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Evaluation of Different Blended Fertilizer Types and Rates for Better Production of Bread Wheat (*Triticum aestivum* L.) at Adiyo District, South West Ethiopia

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Abstract: Bread wheat (*Triticum aestivum* L.) is an important food crop and source of income for farmers. It is the most responsive crop to fertilizer application. Field experiment was carried out on farmer's field in 2016/17 and 2017/18 main cropping seasons to evaluate the response of bread wheat to different blended fertilizers types and rates at Adiyo district, Southwestern Ethiopia. Eight treatments: Control (T1), four rates of NPSB: (46N, 54P_2O_5, 10S, 1.07B (T2); 69N, 72P_2O_5, 13S, 1.4B (T3), 92N, 90P_2O_5, 17S, 1.7B (T4) and 92N, 36P_2O_5, 7S, 0.71B (T5)) and three rates of NPSB+Cu: T2+Cu (T6), T3+Cu (T7), T4+Cu (T8) were laid out in randomized complete block design with three replications. Crop parameters measured were analyzed using proc GLM procedures in the SAS 9.3 version. Analysis was also performed to investigate the economic feasibility of the fertilizers for wheat production. Results indicated that application of both types and three rates of each fertilizer significantly ($p < 0.05$) affected all tested parameters except thousand seed weight, which was improved by only T4. The highest biomass (14.80 ton ha^{-1}) and grain yield (6.537 ton ha^{-1}) were obtained from application of highest rate of NPSB+Cu (T8) whereas the lowest biomass (9.36 ton ha^{-1}) and grain yield (3.657 ton ha^{-1}) were obtained from untreated soil. The application of NPSB+Cu (T8) also gave highest net benefit of Birr 46637.10 and acceptable MRR% was 151.02%. Hence farmers at the study area and similar agro-ecology could use NPSB+Cu @ a rate (92N, 90P_2O_5, 17S, 1.7B) and 600 gm Cu as foliar application. However, further verification study is needed to give reliable and consistent recommendation.

Keywords: Blended Fertilizers, Bread Wheat, Economic Benefit, Foliar Application, Grain Yield

1. Introduction

Wheat is one of the major cereal crop grown in the highlands of Ethiopia and this region is regarded as the largest wheat producer in Sub-Saharan Africa [8]. It is considered a highly responsive crop to starter fertilizers, particularly phosphorus and nitrogen. Wheat yields in many parts of Ethiopia are stagnant mainly due to inadequate conventional blanket fertilizer recommendation, lower fertilizer use efficiency, and imbalanced use of fertilizers. Nutrient mining due to sub optimal fertilizer use coupled with imbalanced fertilizer uses have favored the emergence of multi nutrient deficiency in Ethiopian soils [3, 1] which in part explain fertilizer factor productivity decline despite continued use of the blanket recommendation.

Fertilizer management is a key mode to wheat production and the responsiveness of wheat to application of different fertilizer nutrients was studied extensively [12, 6, 16]. Balanced fertilizers containing N, P, K, S, Zn and B in blend form have been recommended to ameliorate site specific nutrient deficiencies and thereby increase crop productivity. The work in Southern Ethiopia contributed a striking example of how fertilizer use efficiency of potato can be raised when NP fertilizers are combined with K on a location-specific basis. In this study supplementation of K increased potato tuber yields by 197% over the standard NP recommendation alone [23].

The results of recent study of Ethiopian soil map indicates that there are a wide spread of nutrient deficiencies [9]. The

recent national soil inventory data revealed S, B and Zn deficiencies are widespread in Ethiopian soils; some soils are also deficient in K, Cu, Mn and Fe [4], which all potentially hold back crop productivity. However, fertilizer trials involving multi-nutrient blends that include micronutrients are rare. Very recently, a soil test based fertilizer recommendation and calibration efforts have been made by Ethiopian Agricultural Research Institute (EIAR) and Regional Agricultural Research Institutes (RARIs) but only limited to certain location and crop types.

According to Ethio SIS fertilizer type recommendation map, eight types of fertilizer blends are identified for South Nation Nationalities and Peoples Regional State. Similarly three and two types of fertilizer blends were identified for Adiyo Woreda and Boka Kebele respectively. But this needs validation for the identified fertilizer types and determination of rates for specific crops. Therefore, this study was initiated with the objectives of (1) Evaluate the relative influences of NPSB and NPSB+Cu on wheat production and (2) Determine optimum rate of the selected fertilizer type for production of wheat in Adiyo Woreda.

