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Evaluation of blended fertilizer rates for improving production of food barley (*Hordeum vulgare L.*) in Semen Ari District, Southwestern Ethiopia

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ABSTRACT

Depletion of soil fertility, depletion of macro- and micro-nutrients and soil organic matter and inappropriate and imbalanced fertilizer application are among the most important factors that reduces the food barley production in Ethiopia. Therefore, the experiment was conducted to evaluate NPSB blended fertilizer rate effect on improving production of food barley in Semen Ari District, Southwestern Ethiopia during main cropping season. Control, (142 NPS + 159 Urea) kg ha⁻¹, (150 NPSB + 41 Urea) kg ha⁻¹, (200 NPSB + 72 Urea) kg ha⁻¹, (250 NPSB + 102 Urea) kg ha⁻¹ and (100 NPSB + 161 Urea) kg ha⁻¹ treatments were used for the experiment which laid out in RCBD following three replication with spacing of 20 cm between rows; and HB 1307 improved food barley seeds were drilled on prepared rows. Full dose of blended and potassium fertilizers were applied at planting time and urea was applied in two split. The result revealed that food barley responded well to application of N, P, S and B than the unfertilized one. Application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea resulted in highest grain yield of 3806.3 kg ha⁻¹, while the lowest grain yield of 1939.2 kg ha⁻¹ was recorded from the nil. Moreover, the highest net benefit of 32124.56 ETB ha⁻¹ and economic returns of 942.2% was recorded in response to application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea. Application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea gave 49.05% yield increment and 40.24% increment in economic return over the control. Therefore, we recommend application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea for farmers and investor's in study area and similar agro-ecologies as it was optimum for improving food barley production. Further studies and investigation should be done on plant nutrient uptake, nutrient use efficiency and over location.

Keywords: Blended fertilizer, Economic return, Productivity, Soil fertility

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Introduction

Food barley (*Hordeum vulgare L.*) is cereal crop belongs to genus *Hordeum* in the tribe *Triticeae* of the family Poaceae. It is grown worldwide with greater concentration in temperate areas and high altitudes of the tropics and subtropics. It is one of the most important staple food crops in the highlands of Ethiopia. It has the great importance in social and food habits of Ethiopian people; and used for the preparation of different foodstuffs. The straw is used as animal feed, especially during the dry season. It is also useful for thatching roofs and as bedding (MoANR, 2016). It is the fifth most important cereal crop in Ethiopia and third in South Omo Zone in terms of area of production and productivity (CSA, 2016). Despite its wide range of production, the

productivity of barley in the study Zone is low with average yield of 1250 kg ha⁻¹; which is below the crop potential of 4780 kg ha⁻¹ and 3540 kg ha⁻¹ on research station and on farm, respectively for food barley variety HB 1307 (Lakew and Bekele, 2008) and national average yield of 1966 kg ha⁻¹ (CSA, 2016).

Many constraints hamper agricultural productivity in Ethiopia. Ethiopian soils have been subjected to severe degradation caused by natural and man-made factors (IFDC, 2015). Most of Ethiopian soils, especially in the highlands, are low in nutrient content due to erosion, leaching and absence of nutrient recycling (Zeleke *et al.*, 2010). Yihenew (2002)

reported that most of the areas used for cereal crops production, especially for barley, teff and wheat are low in soil fertility which hamper the productivity of cereal crops. Soil fertility problems are the main constraints that hinder barley production (Abera et al., 2011). Farmers recognized that much of their farmlands were not used for barley production because of poor soil fertility problem that reduces yield. Additionally, Agegnehu et al. (2011) reported that poor soil fertility particularly nitrogen and phosphorus nutrient deficiency, is one of the main barley production constraints in Ethiopia. Soil fertility depletion is among the most important limiting factor for barley production in the highlands of Ethiopia (Chilot et al., 1998; Woldeyesus and Chilot, 2002; Bayeh and Berhane, 2011). Fertilizer use in Ethiopia has focused mainly on the use and application of nitrogen and phosphorus fertilizers in the form of Urea and DAP respectively only for almost all crops starting since early 1970's. Such unbalanced application of plant nutrients may aggravate the depletion of other important nutrient elements in soils (Fayera et al., 2014). Moreover, soil fertility improvement for enhanced barley production has not covered all the barley growing areas of the country (Getachew et al., 2011).

