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NPSB Fertilizer Effect on Yield of Wheat (*Triticum Aestivum* L.*)* at Wolaita Zone Sodo Zuria Woreda, South Ethiopia

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Abstract

Wheat (Triticum aestivum) is one of most important cereal crops in Ethiopia. The major obstacle for farmer to produce wheat in Ethiopia was low soil fertility status and nutrient imbalance. The experiment was conducted during 2019 and 2020 "meher" cropping season at Kokate substation of Areka agricultural research center at Sodo Zuria woreda Wolaita zone South Ethiopia with objectives of evaluating the effect of NPSB fertilizers rate on yield and yield component of wheat production. The design of experiment was RCBD with plot size of 4m by 4m with three replications and row spacing of 20 cm. The experiment had 10 treatments used for the field experiment including: (1) control, (2) recommended NP, four different rates of NPSB (3, 4, 5 and 6) and four different rates of NPSBCu (7, 8, 9 and 10). SAS software version 9.0 was used for analysis of collected data and LSD for mean separation. The treatment 2, 4, 5 and 6 gave considered net benefit with acceptable MRR and the T6 gave the optimum yield. Highest MRR was observed in treatment 2; but availability of TSP at local market is under question. Subsequently, treatment 5 has the next highest MRR. Therefore, 250 kg NPSB + 150 kg urea is recommended as the best option and applying 200 kg NPSB + 120 kg urea can be also used as alternative option for wheat producers around Sodo Zuria.

Keywords: Soil fertility, nutrient imbalance, blended fertilizer, productivity, South Ethiopia

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and staple food for one third of world population [1]. Wheat is a major cereal crop in high land of Ethiopia and Ethiopia was largest wheat producers in sub-Saharan Africa [2]. It is produced under rain-fed condition at altitude of 1500 m to 3000 m a.s.l. [3] and it is the dominating food habitat and main source of energy and protein for most population in Ethiopia [4]. As [5] reports, agriculture plays a great role in Ethiopia economics, politics and social stability and contribution to national economy was relatively high but productivity is low. The low productivity of wheat is due to low use of improved technology, decline soil fertility status, agronomic practices and low use of appropriate fertilizer types and rate [6]. According to [7], wheat is most important crop in Ethiopia ranking as third in total grain production nearly 4.64 million ton next to tef, maize and sorghum and fourth in coverage areas. Nutrient imbalance and low soil fertility are major bottlenecks that prevent Ethiopian farmers from high productivity of crop [8]. Soil fertility is a dynamic property which changes with inherent status of soil, crops, cropping intensity and used inputs. The soil nutrient depletion rate ranges from 180 to 250 kg/ha [9].

Adequate application of organic or mineral fertilizers for crop in appropriate amounts and proportions are the vital components of modern

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agriculture [10]. Appropriate nutrient management technology development for different cropping patter is most crucial and should be the immediate goal of soil fertility research [9]. Soil fertility ratifies the role of balanced plant nutrition in optimizing yield and maximizing nutrient use efficiency of crop [11]. According to [12], in the study area, in addition to N and P nutrients, S, B, Cu and K were also identified as deficiency nutrients and determinants of yield and yield components of crops. Based on this information, an assignment was given for the research institutions to determine a specific fertilizer type and rate for the farmers. Therefore, the determination of area-specific fertilizer rate and type for sustainable crop production is essential.

MATERIALS AND METHODOLOGY

Description of the Study Area

The study was conducted at south Ethiopia Wolaita zone Sodo Zuria woreda at kokate kebel. The geographical reference of study site was 6°52’24” N latitude and 37°59’02” E longitude and altitude of 2150 m above sea level (Figure 1). The annual rainfall and mean daily temperature ranges from 1200 mm to 1300 mm and 18°C to 28°C respectively, with bimodal rainfall patterns. According to Abera et al. (2019) [13], the main rainy season at the study site is “Kiremt” which occurs from June to August, followed by the “Belg” rainy season, which occurs from mid-February to mid-May. The soil types in the study area are Eutric Nitisol, associated with Humic Nitisol [14].

