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Response of Food Barley for Different Application Rates of Blended (NPSB) Fertilizer on Niitisol of Welmera Districts in Central Ethiopia

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Abstract: Food barley growers need balanced crop nutrition to maximize its yield potential and get the most out of their fertilizer investment. In practice, this requires making all of the required nutrients available to food barley crop by the right amount or rate. So, the objective was to determine the optimum blended (NPSB) and urea fertilizer rates on growth, yield and yield components of food barley at Welmera district west Showa Zone. The experiment was laid out using randomized complete block design in factorial arrangement with three replications. The treatments consisting of four rates of blended (100,150, 200.250 kg/ha) and three rates of Urea (150, 250 and 350 kg ha^{-1}) were tested with negative control and blanket recommended NP (60/69P_2O kg ha $^{-1}$) and the experiment was conducted from 2018 to 2020 cropping seasons. The experiment was laid out in RCBD with three replications. The results of the study revealed that yield and yield components of food barley affected by application of NPSB and urea fertilizer rates. The highest biomass yield (18383 kg ha^{-1}) was obtained at a rate of 200 kg NPSB with 350kg urea ha^{-1} but the highest grain yield (4876.3 kg ha^{-1}) was recorded from 100 kg NPSB with 250 kg urea ha^{-1} fertilizer, while the lowest biomass yield and grain yield were recorded from control plot. Whereas based on cost benefit analysis, the highest net benefit (83003 ETB) with acceptable MRR (888.0) and at lowest total cost of production for food barley production was obtained at application of 100 kg NPSB with 250 kg urea ha^{-1} provided relatively with high net benefit and hence these could be the best rate to apply.

Key words: Grain Yield · NPSB Fertilizer · Biomass Yield · Fertilizer Rate · Food Barley

INTRODUCTION

Soil fertility is one of the biggest challenges to achieving food security and poverty reduction in Ethiopia [1, 2]. To increase yield, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers as blanket recommendation for the major food crops [3, 4]. The blanket recommendation of 69 kg P_2O_5 and 60 kg N for food barley in the central highlands of Ethiopia does not consider the differences in agro ecological environments [5] which may not be applicable under the current production system and for the foreseeable future. Since the spatial and temporal fertility variations in soils were not considered, farmers have been applying same nutrient 69 kg P_2O_5 and 60 kg N rate. The previous result indicated a fertilizer recommendation in Ethiopia is based on a single recommendation for all crops are the only fertilizer sources that have been in use for the past four decades in the country [2]. Additionally, the nutrients in the blanket recommendation are not well balanced agronomically and its continued use will slowly deplete soil nutrient reserves [2, 6]. Therefore, neither yields nor profits can be sustained using imbalanced application of fertilizers, as the practice outcomes in expanding deficiencies of other soil nutrients [7]. Since absence of one or more nutrients likewise N and P can reduce yield significantly. This could explain, in part, the uncertain crop yield improvements detected over the last few decades in contrast to significant increases in fertilizer use in the country. Currently, in addition to N and P, other nutrients S, B and Zn deficiencies are widespread in Ethiopian soils, while some soils are also deficient in K, Cu, Mn and Fe [8]. Soil test-based application of plant nutrient rather than

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the blanket recommendation of urea and DAP, especially those containing sulfur, boron, and other nutrients is recommended in preventing problems caused due to nutrient deficient soil [1].

Therefore, the use of balanced fertilizers containing both macro and micronutrients, which is based on the site-specific soil fertility assessment, is believed to be one of the solutions for reducing such production constraints. Although nutrient content of the fertilizer that suits the needs and the productivity of the crops, in most part of Ethiopia, particularly, Welmera and Ada'a berga district farmers have limited information on the impact of balanced fertilizer types and rates except only urea and DAP which are source of N and P. However, new blended fertilizer such as NPSB and currently being used by the farmers in the study area based on the soil fertility map of the area [1]. Thus, there is a need to test the blended NPSB fertilizer by supplementing it with urea fertilizer for optimum productivity of food barley. Therefore, the present study was undertaken with the objectives of determine optimum blended NPSB and urea fertilizer rate for food barley production and assess economic feasibility of blended NPSB and urea fertilizer rate for food barley production.