Balanced fertilization is the key to sustainable crop production and maintenance of soil health and economic consideration, however an imbalanced fertilizer application results in low fertilizer use efficiency which leading to less economic returns and a greater threat to the environment (Abiye et al., 2004). Application of NPSB blended fertilizer with rate of 200 kg ha^{-1} for production of food barley gave 70.41% yield increment and 68.97% increment in economic return over the absolute control; it gave 22.45%

and 23.29% yield increment over the recommended NP fertilizer (Melkamu et al., 2019). Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen, phosphorus, sulfur, boron and potassium are widespread in soils of study area (ATA, 2016). Even though, appropriate and balanced application of blended fertilizer including micronutrients resulted in optimum yield and economic return of food barley, information on the application of rate of blended fertilizer (NPSB), was not determined for the study area. Therefore, the experiment was designed to evaluate the effects of NPSB blended fertilizer rates on improving production of food barley (*Hordeum vulgare* L.) in Semen Ari District, Southwestern Ethiopia.

Materials and Methods

Study area description

The experiment was conducted in 2018-2019 and 2019-2020 main season at Shamabuket kebele in Semen Ari District, Southwestern Ethiopia. The experimental site was located at latitude of $06^{\circ}11'35.95''$ N, longitude of $036^{\circ}39'07.95''$ E and elevation of 2579 m.a.s.l. The annual average rainfall of Semen Ari District was 1616 mm. The mean minimum monthly temperature ranges between 10.71°C - 11.50°C and mean maximum monthly temperature ranges between 19.52°C - 23.36°C (Bulki Mender Metro Station). The experimental area has diversity of climate, soil and landforms. The District includes mountains, hills, uplands and lowland plains. The District generally experiences two cropping seasons namely main cropping (September- February) and the second season was from March to August.

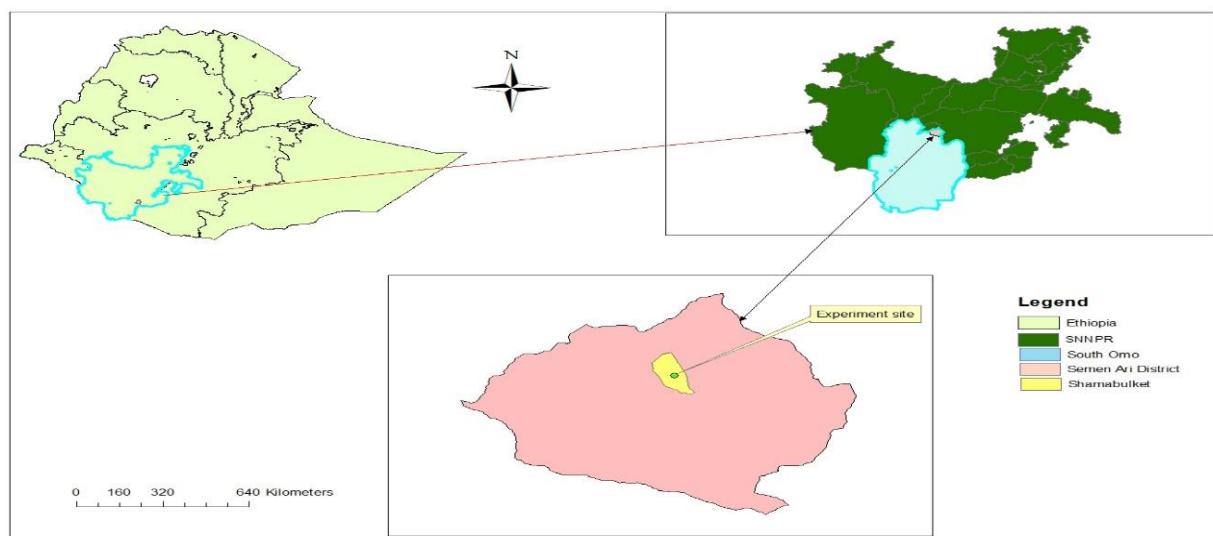


Fig. 1. Map of study area.

