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IMPACT OF ORGANIC-INORGANIC FERTILIZERS ON YIELD AND QUALITY OF DIFFERENT SWEET POTATO VARIETIES

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Abstract

Integrated fertilizer uses through chemical and biofertilizer application enables nutrient cycling in agro-ecosystem inducing better plant growth and production but, sweet potato growers still rely on chemical fertilizers. The experiment was conducted to evaluate the effect of different levels of organic (bio-fertilizer) and inorganic fertilizers to reduce use of chemical fertilizers; and maintain yield and quality attributes of five sweet potato varieties. Five varieties of sweet potato were tested with five fertilizer treatments to check their effect on yield characters and nutrient contents. The best recorded treatment for different yield characters and nutrient contents was further analyzed for quality parameters. Data displayed that chemical fertilizers combined with biofertilizer were best among all treatment combinations in term of yield and nutrient contents of sweet potato. Effect of different combinations along with varieties interaction showed significantly greater size (root length and diameter), higher root weight and yield in SP-12 variety along with chemical fertilizers and biofertilizers combine application. Consequently, nutrient contents showed that N contents were maximum (3.54 %) in SP-02 variety with fertilizers applied as farmer practice. In case of P and K contents combined application of chemical fertilizers combined with biofertilizers for SP-01 resulted in maximum i.e. 0.54% and 4.01% P and K contents respectively. The quality characteristics revealed that SP-01 showed Vitamin A (864.46 IU/100 gram), while in case of Vitamin B6, SP-03 (0.74 mg/100 gram) showed maximum values. Along with this, it was noted that SP-12 produced maximum dry matter (31.92 %) whereas, SP-03 variety showed maximum ether extract (1.45 %) and crude protein percentage (11.24%). Crude fiber (8.52%) and total ash (6.94%) were found highest in SP-01. Thus, it was concluded that the integrated use of chemical fertilizers along with biofertilizer

could be an appropriate nutrient management strategy for enhancing sweet potato yield with better quality on sustainable and ecofriendly basis.

Introduction

In many developing countries, root and tuber crops play an important role in agriculture and help to provide food security. In 2020, 86.41million tons of sweet potatoes were produced worldwide (FAO, 2022). The bulk of the world's population consumes roots and tubers, which also contribute to animal feed and industrial demands as a starch source (Scott *et al.*, 2000). In many regions of the world, sweet potato (*Ipomea batatas*), a kind of edible and medicinal plant, is one of the most significant commercial root crops (Guo *et al.,* 2014). Listed in the "Top 20 Anti-Cancer Vegetables", it was crowned "King of Anti-Cancer Vegetables" (Ji *et al.*, 2021). Due to their unique nutritional and physiological qualities, sweet potatoes have been a popular study focus in recent years. It has a variety of flesh shades, which add to its nutritional diversity. Purple sweet potatoes are a member of the sweet potato family that is mostly composed of carbohydrates (Tanaka *et al.,* 2017). Purple sweet potato has recently yielded various bioactive heteropolysaccharides, including water-soluble polysaccharide (Gou *et al.*, 2019) and alkali-soluble polysaccharide (Chen *et al.*, 2019; Young *et al.*, 2018). The orange flesh sweet potato is a bio-fortified sweet potato that is growing in popularity in the food business (Abidin *et al.*, 2015). It contains enough -carotene, a precursor to Vitamin A that may help with Vitamin A deficiency (Hagenimana and Low, 2000). It is vital to utilize soil amendments such as fertilizer to boost crop yield (Darko *et al.*, 2021). According to research, field studies utilizing soil amendments increased sweet potato output without sacrificing quality (Brobbey, 2015; Ennin, 2007). Nitrogen and potassium are essential elements influencing root tuber output and nutritional content, particularly in sweet potatoes (Kareem, 2013). Potassium also boosts crop leaf photosynthetic rates, carbon transport and carbon dioxide assimilation (El-Baky *et al.*, 2010). Humic acid application increased agricultural output considerably, boosted nitrogen absorption and accumulation by crops, and increased nitrogen fertilizer usage efficiency (Selladurai & Purakayastha, 2016). In Pakistan, agricultural production is complemented by a mixed farming system that includes livestock farming practices. Farmyard manure is high in organic matter and is applied to enhance plant nutritional status. Organic manure not only feeds the plants but also enhances soil texture by binding soil aggregates (Singh *et al.*, 2020). Along with this, bio-fertilizer releases growth-promoting chemicals and vitamins and aids in soil fertility maintenance. They operate as antagonists, suppressing the occurrence of soil-borne plant infections and so aiding in disease biocontrol (Singh *et al.*, 2020). They also promote seed germination and vigor in young plants, resulting in better crop stands (Siddiqui *et al.*, 2014). The goal of this research is to establish the optimum fertilizer combination and its influence on the vegetative and qualitative behavior on sweet potato cultivars.

