

Cost Effectiveness of Sweet Potato Production Using Farmyard Manure and Inorganic Phosphorus Fertilizer at Assosa Western Ethiopia

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Abstract: Sweet potato is one of the food security crop which has been cultivated in the South west, eastern and southern parts of Ethiopia over centuries. Despite that, the yield is below its genetic potential. This is due to less attention given to the crop in the region assuming that there is no response of the crop to fertilizers. A study was conducted to evaluate economic cost effectiveness of using farm yard manure and phosphorus fertilizer for sweet potato production in the study area. The treatment consisted of four levels of farm yard manure (0, 5, 10 and 15 t ha⁻¹) and four levels of P (0, 23, 46 and 69 kg P₂O₅ ha⁻¹). The experiment was laid out as a Randomized Complete Block Design in a factorial arrangement and replicated three times. Analysis of the result showed that using the rate of the combined fertilizers (15tha⁻¹ farmyard manure and 69kg ha⁻¹ phosphorus) gave the highest yield (23.65tha⁻¹) which gave the highest net benefit of 60033Birr ha⁻¹. Therefore, if the farmers use by integrating 15 t ha⁻¹ farm yard manure and 69 kg P₂O₅ ha⁻¹, they can be more profitable in the study area.

Keywords: Farmyard Manure, Sweet Potato, Partial Budget, Phosphorus

1. Introduction

Sweet potato is a member of convolvulaceae family, genus *Ipomoea* and species *batatas* [7]. It is accepted that the cultivated sweet potato has originated in Central America or tropical South America. It has large, starchy, sweet-tasting and tuberous roots. It adapts tropical and warm temperate regions. It is a highly heterozygous cross pollinated crop in which many of the traits show continuous variation. It does well in areas of high rainfall and it requires very little labor and care compared to other crops. Because it readily produces adventitious roots and has trailing vines, sweet potato can colonize soils easily. It is recognized as ideal crop for food security. The yellow and orange-fleshed sweet potato varieties are also known as a good source of vitamin A that is frequently lacking in diets of most African farming communities. However, most varieties in sub-Saharan Africa are white-fleshed, low yielding and lacking beta-carotene, the precursor of vitamin A that was found vital to pregnant women and children. Also, sweet potato is widely used as animal feed [1, 15]

Sweet potato has been cultivated in Ethiopia for the last several years and over 95 percent of the crop is produced in the South west, eastern and southern parts, where it has remained for centuries as one of the major subsistence crops especially in the periods of drought [4]. In Ethiopia, low soil fertility is one of the factors limiting the productivity of different crops including sweet potato which may be caused due to removal of surface soil by erosion, nutrients removal of crop from the soil, complete removal of plant residue from farmland and lack of crop rotation system on the farm land [2].

The national average yield of sweet potato which was estimated to 45.65t ha⁻¹, but the regional average yield of Benisangul Gumuz region was 15t ha⁻¹ which had 30t ha⁻¹ yield gap with the national average yield which implies lower productivity of the crop of the region due to less attention given to the crop in the region assuming that there is no response of the crop to fertilizers. [3]

Sweet potato producers in Ethiopia including Benishangul Gumuz, generally do not use inorganic fertilizer, because the response of various cultivars to fertilizers has not been

clearly established, and because they assume that it is not cost-effective. Farmers do use organic fertilizer occasionally from farmyard manure on sweet potatoes and there is some evidence that using organic fertilizer in combination with phosphorus is effective in raising yields [8-12]. So, the objective of this study was to evaluate economic cost effectiveness of using farm yard manure and phosphorus fertilizer for sweet potato production in the study area

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted under rain fed condition at research farm of Assosa Agricultural Research Center (ASARC) during 2016 cropping year from July to December. Assosa Agricultural Research Center is 660 km away from Addis Ababa which is located at latitude of 10°02' N and longitude of 34°34' E in western Ethiopia. The soil of the site was characteristically reddish brown (*Nitrosol*), which is slightly acidic with pH of 5.7 and texturally clay.

2.2. Treatments and Experimental Design

The treatments consist of 4x4 factorial combinations of phosphorus (0, 23, 46, and 69 kg P₂O₅ ha⁻¹) and FYM (0, 5, 10, 15 ha⁻¹). The treatments were arranged in a randomized complete block design (RCBD) with three replications. A sweet potato variety Awassa 83, was used for the experiment. Triple super TSP containing 46% P₂O₅ was used as inorganic fertilizer sources and well decomposed farmyard manure (FYM) on dry weight basis was used as source of organic fertilizer.

2.3. Data Collection

Data were collected on parameters like total tuber yield, and marketable tuber yield. All data were subjected to analysis of variance using SAS 9.2 software. For treatments that were significant, mean separation was done using the Least Significant Difference (LSD) test at 5% probability level.

2.4. Partial Budget Analysis

Partial budget analysis was employed for economic analysis of fertilizer application and it was carried out for tuber yield. The potential response of crop towards the added fertilizer and price of fertilizers during planting ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988). To estimate economic parameters, sweet potato tuber was valued at an average open market price of 4.00 birr kg⁻¹. To estimate the total costs, mean current prices of TSP (23 Birr kg⁻¹), and manure (1500 birr t⁻¹) were considered at the time of planting.

