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Effects of phosphorus fertilizer treatments on vegetative growth, tuberous yield and phosphorus uptake of sweet potato (*Ipomoea batatas*)

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A variety of sweet potato (Shaba) was studied for its vegetative growth, yield and phosphorus uptake under the influence of four different fertilizers using randomized complete block design (RCBD) in the experimental area of the University of Ibadan. Incubation study revealed that, single super phosphate was the best among them in phosphorus release despite that it favoured suppressed tuberous yield of the experimented plant. Sweet potato plots treated with crystallizer fertilizer at the rate of 445 kg/ha had the highest phosphorus uptake and vegetative growth while control plots produced plants with highest tuberous yield. It is therefore recommended that, crystallizer applied at the rate of 445 kg/ha should be used for significant phosphorous uptake which equally leads to better quality sweet potato tuber production and appreciable vegetative growth. Also, high tuberous yield in sweet potato can be achieved when the soil has low phosphorus level which is as low as 6.80 mg/kg.

Key words: Sweet potato, fertilizer treatment, incubation, phosphorus uptake, yield.

INTRODUCTION

Sweet potato (*Ipomoea batatas*) which belongs to the family of Convolvulaceae is becoming the most widely distributed in most developing countries. It is grown in most parts of the tropics and warm temperate regions (Cobley, 1977). Asia produces over 905 of sweet potato with China alone accounting for over 857.

Sweet potato originated in Tropical America (Mexico, Central America and Caribbean) and the North Western part of South America (FAO, 1990). The Portuguese and Spanish explorers, traders and missionaries in the 16^{th} century brought it in Philippines, Indonesia, India, Japan, and Malaysia (FAO, 1994). The crop now ranks fourth most important after rice, wheat and corn in China (Lu et al., 1989). Africa produces only about 5% of the world's production (Onwueme and Sinha, 1991).

Neither plants nor animals can grow without phosphorus. It is an essential component of the organic component called the energy currency of the living cell: Adenosine triphosphate (ATP). Phosphorus is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance, and of ribonucleic acid (RNA), which directs protein synthesis in both plants and animals. Phospholipids, which play critical roles in cellular membranes, are another class of universally important phosphorus- containing compounds. For most plant species, the total phosphorus content of healthy leaf tissue is not high, usually between 0.2 and 0.4% of the dry matter (Nyle and Ray, 1999).

Adequate phosphorus nutrition enhances many aspects of plant physiology, including the fundamental process of photosynthesis, nitrogen fixation, flowering, fruiting (including seed production), and maturation. Root growth, particularly development of lateral roots and fibrous rootlets, is encouraged by phosphorus. In cereal

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Table 1. Trend of phosphorus release by different P-fertilizers during incubation study.

Treatment	Phosphorus released (mg/kg)
Control	8.11[b]
Organic	9.63[b]
Single super phosphate	15.59[a]
Crystallizer	7.10[b]
LSD (0.05)	8.29

Means with the same letters are not significantly different from one another.

Table 2. Effect of phosphorus fertilizers on vine length production (cm).

Treatment	Vine length (cm)
Control	112.00
Organic	117.90
Single super phosphate	133.10
Crystallizer	144.60
LSD (0.05)	ns

ns = not significant.

crops, good phosphorus nutrition strengthens structural tissues such as those found in straw or stalk, thus helping to prevent lodging (falling over). Improvement of crop quality, especially in forages and vegetables, is another benefit attributed to this nutrient (Olsen and Khasawneh, 1980).

Since an appreciable level of phosphorus in sweet potato tubers can greatly improve its quality as well as increase its shelf life. The present research, therefore, was carried out to study the potential of phosphorus release in different fertilizers and its consequence on yield, vegetative growth and phosphorus uptake in sweet potato to improve its quality further.

