of 200 kg NPSB ha^{-1} with EH1493 variety is recommended to be used by farmers around Walmera district and other areas with similar agro-ecological and edaphic conditions of central highland of Ethiopia.

Key words: Food Barley · NPSB Fertilizers · Grain Yield · Economic Benefit

INTRODUCTION

Barley (*Hordeum vulgare* L.) is most important cereals in the world in terms of both quantities produced and cultivated areas, annually; harvested area was about 140 million tons, obtained from 50 million hectares [1]. Ethiopia is considered as a center of diversity for barley [2]. Similarly, barley production in the world was around 15.87 million tons more than previous year's projection, compared to last year production, represent an increase of 15.87 million tons or 12.33% in barley production around the globe. Its average yield globally, changed during the time starting from 1.39 t ha^{-1} (in 1960) to 2.99 t ha^{-1} in 2018 [3]. Ethiopia is the second largest producer in Africa, next to Morocco, accounting for about 25% of the total barley production in the continent [4]. In Ethiopia, barley is one of the most important widely used staple food cereal crop next to tef, maize, wheat and sorghum [5] that belong to the family *Gramineae*. It has an immense cultural and nutritional position, for instance, it can be used to make bread, porridge, soup and roasted grain and for preparing alcoholic and non-alcoholic drinks.

In Ethiopia, barley production was covered total area of 811, 782.08 hectares and total annual production of about 17, 675, 184.47quintals and productivity of 21.7qtha^{-1} in main season [6]. The average yield is above the national average yield but which is still very low as compared to the potential yield goes up to 6 t ha^{-1} on

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experimental plots [7]. The low yield of food barley is primarily related to the depletion of soil fertility due to continuous nutrient uptake of crops, low fertilizer use especially N and P due to continuous cropping and insufficient organic matter application, soil pH, poor agronomic practices and deficiency of nutrients and low levels of fertilizer application [8] and several biotic factors have contributed to this low productivity, such as use of low yielding cultivars, the limited availability of the very few improved cultivars released, weeds, insects and diseases [9]. In addition, for the last three decades, Ethiopian agriculture depended solely on imported fertilizer products namely urea and di-ammonium phosphate (DAP) which are source of N and P although most Ethiopian soils lack other macro- and micro-nutrients [10]. Low soil fertility is a major bottleneck to sustainable food barley production and productivity in Ethiopia [11]. It is exacerbated by soil fertility depletion through nutrient removal with harvest, tillage, weeding and losses in runoff and soil erosion [12]. Many farmers are unable to compensate for such losses, which resulted in negative nutrient balances [13].

In study area, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of Di-ammonium phosphate (DAP) (18-46-0) and Urea (46-0-0) or blanket recommendation for the major food barley crop. Continuous application of nitrogen (N) and phosphorus (P) fertilizers without due consideration of other nutrients led to the depletion of other important nutrient elements such as potassium (K), magnesium (Mg), calcium (Ca), sulfur (S) and micronutrients in soils [14]. An imbalanced fertilizer use results in low fertilizer use efficiency leading to less economic returns and a greater threat to the environment (Abiye *et al*., 2004). Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%) and zinc (53%) are widespread in Ethiopian soils and similarly in study area [15]. Balanced fertilization is the key to sustainable food barley crop production and maintenance of soil health which has both economic and environmental consideration [14]. However, information on blended fertilizer rate (NPSB), especially for food barley, was not determined for the study area. Therefore, the study was conducted to evaluate the yield and economic analysis of food barley as affected by varieties and blended NPSB fertilizer rates, to determine the optimal rate economic under the existing input and output price levels in the study area.