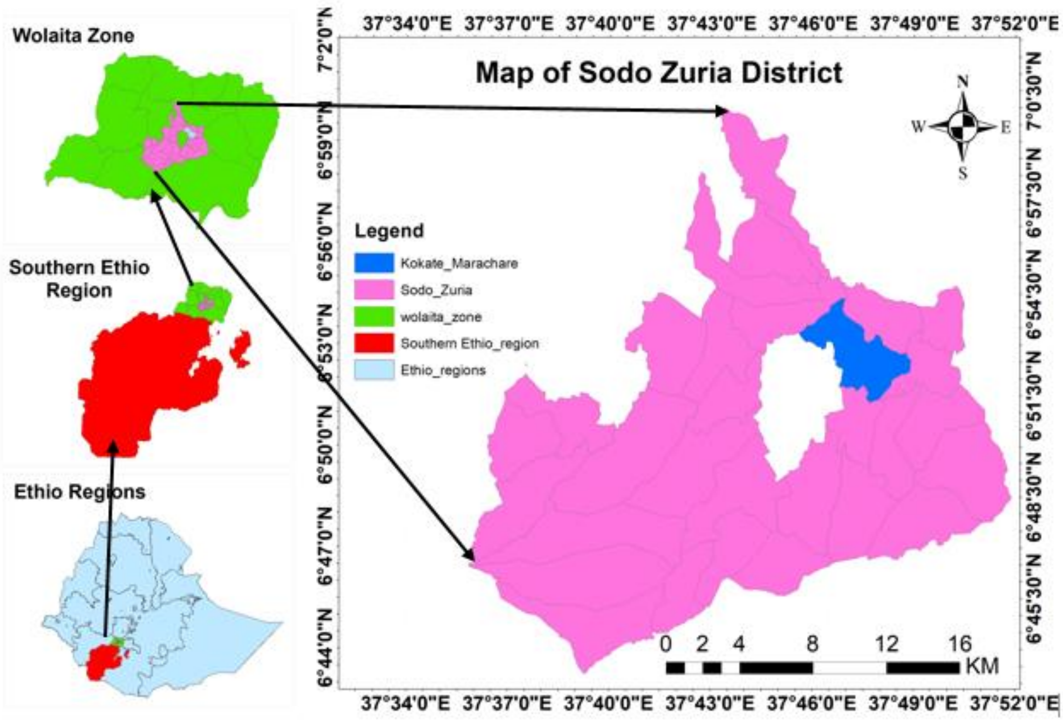

Figure 1. Map of Wolaita zone Sodo zuria Woreda South Ethiopia, Arc-GIS.

Experimental Design and Procedures

The layout of the experiment was a randomized complete block design with a plot size of 4 m by 4 m and replicated three times in two consecutive years. The space between rows, plot and blocks was 0.2 m, 0.5 m and 1 m respectively to prevent mixing and seeds being sown by drilling. The fertilizers used for experiments were TSP, NPSB, NPSBCu and urea as inorganic fertilizer sources, applied at different rates based on treatment arrangements**.** The fertilizers trail was based on nutrient deficiencies in the study area, as recommended in the soil fertility map of Ethiopia by Agricultural Transformation Agency [12].

The experiment consisted of ten treatments including: (T_1) control (no fertilizer), (T_2) recommended NP (69 kg N and 20 kg P), (T_3) NPSB (69 kg N, 24.59 kg P, 10.43 kg S, 0.15 kg B ((150 kg NPSB + 90 kg Urea), (T_4) NPSB: 92 kg N, 32.78 kg P, 13.90 kg S, 0.2 kg B (200 kg NPSB + 120 kg Urea), (T_5) NPSB: 115 kg N, 40.98 kg P, 17.38 kg S, 0.25 kg B (250 kg NPSB + 150 kg Urea), (T_6) NPSB = 138 kg N, 49.17 kg P, 20.85 kg S, 0.3 kg B (300 kg NPSB + 180 kg Urea) , (T_7) NPSB: 69 kg N, 24.59 kg P, 10.43 kg S, 0.15 kg B (150 kg_NPSB+90 kg Urea) + 0.4 kg Cu, (T_8) NPSB: 92 kg N , 32.78 kg P, 13.90 kg S, 0.2 kg B (200 kg NPSB + 120 kg Urea) + 0.4 kg Cu, (T_9) NPSB: 115 kg N, 40.98 kg P, 17.38 kg S, 0.25 kg B (250 kg NPSB + 150 kg urea) + 0.4 kg Cu, (T_{10}) NPSB: 138 kg N, 49.17 kg P, 20.85 kg S, 0.3 kg B (300 kg NPSB + 180 kg urea) + 0.4 kg Cu.