MATERIALS AND METHODS

The research was carried out at the Teaching and Research Farm of Agronomy Department, University of Ibadan at Parry Road, Ibadan, Oyo State (7.27°N 3.54°E). The temperature ranges between 22 and 28°C with annual rainfall between1000 and 1600 mm. The experiment spanned between April and July, 2003.The soil type was sandy loam with a very low level of phosphorus (680 mg/kg).

After preparation of the field, the area was divided into twelve plots. Soil samples were taken from each plot, air dried under shade on sheets of paper and passed through 2 mm sieve. The samples were finally put in new bower vessels and kept in the laboratory for application of treatments and observation of the trend of phosphorus release. Each bower vessel in the laboratory represented a plot on the field. Each soil sample in the vessels was given the same treatment as applied on the field. The soil samples were then supplied with water up to 60% field capacity and were observed for 5 consecutive weeks in the laboratory. On weekly basis, a sample was taken from each bower vessel, air-dried on sheets of paper under shade and analysed for phosphorus content using Bray-P-1 method.

On the field, 25 cm length of sweet potato vines of Shaba variety were planted at an angle of 45° with two thirds of the vine under the soil for proper establishment. The plant spacing was 30 cm by 100 cm with a total of 18 plants per plot. For experimental purpose, 4 treatments in a Randomized Complete Block Design (RCBD) were replicated 3 times. Three different phosphorus fertilizers were applied after fourth week of planting to represent the treatments as follow: Treatment 1 (control), Treatment 2 (Pacesetter organic fertilizer at the rate of 5.217 t/ha), Treatment 3 (Single super phosphate at the rate of 500 kg/ha) and Treatment 4 (crystallizer at the rate of 445 kg/ha).

The plots were regularly weeded to prevent competitive effects of the weeds. The morphological parameters were recorded after one week of fertilizer application and the exercise last for 5 weeks. Three representative pants from each plot were randomly selected and tagged, excluding the border ones and the number of leaves per plant and vine length per plant was recorded. At final harvesting (3 months after planting), leaves of the sampled plants was collected and prepared for laboratory analysis to determine their phosphorous contents using Bray-P-1 method and the tuber yield data were taken to estimate yield per treatment. The data collected were statistically analysed using analysis of variance (ANOVA) and significant means were separated using least significant difference (LSD) at 5% probability level.

RESULTS

In this study, it was found that single super phosphate released significantly higher phosphorus than any other P-fertilizer used. In the same vein, the least phosphorus release was recorded from Crystalizer fertilizer treated soil (Table 1).

Table 2 showed that, the longest vine production was favoured by crystallizer while the control plot had the shortest length though the difference was not significantly pronounced at 0.05 probability level. From Table 3, it was evident that, leaf production was directly related to vine length. That is, the longer the length, the more the number of leaves produced and vice-versa. This was clear from the fact that crystallizer

At harvesting (3 months after planting), the highest mean weight of the harvested tubers was recorded from the control plot while the least mean weight was got from plots treated with Crystallizer (Table 4).

Table 5 revealed that, the plants on the soil treated with crystallizer fertilizer had the highest phosphorus uptake. The leave phosphorus uptake followed the trend of leaf and vine productions. That means the plots treated with crystallizer showed the highest level of phosphorus uptake through their leaves despite the insignificance of its difference from the other treatments. On the other hand, the plots with the lowest number of leaves per plant (control plots) came out with the lowest phosphorus uptake (Table 5). That showed that, the more the vegetative parts (leaves e.t.c.), the more the phosphorus uptake. The plots with no phosphorus fertilizer treatment (control) did not come out with any appreciable vegetative

Table 3. Effect of phosphorus fertilizers on sweet potato leaf production.

Treatment	Number of leaves
Control	55
Organic	66
Single super phosphate	69
Crystallizer	88
LSD (0.05)	ns

ns = not significant.

Table 4. Effect of phosphorus fertilizers on tuber yield of sweet potato (kg/ha).

Treatment	Tuber weight (kg/ha)
Control	193
Organic	185
Single super phosphate	130
Crystallizer	93
LSD (0.05)	ns

ns = not significant.