MATERIALS AND METHODS

Description of the Study Area: The experiment was conducted at Holetta agricultural research center, Walmera district, Oromia National Regional State, special zone around Fifinne (Addis Ababa), in highland of Ethiopia (Figure 1). Holetta Agricultural Research Center (HARC) is located at 09°03’ 19.4’’N latitude and 38°30’ 25.43’’E longitudes and altitude of 2400 masl site. The study was conducted in 2019 main cropping season at Holetta agricultural research center on station. According to Ethiopian agro-ecological classification the experimental site is grouped under *Dega,* the soil type is *Nitisols* [16]. According to the weather record from the National Meteorological Services agency (NMSA) and Holetta Agricultural Research Center (HARC) the annual rainfall and annual mean minimum and maximum temperatures of the area based on the last 10 years (2009 - 2018) records were 1044 mm and 7.7 and 22.9ºC, respectively and mean relative humidity of 62%.

Description of Experimental Materials

Fertilizer Materials: Application of nitrogen fertilizer from urea at the rate of 60 kg N ha^{-1} was used for all treatments as per recommended by Agegnehu *et al.* [17]. Recommended NP (60 kgN and 69 kg P_2O_5) and NPSB (18.9, 37.7, 6.95 and 0.1) were used for the study.

Treatments and Experimental Design: The treatments consists of three varieties of food barley HB1966, EH1493 and HB-1307 (standard check) and five levels of NPSB blended fertilizer (0, 100, 150, 200 and 250kg NPSB ha^{-1}) and one recommended NP (60 kgN/ha and 69 kg P_2O_5/ha) (Table 1). The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement with three replications. The spacing between rows of barley plant was 0.20 m. Each plot consisted of 15 rows. The net plot area that was used for data collection consisted of 11 rows (1.6 x 2.2) with a total area of 3.52 m^2.

Experimental Procedures: The experimental land was prepared by ploughing with machinery. Fine seedbeds were prepared and leveled manually and rows were made across each plot. Treatment was assigned randomly each to the experimental plots within a block. The levels of each blended fertilizer formulations (NPSB) (0, 100, 150, 200 and 250 kg ha^{-1}) and recommended NP (60 kgN/ha and 69 kg P_2O_5/ha) were applied with full dose of basal application based on treatments. The full dose of NPSB were applied at planting time close to the seed drilling line, while to avoid N losses by leaching, N fertilizer in the form of urea