The entire dose of NPSB and TSP was applied at planting time, while Copper was applied foliar, and the recommended N rate was side-dressed in 45 days after planting for all treatments except the second one i.e. T2. For T2, the N rate was applied in splits, i.e., one third at sowing time and the remaining two thirds side dressed. Food Wheat variety “Bondena” was used as a test crop. Agronomic data including plant height (cm), spike length (cm), above ground biomass (ton ha^{-1}) and grain yields (ton ha^{-1}) were collected. Both grain yield and biological were estimated by using harvesting and threshing whole plot size (16 m^2) manually.

Soil Sample and Methods of Analyses

The composite soil samples were collected from each experimental site at a depth of 0–20 cm during planting time at first and second year. The collected samples were well mixed, air dried, ground and passed through 2 mm sieve. The samples were analyzed for different physiochemical parameters, such as texture, pH, organic carbon, available P, total nitrogen, CEC, exchangeable bases, such as Ca, Na, Mg and K using standard analytical techniques as outlined in Manual of soil, plant and water analysis [15].

Statistical and Economic Analysis

The collected data were subjected for analysis of variance (ANOVA) based on experimental design of research. The Least Significant Difference test (LSD) at 5% level of significance was used to separate treatment means (SAS V9.2, SAS Institute Inc., Cary, NC, USA) [16]. The partial budget analysis was carried out according to CIMMITY (1988), and market costs for different inputs for sowing and prices of outputs at harvest. The average grain yield was adjusted downward by 10% as farmers got 10% less yield. The net benefit was calculated as the difference between gross income and total variable cost. The marginal rate of return (% MRR) was calculated as the change in income divided by change in total variable cost (TVC). Treatments with marginal rate of return greater than 100% and the highest net benefit were economically best (CIMMITY, 1988).

RESULTS AND DISCUSSION

Soil Physicochemical Properties of Experimental Site

The overview of soil physicochemical properties of the experimental site were displayed in Table 1 below. Soil pH: the experimental site is moderately acidic [17] which is satisfactory for most crops (Hach Company, 1992). Organic Carbon (%OC): the level of OC of the experimental site is moderate and that is adequate for crop production [17]. The percent of total nitrogen level of the experimental site was 0.16% and is moderate according to [17]. The concentration of available Phosphorus (P) analyzed by Olsen methods and phosphorus level in site was 14.75 ppm. It was high at the experimental site, according to Olsen rating system (Olsen, 1954). Exchangeable potassium of study analyzed by Morgan solution or 1N ammonium acetate and level of potassium was 0.76 meq/100g The result was moderate according to rate of salhimadine and Taye soil, plant and water analysis manual and Beranu rating [18]. CEC: the site has a moderate level of CEC (Booker, 1991). The textural class was clay loam with sand silt and clay proportion of 35%, 28% and 35%, respectively.

Table 1. Physicochemical properties of composite soil of study area.

pH	% OC	P ppm	% TN	B ppm	S–SO4 Ppm	K meq/100g	CEC meq/100g	% Sand	% Clay	% Silt	Textural Class
5.31	1.83	14.8	0.16	0.43	10.3	0.76	22.16	35	37	28	Clay loam

pH: power of hydrogen; OC: organic carbon; P: available phosphorus; K: exchangeable potassium; CEC: Cation exchange capacity.