Experimental design and treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) following three replications. The experimental site was ploughed and harrowed before sowing. The improved food barley variety HB 1307 was used for the experiment. Improved variety HB 1307 was used because of its superior in grain yield performance in most environments with satisfactory grain yield stability, more resistant to scald and leaf rust and comparable for net and spot blotches,

better agronomic characteristics, particularly lodging tolerance with good biomass yields and moderate tolerance to water logging and superiority of its physical grain quality (Lakew and Bekele, 2008). Plot size was 3 m by 4 m. Furrow rows were made manually in spacing of 20 cm apart and food barley seed was drilled manually and thinned appropriately following management recommendation for barley. The experiment consisting of six treatments as presented in Table 1.

Table 1. Treatment set up of the experiment.

Fertilizer (kg ha ⁻¹)	Nutrients in kg ha ⁻¹			
	N	P ₂ O ₅	S	B
Control	0	0	0	0
142 NPS + 159 Urea	92	54	10	0
150 NPSB + 41 Urea	46	54	10.1	1.07
200 NPSB + 72 Urea	69	72	13	1.4
250 NPSB + 102 Urea	92	90	17	1.7
100 NPSB + 161 Urea	92	36	10	1.07

100 kg ha⁻¹ of KCl was applied for all treatments except control or unfertilized treatment.

Urea, TSP and KCl was used as a source of nitrogen (N), phosphorous (P) and potassium (K), respectively. Full dose of blended fertilizers, potassium and phosphorous fertilizers were applied at planting time and urea was applied in two splits; of which half was applied at planting time and half was top dressed during growth stage. The plots were kept free by hand weeding.

Data collection and analysis

Treatment effects were determined using plant height, number of tillers per plant, spike length, seed per spike, above ground biomass, thousand kernel weight and grain yield. Composite soil sample was collected before planting in zigzag movement with the sampling depth of 0-20 cm and analyzed for texture, pH, organic carbon, total nitrogen, available phosphorus, available sulphur and available boron. Analysis of variance was performed using the GLM procedure of SAS Software Version 9.1. Treatment effects were considered significant in all statistical calculations if the P-values were < 0.05. Means were separated using Least Significant Difference (LSD) test.

Partial budget analysis

The economic evaluation comprising partial budget analysis with dominance and marginal analysis was carried out. To estimate economic parameters, the grain yield was valued based on average market price collected from the local markets during two consecutive years of

production. The average cost of urea, NPS, NPSB and KCl was 15.25, 15.57, 15.57 and 15.46 birr per kilogram, respectively. A wage rate of 50 birr a man per day and 11 birr per kilogram of grain value of barley was considered. The dominance analysis was also done, which was used to select potentially profitable treatments; it was carried out by first listing the treatments in order of increasing costs that vary.

Any treatment that has net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated. The selected treatments by using this technique were referred as un-dominated treatments. For each pair of ranked un-dominated treatments, a percentage marginal rate of return (% MRR) was calculated. The percent MRR between any pair of un-dominated treatments denoted the return per unit of investment in crop management practices expressed as percentage. Marginal rate of return (% MRR) was calculated as the ratio of differences between net benefits of successive treatments to the difference between total variable costs of successive treatments (CIMMYT, 1988). For a treatment to be considered a worthwhile option to farmers, the marginal rate of return (MRR) needed to be at least 100%. Thus, the minimum acceptable rate of return was considered to be 100%. Some of the concepts used in the partial budget analysis are gross field benefit (GFB), total variable cost (TVC) and net benefit (NB).