2. Materials and Methods

2.1. Description of the Experimental Area

Field experiment was carried out on three farmers' field for two years at Boka Kebele, Adiyo Woreda of Kaffa Zone, South Nation Nationalities and Peoples Regional State (SNNPRS) in 2016/17 and 2017/18 main cropping season. The altitude of the study area ranges from 2435 to 2550 m.a.s.l. with northing and easting about N 07°15.471' and E 36°25.112'. The area receives 600-1800 mm rainfall annually in a bimodal pattern and temperature ranges from 15-20°C. Topographically, the area consists of gently undulating plain with average slope gradient of 6%. Crop production is mostly characterized by cereals, pulses and tubers. Wheat is extensively grown followed by faba bean [2]. The dominant soil type of the area is Nitisols, with textural class of clay loam [10].

2.2. Experimental Details and Treatment Set-Ups

The treatments were laid out in RCBD replicated three times on each farmers' field. Eight treatments: Control (T1), four rates of NPSB: (46N, 54P_2O_5, 10S, 1.07B or 150 kg NPSB + 41 kg urea top dressing (T2); 69N, 72P_2O_5, 13S, 1.4B or 200 kg NPSB + 72 kg urea top dressing (T3), 92N, 90P_2O_5, 17S, 1.7B or 250 kg NPSB + 102 kg urea top dressing (T4) and 92N, 36P_2O_5, 7S, 0.71B or 100 kg NPSB + 161 kg urea top dressing (T5)) and three rates of NPSB+Cu: T2+Cu (T6), T3+Cu (T7), T4+Cu (T8) were determined. 600 gm Cu ha^{-1} for three treatments; and 100 kg KCl for all treatments were applied. The plot size was 3m*3m ($9m^2$) and the spacing between rows was 20 cm. The improved wheat variety *danda'a* was used as a test crop. Urea was used as source of N in addition to NPSB and NPSB+Cu blends. Blended and KCl fertilizers were applied at planting whereas half urea fertilizer was top dressed after 45 days of planting. The $CuSO_4$ used as source of Cu by foliar application was applied 45 days after germination. The test crop was planted by drilling and other crop management practices were applied as per the recommendation.

2.3. Soil Sampling and Analysis

Representative composite surface soil samples were collected from 0-20 cm depth at each experimental unit just before sowing. After manual homogenization, the samples were ground to pass through sieves (2 mm for soil pH, texture, cation exchange capacity and available phosphorus; 0.5 mm for total nitrogen and organic carbon) and analyzed for texture, pH, organic carbon, total nitrogen, cation exchange capacity and available phosphorus.

2.4. Agronomic Data Collection

The yield components: plant height (cm), spike length (cm), number of tiller per plant, thousand seed weight (gm), biomass yield (ton), and grain yield (ton) were collected and subjected to analysis of variance (ANOVA). The grain yield was determined from each experimental plot and adjusted to constant moisture levels of 12%.

2.5. Economic Analysis

Partial budget analysis was carried out to determine the net benefit and percent marginal rate of return (%MRR) of specific fertilizer type and rate. Wheat grain yield was valued at an average open market value of the local market price of Birr 900 per 100 kg whereas average price of urea and NPSB fertilizers were Birr 10 and 14 per kg, respectively whereas the price of copper sulfate was 1625 per kg. The cost of other production practices like, seed and weeding were assumed to remain the same or insignificant among the treatments. The grain yield was down adjusted to reflect the situation in actual production by farmers [5].

2.6. Statistical Analysis

Analysis of variance (ANOVA) was carried out using SAS version 9.3 statistical software programs [21]. Significant difference between and among treatment means were assessed using the least significant difference (LSD) at 0.05 level of probability [13].

3. Results and Discussion

3.1. Physico-chemical Properties of Soil Before Planting

Soil sampled collected before planting from study area was analyzed in the laboratory. The analysis results indicated that the experimental sites soil textural class was clay loam with the proportion of 37% sand, 35% clay, and 28% silt. The soil pH value of the area was 5.1 and classified as strongly acidic as per the pH rating category suggested [22].

Organic matter content of the experimental site value was 7.3% and is classified in highest range as rating [22]. On most of highly acidic condition soils, as microbial activity is

low and the decomposition rate is slow which resulting to the accumulation of organic matter. Total nitrogen value of the experimental soil was 0.4% which is rated high [22]. Generally the high total nitrogen content of the soil might be due to highest organic matter content of the area. Available phosphorus content of the experimental site was 12.5ppm which is rated as low [15, 18], reported low amount of available phosphorus content on soils which are cultivated repeatedly due to P fixation and P mining. [14], also reported that low content of available phosphorus was due to fixation problem. The CEC of the site was 5.6 $cmol_{(+)}$/kg. The cation exchange capacity of the site was found in a low range [17].

