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Evaluation of Different Blended Fertilizers Types and Rates for Better Production of Potato at Bule Soil Condition, Southern Ethiopia

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Keywords: *macro and micronutrient, potato, sufficient nutrient, economic feasibility.*

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Abstract- Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer (only N and P) uses on other has favored the emergence of multi nutrient deficiency in Ethiopian soils. This problem demands different studies to balance the nutrient combination to improve potato yield and quality. A trial was conduct to evaluate different fertilizer types for potato production and to enrich its quality in Southern Ethiopia during the main cropping season of 2016 and 2017. Fertilizer treatments were based on limiting nutrients of the area including N, P, K, S, B and at different rate and cobination. The trial consists of ten treatments (1) no fertilizer (control) (2) NPSB: 69 kg N + 23.5 kg P + 10 kg S + 1.07 kg B/ha (3) NPSB: 92 kg N + 31 kg P + 13 kg S + 1.4 kg B/ha (4) NPSB: 115 kg N + 39 kg P + 17 kg S + 1.7 kg B/ha (5) NPSB: 138 kg N + 47 kg P + 20 kg S + 2.0 kg B/ha (6) NPSBCu: 69 kg N + 31 kg P + 17 kg S + 1.4 kg B + 0.625 kg Cu/ha (7) NPSBCu: 92 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha (8) NPSBCu: 115 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha (9) NPSBCu: 138 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha and (10) NPS: 112 kg N + 40 kg P + 17 kg S/ha was used as positive control. In addition, except the absolute control all plots were received 60 kg K/ha. The trial was conducted on two farms and treatments were laid out in a randomized complete block design replicated three times in each farm. Crop characteristics measured were analyzed using Proc GLM procedures in the SAS 9.3 program. Economic analysis was also performed to investigate the economic feasibility of the fertilizers for potato production. Applying blended fertilizer increase potato yield. The economic analysis revealed that except treatment 2 and 3 all the treatments were dominated by the treatment with low total cost that varies. The highest net benefit was obtained from treatment 3 with acceptable marginal rate of return. However, treatment 2 also met more than the required return. This result also confirmed by the sensitivity analysis, both treatments sustains acceptable returns even under 20% input price increment. Therefore, NPSB: 69 kg N + 23.5 kg P + 10 kg S + 1.07 kg B/ha and NPSB: 92 kg N + 31 kg P + 13 kg S +1.4 kg B/ha are recommended for potato production.

Keywords: macro and micronutrient, potato, sufficient nutrient, economic feasibility.

I. Introduction

Potato (solanumtuberosum L.) is the fourth most important food crop in the world after rice, maize and wheat in terms of human consumption (Karam et al., 2009; Kandil et al., 2011). The quantity produced yearly exceeds 300 million metric tons and more than a billion people consume worldwide. Potato is rich in carbohydrates, protein, vitamins, dietary fibers, simple sugars and minerals (CIP, 2010; FAO, 2008). However, the yield is very low (below 10 t ha^{-1}) as compared to the yield in developed countries (30 to 40 t ha-1) where sufficient amount of fertilizers are applied (FAO, 1991).

Fertilizer application has important effects on the quality and yield of potatoes (Leytem and Westermann, 2005). Nitrogen supply plays an important role to balance between vegetative and reproductive growth for potato (Alva, 2004; White et al., 2007). Previous studies have shown that N fertilizer applications can increase dry matter content, protein content of potato tubers, total and/or marketable tuber yield (Zebarth et al., 2004; Zelalem et al., 2009). Nitrogen uptake on per day basis is sometime even more than 1.5 kg ha-1 during active growth period (Kumar and Trehan, 2012).

Similarly, uptake of fertilizer nutrients (NPK) by potato per unit area and time is quite high because of the rapid rate of early growth and tuber bulking (Singh and Trehan, 1997). A healthy crop of potato removes about 170-230 kg K_2O ha^{-1} indicating higher requirement for K as compared to cereals. On the other hand nutrients present in mineral fertilizers are more effective than the equivalent amount of these nutrients present in FYM (Bagdoniene et al., 1998) which indicates mineral fertilizer efficacy for potatoes was noticeably higher than that of organic fertilizer (Antanaitis and Svedas, 2000).

Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer (only N and P) uses on other has favored the emergence of multi nutrient deficiency in Ethiopian soils (Abyie et al., 2003, Beyene, 1984; Wassie et al., 2011). Currently, the soil fertility map of Ethiopia is developed by Agricultural Transformation Agency (ATA) and reported the deficient nutrients in the south nation nationalities and people regional state (SNNPRS) in 2016. Based on the soil fertility map, 13 blended fertilizers containing N, P, K, S, B, Zn and Cu in different mix form have been recommended for SNNPRS. Therefore, to benefit farmers from their small holding, identification of proper

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fertilizer blends for specific site to enhance potato production is crucial.

II. Materials and Methods

Field experiment was conducted to evaluate different blended fertilizers for potato production in Buleworeda (district) of the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) in the main cropping season of 2016 and 2017. Treatments were prepared based on the nutrient deficiency of the area which indicated in the soil fertility map of Ethiopia produced by Agricultural Transformation Agency (ATA) (2016). Accordingly, three types of fertilizers (NPSB, NPSBCu and NPS) were used in different rates. The experiment consists of ten treatments (1) no fertilizer (control) (2) NPSB: 69 kg N + 23.5 kg P + 10 kg S + 1.07 kg B/ha (3) NPSB: 92 kg N + 31 kg P + 13 kg S + 1.4 kg B/ha (4) NPSB: 115 kg N + 39 kg P + 17 kg S + 1.7 kg B/ha (5) NPSB: 138 kg N + 47 kg P + 20 kg S + 2.0 kg B/ha (6) NPSBCu: 69 kg N + 31 kg P + 17 kg S + 1.4 kg B + 0.625 kg Cu/ha (7) NPSBCu: 92 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha (8) NPSBCu: 115 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha (9) NPSBCu: 138 kg N + 39 kg P + 10 kg S + 1.7 kg B + 0.625 kg Cu/ha and NPS: 112 kg N + 40 kg P + 17 kg S/ha was used as positive control. In addition, except the absolute control all plots were received 50 kg K/ha.

III. Experimental Layout

The experiment was conducted on two farms in each year and laid out in a randomized complete block design using 3.75 m by 3.9 m plot size and replicated three times in each farm. To avoid mixing up of treatments the plots were separated by 1 and 1.5 m space between plots and blocks, respectively. All doses of NPS, NPSB and potassium fertilizers were applied at planting time and urea was top dressed 45 days after planting. Foliar application was used for copper selfate. Improved potato variety (Gudene) was planted in rows and other crop management practices were used as recommended for the crop.

IV. Agronomic and Economic Analysis

Agronomic data for potato, including plant height, number of plant/hill, number of tuber/hill, above ground total biomass, marketable and unmarketable tuber yield were measured. Analysis of variance for all data was done using Proc GLM procedures in the SAS 9.3 program (SAS Institute Inc., Cary, NC USA). The least significant difference (LSD) at 5% probability level was used to establish the significance of differences between the means.

An economic analysis was used to investigate the economic feasibility of the fertilizer types (NPS, NPSB and NPSBCu) for poato production. The partial budget, dominance and marginal rate of return were calculated. For partial budget analysis averages yield that was adjusted downwards by 10% was used, assuming that farmers would get ~10% less yield than is achieved on an experimental site. The average open market price for potato (6.5 Ethiopian Birr (ETB))/kg) and potato seed (10.0 ETB/kg); and the official prices for NPS (10.94 ETB/kg), NPSB (10.28 ETB/kg), N as Urea (8.76 ETB/kg), potassium chloride-K (14.0 ETB/kg)and copper sulfate-Cu (1000 ETB/kg) were used for the analysis. For a treatment to be considered a worthwhile option for farmers, the minimum acceptable marginal rate of return should be over 50% (CIMMYT, 1988). However, Gorfu et al. (1991) suggested a minimum acceptable rate of return should be 100%. Therefore, the minimum acceptable marginal rate of return considered in this study is 100%.

V. Result and Discussion

The combined analysis result presented in table 1 revealed that all plots treated with different types and rates of fertilizers significantly ($P < 0.05$) increased the marketable tuber yield and plant height of potato at Bule. In the control plot, the lowest marketable yield was measured. The yield advantage was 50.6% in the lowest yield measured from treatment 7 compared to the untreated plots (table 1). However, statistically significant difference was not observed in biomass and number of tuber per hill among all treatments. This result might be obtained due to the cumulative contribution of macro and micro nutrients which were identified as deficient soil nutrients in the soil fertility map of the area. Abay A. and Tesfaye D., 2011, reported that 111 kg N + 39 kg P ha^{-1} or 10 t compost + 73.4 kg N + 26 kg P ha^{-1} increased potato tuber yield. In the current study, economically feasible rates were 92 N, 31 P, 13 S, 1.4 B kg/ha. Nitrogen and phosphorus were reduced to 92 and 31 compared to the above authors. This result might be contributed from the additional micro nutrients.