Gross margin (ETB ha⁻¹) = Total revenue (ETB ha⁻¹) – Total variable cost (ETB ha⁻¹).

NR Net return (ETB ha⁻¹) = Gross margin (ETB ha⁻¹) – Total fixed cost (ETB ha⁻¹).

Total cost of production (ETB ha⁻¹) = Total variable cost (ETB ha⁻¹) + Total fixed cost (ETB ha⁻¹).

Benefit-cost ratio = Net Return / Total Cost Production (CIMMYT, 1988).

Results and Discussion

Soil analysis

Analysis of soil sample collected before experiment was done at soil laboratory of Jinka Agricultural Research Centre (Table 2). The soil of the experimental site has a proportion of 5% sand, 41% silt and 54% clay; which was classified as sandy clay based on the soil textural triangle. The organic carbon of experimental site was 2.63% done by Walkley-Blacky methods (Black, 1965), which was rated as medium (Tekalign et al., 1991). The pH of the experimental site was 5.02, which was implied that the soil of experimental site was strongly acidic according to Tekalign et al. (1991) and Murphy (1968).

The soil of experimental site has total nitrogen of 0.133% by Kjeldahl digestion and distillation followed by titration method, which showed that the experimental site has moderate level of total nitrogen according to Tekalign et al. (1991) and Murphy (1968). The experimental soil has

available phosphorus of 9.25 ppm analysed by Olsen methods which was effective for both alkaline and acidic soil and extracted by 1 M NaHCO₃, which was rated as medium according to Olsen et al. (1954).

The soil of experimental site has available sulphur of 6.32 ppm exist in soil in sulphate (SO₄²⁻-S) form which was done by turbidimetric methods of analysis (acidic and non-calcareous soil) and its extractant was calcium chloride dehydrate as sulphate, which showed that the soil has medium level of sulphur according to Marx et al. (1999) and Horneck et al. (2011); and available boron of 1.24 ppm done by dilute HCl methods in which most effective and efficient, most applicable for acidic, neutral and alkaline soil and more economical than that of hot water methods (only for alkaline soil), which was categorized under high level according to Horneck et al. (2011).

Table 2. Some physical and chemical properties of the soil before the experiment.

Soil Properties		Composition	
Sand (%)		5.00	
Silt (%)		41.00	
Clay (%)		54.00	
Textural class		Sandy clay	
pH (H ₂ O) (1:2.5)		5.02	
OC (%)		2.63	
TN (%)		0.13	
Available P (ppm)		9.25	
B (ppm)		1.24	
S (ppm) as SO ₄		6.32	

Table 3. Food barley growth, yield and yield components as influenced by NPSB blended fertilizer rate.

Treatments	Plant	Tiller	Spike	Seed	Biomass	Grain	TKW (g)
	Height (cm)	No./Plant	Length (cm)	No./Spike	(kg ha ⁻¹)	Yield (kg ha ⁻¹)	
Control	72.50 ^b	1.60 ^c	4.56 ^c	29.77 ^c	5974.70 ^d	1939.20 ^d	43.89
142 kg ha ⁻¹ NPS + 159 kg ha ⁻¹ Urea	94.43 ^a	2.70 ^b	6.48 ^a	40.37 ^a	10740.30 ^b	3479.80 ^{ab}	45.24
150 kg ha ⁻¹ NPSB + 41 kg ha ⁻¹ Urea	92.33 ^a	2.97 ^{ab}	5.65 ^b	35.07 ^b	8709.10 ^c	2699.50 ^c	48.44
200 kg ha ⁻¹ NPSB + 72 kg ha ⁻¹ Urea	94.20 ^a	3.00 ^{ab}	6.03 ^{ab}	34.70 ^b	9657.70 ^{bc}	3042.30 ^{bc}	47.58
250 kg ha ⁻¹ NPSB + 102 kg ha ⁻¹ Urea	96.47 ^a	3.00 ^{ab}	6.15 ^{ab}	38.33 ^{ab}	9780.50 ^{bc}	3234.60 ^{abc}	47.55
100 kg ha ⁻¹ NPSB + 161 kg ha ⁻¹ Urea	95.10 ^a	3.60 ^a	6.78 ^a	38.23 ^{ab}	12497.80 ^a	3806.30 ^a	44.10
LSD _{0.05}	4.43	0.89	0.81	4.59	1747.80	672.82	NS
CV (%)	2.69	17.47	7.53	6.99	10.05	12.19	7.10