3.2. Blended Fertilizer Types and Rates Influence On Yield and Yield Components of Wheat

Data analysis indicated that a year by treatment effects did not occur, so data are averaged across years. Average wheat yield and yield component data are presented in tables 1 and 2. In general, application of both fertilizer types and all rates statistically significantly ($p<0.05$) improved yield and yield components of wheat in comparison to untreated soil. Mean biomass and grain yield of both years and combined over years mean significantly affected by applied different fertilizer types and rates (Table 1). The grain yields significantly increased as the rates of two blended fertilizers rate increased. However, averaged over years, significantly highest biomass (14.80 ton ha^{-1}) and grain yield (6.5 ton ha^{-1}) of wheat was obtained by application of NPSB + Cu @ rate 250 NPSB + 600 Cu ($CuSO_4$) and 102 kg urea top dressing (92N, 90P_2O_5, 17S, 1.7B + Cu) at Adiyo district. All yield components except thousand seed weight are affected by fertilizer types and rates in similar trend with grain yields (Table 2).

Table 1. *Mean grain yield and biomass yield of bread wheat as influenced by blended fertilizer types and rates at Adiyo district.*

Treatment	Biomass yield ton/ha	Grain yield ton/ha
1. Control	9.3642^{d}	3.657^{f}
2. NPSB=46,54,10, 1.07	12.3525^{c}	5.229^{e}
3. NPSB=69, 72, 13, 1.4	13.5247^{b}	5.839^{c}
4. NPSB=92, 90, 17, 1.7	13.537^{b}	6.203^{b}
5. NPSB=92, 36, 7, 0.71	13.6543^{b}	5.852^{c}
6. NPSBCu=Tr2 + Cu	12.5062^{c}	5.472^{de}
7. NPSBCu=Tr3 + Cu	12.8642^{bc}	5.765^{cd}
8. NPSBCu=Tr4+ Cu	14.80^{a}	6.537^{a}
Mean	12.83	5569.52
LSD (0.05%)	8.07	317.83
CV%	9.51	8.62

Table 2. *Mean yield components of bread wheat as influenced by blended fertilizer types and rates at Adiyo district.*

Treatment	PH (cm)	SL (cm)	TPP	TSW (gm)
1. Control	84.2^{c}	7.0^{c}	3.9^{d}	49.1^{b}
2. NPSB=46,54,10, 1.07	93.7^{b}	7.8^{b}	5.4^{abc}	49.9^{b}
3. NPSB=69,72,13,1.4	93.8^{b}	7.9^{b}	5.2^{bc}	50.1^{b}
4. NPSB=92, 90, 17, 1.7	96.2^{ab}	8.0^{b}	5.0^{c}	56.5^{a}
5. NPSB=92, 36, 7, 0.71	96.7^{ab}	8.0^{b}	5.6^{ab}	49.4^{b}
6. NPSBCu=Tr2 + Cu	93.6^{b}	8.0^{ab}	5.3^{bc}	50.5^{b}
7. NPSBCu=Tr3 + Cu	94.0^{ab}	8.1^{ab}	5.8^{a}	49.6^{b}
8. NPSBCu=Tr4+ Cu	97.5^{a}	8.4^{a}	5.8^{a}	49.3^{b}
Mean	93.72	7.9	5.26	50.55
LSD (0.05%)	3.61	0.39	0.47	4.10
CV%	5.85	7.44	13.43	12.25

N.B: LSD (0.05%): least significant difference at 5% level; CV: coefficient of Variation; PH: plant height; SL: spike length; TPP: number of tiller per plant; TSW: thousand seed weight; Means in a column followed by the same letters are not significantly different at 5% level of Significance

Blended fertilizer types and rates application increased biomass yield of bread wheat by 31.91-58.04% over the control. This might be due to better crop nutrition through applied blended micronutrients (B and Cu) with macronutrients (N, P, and S), which may result in improved vegetative growth of crops. In agreement with this finding [11] reported that above ground dry biomass yield of teff was significantly influenced by application of blended fertilizers.

The significant increase in wheat yield with the application of blended fertilizer types and rates (NPSB and NPSB+Cu) over the control was showed 42.98 to 78.75% range. [19], reported that application of some macro and micro nutrients significantly increased grain yield and yield component of bread wheat as compared to the control.

The response of wheat yield to blended fertilizer types and rates was showed variation between treatments; also it indicated that application of higher NPSB rate with copper was significant for wheat crop production. The higher wheat grain yield recorded by application of 92N, 90P_2O_5, 17S, 1.7B + Cu when compared with that of 92N, 90P_2O_5, 17S, 1.7B. It suggests that inclusion of Cu is important fertilizer management practice for wheat production at the study area. This result is in line with [20] who reported that wheat responses to copper was effective in correcting deficiency limitation for growth of wheat. Increasing the application of blended fertilizer (NPSB) rates on the bread wheat production constantly increased amount of yield in the experimental site. [7], also reported that increasing rate of blended fertilizers increased grain yield of wheat.