Table 1: Yield and yield components of potato influenced by different blended fertilizers at Bule

Treatments	Plant height (cm)	No. of Plant/hill	No. of tuber/hill	Unmarketable yield t/ha	Marketable yield t/ha
1.Control (no fertilizer)	66.73e	3.592	8.467	0.5	19.892 b
2. NPSB: 69 + 23.5 +10 + 1.07 kg/ha	84.48d	3.892	9.533	0.508	32.125 a
3. NPSB: 92, 31, 13,1.4 kg/ha	87.91bcd	3.875	9.9	0.533	34.075 a
4. NPSB: 115, 39, 17,1.7 kg/ha	91.16bc	3.925	10.33	0.742	32.817 a
5. NPSB: 138, 47, 20,2.0 kg/ha	97.83a	3.733	9.467	0.758	33.975 a
6. NPSBCu: 69,31,17, 1.4, 0.625 kg/ha	84.67cd	3.492	8.642	0.592	30.883 a
7. NPSBCu: 92, 39, 10,1.7, 0.625 kg/ha	87.08cd	3.492	10.29	0.908	29.950 a
8. NPSBCu: 115, 39, 10,1.7, 0.625 kg/ha	94.27ab	4.167	10.4	0.45	33.392 a
9. NPSBCu: 138, 39, 10,1.7, 0.625 kg/ha	90.73bcd	3.708	9.308	0.625	32.867 a
10. NPS: 112, 40, 17 kg/ha	88.56bcd	3.967	10	0.508	31.400 a
LSD (0.05)	6.59	NS	NS	NS	5.7647
CV (%)	8.74	22.00	24.59	61.40	15.58

Note: Values followed by the same letter are not significantly different at $P < 0.05$.

VI. Economic Analysis

The dominance analysis (table 2) showed that except treatment 2 and 3 all other treatments were dominated by the treatments with lower variable cost and higher net benefit. Treatment 2 had the lower total variable costs and higher net benefits than the treatment with the next lowest total variable costs, treatments 6. Treatment 3 had lower total variable cost and gave high net benefit compared to treatment 4, 5, 7, 8, 9 and 10. Based on the dominance analysis treatment 2 and 3 were potential options (table 2). Therefore, treatments 4, 5, 6, 7, 8, 9 and 10 were eliminated from further economic analysis and only the dominant treatments were considered further in the partial budget analysis (table 3).

The partial budget analysis (table 3), showed that treatment with the higher net benefit was treatment 3 (175,123ETB/ha) with acceptable marginal rate of return compared to treatment 2 which gave 164,492 ETB/ha. However, the marginal rate of return for this treatment was 1512%. This means for each 1 ETB investment, the producer can get 15.12 ETB. Since the minimum acceptable rate of return assumed in this experiment was 100%, both these treatments can give an acceptable marginal rate of return for the extra investment. Therefore, treatment 2 and 3 can be accepted as the preferred option for farmers.

Table 2: Economic (partial budget and dominance) analysis of fertilizers on potato at Bule

Treat	NPSB (kg/ha)	NPS (kg/ha)	Cu (kg/ha)	N kg/ha	K kg/ha	Potato seed kg/ha	Av. Yield	Adj. yield	TCTV (EB/ha)	Revenue (EB/ha)	NB (EB/ha)	MRR (%)
1	0	0	0	0	0	1900	19.9	17.9	19000	116368	97368	
2	150	0	0	91	90	1900	32.1	28.9	23439	187931	164492	
6	150	0	0.625	91	90	1900	30.9	27.8	23939	180666	156727	D
3	200	0	0	121	90	1900	34.1	30.7	24216	199339	175123	
7	200	0	0.625	121	90	1900	30.0	27.0	24716	175208	150492	D
4	250	0	0	152	90	1900	32.8	29.5	25001	191979	166978	D
10	0	242	0	143.5	90	1900	31.4	28.3	25005	183690	158685	D
8	250	0	0.625	152	90	1900	33.4	30.1	25501	195343	169842	D
5	300	0	0	182	90	1900	34.0	30.6	25778	198754	172976	D
9	300	0	0.625	182	90	1900	32.9	29.6	26278	192272	165994	D

Yield adjustment =10%, field price of potato = 6.5 Ethiopian Birr (ETB)/kg, potato seed = 10 ETB/kg, official price for urea-N = 8.75 ETB/kg, NPS fertilizer = 10.9 ETB/kg, NPSB fertilizer = 10. 3 ETB/kg, potassium chloride-K =14ETB/kg, copper sulfate-Cu= 1000 ETB/kg, TCTV = total costs that varies, NB = net benefit, D indicates dominated treatments that are rejected, MRR = marginal rate of return.