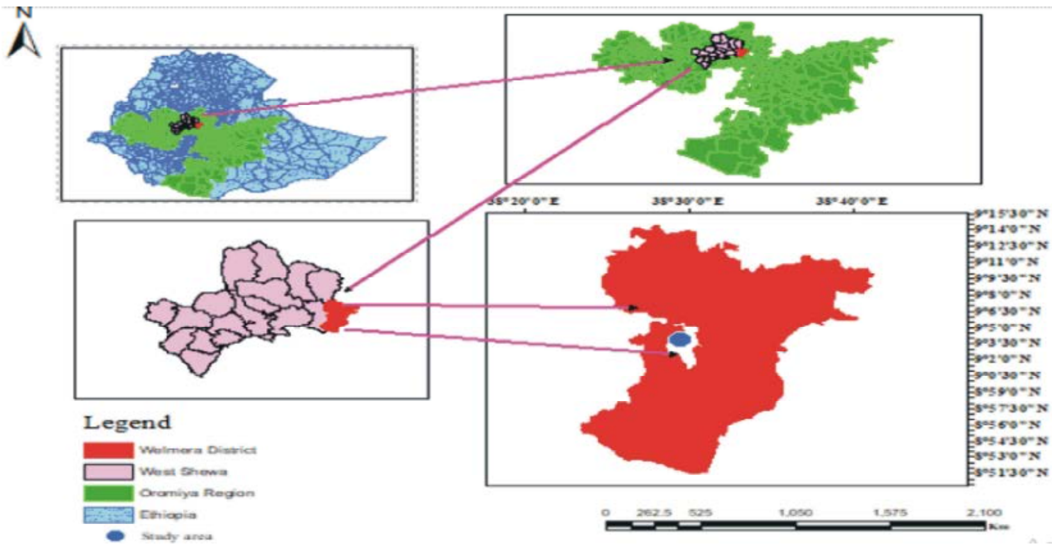

Fig. 1: Map of the Study Area

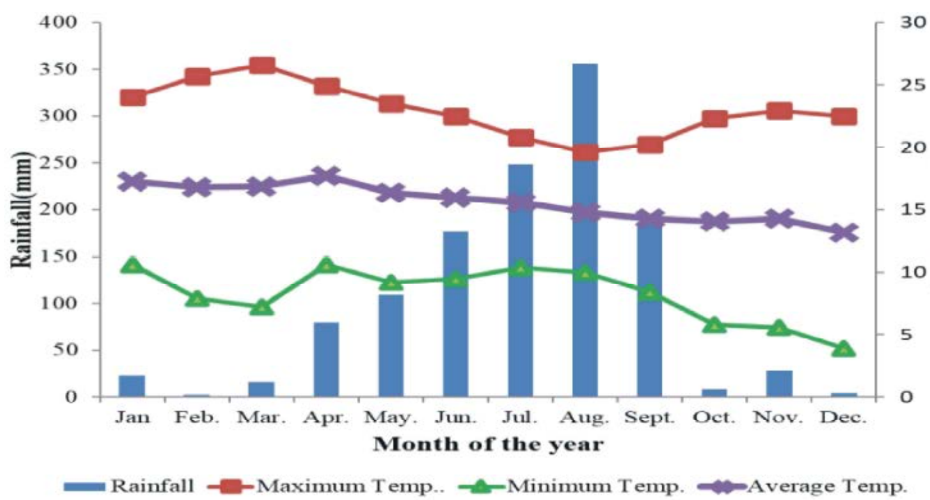

Fig. 2: Mean monthly meteorological data of the study area

Table 1: Fertilizer treatment rates used and their nutrient contents

Fertilizer rates	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	S (kg ha^{-1})	B (kgha^{-1})
Control	0	0	0	0
100kg NPSB ha^{-1}	18.9	37.7	6.95	0.1
150kg NPSBha^{-1}	28.35	56.5	10.42	0.15
200kg NPSBha^{-1}	37.8	75.4	13.9	0.2
250kg NPSBha^{-1}	47.3	94.3	17.38	0.25
130kg Urea +150kg DAPha^{-1}	60	69	0	0

N=Nitrogen; P_2O_5=Phosphorus Penta Oxide; DAP= Di Ammonium Phosphate; S=Sulfur; B=Boron and NPSB= Nitrogen Phosphorus Sulfur and Boron.

was applied in split application, half at planting time and the remaining half N fertilizer was top dressed at 35 days after planting and second weeding in the form of urea. Application of nitrogen fertilizer from urea at the rate of 60 kg N ha^{-1} was used for all treatments as per recommended [17]. Three food barley varieties namely HB1966, EH1493 and HB-1307 were drilled at the rate of 125 kg ha^{-1} in rows 20cm apart, respectively in 11th July, 2019. All other recommended cultural practices for the test crops were done as per the recommendation of the area.

Statistical Analysis: The collected data were subjected to Analysis of Variance (ANOVA) using SAS version 9.3 statistical software programs. Comparisons among treatment means with significant difference for measured and scored characters were made using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Economic Analysis: The partial budget analysis was done for economic analysis as described by CIMMYT [18]. The economic advantages of applied blended NPSB and varieties were carried out using partial budget analysis. In this experiment, the costs that vary were calculated by adding costs of fertilizer and labor for fertilizer application. However, other management and fixed costs were assumed to be equal for all and not included in the calculation. The cost of blended NPSB was 14.80 birr kg^{-1} and the seed cost for improved variety was 16.00 birr kg^{-1} and for standard check 14.00 birr kg^{-1} respectively. Price of food barley grain was 14.00 ETB kg^{-1} and the straw was 2.0 ETB kg^{-1}. The average grain yield and straw yield were adjusted by 10%. Ten percent down wards to reflect the difference between the experimental yield and the farmers yield would expect from the same treatment. It was estimated that 2 man-days were needed for application of 100 kg Urea ha^{-1}. Similarly, 6 man-days were needed to apply 100 kg NPSB ha^{-1}.