Table 3. *Partial budget and dominance analysis for blended fertilizers on bread wheat at Adiyo district.*

No.	Treatment	GY (kg ha^{-1})	Adjusted GY (kg ha^{-1})	FC (ETB ha^{-1})	AC (ETB ha^{-1})	TVC (ETB ha^{-1})	GB (ETB ha^{-1})	NB (ETB ha^{-1})	MRR%
1	Control (no fertilizers)	3657.4	3291.66	0	0	0	29624.94	29624.94	
2	NPSB=46,54,10, 1.07	5229.0	4706.10	2469	450	2919	42354.9	39435.90	
5	NPSB=92, 36, 7, 0.71	5851.9	5266.71	2849	406.5	3255.5	47400.39	44144.89	
6	NPSBCu=Tr2 + Cu	5472.2	4924.98	3444	550.2	3994.2	44324.82	40330.62	D
3	NPSB=69, 72, 13, 1.4	5839.5	5255.55	3448	598.1	4046.1	47299.95	43253.85	D
7	NPSBCu=Tr3 + Cu	5765.4	5188.86	4423	698.5	5121.5	46699.74	41578.24	D
4	NPSB=92, 90, 17, 1.7	6203.7	5583.33	4418	819.1	5237.1	50249.97	45012.87	
8	NPSBCu=Tr4+ Cu	6537.0	5883.30	5393	919.6	6312.6	52949.70	46637.10	

Table 4. *Analysis of net benefit and MRR% of blended fertilizers on bread wheat after removal of dominated treatments.*

No.	Treatment	GY (kg ha^{-1})	Adjusted GY (kg ha^{-1})	FC (ETB ha^{-1})	AC (ETB ha^{-1})	TVC (ETB ha^{-1})	GB (ETB ha^{-1})	NB (ETB ha^{-1})	MRR%
1	Control (no fertilizers)	3657.4	3291.66	0	0	0	29624.94	29624.94	
2	NPSB=46,54,10, 1.07	5229.0	4706.10	2469	450	2919	42354.9	39435.90	336.1
5	NPSB=92, 36, 7, 0.71	5851.9	5266.71	2849	406.5	3255.5	47400.39	44144.89	1399.4
4	NPSB=92, 90, 17, 1.7	6203.7	5583.33	4418	819.1	5237.1	50249.97	45012.87	43.8
8	NPSBCu=Tr4+ Cu	6537.0	5883.30	5393	919.6	6312.6	52949.70	46637.10	151.02

N.B: Yield adjustment: 10%, ETB ha^{-1}: Ethiopian Birr per hectare, GY: grain yield, FC: fertilizer cost, AC: application cost, TVC: total variable cost, GB: gross benefit, NB: net benefit, D: indicates dominated treatments that are rejected, MRR: marginal rate of return

Partial economic analysis also indicated that application NPSB+Cu @ rate 250 NPSB+Cu and 102 kg top dressing (92 N, 90 P_2O_5, 17S, 1.7B +Cu) gave highest net benefit and inclusion of Cu in NPSB blend gave 138% MRR. Thus it could be recommended that farmers at the study and similar AEZ could apply 250 kg NPSB+Cu ha^{-1} and 102 kg urea top dressing for enhanced wheat production. Application of NPSB @ rate 250 NPSB with 102 kg urea top dressing gave modest wheat grain yield and could be optionally used in the absence of Cu blends and lower NPSB rates might be accepted on the farmer yield goal.

4. Conclusion and Recommendation

Based on the results of this study, it is generally concluded that, application of blended fertilizer types and rates revealed considerable difference of biomass yield and grain yield over untreated soil at the study area. Application of blended fertilizer types and rates significantly affected plant height, spike length, number of tiller per plant, thousand seed weight, biomass yield and grain yield. In conclusion, application of NPSBCu @ rate 250 NPSB+Cu and 102 kg urea top dressing (92N, 90P_2O_5, 17S, 1.7B + Cu) significantly improved bread wheat yield and gave high net benefit and %MRR at Adiyo. Both the highest net benefit and MRR% was obtained by application of (92N, 90P_2O_5, 17S, 1.7B + 600 gm Cu) at Adiyo. Hence the application of NPSB: 92N, 90P_2O_5, 17S, 1.7B as option and NPSB+Cu: 92N, 90P_2O_5, 17S, 1.7B + 600 gm Cu predominantly for bread wheat productivity in the study area are recommended. However, to reach at a conclusive recommendation, the experiment should be repeated with multi-locations and soil types in different agro-ecologies for wider use.

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