Yield and Profitability of Sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as Affected by the Levels of Solophos and Muriate of Potash Fertilizers

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Abstract

Application of fertilizer on sweetpotato can boost the growth and yield of sweetpotato. This study was conducted to: (1) evaluate the growth and yield response of sweetpotato to the different levels of P and K fertilizers; (2) determine the appropriate levels of P and K fertilizers that will give the optimum yield for sweetpotato; and (3) determine the profitability of sweetpotato production per hectare using solophos and muriate of potash. Application of different levels of solophos and muriate of potash significantly increased the fresh herbage weight, length of the main vines, and leaf area index. NSIC Sp36 applied with fertilizer regardless of the levels showed a significantly longer length of main vines (T_2-T_6) than the plants not applied with fertilizer (T_1). On the other hand, plants applied with 45-55-55 kg ha^{-1} N, P_2O_5, K_2O (T_6) had the highest LAI but were significantly comparable to plants applied with 45-45-20 kg ha^{-1} N, P_2O_5, K_2O (T_4). However, applying different solophos and muriate of potash did not significantly influence the yield and yield component and harvest index of NSIC Sp36 variety. The highest net return of PhP274,039.24 ha^{-1} was realized when sweetpotato was applied with 45-20-45 N, P_2O_5, K_2O kg ha^{-1}.

Keywords: Muriate of potash, Profitability, Solophos, Sweetpotato, Yield

Research article
Received Date: 21 November 2023
Accepted Date: 25 December 2024

INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L.) Lam) is one of the most common and essential agronomic crops in the Philippines. It is a perennial crop that is widely grown as an annual crop used as animal feed and for manufacturing of industrial food products. It provides livelihood and food security, especially among vulnerable subsistent people living in a fragile upland environment. It is suitable as substitutionary food for rice and corn in times of scarcity and plays a supplementary role to cassava and maize as a source of seasonal food and cash crops. Sweetpotato is also used as a good cover crop to minimize soil erosion. Also, it is a climate resilience crop that is ideal for unfavorable conditions, just like in the Philippines (Relente and Asio, 2020). Farmers have found that sweetpotato is a niche in the global market, and it surpasses other primary foods. Also, it is a perfect substitution as a staple food and an immediate source of human income.

Furthermore, sweetpotato plays an essential role as an energy and phytochemical source in human nutrition and animal feed. Aside from that, this crop has essential medicinal value, and its various parts are used in traditional medicine in different countries (Mohanraj and Sivasanker, 2014). Sweetpotato has many uses, not only grown as a substitute crop for corn and rice but also as a potential source of raw materials for industrial purposes. Therefore, this crop has the potential to contribute significantly to food security as well as farmer`s income.

On the other hand, the soil rarely contains all the nutrients the plant needs because of socio-economic and demographic pressure through continuous cultivation in the agricultural sector of arable land. The yield of sweetpotato is known to be limited due to poor soil fertility and cultural management (Law-Ogbomo et al., 2019). One of the problems in sweetpotato is low yield and uniformity of storage root (SR) size, ranging from a few vast SRs to many small ones with no commercial value (Ratilla et al., 2018). However, farmers in my locality provided a small and marginal portion of their production area for sweetpotato. As a result, they did not apply fertilizers to sweetpotato, thus, resulting in low yield and income. This problem occurs because they don't know the effect or the response of sweetpotato to fertilizer. Therefore, it is essential to inform the farmers that sweetpotato needs a recommended fertilizer rate to obtain optimum yield.

