Research Journal of Chemical and Environmental Sciences
Res. J. Chem. Env. Sci., Volume 1 Issue 3 (August 2013): 50- 55
Available Online http://www.aelsindia.com

Online ISSN 2321-1040

ORIGINAL ARTICLE

Growth, Yield and Phosphorus Uptake of Sweet Potato (*Ipomoea batatas*) Under the Influence Phosphorus Fertilizers

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ABSTRACT
Despite the importance of phosphorus nutrition in the life of sweet potato and other tubers, the element was not in abundance for production of the crop. Therefore, this research was carried out to establish how different phosphorus fertilizers release the nutrient and its influence on the crop.
A variety of sweet potato (Shaba) was studied for its vegetative growth, yield and phosphorus uptake under the influence of three different phosphorus fertilizers which were Pacesetter organic fertilizer, single super phosphate and crystallizer using Randomized Complete Block Design (RCBD) with three replications. Also Incubation study on how the fertilizers used released the nutritional element under investigation was concurrently carried out.
The Incubation study revealed that single super phosphate was the best in phosphorus release with an attendant suppression of tuberous yield of the experimented plant. Sweet potato plots treated with crystallizer fertilizer at the rate of 500kg/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 500kg/ha be used for significant phosphorous uptake which equally leads to better quality sweet potato tuber production and appreciable vegetative growth. It is also recommended that the soil phosphorus be maintained at low level around 6.80mg/kg for achievement of high tuberous yield in sweet potato.
Key Words: *Sweet potato, Phosphorus Fertilizer, Incubation, Phosphorus uptake, and Yield.*

Received 21/05/2013 Accepted 19/07/2013

INTRODUCTION

Sweet potato (*Ipomoea batatas*) which belongs to the family Convolvulaceae is becoming the most widely distributed root crop in most developing countries. Sweet potato (*Ipomoea batatas* L.) is a foremost tuber crop in respect of calorific value and is grown in almost all soil types in most parts of the tropics and warm temperate regions. Globally, it is among the important food crops which are wheat, rice, maize, Irish potato, and barley and it ranks second among the world's production of root and tuber crops and third in consumption in several parts of tropical Africa [1]. It has been established that sweet potato is more nutritious and flavourful. Therefore, it should be grown in greater quantities. It is also an excellent source of complex carbohydrates, high antioxidants, vitamins (A and C), phosphorus, potassium, magnesium, calcium, sulfur, iron,manganese, copper, boron, zinc, iodine, folic acid, cystine fiber, starch, protein, niacin, tryptophan and tyrosine. The starch in sweet potato easily converts to sugar and provides quick energy. So, it is actually a super food [2][3]. The consumption of sweet potato is in different forms. It can be consumed as vegetable, boiled, fried as chips, backed, roasted or often fermented into food and beverages.

Phosphorus element is one of the main nutrients for most plant species including sweet potato plants (*Ipomoea batatas*, L.).The necessity of phosphorus as a plant nutrient is emphasized by the fact that it is an essential constituent of many organic compounds that are very important for metabolic processes, blooming and root development [4]. In the same vein,neither plant nor animals can grow without phosphorus because it is an essential component of the energy currency of the living cell: Adenosine Triphosphate (ATP) as well as deoxyribonucleic acid (DNA), the seat of genetic inheritance. It equally forms an essential part of ribonucleic acid (RNA) which is responsible for directing protein synthesis in both plants and animals. Moreover, phospholipids which play critical roles in cellular membranes are another class of universally important phosphorus- containing compounds. Furthermore, adequate phosphorus nutrition enhances many aspects of plant physiology like fundamental process of photosynthesis, nitrogen fixation, flowering, fruiting (including seed production) and maturation. Root growth, particularly development of lateral roots and fibrous rootlets, is also encouraged by phosphorus. In cereal crops, good phosphorus nutrition strengthens structural tissues such as those found in straw or stalk, thus helping in prevent lodging (falling over). Improvement of crop quality, especially in forages and vegetables, is another benefit attributed to this nutrient. As important as this nutrient element is, its total content in the healthy leaf tissue of most plant species is not high and usually ranges between 0.2% and 0.4% of the dry matter [5].