Materials and Methods

The experiment was conducted at NARC, HRI, Potato Program during the summer 2022-23. A total of 03 exotic [SP-01 (New), SP-02 (HRI-SP 4313) and SP-03(Handorus)] and 02 local [SP-06 (Puertorica) and SP-12 (White Star)] varieties of sweet potato were selected to evaluate their yielding and qualitative behavior. The experiment was laid out with three replications, according to Randomized Complete Block Design (RCBD) with the treatments including: T_1**:** Farmer Practice (N=32, P=23, K=25 kg), T_2**:** Recommended Chemical Fertilizers (N=33, P=23, K=75 kg), T_3**:** RNM using chemical fertilizers + farmyard manure (1 ton/ha), T_4**:** 75% RNM, using chemical fertilizers + bio-fertilizer and T_5**:** 75% RNM, using chemical fertilizers + Humic acid. Plants were uprooted and data were recorded for total no of roots plant^{-1}. Root weight was measured on electronic balance while root size was found with the help of vernier calipers. The sweet potato

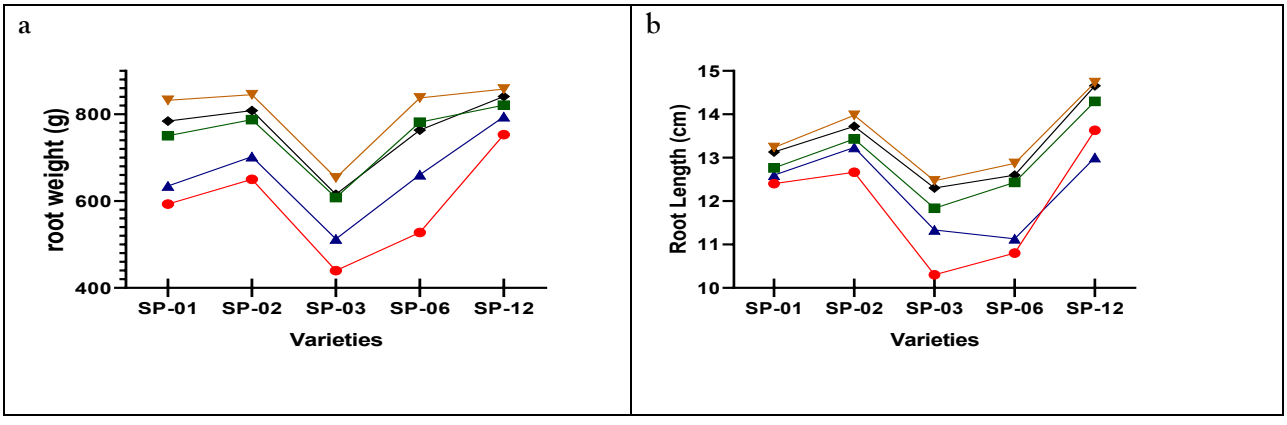
quality characteristics including dry matter, ether extract, crude protein, crude fiber and total ash contents were determined in animal sciences lab, at NARC according to methods described by Islam *et al.* (2016) whereas, quantitative attributes like Vitamin A and Vitamin B6 at Pakistan Council of Scientific and Industrial Research (PCSIR) using High-performance liquid chromatography (HPLC) technique. The nutrient contents such as N, P and K were determined in soil fertility laboratory at NARC Islamabad. Total nitrogen was estimated by double distillation/titration method and finally measured on Kjeltech machine (Chapman and Parker, 1961) whereas, P and K were determined by di-acid digestion method in 2:1 HNO_3:$HClO_3$. Where P was estimated on spectrophotometer (Olsen *et al.*, 1954) and K at flame photometer (Chapman and Parker, 1961).