Means with the same letter within column shows statistically not significant different at LSD_{0.05}

No. = Number; TKW= Thousand Kernel Weight; CV= Coefficient of Variation

Food barley growth, yield and yield components have influenced by NPSB blended fertilizer rate. Plant height, tiller number per plant, spike length, number of seed per spike, above ground biomass and grain yield were influenced by NPSB blended fertilizer rate, whereas thousand kernel weight did not affected by NPSB blended fertilizer rate.

Plant height

The highest plant height of 96.47 cm was recorded from 250 kg ha⁻¹ NPSB + 102 kg ha⁻¹ Urea followed by 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea which was in statistical parity with the rest treatment except unfertilized one, while the lowest height of 72.50 cm was recorded from the absolute control treatment. This result was in line of agreement with application of different

blended fertilizers had significant influence on plant height of barley with increasing blended fertilizers application rates (Melkamu et al., 2019; Abdisa, 2020); and also macro- and micro-nutrients (Nitrogen, Phosphorous with Sulfur and Boron) fertilizers application can increase plant height with increasing doses and combination (Dewal and Pareek, 2004; Gupta et al., 2004; Arif et al., 2006; Bereket et al., 2014).

Tiller number per plant

Number of tiller per plant was affected by NPSB blended fertilizer rate of which the largest tiller number of 3.60 was recorded from 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea which was in statistical parity with all treatments rather than 142 kg ha⁻¹ NPS + 159 kg ha⁻¹ Urea and absolute control treatments, while the smallest tiller number of 1.60 was recorded from nil one. In agreement with this result, Abdisa (2020) reported that increase in the numbers of total tillers in response to increasing the rate of NPSB blended fertilizer which may indicate that the importance of availability of balanced nutrients for better growth and development of the plant; and also agree with tiller number per plant was increased significantly across the increased rates of NPS fertilizer (Yared et al., 2020).

Spike length

The result has revealed that NPSB blended fertilizer rate affects spike length of food barley of which the longest spike length of 6.78 cm was recorded from 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea which was in statistical parity with the rest of treatments except 150 kg ha⁻¹ NPSB + 41 kg ha⁻¹ Urea and absolute control treatments, while the shortest spike length of 4.56 cm was recorded from the nil one. The result was in agreement with the highest spike length was recorded at highest application rates of blended fertilizer on food barley (Melkamu et al., 2019); and nitrogen and phosphorus fertilizer increases spike length, number of seeds per spike, number of fertile tillers, non-fertile tillers and grain yield of barley, especially at higher doses (Wakene et al., 2014; Mesfin and Zemach, 2015).

Number of kernels per spike

Number of seed per spike was significantly influenced by NPSB blended fertilizer rate of which the largest number of seed per spike of 40.37 was recorded from 142 kg ha⁻¹ NPS + 159 kg ha⁻¹ Urea which was in statistical parity with 250 kg ha⁻¹ NPSB + 102 kg ha⁻¹ Urea and 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea treatments, whereas the lowest number of seed per spike of 29.77 was recorded from the unfertilized treatment. The result was agree with NPSB blended fertilizer enhances number of kernels per spike which

might be due to the fact that phosphorous level increment is essential in development of grains (Abdisa, 2020) and increment of number of kernel with the application blended fertilizer (Abebe, 2018). This may be due to the reason that Boron plays a vital role in grain setting and helps in grain filling and ultimately sterility is reduced and number of grains per spike increased (Tahir et al., 2009; Mitra and Jana, 1991).