Table 5. Effect of phosphorus fertilizers on leaf phosphorus uptake of sweet potato (mg/kg).

Treatment	Concentration of P (mg/kg)
Control	3.25×10^{-3}
Organic	3.10×10^{-3}
Single super phosphate	3.65×10^{-3}
Crystallizer	4.12×10^{-3}
LSD (0.05)	ns

ns = not significant.

growth in sweet potato (Tables 3 and 4).

Despite the above observation, control plots came out with the highest yield in tuber production. This can be attributed to less nutrient imbalance the plots had compared with the pronounced nutrient imbalance in other plots as a result of additional phosphorus nutrition through fertilizer application.

DISCUSSION

The trend of phosphorus release among the fertilizers used in this experiment showed that, single superphosphate released the highest level of phosphorus into the soil (Table 1). This is because single superphosphate contained the highest P or P_2O_5 level. To this end, single super phosphate (the highest phosphorus releaser) showed the potential of being capable of correcting phosphorus deficient soils since its difference was significantly higher.

However, the level of phosphorus release was not directly proportional to P availability and uptake by the plant leaves. This was in line with the observation of Olusola (2009) that, despite the higher amount of phosphorus released, recovery of P-fertilizer by crop uptake is about 15 to 30% while about 60% of the P-fertilizer is adsorbed or fixed by the soil. Therefore, a certain amount of P is added every year to top the amount already present in the soil. To this end, sweet potato on the soil with highest phosphorus release in this experiment had the least P uptake.

The best phosphorus releasing fertilizer among the treatments used (Single superphosphate) did not produce the longest vine but the least phosphorus releasing one (crystallizer fertilizer) produced the longest vine (Table2). This implied that, the more the phosphorus in the soil, the shorter the vine (vegetative parts). This is in consonance with the finding of Rashid and Waithaka (2009) that discovered that, phosphorus nutrition did not significantly increase vine production in sweet potato and that higher level of phosphorus application produced shorter vines.

It was noted from this experiment that, lower phosphorus nutrition through application of crystallizer fertilizer or any other low-phosphorus releasing fertilizer was beneficial to vegetative success (leaf production) of sweet potato (Table 3). This will eventually lead to trapping enough solar energy for higher food production which will finally be translocated to the roots for appreciable tuber development which is the ultimate target of crop production. This also confirmed Rashid and Waithaka (2009) discovery who established that, leaves and other vegetative parameters were less increased by high phosphorus nutrition than high concentration of such.

The effect of different fertilizers on tuberous yield of sweet potato was completely different from the expected result (that is, the more the phosphorus in the soil, the more the tuberous yield) (Table 4). This result established the fact that, high phosphorus level in the soil suppresses tuber development. This result was in line with the result gotten from an experiment carried out at Institute of Tropical Agriculture (IITA, 1992). The result also supported the assertion that, very little mention has been made in literature on the use of phoshatic fertilizers to sweet potato which was perhaps due to lack of response of sweet potato to phosphorus nutrition. Also, MacDonald (1963) found that, phosphorus does not appear to be an important nutrient for sweet production although phosphorus is usually recommended in the fertilizer mixture. Furthermore, trials conducted at CTCRI to compare the efficiency of rock phosphate on sweet potato indicated that, the effect of superphosphate and mussoorie-phosphate as P source were on par with respect to yield. Moreover, FAO (2005) gave credence to this result with its assertions that, when phosphorus is eliminated, the yield of sweet potato is not affected.

The level of vegetative growth (number of leaves) had been the significant reason behind the discrepancy in the level of phosphorus uptake. Therefore, it could be categorically said that, the P uptake has positive correlation with the number of leaves produced by sweet potato plants. So, the fertilizer which aided the level of leaf production directly encourages the highest phosphorus uptake. In essence, when there is high vegetatitive production there will be effective absorption of available phosphorus in the soil and phosphorus fixation will be reduced dramatically.

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