Statistical analysis

All data from experiments were statistically analyzed by analysis of variance (ANOVA) using the software package Statistix 8.1 displaying significant variations between means of treatments and varieties and their interactions for yield and nutrient contents. The qualitative attributes were analyzed by applying single factor factorial design at 5% level of significance.

Results

In this part of the study, effect of the separate and combined use of chemical and bio fertilizers on exotic and indigenous varieties of sweet potato was examined. Our findings reported that in control soil (farmer practice), the root weight, length and diameter of sweet potato was recorded (73.33g, 10.30 cm, 5.43 cm, respectively) minimum for SP-06 variety. In comparison, SP-01 showed better root weight (120.50g), length (14.73 cm) and diameter (8.23 cm) with the application of chemical fertilizer along with biozote among all treatments, combined with the resultant increase of 48.67%, 35.40% and 40.99% respectively over control as shown in Figure 1. In case of treatment effect, average overall varieties, soil treated as per farmer practice produced minimum root weight (96.33g), length (11.96 cm) and diameter (6.66 cm) which increased up to 108.60 g, 13.45 cm and 7.51 cm respectively in the combined application of biozote and chemical fertilizer. Similarly, varietal effect, the average overall treatment showed maximum root weight (115.33g), length (14.06cm) and diameter (7.78cm) in SP-01 compared to a minimum in SP-06 (92.27g, 11.65 cm and 6.17 cm respectively).



C

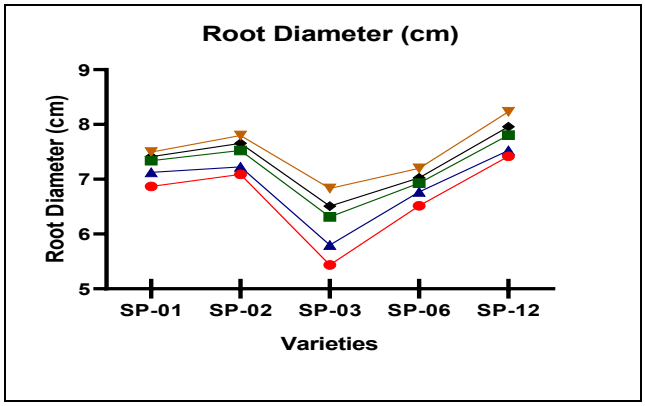


Figure 1: Comparison of **a** (Root weight), **b** (Root Length) and **c** (Root Diameter) with different doses of fertilizers, represented as ● (Farmer practice), ■ (recommended chemical fertilizer (RCF)), ▲ (RCF + FYM), ▼ (RCF + Biozote) and ◆ (RCF + Humic acid).

It was evident from the result that the application rate of fertilizers as done by farmers**,** no. of roots and yield of sweet potato was recorded (4.20 and 15.35 t/ha respectively) minimum for SP-03 variety while SP-04 showed better no. of roots and yield (8.61 and 29.96 t/ha respectively) with the application of chemical fertilizer along with biozote among all treatments, combined with the relative increase of 68.85% and 64.49% respectively (Figure 2)**.** In case of treatment effect, average overall varieties, soil treated as per farmer practice produced no. of roots (6.25) and yield (20.69 t/ha) which increased up to 7.53 and 28.12 t/ha respectively in the combined application of biozote and chemical fertilizer showing relative increase of -%**.** Similarly, varietal effect average overall treatment showed maximum no. of roots (8.27) and yield (28.41t/ha) in SP-12 compared to a minimum in SP-03 (5.09 and 19.76t/ha respectively).