MATERIALS AND METHODS

Description of the Study Site: The experiment was conducted in West Shewa Zone of Oromia Regional State for three consecutive cropping seasons (2017 -2019). The experiment site is located at 09° 03' N latitude and 38° 30' E longitudes and an altitude of about 2400 m above sea level. The mean annual rainfall of the study area was 1100 mm, of which about 85% falls from June to September and the rest from march to May and the mean annual temperature was about 14.3°C, with the mean maximum and minimum temperatures of 21.7°C and 6.9°C, respectively and mean relative humidity of 60.6%9 [9] (Fig 1). The environment is seasonally humid and the major soil type is Nitisols [10].

Experimental Design and Treatments: The experiment was laid out in RCBD with three replications. NPSB fertilizer was applied as basal application at planting and urea was applied in split form. The treatments consisted of five four levels of blended (100,150, 200, and 250 kg NPSB ha^{-1}) and three rates of urea (150, 250, 350 kg ha^{-1}), and as positive control (standard check) recommended NP (60 kg N/ 69 kg P_2O_5) ha^{-1} fertilizers and one treatment as negative control were used.

Data Collection: Agronomic parameters collected were plant height and spike length (cm), was measured by taking five randomly selected plants per plot as the distance in cm from the soil surface to the top most growth point of aboveground at full maturity. Grain and biomass yield were measured based on plant samples taken from ten central rows at full maturity stage. Grain yield and biomass yields recorded on plot basis were converted to kg ha^{-1} for statistical analysis.

Soil Sampling and Analysis: Soil samples (0-20 cm) were collected randomly by Auger in a zigzag pattern before sowing the crop from the entire experimental field and composited into one sample. From this composite sample, a sample weighing 1.0 kg was taken. Air dried soil sample was ground with a pestle and mortar under shading. The sample was sieved through a 2 mm sieve mesh. The soil analysis was done for soil textural class, soil pH, organic carbon, total N, available P, cation exchange capacity (CEC) and, available S. The soil analyses were done at Holeta agriculture research center Soil and Water Analysis Laboratory.

Soil textural Class was determined by Bouyoucos Hydrometer Method [11]. Soil pH was determined in 1:2.5 soils: water ratio using a glass electrode attached to a digital pH meter [12]. Organic carbon was estimated by the wet digestion method [13] after air-dried soil was ground to pass a 0.2 mm sieve. To determine the cation exchange capacity (cmol kg^{-1} soil), the soil sample first was leached using 1 M ammonium acetate, washed with ethanol and the adsorbed ammonium was replaced by sodium (Na). Then, the CEC was determined titrimetrically by distillation of ammonia that was displaced by Na [14]. Total nitrogen (%) was determined using the Kjeldhal method [15]. Available phosphorus (ppm) was determined by Bray II method [16]. Available sulfur (S) was determined by mono-calcium phosphate extraction method [17].

Statistical Analysis: Differences between treatments were determined by analysis of variance (ANOVA) using SAS software [18]. The result interpretations were made following the procedure of Gomez and Gomez [19]. Mean separation were done using the Fishers' protected Least Significant Difference (LSD) test at 5% level of significance.