Following the CIMMYT partial budget analysis methodology, total variable costs (TVC), gross benefits (GB) and net benefits (NB) were calculated. To identify treatments with maximum return to the farmer's investment marginal analysis was performed on non-dominated treatments. For a treatment to be considered as a worthwhile option to farmers, the marginal rate of return (MRR) need to be at least between 50% and 100% [18]. However, other researchers suggested a MRR of 100% as realistic [19, 20]. Marginal rate of return (MRR) (%): was calculated by dividing change in net benefit (ΔNB) by change in total variable cost (ÄTVC) as MRR (%) =ΔNB/ ΔTVC*100.

RESULTS AND DISCUSSION

Soil Physico-Chemical Properties Before Sowing: Soil analysis for specific parameters relevant to the current study was carried out at Holeta Agricultural Research Center soil laboratory. According to the laboratory analysis, the soil texture of the experimental area was dominated by clay (68.75%).The soil texture (proportion of sand, silt and clay in the soil) of experimental site was 20% sand, 11.25% silt, 68.75% clay. The texture properties of the soil influence water holding capacity, water intake rate, aeration, root penetration and soil fertility.

Soil pH: The results were found to be highly acidic Nitisols with a pH value of 4.71. According to Tekalign [21], pH values classified as < 4.5 very strongly acid, 4.5-5.2 strong acid, 5.3-5.9 moderately acidic, 6.0-6.6 slightly acid, 6.7-7.3 neutral, 7.4-8.0 moderately alkaline and >8.0 strongly alkaline. According to the result obtained from soil laboratory, the value of pH was in strong acid (4.71).The pH of the soil was found out of the suitable range (5.00-7.55) for crop production.

Cation Exchange Capacity: The CEC of the site was 16.42cmol/kg. According to Landon [22] reported that soils having CEC of >40, 25-40, 15-25, 5-15, <5 cmol kg^{-1} categorized as very high, high, medium, low and very low, respectively. According to the result obtained from pre-sowing soil analysis, the value of CEC was in medium range.

Organic Carbon: The study area soil organic carbon content was 1.26%. According to Tekalign [21], rating, organic carbon content of the soil was very low (< 0.50), low (0.5 - 1.5), medium/moderate (1.5 - 3.0), high (> 3.0) and very high (not given). According to the result, the value of OC was in low range. According to Boix-Fayos *et al.* [23] showed that a threshold of 3-3.5% soil organic carbon had to be attained to achieve increases in aggregate stability; no effects on aggregate stability were observed in soils below this threshold.

Organic Matter: The study area soil organic matter content was 2.17%. According to Tekalign [21], rating, organic matter content of the soil was very low (<0.86%), low (0.86 to 2.59), medium (2.59 to 5.17), high (>5.17). The experimental site can be classified in low range. Organic matter plays a key role in a soil aggregate formation which reduces soil bulk density and compaction. As a result, it increases the soil water holding capacity. Soil organic matter provides an energy source for soil microbes and fauna, which are vital for decomposition and soil nutrient recycling.

Total Nitrogen: Total nitrogen value of the experimental soil was 0.18%. According to Tekalign [21], classified soil nitrogen availability as very low, low, moderate and high with < 0.05, 0.05-0.12, 0.12-0.25 and > 0.25 %, respectively.

The experimental site can be classified in moderate range. Generally the moderate nitrogen content of the soil might be due to low vegetation cover, cultivation of land repeatedly and less crop residue from the fields.