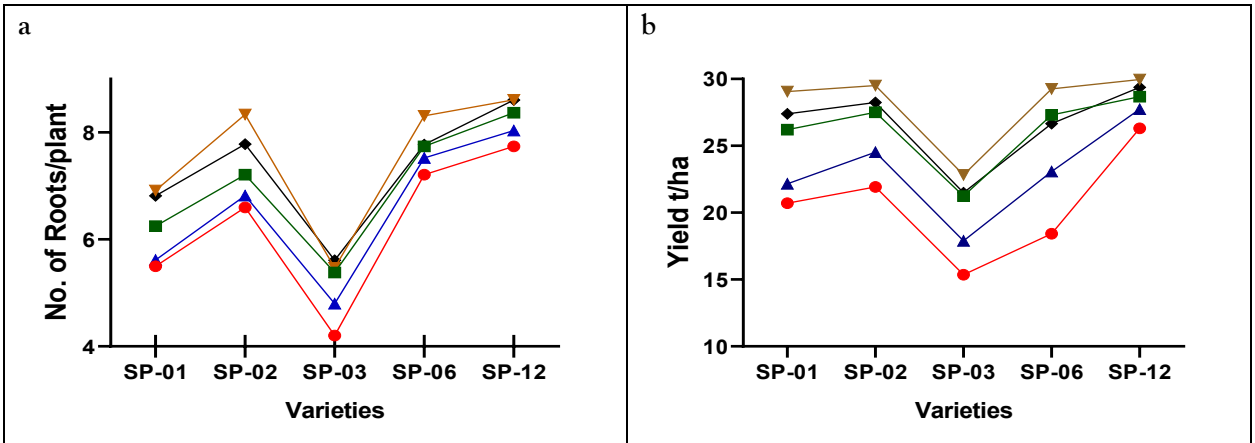


Figure 2: Comparison of **a** (No. of roots per plant) and **b** (Yield t/ha) with different doses of fertilizers, represented as ● (Farmer practice), ■ (recommended chemical fertilizer (RCF)), ▲ (RCF + FYM), ▼ (RCF + Biozote) and ◆ (RCF + Humic acid).

The interaction effect of variety and treatment shows that control soils show maximum nitrogen (3.54%) in SP-02 while biozote combined with chemical fertilizer resulted in maximum phosphorus (0.54%) and potash (4.01%) content in SP-01. On the other hand, roots of SP-03 contain minimum nitrogen (1.21%) and potash (0.93%) contents in control and recommended

dose applied soils respectively. Whereas application of chemical fertilizer along with FYM, resulted in minimum phosphorus (0.13%) content in roots of SP-02 (Figure 3). In case of treatment effect, average overall varieties, soil treated as per recommended chemical fertilizers, the nitrogen content of 2.32% was found maximum while sweet potato treated with biozote and chemical fertilizer resulted in maximum phosphorus (0.42%) and potash (2.36%) contents. Farmyard manure with chemical fertilizers produced minimum nitrogen (2.14%) and potash (1.61%) content, while phosphorus (0.27%) was found minimum in humic acid treated soil. Similarly, varietal effect average overall treatment showed maximum nitrogen (2.66%), phosphorus (0.37%) and potash (2.43%) in SP-02, SP-03 and SP-01 respectively. Along with this, minimum nitrogen (2.06%), phosphorus (0.29%) and potash (1.55%) content in SP-12, SP-02 and SP-06 respectively.