When cow dung is fortified with NPK fertilizer and applied to sweet potato, there will be higher nutrient uptake of which phosphorus is a part. This consequently leads to resultant increase in crop yield. This increase in yield has been attributed to the significant increase in P, K and Ca uptake by sweet potato [6]. Since phosphorus is not as mobile as nitrogen and potassium, some available phosphorus which is not used up by sweet potato may not experience leaching [7].

It has been estimated that nearly 36.78 million tonnes of P-based fertilisers (in terms of P_2O_5) are applied worldwide every year [8]. However, the use efficiency of applied P is generally very low ranging from 10 to 30% in the year of application [9]. In most soils, in spite of the considerable addition of P-fertilizers, the amount available for plants is usually low since it is converted to unavailable form by its reaction with the soil constituents [10][11][12]13][14]. Despite this, [14] still reported that P-fertilizer application positively increased sweet potato productivity compared with the untreated control. These increments were attributed to the beneficial effect of P-element on the activation of photosynthesis and metabolic processes of organic compounds in plants and hence increase in plant growth [4]. They were also attributed to the important role of phosphorus as an essential component of many organic compounds in plants such as phospholipids, nucleic acids and nucleotides which may indirectly reflect positively on yield [9]. Similar results were reported by [15][12][13][14] who found that fertilization of sweet potato plants with P fertilizer caused significant increase in total and marketable yield. Because phosphorus is an essential element in the energy transfer processes, formation of fat, transformation of starch to sugar, flowering and fruiting stage of the crop, it is considered one of the major growth – limiting factors for plants in many natural ecosystems. Combating the problem of limitation posed by phosphorus nutrition, plants have developed several adaptive mechanisms to overcome its stress [10].

Since an appreciable level of phosphorus can greatly improve quality as well as increase shelf life of root and tuber crops, the present research was, therefore, carried out to study the potential of phosphorus release from different phosphorus fertilizers, phosphorus uptake of the plant and their effects on vegetative growth and tuber yield.

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^{o}N 3.54^{o}E). The temperature ranges between 22^{o}C and 28^{o}C with annual rainfall between1000mmand 1600mm.The soil type was sandy loam with a very low level of phosphorus (6.80mg/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 2mm 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 left in the laboratory for phosphorus release to occur. At the end of the fifth week, a sample was taken from each bower vessel, air-dried under shade on sheets of paper and then analysed for phosphorus content. Available phosphorus was extracted by Bray No 1 method, and determined by the molybdenum blue method [16].

On the field, 25cm length of sweet potato vines of Shaba variety were planted at an angle of 45^o with two thirds of the vine under the soil for proper establishment. The plant spacing was 30cm by 100cm with a total of 18 plants per plot. For experimental purpose, four treatments in a Randomized Complete Block Design (RCBD) were replicated three times. Three different phosphorus fertilizers were applied after fourth week of planting. The treatments were as follows: treatment 1(control), treatment 2(Pacesetter organic fertilizer at the rate of 5t/ha), treatment 3 (Single super phosphate at the rate of 500 kg/ha) and treatment 4 (Crystallizer at the rate of 500kg/ha).

The plots were regularly weeded to prevent competitive effects of the weeds. Three representative plants from each plot were randomly selected and tagged with exclusion the border row ones. The following morphological parameters: number of leaves per plant and vine length per plant were recorded five weeks after fertilizer application. At final harvest (three months after planting), leaves of the sampled plants were collected and prepared for laboratory analysis to extract their phosphorous contents by Bray No 1 method and determine them by the molybdenum blue method[16].

The data collected were statistically analysed using analysis of variance (ANOVA) with the aid of GENSTAT statistical package and significant means were separated using least significant difference (LSD) at 5% probability level.

RESULTS

Single super phosphate (SSP) released significantly higher phosphorus than any other P-fertilizer used. On the other hand, the least phosphorus release was recorded from Crystallizer fertilizer treated soil (Figure 1).