Available Phosphorus: Available P content of the experimental site was 13.46 ppm. According to Bray and Kurz [24] the range of phosphorus in Bray method is < 7, 8-19, 20-39, 40-58 and >59 was very low, low, medium, high and very high, respectively. Based on this, the available phosphorous of the study area is low and needs phosphorous fertilizer. This low phosphorous content is due to intensive mining of the farm fields and fixation by heavy metal captions. According [25] also reported low amount of P content on soils which are cultivated repeatedly due to P fixation and P mining.

Available Sulfur: Available sulfur value of the study area was 0.018 ppm. According to EthioSIS [10] reported soil classification for sulfur values lies on very low range. The classification is < 9 very low, 10-20 low, 20-80 optimum and > 80 mg kg^{-1} high. So addition of fertilizer which contains sulfur is relevant. This very low in sulfur content of the soil may be due to lack of using sulfur source mineral fertilizer, poor use of organic fertilizers and changing in cropping systems including the use of high yielding commercial varieties coupled with intensive management practices [26]. It was also related to continuous cultivation which result intensive mining of sulfur from the soil.

Available Boron: Available Boron value of the study area was 0.43 ppm. This shows that soils of the study area are deficit in boron suggesting application of fertilizer which contains boron. Intensive cultivation in the area was responsible for low boron content of the soil.

Soil Physico-Chemical Properties after Harvesting: The soil analysis data showed non-significantly differences among blended NPSB fertilizer treatments, varieties and their interaction for total nitrogen (Table 2). The main factor NPSB fertilizer rates, variety and the interaction of varieties and NPSB fertilizer levels did not showed significant effect on soil pH of the study area (Table 2). Main effect varieties, NPSB fertilizer levels and the interaction of main factors did not influenced CEC significantly (Table 2). Results of the study also indicated that there was non- significant difference between main effect of varieties, blended NPSB fertilizer levels and their interaction on organic carbon and organic matter content of the experimental soil (Table 2). However, the result showed that the mean organic carbon and organic matter of the soil was medium and low based on the rating done by Tekalign [21]. The particulate fraction of soil organic matter and organic carbon is more sensitive to soil management practices because there is high decomposition (mineralization) rates and variations of residual inputs of the plants present in the soil at tropical zone resulting from absent of application of organic matter sources year after year [27]. The main effect of varieties, blended NPSB rates and their interaction had highly significant ($p \leq 0.01$) effect on available phosphorous. The maximum phosphorus level (24.08) after harvest was recorded from 60/69kg NP ha^{-1} with BH1966 variety, while the lowest phosphorus level (13.14) was obtained from 0kg NPSB ha^{-1} with HB-1307. According to rating done by Bray and Kurz [24] the soil laboratory test result showed that the mean available P_2O_5 was ranged as low.

Grain Yield: The end goal in crop production is maximum economic yield, which is a complex function of individual yield components in response to the genetic potential of the cultivars and inputs used. The analysis of variance revealed that the grain yield of food barley was significantly ($p<0.001$) influenced by the main factor blended NPSB fertilizers, varieties and their interaction (Table 3). The maximum grain yield was recorded on variety EH1493 (4713.5 kg ha^{-1}) with 200 kg NPSB ha^{-1} which was at par with variety HB1966 (4534.77 kg ha^{-1}) with the same NPSB fertilizer rate, while the minimum grain yield (2439.94 kg ha^{-1}) was obtained at control NPSB treatment with EH1493 variety. The yield obtained from variety EH1493 with 200 kg NPSB ha^{-1} gave 22.4% grain yield increment over recommended NP fertilizer application and 48% yield increment over control treatment. The high grain yield obtained from both varieties could be due to varietal response to NPSB blended fertilizer and their highest fertilizer use efficiency. Moreover, the synergistic effect of the four nutrients might contributed for improved root growth and increased nutrient use efficiency, thus improved yield components and yield. This result agrees with the previous finding of Woubshet *et al.* [28] who reported that application of NPSB blended fertilizer increase the grain yield. According to Malakouti [29], the grain yield increased due to application of boron with micro nutrients, with the benefits 4 to 11% yield.