Other common reasons for the low yield of sweetpotato in the locality of Cabulisan, Inopacan, Leyte are poor cultural management practices like selecting the certified NSIC recommended varieties and fertilizer management. Thus, researchers would find ways to improve the productivity and income of sweetpotato farmers through proper cultural management of sweetpotato such as the correct selection of variety and amount of fertilizer application. The fertilizer as nutrients for the crop is an essential component in crop production. The macro elements like Phosphorous (P) and Potassium (K) influences crop growth and development. Phosphorus is involved in several key plant functions, including photosynthesis, energy transfer, and transformation of sugar and starches. It affects tuber quality since it functions in cell division and synthesis and storage of starch in the tubers (Fernanes et al., 2014). It is one of the most critical nutrients for sweetpotato production. Potassium is also essential in sweetpotato for it improves nutrient value and enhances taste, color, and texture. It also promotes disease resistance and optimizes yield and quality. Phosphorus fertilizer determines the number of tubers produced, the size, and the time at which maximum yield will be obtained (Belachew, 2016). In sweetpotato cultural management, K fertilizer application has been identified as affecting tuber bulking. Potassium ions promote starch synthesis in tuberous roots. It influences tuber quality and significantly increases the rate of photosynthesis (Cruz et al., 2016). Potassium application causes a reduction in excessive vegetative growth following high nitrogen application. The use of K has also been associated with reduced disease resistance. (Jackson et al., 1990) reported reduced stem rot incidence (*Erwinia carotovora*) with K fertilizers treatments (Muoneke and Ukpe, 2010).

This study focuses on the application of different levels of phosphorus and potassium fertilizers in sweetpotato production. It is a big challenge for the researcher to promote the use of fertilizer as a critical factor in the growth and yield of sweetpotato and to determine the profitability of this fertilizer management to sweetpotato production per hectare.

MATERIALS AND METHODS

An area of 351.125 m^2 was used in this study. The area was plowed and harrowed using a four-wheeled tractor to incorporate the weeds, pulverize, and level the soil to provide better crop root development. After harrowing, furrows were immediately made at 0.75 m apart. Ten (10) soil samples were randomly collected at a depth of 0-20 cm using auger at the different spots in the experimental area. All the collected soil samples were mixed or composited, air-dried, pulverized, and sieved using a 2 mm wire mesh sieve. The soil sample was submitted for analysis at the Central Analytical Services (CASL) PhilRootcrops, Visayas State University, Baybay City, Leyte, for the determination of pH level (1:2.5 soil water ratio; ISRIC 1995), organic matter (%) (Modified Walkley Black Method, PCARR, 1980), total nitrogen (%) (Modified Ljedahl Method, PCARR 1980), available phosphorus (Modified Olsen Method, Olsen, and Sommer, 1982) and exchangeable potassium (Ammonium Acetate Method, PCARR, 1980). After harvest, three (3) soil samples were collected from every treatment plot from the harvestable area for final analysis.

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each treatment plot measured 4 m x 3.75 m. A 1.0 m alleyway was provided between replications and 0.5m alleyway between treatment plots to facilitate farm management and data gathering. The different treatments were designated as follows: T_1= No Fertilizer (Control), T_2= 45-45-45 kg ha^{-1} N, P_2O_5, K_2O (RR-Positive Control), T_3= 45-20-45 kg ha^{-1} N, P_2O_5, K_2O, T_4= 45-45-20 kg ha^{-1} N, P_2O_5, K_2O, T_5= 45-35-35 kg ha^{-1} N, P_2O_5, K_2O, T_6= 45-55-55 kg ha^{-1} N, P_2O_5, K_2O

The cuttings of sweetpotato NSIC Sp36 variety were procured from the experimental area of the Department of Agronomy Visayas State University, Visca Baybay City, Leyte. Apical cuttings 25-30cm long were taken from the healthy and matured vines. A total of one thousand four hundred forty cuttings were used in this study. It was planted in a slanting position for better development of the roots in every plot. One cutting was planted per hill at 0.75m between rows and 0.25m between hills. Urea (45-0-0), solophos (0-18 -0), and muriate of potash (0-0-60) fertilizer were used in this study. One-time fertilizer application was made in every treatment. It was done through band application seven days after planting.

Watering was done using water cans to maintain the growth and development of the plants. However, watering the plant only lasted two weeks due to occasional rainfall. Two weeks after planting, hand weeding and hilling up was done. Leaf miner (*Bedellia somnulentella*) infestation was observed but only minimal. Thus, no control measures were taken. The infected leaves turn brown, and later there are numerous holes. Sweetpotato weevil was observed during harvesting as indicated by undesirable odor, marks, and tiny holes in fleshy roots, but only caused minimal damage. Damage caused by sweetpotato weevil has not reached a threshold level. Thus, no control measures were employed on sweetpotato plants. On the other hand, the storage roots of sweetpotato were harvested 105 days after planting by manually digging the soil with a sharp bolo after cutting the vines. Freshly harvested roots, and fresh herbage, were collected and clean by washing the roots with water.