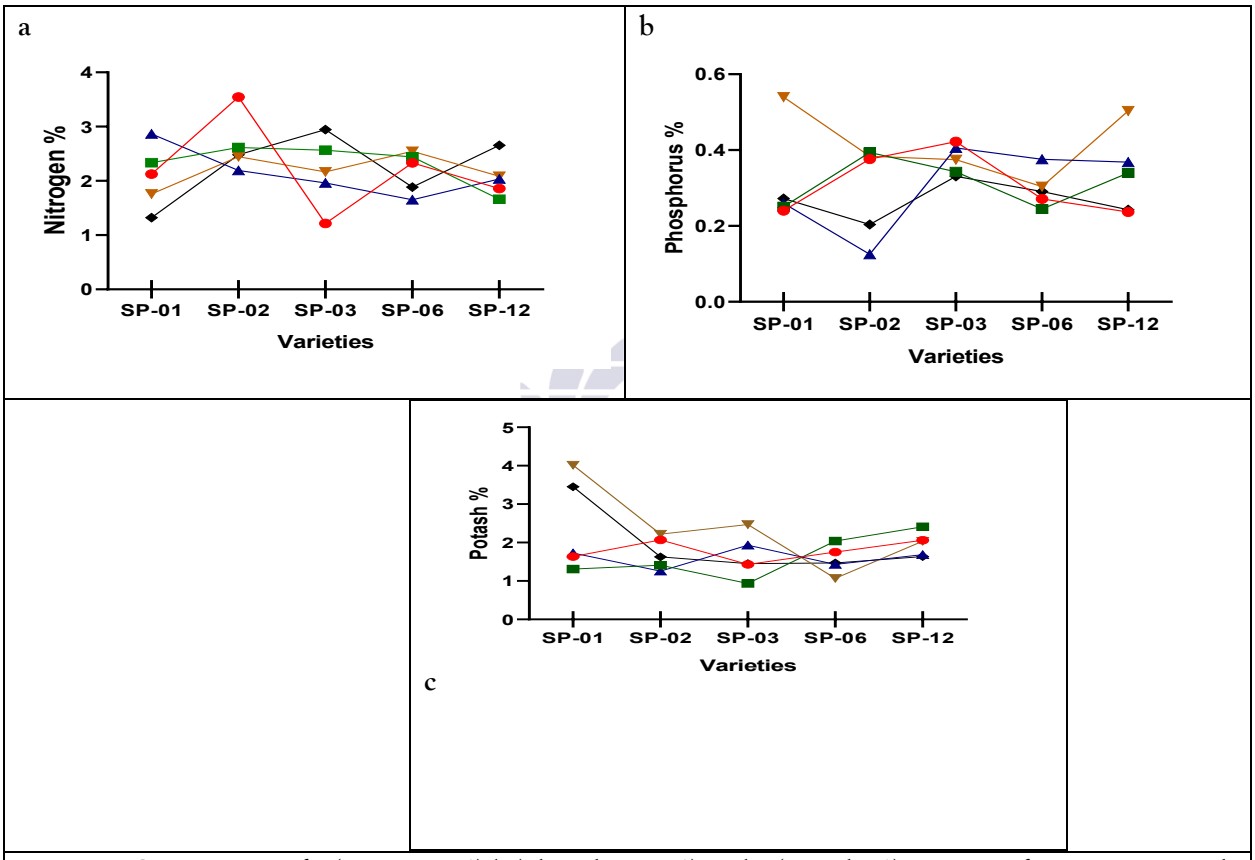


Figure 3: Comparison of **a** (Nitrogen %) **b** (Phosphorus %) and **c** (Potash %) in roots of sweet potato with different doses of fertilizers, represented as ● (Farmer practice), ■ (recommended chemical fertilizer (RCF)], ▲ (RCF + FYM), ▼ (RCF + Biozote) and ◆ (RCF + Humic acid).

In this part of the study, qualitative properties of sweet potato were examined. It was evident from the result that ether extract (0.59%) and crude protein (5.83%) of sweet potato was recorded minimum for SP-02 and SP-06 variety respectively, while ether extract (1.45 %) and crude protein (11.24%) were significantly superior in SP-03 with the resultant increase of 84.31% and 63.38% respectively (Figure 4). The crude fiber (4.52%) and total ash content (3.58%) of sweet potato was recorded minimum for SP-12 and SP-06 variety respectively, while roots of SP-01 were found significantly enriched with crude fiber (8.52%) and total ash content (6.94%) with the resultant

increase of 61.35% and 63.87% respectively. The dry matter of sweet potato was recorded highest (31.92%) in SP-12. On the contrary, SP-01 produced minimum (17.97%) dry matter contents.