Partial Budget Analysis: The partial budget analysis was done as described by CIMMYT [20]. The economic advantages of applied blended NPSB and urea fertilizers

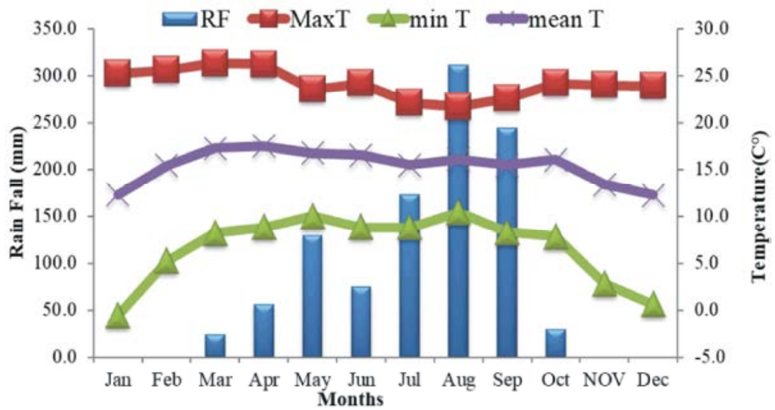

Fig. 1: Mean monthly rainfall, minimum and maximum temperature (°C) of Welmera District

were carried out using partial budget analysis. In this experiment, the costs that vary were calculated by adding costs of fertilizer. The costs of blended NPSB and urea were 15 ETB kg^{-1} and 13 ETB kg^{-1}, respectively. The average grain was adjusted by 10%. Following the partial budget analysis method, 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) needs to be at least between 50% and 100% [20]. However, other researchers suggested a MRR of 100% as realistic [21]

RESULTS AND DISCUSSION

Soil Physico-Chemical Properties: The results of the soil laboratory analyses indicated that the soil of experimental site was 52.75% clay, 30 % silt and 17.25 % sand (Table 1). Thus, the texture class of the soil was clay according to Bouyoucos [11] classification. In clay soil high rain fall in the field causes yield reduction in most crops. The pH of the soil was 5.2 (Table 1) which was acidic in reaction [22]. The organic carbon (OC) analysis indicated that the experimental field had 0.6 % organic carbon (Table 1) it was found in Low range as per [22]. The total nitrogen of experimental soil was 0.25%, which was low according to Berhanu [23]. The available phosphorus content of the soil was 8.12 ppm found in low range as per rated [1]. The analysis for available sulfur indicated that the experimental soil had value of 6.18 ppm of available sulfur which is rated under very low [1]. The result is in line with the EthioSIS report that classify 65% of the highland soils are deficient in S. Thus, it is essential to apply sulfur sources fertilizer to improve yield and quality of wheat [26].

Effect of Blended (NPSB) with Urea on Growth of Barley

Spike Length (cm): Analysis of results revealed that application of blended (NPSB) fertilizer with urea, had no a significant ($p<0.05$) effect on Spike length (Cm) (Table 2) and influenced by application of blended fertilizer rate.

The highest spike length (7.86 cm) was recorded from the application of 100 kg ha^{-1} of blended fertilizer with 350 kg ha^{-1} of urea as compared the shortest spike length (7.1 Cm) obtained from the control plot (Table 2).

Plant Height (cm): The analysis of variance revealed that Plant height was significantly ($p<0.05$) influenced due to different rates of blended fertilizer and different rates of urea (Table 2). Maximum plant height (114.22 cm) was observed for 200kg ha^{-1} blended fertilizer with 350 kg ha^{-1} of urea, whereas the minimum plant height (96.78 cm) was observed at control. The maximum plant height recorded at 200 kg ha^{-1} blended fertilizer rate was statistically superior to the control and this was statistically not significant with the rest blended fertilizer rates. There was a linear increase in plant height with increasing urea fertilizer. This in line with many authors [27,28] research find reports, plant height of barley increased by increasing rates of N which is added from urea source.

Effect of Blended Fertilizer and Urea on Yield and Yield Components

Biomass Yield (kg ha^{-1}): The different rates of blended fertilizer on barley have shown a significant ($p<0.05$) influence on biomass yield production (Table 3).