Table 2: Main effects of blended NPSB fertilizers and varieties on soil chemical properties of the study area after harvesting

NPSB (kg ha^{-1})	pH (1;2.5HO)	CEC (Cmol(+)kg	N (%)	Av.S (ppm)	OC (%)	OM (%)
0	4.68	17.19	0.105	2.27e	1.4	2.42
100	4.77	17.42	0.126	3.81d	1.48	2.56
150	4.82	17.23	0.13	6.86c	1.47	2.53
200	4.87	17.61	0.133	8.96a	1.48	2.55
250	4.83	17.2	0.131	7.59b	1.44	2.48
Rec.NP	4.86	17.77	0.133	6.94c	1.44	2.49
Mean	4.81	17.4	0.126	6.07	1.45	2.5
Varieties EH1493	4.79	17.63	0.127	6.05	1.47	2.53
HB1966	4.78	17.13	0.122	6.08	1.48	2.55
HB-1307	4.84	17.46	0.129	6.08	1.41	2.43
Mean	4.8	17.4	0.126	6.07	1.45	2.5

Means with the same letter in columns are not significantly different at 5% of Significance level

Table 3: Interaction effect of blended NPSB fertilizer levels and varieties on grain yield (kg ha^{-1}) of food barley

	NPSB(kg ha^{-1})						
Treatment	0	100	150	200	250	Rec.NP	Mean
Varieties							
EH1493	2439.94^{k}	3829.16^{gh}	3960.94^{fg}	4713.5^{a}	3943.83^{fg}	3653.88^{h}	3756.8^{b}
HB1966	3291.83^{i}	4322.77^{bcd}	4488.61^{b}	4534.77^{ab}	4017.38^{efg}	4348.5^{bcd}	4167.3^{a}
HB1307	2923.5^{j}	3081.72^{ij}	4417.66^{bc}	4329.5^{bcd}	4232.77^{cde}	4150.88^{def}	3856.0^{b}
Mean	2885.09^{d}	3744.55^{d}	4289.07^{c}	4525.92^{a}	4064.66^{c}	4051.08^{b}	
CV (%)	5.5						

Means with the same letters are not significantly different at 5% of Significance level

Economic Analysis: The partial budget analysis was employed to estimate the gross benefit, total variable costs, net benefit and marginal rate of return that could be obtained from various alternative treatments. The partial budget analysis shows also the level of profitability and helps to decide whether to adopt a new technology or not. The interest of producers use of NPSB fertilizer rate applying and food barley varieties is not limited to, increasing yield alone, but also to make a profit out of it . Towards maximizing profit, different barley varieties and NPSB fertilizer rates application they apply as well as the cost of seed, fertilizers and the price of yields are determining factors. To identify treatments with the optimum return to the farmer's investment, marginal analysis was performed on non-dominated treatments. For a treatment to be considered as worthwhile to farmers, between 50% and 100% marginal rate of return (MRR) was the minimum acceptable rate of return [18]. From partial budget analysis, maximum net benefit 69, 548.42 Eth-Birr was obtained from plot treated with 200 kg NPSB ha^{-1} and EH1493 variety with marginal rate of return 1475.41 percent. While the lowest net benefit 35191.324 Birr ha^{-1} was obtained from 0 kg NPSB ha^{-1} application and EH1493 variety (Table 4). The result of economic analysis of the treatments using a partial budget method showed that net benefit income was higher in the NPSB fertilizer rates and variety of (200 kg NPSB ha^{-1} and EH1493 variety) than the other rate of treatments. The net benefits had increased, except in the case of treatments; 0 kg NPSB ha^{-1} and HB1307 variety, 0 kg NPSB ha^{-1} and EH1493 variety, 100 kg NPSB ha^{-1} and EH1493 variety, 150 kg NPSB ha^{-1} and EH1493 variety, 200 kg NPSB ha^{-1} and HB1307 variety, 60 kg N & 69 kg P_2O_5 ha^{-1} (Rec. NP) and HB1307 variety, 200 kg NPSB ha^{-1} and HB1966 variety, 250 kg NPSB ha^{-1} and HB1307 variety, 60 kg N & 69 kg P_2O_5 ha^{-1} (Rec. NP) and HB1966 variety, 60 kg N & 69 kg P_2O_5 ha^{-1} (Rec. NP) and EH1493 variety, 250 kg NPSB ha^{-1} and HB1966 variety and 250 kg NPSB ha^{-1} and EH1493 variety. These treatments were not recommended to farmers, because of higher costs and lower net benefits; which are dominated. These can be eliminated from further consideration; and the value of the increase in yield is not enough to compensate for the increase in costs.