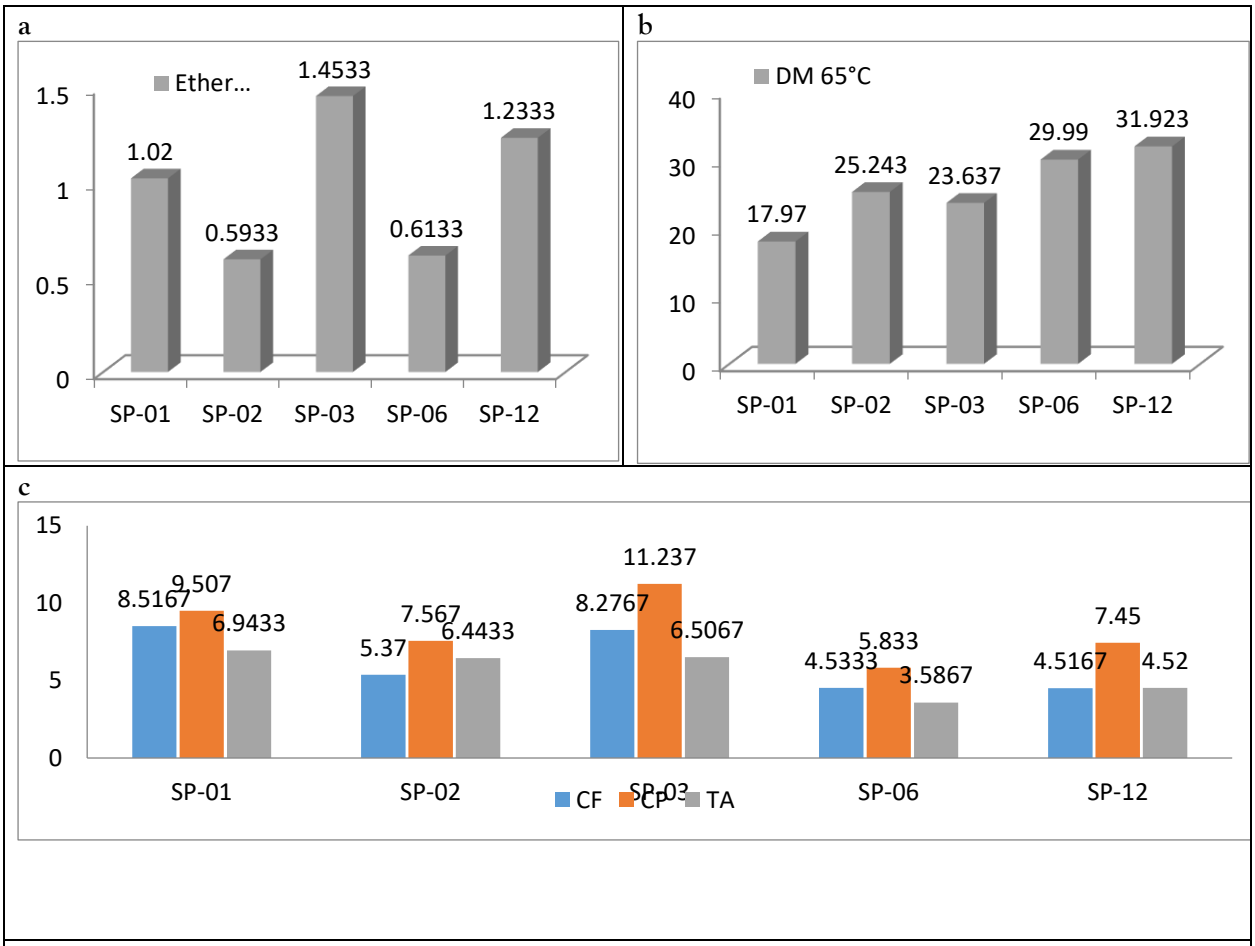
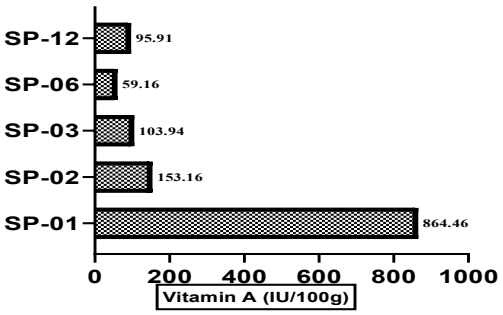


Figure 4: Comparison of **a** (Ether extract), **b** (Dry matter content) and **c** (Crude protein, Crude fiber and Protein content) among different varieties of sweet potato.

The investigation revealed that the vitamin A (59.16 IU/100 gram) and vitamin B6 (0.03 mg/100 gram) were recorded minimum for SP-06 and SP-02 respectively while SP-2 and SP-03 showed maximum Vitamin A contents (864.46 IU/100g) and vitamin B6 (0.74 mg/100g) respectively as shown in Figure 5.

a	b



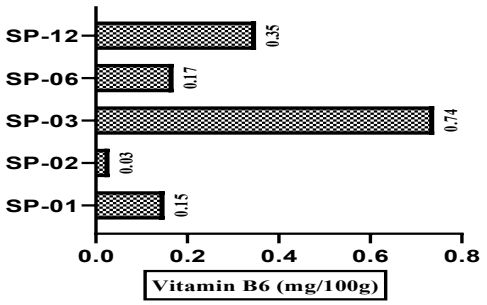


Figure 5: Comparison of **a** (Vitamin A) and **b** (Vitamin B6) among different varieties of sweet potato.