Table 3: Economic (partial budget and marginal rate of return) analysis of fertilizers on potato at Bule

Treatments	Av. Yield (t/ha)	Adj. yield (t/ha)	TCTV (EB/ha)	Revenue (EB/ha)	NB (EB/ha)	MRR (%)
1. No fertilizer	19.9	17.9	19000	116368	97368	
2. NPSB: 69,23.5,10, 1.07	32.1	28.9	23439	187931	164492	1512
3. NPSB: 92, 31, 13,1.4	34.1	30.7	24216	199339	175123	1369

Yield adjustment =10%, field price of potato = 6.5 Ethiopian Birr (ETB)/kg, potato seed = 10 ETB/ha, official price for urea-N = 8.75 ETB/kg, NPS fertilizer = 10.9 ETB/kg, NPSB fertilizer = 10. 3 ETB/kg, potassium chloride-K= 14 ETB/kg, copper sulfate-Cu= 1000 ETB/kg, TCTV = total costs that varies, NB = net benefit, MRR = marginal rate of return.

VII. Sensitivity Analysis

In different reasons market prices are ever changing and recalculation of the partial budget considering future prices is necessary to pinpoint treatments which can be remain stable and sustain acceptable returns for farmers despite input price fluctuations. In the present study, assuming that the official price of NPSB, urea and potassium fertilizers will increase by 20%. The assumption of price increment in these fertilizers is mainly the change in the exchange rate and price change in transport.

Based on the sensitivity analysis (table 4), treatments 2 (NPSB: 69 kg N + 23.5 kg P + 10 kg S + 1.07 kg B/ha)) and 3 (NPSB: 92 kg N + 31 kg P + 13 kg S +1.4 kg B/ha) gave an economic yield response and also sustain acceptable returns even under 20% input price increment likely farmers face in the future. Therefore, farmers could choose either of the two new fertilizer rates depending on their resource.

Table 4: Partial budget analysis at projected future prices of NPS, NPSB and urea fertilizers at Bule

Treatments (kg/ha)	Av. Yield	Adj. yield	TCTV (EB/ha)	Revenue (EB/ha)	NB (EB/ha)	MRR (%)
1. No fertilizer	19.9	17.9	22800.0	116368.2	93568.2	
2. NPSB: 69,23.5,10, 1.07	32.1	28.9	28126.8	187931.3	159804.5	1243
3. NPSB: 92, 31, 13,1.4	34.1	30.7	29058.8	199338.8	170279.9	1124

Yield adjustment =10%, field price of potato = 6.5 Ethiopian Birr (ETB)/kg, potato seed = 10 ETB/ha, official price for urea-N = 8.75 ETB/kg, NPS fertilizer = 10.9 ETB/kg, NPSB fertilizer = 10. 3 ETB/kg, potassium chloride-K= 14 ETB/kg, copper sulfate-Cu= 1000 ETB/kg, TCTV = total costs that varies, NB = net benefit, MRR = marginal rate of return.

VIII. Conclusion and Recommendation

This study showed that potato yield increased using the blended fertilizers compared to the control. However, there was no significant difference between the different types and levels of blended fertilizers.

The economic analysis revealed that except treatment 2 and 3 all the treatments were dominated by the treatment with low total cost that varies. The highest net benefit was obtained from treatment 3 with acceptable marginal rate of return. However, treatment 2 also met more than the required return. This result also confirmed by the sensitivity analysis, both treatments sustains acceptable returns even under 20% input price increment. Therefore, treatment 2 (NPSB: 69 kg N + 23.5 kg P + 10 kg S + 1.07 kg B/ha) and treatment 3 (NPSB: 92 kg N + 31 kg P + 13 kg S +1.4 kg B/ha) with 50 kg K/ha are recommended and farmers could choose either of the two new fertilizer rates depending on their resource.

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