Twenty workers for manure application, sixteen workers for phosphorus application were considered per hectare. The wage rate per worker was 30 Birr per day. Cost of protection, storage, planting material, post harvest, and others were not included in the calculation. The economic analysis was based on the formula developed by CIMMYT (1988) and given as follows:

Marketable tuber yield (ton ha⁻¹): is an average yield of each treatment

Adjusted yield (AJY): is the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers.

$$AJY = MTY - (GAY * 0.1)$$

Gross field benefit (GFB): was computed by multiplying field/farm gate price that farmers receive for the crop when they sale it by adjusted yield.

$$GFB = AJY * \text{field/farm gate price of a crop}$$

Total variable cost (TVC): mean current cost of FYM (150 birr /100 kg), TSP (23 birr kg⁻¹), wage for manure application, and phosphorus application, were considered per hectare.

Net benefit (NB): was calculated by subtracting the total variable costs from the gross field benefit for each treatment.

$$NB = GFB - TVC$$

Marginal Benefit (MB) = Change in benefit between treatments

Marginal cost (MC) = Change in cost between treatments

Marginal rate of return (MRR (%)) = (MB/ MC)*100

3. Result and Discussion

Total tuber yield of sweet potato was significantly affected by the interaction of farmyard manure and phosphorus. The maximum tuber yield per hectare (24.6 t ha⁻¹) was recorded at 15 t FYM ha⁻¹ + 69 kg P₂O₅ ha⁻¹ and the lowest yield (5.5 t ha⁻¹) was recorded at 0 t FYM ha⁻¹ + 0 kg P₂O₅ ha⁻¹.

The large yield gap between the treatments may be due to the low fertility level of the experimental site which resulted lowest yield but when it was amended with FYM in combination with P, the soil became productive and reach and enabled to give better yield. This result agrees with the findings of [5] where they have observed that the nutrient use efficiency of a crop increased through a combined application of organic manure and inorganic fertilizer. In addition, the combination of 15 t FYM ha⁻¹ + 69 kg P₂O₅ ha⁻¹ produced the highest marketable root yield (23.65 t ha⁻¹) while the lowest yield (5.6 t ha⁻¹) was from 0 t ha⁻¹ FYM + 0 kg P₂O₅ ha⁻¹

Table 1. Effect of applied FYM and Phosphorus fertilizer on marketable tuberous root yield (t ha⁻¹) of sweet potato in 2016 cropping season.

Treatments	P ₂ O ₅ rate (kg ha ⁻¹)			
FYM (t ha ⁻¹)	0	23	46	69
0	3.61 ^{gh}	5.02 ^h	5.88 ^{efgh}	5.42 ^{gh}
5	9.13 ^{bcd}	4.85 ^{gh}	5.88 ^{efgh}	4.60 ^{gh}
10	6.85 ^{defgh}	8.78 ^{cdefg}	9.55 ^{bcd}	11.98 ^{bc}
15	10.76 ^{bcde}	11.10 ^{bcd}	13.73 ^b	23.65 ^a
LSD (Px FYM)	4.91			
Cv (%)	34			

CV: Coefficient of variations; LSD: least significance difference: means sharing common letter(s) are not significantly different at 5% level of significance.

4. Partial Budget Analysis of Fym and Phosphorus Application

The highest tuber yield (23.65 t ha^{-1}) was recorded at $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. Similarly, the adjusted tuber yield (23.65 t ha^{-1}) according to CIMMYT (1988) was high when $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ was applied (Table 2).

The partial budget analysis indicated that the highest net benefit of $60,033 \text{ Birr ha}^{-1}$ was recorded at $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ (Table 2). From the above results, it was apparent that the treatments with $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ were more profitable and cost effective than other treatment combinations.

Marginal rate of tuber analysis was performed on non-

Table 2. Partial budget analysis of FYM (ton ha^{-1}) and P (kg ha^{-1}) applied at different rate of combinations.

TRT		MTY (t ha^{-1})	ATY (t ha^{-1})	GFB (Birr ha^{-1})	TVC (Birr ha^{-1})	NB (Birr ha^{-1})	MRR (%)
FYM (t ha^{-1})	P ₂ O ₅ (kg ha^{-1})						
0	0	3.6	3.24	12960	0	12960	-
0	23	5.02	4.52	18080	1009	17071	-
0	46	5.885	5.3	21200	1538	19662	480
0	69	5.42	4.88	19520	2067	17453	-
5	0	9.125	8.2	32800	8100	24700	120
5	23	4.85	4.4	17600	9109	8691	-
5	46	5.88	5.3	21200	9660	11540	520
5	69	4.6	4.14	16560	10189	6371	-
10	0	6.85	6.2	24800	15600	9200	52
10	23	8.78	7.9	31600	16609	14991	574
10	46	9.55	8.6	34400	17138	17262	430
10	69	11.98	10.8	43200	19227	23973	772.2
15	0	10.76	9.7	38800	23100	14500	-
15	23	11.1	9.99	39960	24109	14651	150
15	46	13.73	12.35	49400	24638	24762	1911
15	69	23.65	21.3	85200	25167	60033	6667.5

TRT= treatment, FYM= Farmyard manure, MTY=Marketable tuber yield, AJY=Adjusted marketable tuber yield, GFB=Gross field benefit, TVC=Total variable cost, NB=Net benefit, MRR =Marginal rate of return.

5. Summary and Conclusion

It can be summarized that by using farmyard manure and phosphorus fertilizer, the highest tuber yield (23.65 t ha^{-1}) was recorded at $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. The partial budget analysis indicated that the highest net benefit of $60,033 \text{ Birr ha}^{-1}$ was recorded at $15 \text{ t FYM ha}^{-1} + 69 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ and the (MRR) according to [16] indicated that using the above rate of fertilizer gave (6667.5%) meaning that using the combination of the two fertilizers can make the farmers of the study areas more profitable and enables them to boost up their income by producing sweet potato.

Therefore, it is highly recommendable that using fertilizers is cost effective for the farmers of the study areas rather than producing without fertilizer.

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