Therefore, the yield response and economic indicators of food barley indicated that higher variable costs and lower net benefits were identified compared with non-dominated treatments. Results from the marginal rate of return analysis revealed that the maximum marginal rate of return, 1475.41% was obtained from the application of 200 kg NPSB ha^{-1} with EH1493 variety, which is superior compared to other varieties and the NPSB rate of

Table 4: Partial budgets analysis of food barley varieties yield as influenced by blended fertilizer rates application

Varieties	NPSB ($kgha^{-1}$)	AGY 10%	ASY 10%	TGB (birr ha^{-1})	TVC(birr ha^{-1})	NB (birr ha^{-1})	MRR (%)
HB1966	0	2962.5	3487.32	48451.7	2000	46451.7	-
HB1307	0	2631.5	3618.81	44073.72	1625	41488.72D	-
EH1493	0	2195.5	3704.04	38151.32	2000	35191.3D	-
HB1307	100	2773.5	6776.46	52382.59	5226.42	47156.17	21.83
HB1966	100	3890.49	4409.19	63285.28	5601.42	57683.86	311.88
EH1493	100	3446.24	6403.77	61054.96	5601.42	55443.5D	-
HB1307	150	3975.89	5682.24	67027	5700.83	61326.17	3663.92
EH1493	150	3564.85	5835.15	61578.14	6075.83	55522.3D	-
HB1966	150	4039.75	6060.24	68676.97	6075.83	62601.14	339.99
HB1307	200	3896.55	6003.45	66558.6	6172.38	60386.2D	-
HB1307	Rec.NP	3735.79	5384.16	63069.41	6525	56544.4D	-
HB1966	200	4081.29	5718.69	68575.48	6547.38	62028.1D	-
EH1493	200	4242.15	8357.85	76105.8	6547.38	69558.42	1475.41
HB1307	250	3809.49	6040.53	65413.96	6646.66	58767.3D	-
HB1966	Rec.NP	3913.65	5446.35	65683.8	6900	58883.8D	-
EH1493	Rec.NP	3288.49	6611.49	59261.87	6900	52361.8D	-
HB1966	250	3615.64	5684.31	61987.61	7021.66	54965.9D	-
EH1493	250	3549.45	6650.55	62993.36	7021.66	55871.7D	-

where, AGY= Adjusted grain yield, ASY=Adjusted straw yield, TGB=Total gross benefit, TVC=Total variable cost, NB=Net benefit, NPSB cost= 14.80 Birr kg^{-1}, Urea cost= 13 Birr kg^{-1}, Seed cost=EH1493& HB1966=16 Birr kg^{-1} HB-1307=14 Birr kg^{-1} Labour cost=120 Birr 2manday's^{-1} sales of price of food barley grain=14Birr kg^{-1}, Straw sales price=2birr kg^{-1}, MRR (%) =Marginal Rate of Return, D= Dominated treatment, Control= Unfertilized treatment