Table 1: Selected Soil physico- chemical characteristics of the study site

Soil parameters	Value	Rating	Reference
Particle size			
Sand (%)	17.25	-	[11]
Silt (%)	30.00	-	
Clay (%)	52.75	-	
Textural class		Clay	
Soil pH	5.2	Acidic	[22]
Organic carbon (%)	0.6	Low	[22]
Total, N (%)	0.25	Low	[23]
Available P (ppm)	8.12	Low	[1]
Exchangeable k ($Cmol^+$ /kg)	0.56	Medium	[24]
Available S ($Cmol^+$ /kg)	8.63	Very low	[1]
CEC ($Cmol^+$ /kg)	11.02	Low	[25]

Table 2: Effect of blended fertilizer and urea application rate on growth parameters of Barley

NPSB (kg ha^{-1})	Urea (kg ha^{-1})	SL (cm)	PH (cm)
0	0	7.1	96.78g
100	150	7.52	107.56def
150	150	7.48	109.00bcdef
200	150	7.47	108.06cdef
250	150	7.47	110.69abcde
100	250	7.70	112.22abcd
150	250	7.81	109.50abcdef
200	250	7.25	105.67ef
250	250	7.60	112.78abc
100	350	7.86	113.17ab
150	350	7.51	113.94ab
200	350	7.71	114.22a
250	350	7.42	113.61ab
Recommended NP (kg 60N/69P_2O_5) ha^{-1}		7.20	104.89f
Mean		7.5	109.43
$LSD_{(0.05)}$		NS	5.08
CV (%)		24.5	7.07

where: Means followed by the same letters on the same column are not significantly different at 5 % probability level

Table 3: Effect of blended fertilizer and urea on yield and yield components of barley

NPSB (kg/ha)	Urea rate kg/ha	BY (kg/ha)	GY(kg/ha)
0	0	12869e	2618.1c
100	150	16347abcd	4324.3 ab
150	150	14980cde	4574.4ab
200	150	15492bcd	4640.6ab
250	150	17099abc	4547.3ab
100	250	16212abcd	4876.3a
150	250	16435abcd	4499.1ab
200	250	15845bcd	4527.8ab
250	250	16245abcd	4302.3ab
100	350	17370abc	4382.7ab
150	350	18337a	4488.9ab
200	350	18383a	3989.8b
250	350	17654ab	4049.0 b
Recommended NP (kg 60N/69P_2O_5) ha^{-1}		14559de	4567.4ab
Mean		16274	4313.4
LSD (0.05)		2392.6	762.04
CV (%)		22.39	26.9

Means followed by the same letters on the same column are not significantly different at 5 % probability level

Table 4: Cost benefit analysis of blended with urea fertilizer rate for food barley production

NPSB (kg ha^{-1})	Urea rate (kg ha^{-1})	GY (kg/ha)	ADGY (kg/ha)	TVC(ETB)	GFB	NB (ETB)	MRR
0	.0	2618.1	2356	20	47126	47106	0
100	150	4324.3	3892	3470	77837	74367	790.2
Recommended NP (60/69) kg/ha		4018.6	3617	3623	72335	68712	D
150	150	4574.4	4117	4220	82339	78119	500.2
100	250	4876.3	4389	4770	87773	83003	888.0
200	150	4640.6	4177	4970	83531	78561	D
150	250	4499.1	4049	5520	80984	75464	D
250	150	4547.3	4093	5720	81851	76131	D
100	350	4382.7	3944	6070	78889	72819	D
200	250	4527	4074	6270	81486	75216	1198.7
150	350	4488.9	4040	6820	80800	73980	D
250	250	4302.3	3872	7020	77441	70421	D
200	350	3989.8	3591	7570	71816	64246	D
250	350	4984	4486	8320	89717	81397	2286.8

where, ADGY=adjusted grain yield, TVC=total variable cost, GFB= growth field benefit, NB=Net benefit, MRR= marginal rate of return, D=dominated, costs of NPSB and urea were 15 ETB kg^{-1}and 13 ETB kg^{-1},