Discussion

Farmers have to struggle with all types of challenges, like the high costs of fertilizers, soil degradation, the decline of agricultural production, and the increase of diseases and droughts. In this scenario, environment-friendly agricultural techniques are not an alternative but the necessary solution to ensure food sovereignty. One of the option to the resulting fertilization issue is the use of PGPR (Castillo *et al.*, 2016). Various researchers have proved their effectiveness or benefits before using chemical fertilizers. They support the environmental protection and the development of sustainable agriculture in many crops, including certain studies in sweet potato (Pérez and Sánchez, 2017).

Using biofertilizer that includes live microorganisms is one of the management strategies that may increase soil fertility in arable soils (Dębska *et al.*, 2016). The combination of chemical fertilizer and biofertilizer boosts the soil chemical characteristics of accessible phosphorus (P) and potash (K) in cotton crops (Li *et al.*, 2017). The biofertilizer used in the current investigation includes *B. Subtilis* and *T. Pseudokiningii*. The application of biofertilizer significantly boosted the activities of crop vegetative and reproductive behavior and significantly increased the soil accessible P and K. The combined application of biofertilizer and NPK improved N and P availability in sweet potato (Agbede, 2010; Duan *et al.*, 2022). Most of the microbial species in the soil are positively connected with the nutrient concentration in the soil (Huang *et al.*, 2017). The discovered findings exhibited points of consistency with the same effect reported by Ranjbar-Moghaddam & Aminpanah (2015) when they evaluated the reaction of a triple superphosphate fertilizer and phosphate bio-fertilizer application (seed inoculated with phosphate bio-fertilizer containing Pseudomonas fluorescens) (seed inoculated with phosphate bio-fertilizer containing Pseudomonas fluorescens). They found that pod number per plant and pod production improved by 16 and 15 percent, respectively, when phosphate bio-fertilizer was administered. Santana-Fernández *et al.* (2021) also revealed that the biofertilizer boosted the overall growth and production of the crop.

The dry matter content of the roots discovered in this research was more remarkable than 27.16 percent, which was stated in the US Department of Agriculture, Nutrient database of 2001 (US Department of Agriculture, Nutrient database, 2001). Other studies have indicated the dry matter content of fresh sweet potato roots to be varying between 28.78 and 40.9 percent (Omodamiro *et al.*, 2013), which are greater than the values obtained in the present research. The maximal protein content of the sweet potato roots employed in the current investigation was determined to be 11.24 percent on a dry matter basis. This result is greater than the Figure of 6.22 percent, given by the US Department of Agriculture, Nutrient database of 2001 (US Department of Agriculture, Nutrient database, 2001). On the other hand, this Figure was relatively low compared to the findings of Omodamiro (2013) (Omodamiro *et al.*, 2013), who found positively high protein content in the

sweet potato roots that varied from 13.7 percent to 16.9 percent. The ash content of the sweet potato roots was determined to be 6.94 percent. This was greater than the values provided in the US Department of Agriculture, Nutrient database of 2001, which showed 3.5 percent ash on a DM basis. Along with this, the numbers provided by Omodamiro (2013) (Omodamiro *et al.*, 2013) were similarly low who indicated a range of 1.74 percent to 3.72 percent on a dry matter basis. Our research revealed that selected varieties yield better fiber content ranging from 4.52 percent to 8.52 percent, which is substantially higher than Ji *et al.* (2015) reported. Those are 1.85 percent to 2.35 percent. The maximal ether extract percentage of the roots employed in the present investigation was determined to be 1.45 percent. This amount is more significant than the Figure of approximately 0.70 percent, published by Kareem (2013).

Conclusion

The combination of biofertilizer with chemical fertilizer positively affected the soil microbes and soil, thereby promoting plant nutrient absorption, and exhibiting high NK accumulation by roots. This cultivation measure finally exhibited higher root yield and improved root quality by maintaining relatively high contents of phosphorus and potash contents. This can effectively relieve the problems associated with the consecutive monoculture of sweet potato.

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Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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