Data Gathered

For the agronomic characteristics; a) Length (cm) of main vines, b) Number of lateral vines, c) Leaf Area Index (LAI). LAI was gathered 60 days after planting by measuring the fully open leaves of sweetpotato. This was computed using this formula:

$$\text{LAI} = \frac{\text{Total leaf area (TLA)}}{\text{Area of the Quadrat } (2500\ \text{cm}^2)} \quad (1)$$

$$\text{TLA} = \sum (\text{L x W x CF}) \quad (2)$$

Where: L=length, W=width, CF=Correction factor of 0.49 (Cajefe, 2003).

a) Fresh herbage weight (t ha^{-1}). The weight of fresh herbage was converted to tons per hectare using this formula:

$$\text{Herbage weight } (\text{t ha}^{-1}) = \frac{\text{Plot yield (kg)}}{\text{HA } (7.875\ \ \text{m}^2)} \times \frac{10{,}000\ \text{m}^2\ \text{ha}^{-1}}{1{,}000\ \text{kg t}^{-1}} \quad (3)$$

Likewise, for the yield and yield components, a) Number of marketable and non-marketable roots per hectare. This was determined by counting the roots from marketable and non-marketable roots from the harvestable area per plot and was converted to per hectare basis, using the formula:

$$\frac{\text{No. of roots ha}^{-1}}{\text{HA } (7.875\ \ \text{m}^{2)}} = \frac{\text{No. roots ha}^{-1}}{10{,}000\ \text{m}^2} \quad (4)$$

The considerable marketable storage roots had at least 2.5cm in diameter (broadest part) and 6.5cm in length (proximal to distal end) (Relente and Asio, 2020). The root damage by pests and disease are included in the number of non-marketable.

b) Weight (t ha^{-1}) of marketable and non-marketable roots. This was obtained by weighing the roots separately from marketable and non-marketable taken from the harvestable area in each treatment plot.

Then, the weight was converted to tons per hectare using this formula:

$$\text{Root yield } (\text{t ha}^{-1}) = \frac{\text{Plot yield (kg)}}{\text{HA } (7.875\ \ \text{m}^{2)}} \times \frac{10{,}000\ \text{m}^2\ \text{ha}^{-1}}{1{,}000\ \text{kg t}^{-1}} \quad (5)$$

c) Total root yield (t ha^{-1}). This was obtained by adding the weight of both marketable and non-marketable roots in tons per hectare.

Parameters Gathered:

1. Harvest Index (HI)

This is the ratio between the weight (kg) of the roots as the economic yield and the total weight (kg) of the vegetative parts, including the total fresh weight of roots as the biological yield from the three (3) sample plants. A high harvest index means that the crop has efficiently converted the photosynthates into the production of economic yield than biological yield. In contrast, a low harvest index indicates that the photosynthates were utilized in the vegetative parts. Thus, low production of economic yield and high production of biological yield. Harvest Index (HI) was computed using the formula:

$$\text{HI} = \frac{\text{Fresh weight of herbage (kg)}}{\text{Fresh weight of herbage (kg)} + \text{Fresh weight of root (kg)}} \qquad (6)$$

2. Cost and Return Analysis

The production cost was determined by recording all the expenses incurred in growing sweetpotato including the cost of the land preparation, fertilizer application, planting, hand weeding, harvesting, cleaning and sorting, sweetpotato cuttings and fertilizers. Gross income was determined by multiplying the marketable yield of each plot by the current price of sweetpotato per kilogram. Then, all the expenses were summed up to determine the total cost of production per hectare. The income was computed using this formula.

$$\text{Net Return (PhP)} = \text{Gross Income (PhP)} - \text{Total Expenses (PhP)} \qquad (7)$$

3. Meteorological Data

Data on the total weekly rainfall (mm) and average daily temperatures (minimum and maximum, ^{o}C) and relative humidity (%) throughout the study were obtained from the PAGASA Station, VSU, Visca, Baybay, City, Leyte.