Biomass

Analysis of Variance revealed that above ground biomass of food barley has significantly influenced by NPSB blended fertilizer rate of which the highest above ground biomass of 12497.80 kg ha⁻¹ was obtained from application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea followed by 142 kg ha⁻¹ NPS + 159 kg ha⁻¹ Urea treatment with biomass of 10740.30 kg ha⁻¹, while the lowest above ground biomass of 5974.70 kg ha⁻¹ was recorded from the unfertilized treatment. The result was agree with blended fertilizer supply had a marked effect on the above ground biomass, grain yield and straw yield of which the maximum above ground biomass (12.63 t ha⁻¹) was obtained from 200 kg ha⁻¹ NPSB of blended fertilizer application (Melkamu et al., 2019). Likewise, blended fertilizer application increases above ground biomass in 20.17% over the control with recommended NP fertilizer (Abebe, 2018) and nitrogen increases vegetative growth of plants, especially at higher doses and contributed for the significant increase in total biomass (Wakene et al., 2014).

Grain yield

Grain yield of food barley has significantly influenced by NPSB blended fertilizer rate of which the highest grain yield of 3806.30 kg ha⁻¹ was recorded from 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea which was in statistical parity with application of 142 kg ha⁻¹ NPS + 159 kg ha⁻¹ Urea and 250 kg ha⁻¹ NPSB + 102 kg ha⁻¹ Urea treatments, while the lowest grain yield of 1939.20 kg ha⁻¹ was recorded from unfertilized treatment. Similarly, grain yield of wheat significantly increased due to increasing of nitrogen fertilization (Bereket et al., 2014); application of NPSB blended fertilizer in 200 kg ha⁻¹ NPSB increases the grain yield of barley in 70.40% over absolute control (Melkamu et al., 2019); The yield obtained from variety EH 1493 with 200 kg ha⁻¹ NPSB gave 22.40% grain yield increment over recommended NP fertilizer application and 48% yield increment over control treatment due to the synergistic effect of the four nutrients might contributed for improved root growth and increased nutrient use efficiency, thus improved yield components and yield (Abdisa, 2020); and also compared to the control

(with recommended NP fertilizers), the grain yield were increased by 26.90% with the application of blended fertilizer $NPS_3B_3K_3$ (Abebe, 2018).

Thousand kernel weight

Analysis of Variance revealed that NPSB blended fertilizer rate did not significantly affects thousand kernel weight of food barley. The result was in line of agreement with different blended fertilizer rates on malt barley has shown no significant influence on thousand kernel weight (Kedir and Ashenafi, 2020); and the interaction blended fertilizer with variety did not

significantly affects thousand kernel weight of barley (Fisseha et al., 2020).

Economic analysis

Partial budget analysis of blended fertilizer rate effect on food barley experiment in Semen Ari District was revealed that the highest net return (28721.81 ETB ha^{-1}) was obtained in response to application of 100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea which showed 33.16% higher net return over the nil one (19198.08 ETB ha^{-1}); followed by 142 kg ha^{-1} NPS + 159 kg ha^{-1} Urea treatment with net return of 24866.12 ETB ha^{-1} . The lowest net return (19198.08 ETB ha^{-1}) was obtained from unfertilized treatment (nil treatment) (Table 4).

Table 4. Partial budget analysis, effect of NPSB blended fertilizer rate on barley production experiment.