Effects of Blended Fertilizer Rate on the Yield of Wheat at Sodo Zuria District

The mean data of yield and yield components of wheat are described in Table 2 below. and results of ANOVA indicated statistically significant differences among treatments for all tested parameters in general. When compared with RNP, the data of tillering and spike length showed that BF in different rates produced higher results, except in T_7. In terms of grain yield, data for different BF rates showed higher product except in T_3, T_7, and T_8. Numerically, grain yield of T_{10} had better yield even if statistically not significant when compared with T_2, T_4, T_5 T_6 and T_9.The yield advantage of the two highest yielded treatment's (T6 and T10) over RNP was 26.37 % and 27.44% respectively. While plant height data of BF applied was statistically significant when compared with RNP. Except in case of plant height, those comparisons point out the need for balanced nutrients for wheat production in Sodo Zuria district. When we compare two treatments with and without copper (Cu) having the same dosage of NPSB: T_3 (without Cu) and T_7 (T_3 + 0.4 kg Cu), the output of T_3 was better than T_7 in all parameters except for plant height. In comparison between T_6 with T_{10}, T_6 yielded better in all parameters except for grain yield. In comparison with T_4 with T_8 (T_4 + 0.4 kg Cu), the output of T_4 performed better in all parameters. In comparison with T_5 with T_9 (T_5 + 0.4 kg Cu), T_9 gave better results in all parameters. According to [12], the study area is deficient in copper but the experimental results show that the soil in the study area has adequate copper , with 65% proportion, indicating that yield and yield components of wheat at the study site are not affected by copper deficiency when compared with additional copper applied.

Table 2. Effects of blended fertilizer rate on the yield of wheat at Sodo Zuria district.

No	Treatment	PH (cm)	Tiller	SL (cm)	BM (kg/ha)	GY (kg/ha)
T_1	Control (no fertilizer)	64.5^{b}	1.33^{f}	5.95^{c}	38906.3^{f}	9947.8^{d}
T_2	RNP (69, 20)	75.4^{a}	1.63^{ef}	6.99^{b}	67929.7^{e}	26741.9^{abc}
T_3	NPSB = 69, 24.59, 10.43, 0.15	74.5^{a}	2.08^{cd}	7.08^{b}	71992.2^{de}	24569.7^{bc}
T_4	NPSB = 92, 32.78, 13.90, 0.2	75.4^{a}	2.23^{bcd}	7.49^{ab}	79570.3^{bcde}	27789.9^{abc}
T_5	NPSB = 115, 40.98, 17.4, 0.25	76.5^{a}	2.3^{bc}	7.33^{ab}	88750^{abcd}	32756.9^{ab}
T_6	NPSB = 138, 49.17, 20.85, 0.3	78.8^{a}	2.75^{a}	8.01^{a}	103906.3^{a}	36352.3^{a}
T_7	T_3 + 0.4 kg Cu	75.8^{a}	1.95^{df}	6.96^{b}	69726.6^{e}	20204.1^{cd}
T_8	T_4 + 0. kg Cu	75.2^{a}	2.18^{bcd}	7.34^{ab}	73398.5^{cde}	24489.8^{bc}
T_9	T_5 + 0.4 kg Cu	76.95^{a}	2.5^{ab}	7.58^{ab}	89492.2^{abc}	33375.2^{ab}
T_{10}	T_6 + 0.4 kg Cu	77.5^{a}	2.5^{ab}	7.94^{a}	94648.5^{ab}	36772.9^{a}
LSD ($p < 0.05$)		6.89	0.34	0.71	17458	10875
CV (%)		5.61	9.65	6.00	13.70	24.33

Note: PH: Plant height, SL: Spike length, BM: Biomass, GY: Grain yield, T_1–T_{10}: Treatment 1 up to 10: RNP: Recommended N and P; Cu: Copper; LSD = Least significant difference; CV = Coefficient of variance; 100 kg NPSB = 18.9 N, 37.7 P_2O_5, 9.65 S and 0.1 B.

ECONOMIC ANALYSIS

From Table 3, the economic analysis indicates that Treatment 7 and 8 were dominant treatments, having lower variable cost and higher net benefit. When comparing treatments 7 and 8 with T3, it was noted that T3 had the lowest variable cost and higher net benefit than T7 and T8. Also comparing T4 with T8, T4 had lower total variable cost and higher net benefit than T8 (Table 3). From economic analysis Table 3, all treatment, except T7 and T8, were potential options based on dominance analysis. Based on partial budget analysis (Table 4), T10 had higher net benefit compared with T2, T3, T4, T5, T6 and T9; but its marginal rate of return (MRR) was below minimum acceptable rate of return for this study, which is 100%.Therefore, T9 and T3 were rejected due to not meeting the minimum acceptable rate of returns. Therefore, the producer invests 1 ETB and gets 45.24 ETB/ha, 24.87 ETB/ha and 27.23 ETB/ha for T2, T4 and T5 respectively which is more than MRR (100%). Finally, T2, T4 and T5 were higher than the minimum acceptable rate of return of 100% and indicating potential for extra investment for producers.