Statistical Tool

Statistical Tool for Agricultural Research (STAR version 2.0) software was used to analyze all the data gathered. Significant differences between means were compared using Honestly Significant Difference (HSD) test at 5% significance level.

RESULTS AND DISCUSSION

Soil Chemical Analysis

Results of the initial and final soil analysis are presented in Table 1. The initial analysis shows that the experimental area had a pH of 5.98, 1.007 % organic matter, 0.127 % total N, 27.76 mg kg^{-1} available phosphorus, and 0.75 me 100g^{-1} soil exchangeable potassium. These indicated that the soil is moderately acidic, with shallow organic matter, low in nitrogen but high in available phosphorus, and exchangeable potassium (Landon, 1991).

Table 1. Soil chemical properties before and after harvest of sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as affected by the levels of solophos and muriate of potash

Treatment	Soil pH (1:2.5)	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable K (me $100g^{-1}$)
A. Initial analysis					
	5.98	1.01	0.13	27.76	0.75
B. Final analysis					
T_1	6.28	1.41	0.10	21.52	0.81
T_2	6.27	1.43	0.10	20.58	0.84
T_3	6.17	1.40	0.12	19.88	0.76
T_4	6.42	1.35	0.12	18.74	0.82
T_5	6.08	1.37	0.11	21.48	0.77
T_6	5.95	1.35	0.13	39.66	0.77
Mean	6.20	1.39	0.11	23.64	0.80

Legend:
T_1= No Fertilizer (Control)
T_2= 45-45-45 kg ha^{-1} N, P_2O_5 K_2O
T_3= 45-20-45 kg ha^{-1} N, P_2O_5 K_2O
T_4= 45-45-20 kg ha^{-1} N, P_2O_5 K_2O
T_5= 45-35-35 kg ha^{-1} N, P_2O_5 K_2O
T_6= 45-55-55 kg ha^{-1} N, P_2O_5 K_2O

The final analysis, on the other hand, showed a relative increase in soil pH, organic matter, and exchangeable K over the initial analyses, but a relative decrease in available P and total N was observed. The increase of exchangeable K may be due to increasing organic matter since organic matter decreases potassium fixation and increases potassium release (Bader et al., 2021). However, the relative decrease in available P and total N was due to plant uptakes and leaching.

Agronomic Characteristics

The agronomic characteristics of sweetpotato NSIC Sp36 as affected by the solophos and muriate of potash levels are presented in Table 2. The result revealed that the agronomic parameters differed significantly except for the number of lateral vines. Results revealed that sweetpotato applied with inorganic fertilizer, regardless of the levels, showed a significantly longer length of main vines (T_2-T_6) compared to the plants not applied with fertilizer (T_1). On the other hand, plants applied with 45-55-55 kg ha^{-1} N, P_2O_5 K_2O (T_6) had a higher LAI than the plants not applied with fertilizer but were significantly comparable to plants applied with 45-45-20 kg ha^{-1} N, P_2O_5 K_2O (T_3), 45-20-45 (T_4) kg ha^{-1} N, P_2O_5 K_2O and 45-35-35 kg ha^{-1} N, P_2O_5 K_2O (T_5). The least LAI was noted in the plants not applied with fertilizer (T_1) but significantly similar to plants applied with recommended inorganic fertilizer (T_2). Related studies found that increasing the application of fertilizer, especially phosphorus, to sweetpotato significantly increased the length of the vines and plant leaf area (Prasad and Roa, 1986; El-Gamal and Abdel-Nasser, 1996; El-Morsy et al., 2002; Hassan et al., 2005).

Table 2. Agronomic characteristics of sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as affected by the levels of solophos and muriate of potash fertilizer

Treatment	Length of main vines (cm)	No. of Lateral Vines	Leaf Area Index	Fresh Herbage Weight (t ha^{-1})
T_1	201.16 b	3.80	0.59 b	16.27 b
T_2	252.86 ab	5.00	1.32 ab	32.38 ab
T_3	244.10 ab	4.97	2.17 a	40.83 a
T_4	264.29 a	5.27	1.70 a	37.78 a
T_5	256.48 a	5.03	1.68 a	33.73 ab
T_6	283.63 a	5.03	2.22 a	34.78 a
Mean	250.42	4.85	1.61	32.63
Pr > F	*	ns	*	*
CV (%)	7.67	22.76	22.34	19.32

Treatments means within the same column and without a letter are not significantly different at 5% level based on Tukey's HSD test.