Treatments	Ave. Yield (kg ha^{-1})	10% Adj. Yield kg ha^{-1}	Total Revenue (TR) in ETB ha^{-1}	Total Variable Cost (TVC) in ETB ha^{-1}	Net Benefit (ETB ha^{-1})
Control	1939.2	1745.28	19198.08	0	19198.08
142 kg ha^{-1} NPS + 159 kg ha^{-1} Urea	3479.8	3131.82	34450.02	6181.15	28268.87
150 kg ha^{-1} NPSB + 41 kg ha^{-1} Urea	2699.5	2429.55	26725.05	4506.45	22218.60
200 kg ha^{-1} NPSB + 72 kg ha^{-1} Urea	3042.3	2738.07	30118.77	5757.50	24361.27
250 kg ha^{-1} NPSB + 102 kg ha^{-1} Urea	3234.6	2911.14	32022.54	6993.32	25029.22
100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea	3806.3	3425.67	37682.37	5557.81	32124.56

10% Adj. Yield= Grain Yield Adjusted to 10% downward; TVC= Total Variable Cost; ETB= Ethiopian Birr.

Dominance analysis revealed that among treatments only treatment, which receives 100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea and 150 kg ha^{-1} NPSB + 41 kg ha^{-1} Urea were un-dominated. This indicated that increase in the total cost of these treatments increases the net benefit proportionally; which implies benefits were

greater than the lower total costs. The highest net benefit was obtained from the application of 100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea with highest marginal rate of return of 942.2% (Table 5). Therefore, 100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea with MRR of 942.2% was accepted according to CIMMYT (1988) as MRR (%) was above 100%.

Table 5. Dominance and Marginal (MRR) Analysis.

Treatments	10% Adj. Yield kg ha^{-1}	Variables			
		TVC (ETB ha^{-1})	Net Benefit (ETB ha^{-1})	Dominance Analysis	MRR (%)
Control	1745.28	0	19198.08	-	-
150 kg ha^{-1} NPSB + 41 kg ha^{-1} Urea	2429.55	4506.45	22218.60	ND	67.03
100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea	3425.67	5557.81	32124.56	ND	942.20
200 kg ha^{-1} NPSB + 72 kg ha^{-1} Urea	2738.07	5757.50	24361.27	D	-
142 kg ha^{-1} NPS + 159 kg ha^{-1} Urea	3131.82	6181.15	28268.87	D	-
250 kg ha^{-1} NPSB + 102 kg ha^{-1} Urea	2911.14	6993.32	25029.22	D	-

D= Dominated; ND= Non-Dominated; MRR (%) = Marginal Rate of Return in percent.

Conclusion and Recommendation

Depleting of soil fertility, inappropriate and imbalanced fertilizer application including different blended fertilizer are among the most important factors that reduces the productivity of cereal crops including food barley in the study area specifically and in region as compared to the crop potential and average yield of other African countries. Therefore, the experiment was carried out to evaluate the effect of different blended fertilizer rates on improving the production of food barley in Semen Ari District, Southwestern

Ethiopia. The finding of this experiment has revealed that food barley responded well to the application of N, P, K, B and S than the nil one. Plant height, tiller number per plant, spike length, number of seed per spike, above ground biomass and grain yield were influenced by NPSB blended fertilizer rate, whereas thousand kernel weight did not affected by NPSB blended fertilizer rate. Application of 100 kg ha^{-1} NPSB + 161 kg ha^{-1} Urea resulted in highest grain yield, while the lowest grain yield was recorded from the nil. Moreover, based on partial budget analysis, also the highest net benefits of 32124.56 ETB ha^{-1} and economic

returns/marginal rate of return of 942.2% was recorded in response to application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea. Application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea gives 49.05% yield increment and 40.24% increment in economic return over the control. Therefore, we recommend application of 100 kg ha⁻¹ NPSB + 161 kg ha⁻¹ Urea for farmers and investor's in study area and similar agro-ecologies as it was optimum for improving food barley productivity. Further studies and investigation should be done on plant nutrient uptake, nutrient use efficiency and over location.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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