According to the data, there is an association between blended and urea fertilizer for biomass production. Furthermore, their interaction effect between blended and urea fertilizer on biomass yield (Table 3). The highest biomass yield (18337 kg ha^{-1}) and (18383 kg ha^{-1}) was recorded from application of 150 kg NPSB /350 kg urea ha^{-1}, 200 kg NPSB/ 350kg urea ha^{-1} respectively (Table 3). The maximum biomass obtained 150 kg NPSB /350 kg urea ha^{-1}, 200 kg NPSB/ 350kg urea ha^{-1} were statistically superior to control and similar with that of the rest blended fertilizer rates. On the other hand, the application of (250/150, 100/150, 250/250,100/350, and 250/350 kg blended NPSB/urea ha^{-1}) were statistically at par from each other (Table 3). As application of blended fertilizer rate increase, dry biomass yield of barley also increased. Likewise, Melkamu *et al.* [29] blended fertilizer source had a balanced effect on the biomass yield of food barley. In general, biomass yield was increased with increase in NPSB and Urea rate, which might be due to improved growth and increased uptake of nutrients favoring better growth. Similar authors, Abebual Woldetsadik *et al.* [30] reported that the agronomic performance was improved through application of blend of macro with micronutrient in a suitable form in nutrient deficient soil, which increase grain yield. This is in line with the finding [31] who stated matching appropriate essential macro and micronutrients that improve nutrient uptake and optimize crop yield.

Grain Yield (kg ha^{-1}): Different rates of blended and urea fertilizer have significantly ($p<0.05$) influenced the grain yield of barley (Table 3). Significantly higher grain yield was obtained by application of 100 kg NPSB with 250 kg urea ha^{-1} than the same rate of the conventionally used DAP fertilizer (Recommended NP (kg 60N/69P_2O_5) ha^{-1}). Relatively, the highest grain yield (4876.3 kg ha^{-1}) was recorded from combined application of 100 kg NPSB with 250 kg urea ha^{-1} fertilizer rates. Significantly, lower grain yield (2618.1 kg ha^{-1}) was obtained from the control (unfertilized) plot (Table 3). Increasing the application of blended fertilizer rates increased the grain yield production of food barley to the area. This might be due to the combined effect of nutrients like N, P, S, and B in blended fertilizer which might have improved growth and development of crop as compared to the negative control plots [32]. This was due to Sulfur enhanced the formation of chlorophyll and encouraged vegetative growth and B helps in N absorption. The results agreed with [33] that reported the grain yield was the lowest for lowest nitrogen treatment.

Partial Budget Analysis: The partial budget analysis result is indicated in Table 4. The highest net benefit (83003 ETB) with marginal rate of return (888.0%) and at lower total cost of production for food barley production was obtained at application of 100 kg NPSB ha^{-1} with 250 kg urea ha^{-1}. The highest marginal rate of return (2286.8%) was attained from application of 250 kg NPSB ha^{-1} with of 350kg urea ha^{-1} with maximum total cost of the production. Most of the time, farmers /the growers prefer the highest benefit (profit) with low cost of production and high income. Considering this point of view, the optimum yield with high net benefit and relatively low total cost of production was economically advisable to producers at 100 kg NPSB ha^{-1} with 250 kg urea ha^{-1}.

CONCLUSION AND RECOMMENDATION

The results of this field work clearly indicated the importance of site-specific and balanced fertilizer application on achieving maximum yield of barley on nitisol types at Welmera district. The results revealed that spike length, plant height, biomass yield and grain yields were significantly affected by NPSB and urea fertilizer. The highest grain yield (4876.3 kg ha^{-1}) was recorded from the combined application of 100 kg NPSB with 250 kg urea ha^{-1} fertilizer rates. Whereas based on partial budget analysis method, the optimum yield with high net benefit and relatively by low total cost of production was economically advisable to the producers at 100 kg NPSB ha^{-1} with 250 kg urea ha^{-1}.

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