Legend:
T_1= No Fertilizer (Control)
T_2= 45-45-45 kg ha^{-1} N, P_2O_5 K_2O
T_3= 45-20-45 kg ha^{-1} N, P_2O_5 K_2O
T_4= 45-45-20 kg ha^{-1} N, P_2O_5 K_2O
T_5= 45-35-35 kg ha^{-1} N, P_2O_5 K_2O
T_6= 45-55-55 kg ha^{-1} N, P_2O_5 K_2O

Likewise, plants applied with inorganic fertilizer (T_2- T_6) show a significantly higher fresh herbage weight than the control plants. The higher herbage weight could be attributed to the length of the main vines, indicating more lateral vines and a larger size of leaf area. On the other hand, plants not applied with fertilizer (T_1) (16.27 t ha^{-1}) have the lowest herbage weight recorded than the other treatments applied with fertilizer regardless of the amounts. According to Kareem (2013), the longer the length of main vines, the more leaf produced that could be contributed to the weight of the herbage yield. Likewise, Beltran and Cagasan (2021) reported that sweetpotato applied with inorganic fertilizer, regardless of the levels, produced more lateral vines and consequently resulted in heavier plant herbage weight. The result implies that fertilizer can significantly affect the length of main vines, leaf area, and fresh herbage weight of sweetpotato than the unfertilized plants.

Yield and Yield Components and Harvest Index

Yield components and harvest index of sweetpotato NSIC Sp36 are presented in Table 3. Results revealed that the number of marketable and non-marketable roots, weight of marketable and non-marketable roots and harvest index did not vary significantly except on the total root yield (t ha^{-1}). Results revealed that no significant difference interms of yield on the treatments applied with fertilizer than the plants not applied with fertilizer as the control.

This can be attributed to the effects of fertilizer to provide nutrients to sweetpotato that improves the yield of the crop. Likewise, other parameters responded positively to solophos and muriate of potash application. Still, they were significantly comparable to the unfertilized sweetpotato plants (control) and the same goes for the total root yield (tha^{-1}).

Table 3. Yield components and harvest index of sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as affected by the levels of solophos and muriate of potash fertilizer

Treatment	No. of root (ha^{-1})		Wt. of root ($t\ ha^{-1}$)		Total Root Yield ($t\ ha^{-1}$)	Harvest Index
	Marketable	Non-marketable	Marketable	Non-marketable		
T_1	100317	80000	7.54	1.63	8.17b	0.37
T_2	113438	108360	10.74	2.62	13.36a	0.47
T_3	139259	113962	13.47	2.64	16.23a	0.41
T_4	109206	94815	11.10	2.48	13.58a	0.36
T_5	116825	11174	10.80	2.64	13.44a	0.31
T_6	128254	79153	11.89	1.97	13.86a	0.34
Mean	117883	98006	10.92	2.33	13.27	0.38
Pr>F	ns	ns	ns	ns	*	ns
CV (%)	23.83	17.28	25.37	21.82	20.87	16.09

Treatments means within the same column and without a letter are not significantly different at 5% level based on Tukey's HSD test

Legend:
T_1= No Fertilizer (Control)
T_2= 45-45-45 kg ha^{-1} N, P_2O_5 K_2O
T_3= 45-20-45 kg ha^{-1} N, P_2O_5 K_2O
T_4= 45-45-20 kg ha^{-1} N, P_2O_5 K_2O
T_5= 45-35-35 kg ha^{-1} N, P_2O_5 K_2O
T_6= 45-55-55 kg ha^{-1} N, P_2O_5 K_2O