Table 3. Economic (partial budget and dominance) analysis of fertilizers on wheat at Sodo Zuria.

Treatment	NPSB (kg/ha)	Urea (kg/ha)	TSP (kg/ha)	Cu (kg/ha)	Adjusted Yield (kg/ha)	TVC (ETB)	GFB (ETB)	NB (ETB)	Dominancy
1	0	0	–	–	9947.77	0	27500	27500	
2	0	150	100	–	26741.88	5188	73425	68237	
3	150	90	–	–	24569.70	5063	67650	62586.9	
4	200	120	–	–	27789.91	6751	76450	69699.2	
5	250	150	–	–	32756.85	8439	90200	81761.5	
6	300	180	–	–	36352.31	10126	100100	89973.8	
7	150	90	–	0.4	20204.09	5943	55550	49606.9	D
8	200	120	–	0.4	24489.77	7631	67375	59744.2	D
9	250	150	–	0.4	33375..14	9319	91850	82531.5	
10	300	180	–	0.4	36772.90	11006	101200	90193.8	

Note: Yield adjustment = 10%; TSP: Triple super phosphate; Cu: Copper; Kg/ha: Kilo gram per hectare; TVC: Total variable cost; GFB: Gross field benefit; NB: Net benefit; ETB: Ethiopian birr; D: Dominated.

Table 4. Economic (partial budget and MRR) analysis of fertilizers on wheat at Sodo Zuria.

Treatments		Adjusted Yield (ton/ha)	TVC (ETB)	GFB (ETB)	NB (ETB)	MRR (%)
1	No fertilizer	9947.77	0	27500	27500.00	
2	RNP: 69, 20	26741.88	5188	73425	68237.00	4523.70
3	NPSB: 69, 24.59, 10.43, 0.15	24569.70	5063	67650	62586.90	692.99
4	NPSB: 92, 32.78, 13.90, 0.2	27789.91	6751	76450	69699.20	2487.59
5	NPSB: 115, 40.98, 17.38, 0.25	32756.85	8439	90200	81761.50	2725.93
6	NPSB: 138, 49.17, 20.85, 0.3	36352.31	10126	100100	89973.80	921.42
9	T5 + 0.4 kg Cu	33375.14	9319	91850	82531.50	87.50
10	T6 + 0.4 kg Cu	36772.90	11006	101200	90193.80	25.00

Note: Yield adjustment=10%; RNP: Recommended N and P; Cu: Copper; Ton/ha: Ton per hectare; TVC: Total variable cost; GFB: Gross field benefit; NB: Net benefit; ETB: Ethiopian birr: MRR: Marginal rate of return.

CONCLUSIONS AND RECOMMENDATION

The study was conducted at acidic soil of South Ethiopia to improve production and productivity of wheat by applying deficient soil nutrients, such as Nitrogen, Phosphorus, Sulfur and Boron. The soil of study area was strongly acidic and has low level of N, P, S, B and Potassium and medium level of OC and CEC. The soil's textural class was clay loam. The highest net benefit was obtained from treatment 6, which had an acceptable marginal rate of return (MRR). The treatments 2, 4, and 5 gave net benefit with associated marginal rate of return (MRR). The treatment 2 exhibited highest MRR, while treatment 5 gave the next highest MRR (NPSB: 115, 40.98, 17.38, and 0.25). Based on statistical analysis and economic analysis T5, which consists of NPSB fertilizers in the ratio of 115, 40.98, 17.38, 0.25 (250 kg NPSB + 150 kg urea) is recommended as the best option for wheat producers around Sodo Zuria district. Additionally, applying NPSB = 92, 32.78, 13.90,0.2 (200 kg NPSB + 120 kg urea) can be also used as an alternative option.

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