treatments. The minimum MRR 311.88% was obtained from plot treated with 100 kg NPSB ha^{-1} with HB1966 variety. The changing MRR % was 311.88% (100 kg NPSB ha^{-1} and HB1966 variety), 3663.92 % (150 kg NPSB ha^{-1} and HB1307 variety), 339.99 % (150 kg NPSB ha^{-1} and HB1966 variety) and 1475.41% (200 kg NPSB ha^{-1} and EH1493 variety) (Table 4). The MRR between any pair of un-dominated treatments was denoted as the return per unit of investment for inputs as expressed in percentage. The results of un-dominated treatments indicated that for each one birr invested in the purchase or production of treatments that was possible to recover one birr plus an extra of 3.11, 3.39, 36.63 and 14.75 Eth-Birr by using 100 kg NPSB ha^{-1} and HB1966 variety, 150 kg NPSB ha^{-1} and HB1307 variety, 150 kg NPSB ha^{-1} and HB1966 variety and 200 kg NPSB ha^{-1} and EH1493 variety, respectively (Table 4).

According to CIMMYT [18] the minimum acceptable marginal rate of return should be 100%. This study indicated that the marginal rate of return was found to be above 100% for treatment combinations. The high net benefit from the table mentioned treatments could be mainly attributed to the high grain yield resulted from the use optimum NPSB fertilizers rates and high responsive variety to NPSB fertilizer. From the table result, the treatments with 200 kg NPSB ha^{-1} with EH1493 variety was more profitable than the rest of treatment combinations considering the net economic benefit. This comparison is important to farmers because they are interested to compare the increase in costs required to obtain a given increase in net benefits. Therefore, the net positive benefit obtained with application of 200 kg NPSB ha^{-1} with EH1493 variety was economically profitable application rates and responsive variety that can be recommended for farmers in the study area and other areas with similar agro-ecological and edaphic conditions.

CONCLUSIONS

Based on the result of the study, the following conclusions are drawn: - Depletion of soil fertility, inadequate of improved varieties and poor agronomic practices are among the major challenges responsible for the low productivity of food barley in the study area. Based on the soil physico-chemical analysis, soil of the study area is clay in texture and strongly acidic with low organic matter, organic carbon, available phosphorus, available sulfur, available boron and with medium total nitrogen and cation exchange capacity. Grain yield were increased with increased NPSB fertilizer level up to 200 kg ha^{-1} but when NPSB fertilizer increased, more than 200 kg ha^{-1} it was decreased. Among tested food barley, EH1493 variety had higher yield performance than others experimental varieties. Moreover, EH1493 variety with 200 kg ha^{-1} NPSB fertilizer gave the maximum grain yield (4.7 t ha^{-1}) and net benefit of ETB 69, 558.42, with a marginal rate of return (1475.41) in the study area.

Recommendations: Depending on the result of this research, the following recommendations are given to improve the production and productivity of food barley in the study area:- Application of 200kg ha^{-1} NPSB fertilizer on EH1493 variety gave maximum grain yield (4.7 t ha^{-1}), maximum net benefit (69, 558.42 ETB) with a marginal rate of return (1475.41 %) in the study area. Hence, farmers in study area and areas with the same agroecology and soil type can be advised to use EH1493 variety with 200kg ha^{-1} NPSB fertilizer to improve the production, productivity and quality of food barley as compared to HB1307 variety which is now under production. For more information, it is advisable to undertake further research across soil types, season and locations to draw sound recommendation on a wider scale and for longer duration and variable cropping systems.

ACKNOWLEDGMENT

The author is grateful the final support provided the Ethiopian Institute of Agricultural Research (EIAR) to undertake the experiment. Also my special gratitude goes to Holeta Agricultural Research Center (HARC) and agronomy research teams and soil fertility research colleagues at HARC for their technical and material support throughout the entire work.

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