The result obtained was not statistically significant. This might be due to the inherent nutrients in the soil from the experimental area where the initial soil chemical analysis resulted in low total N (0.13 %) but high available P (27.76 mg kg^{-1}) and exchangeable K (0.75 me $100g^{-1}$) that might be enough nutrients needed by sweetpotato NSIC Sp36 for the growth and root yield development. Likewise, the soil pH of the experimental area was considered favorable for sweetpotato production. The initial soil chemical analysis was moderately acidic (5.98 1:2.5), and the final analysis increased slightly acidic except for T_6. Bradenberger et al. (2022) stated that the optimum soil pH for a high yield of quality sweetpotato is 5.8 to 6.0. Also, continuous rainfall during the entire duration of the study might cause the fertilizer not to be efficiently utilized by the sweetpotato plants. According to Kuo et al. (2020), excessive rainfall results in leaching and surface runoff of fertilizer containing N, P, and K from the soil.

Cost and Return Analysis

The cost and return analysis of sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as affected by the levels of solophos and muriate of potash is presented in Table 4. The data revealed that all treatments obtained a higher net income, including the control plants not applied with fertilizer.

Table 4. Cost and return analysis of sweetpotato (*Ipomoea batatas* (L.) Lam) NSIC Sp36) as affected by the levels of solophos and muriate of potash fertilizer

Treatment	Root Yield ($t\ ha^{-1}$)	Gross Income (PhP)	Cost of Production (PhP)	Net Return (PhP)
T_1	7.54	188,500	52,133.00	136,367.00
T_2	10.74	260,500	64,933.00	195,567.00
T_3	13.47	336,750	62,710.76	274,039.24
T_4	11.10	330,500	63,266.20	267,233.80
T_5	10.80	270,500	63,377.24	207,122.76
T_6	11.89	297,750	66,487.86	231,262.14

*Calculation of gross income is based on the current price of sweetpotato at PhP25 kg^{-1}

Legend:
T_1= No Fertilizer (Control)
T_2= 45-45-45 kg ha^{-1} N, P_2O_5 K_2O
T_3= 45-20-45 kg ha^{-1} N, P_2O_5 K_2O
T_4= 45-45-20 kg ha^{-1} N, P_2O_5 K_2O
T_5= 45-35-35 kg ha^{-1} N, P_2O_5 K_2O
T_6= 45-55-55 kg ha^{-1} N, P_2O_5 K_2O

However, when sweetpotato variety NSIC Sp36 was applied with 45-20-45 kg ha^{-1} N, P_2O_5 K_2O (T_3) it gave a higher net return of PhP274,039.24 followed by sweetpotato applied with 45-45-20 kg ha^{-1} P_2O_5 K_2O (T_4) at PhP267,233.80 and 45-55-55 kg ha^{-1} P_2O_5 K_2O (T_6) at PhP231,262.14. The difference in the net income could be due to the variation in yield and the cost of fertilizer the solophos and muriate of potash. According to the study of Beltran and Cagasan (2021), when the sweetpotato variety NSIC Sp36 was applied with the recommended inorganic fertilizer at 45-45-45 $kgha^{-1}$ N, P_2O_5 K_2O, it produces more tubers and consequently obtained a favorable high net return.

CONCLUSION AND RECOMMENDATION

Application of P and K fertilizers at different levels did not show a significant difference on the agronomic and yield components as well as on the harvest index of sweetpotato plants. However, it showed a significantly longer length of main vines, leaf area index and fresh herbage weight ($t\ ha^{-1}$) than the control plants not applied with fertilizers. Likewise, the application of P and K fertilizers at any level did not cause to vary the root yield (tha^{-1}) of sweetpotato (variety NSIC Sp36) but significantly higher yield than the control plant not applied with fertilizer. Thus, application P and K at any level can be used for sweetpotato production.

On the other hand, sweetpotato variety NSIC Sp36 applied with 45-20-45 kg ha^{-1} N, P_2O_5 , K_2O gave the highest profit of PhP274,039.24 followed by sweetpotato applied with 45-45-20 kg ha^{-1} N, P_2O_5 K_2O at PhP267,233.80. It is farther conclude that the general recommendation of 45-45-45 kg ha^{-1} N, P_2O_5, K_2O is still applicable in sweetpotato production. It is recommended that a study be conducted under a hilly land area with low available P and low exchangeable K soils.

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