The longest vine production was favoured by crystallizer while the control plot had the shortest length though the differences that existed among were not significantly pronounced at 5% probability level (Figure 2).

It was evident that leaf production was directly related to vine length (Figure 3).That is, the longer the length, the more the number of leaves produced and vice-versa. This was clear from the fact that crystallizer produced the longest vine and consequently the highest number of leaves while the control that had the shortest vine produced the number of leaves. The differences here too were not significantly higher in one than in the other at 5% probability level.

At harvesting (three 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 (Figure 4).Still, the fresh weight increase of the tubers were not significant different at 5% probability level.

The plants from the soil treated with Crystallizer fertilizer had the highest leaf phosphorus uptake. The leaf phosphorus uptake followed the trends 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. In the same vein, the plots with the lowest number of leaves per plant (control plots) came out with the lowest phosphorus uptake (Figure 5). It means that the more the vegetative parts (leaves e.t.c.), the more the phosphorus uptake. Moreover, the plots with no phosphorus fertilizer treatment (control) did not come out with any appreciable vegetative growth in sweet potato (Figures 3 and 4). Despite this observation, the control plots came out with the highest yield in tuber production (193kg/ha).

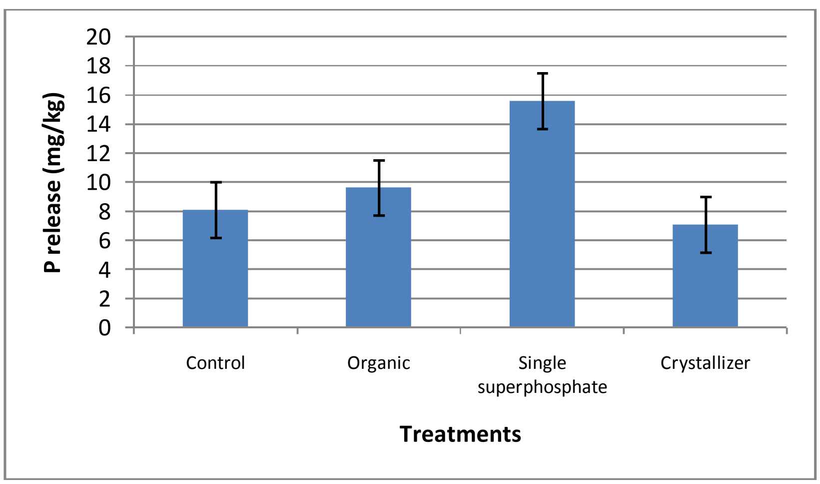

Figure 1: Trend of phosphorus release by different P-fertilizers during incubation study (mg/kg)

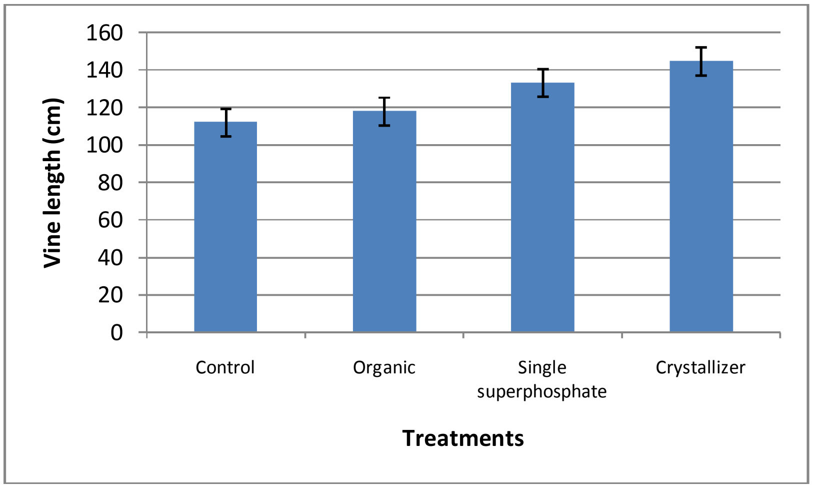

Figure2: Effect of phosphorus fertilizers on vine length production (cm)

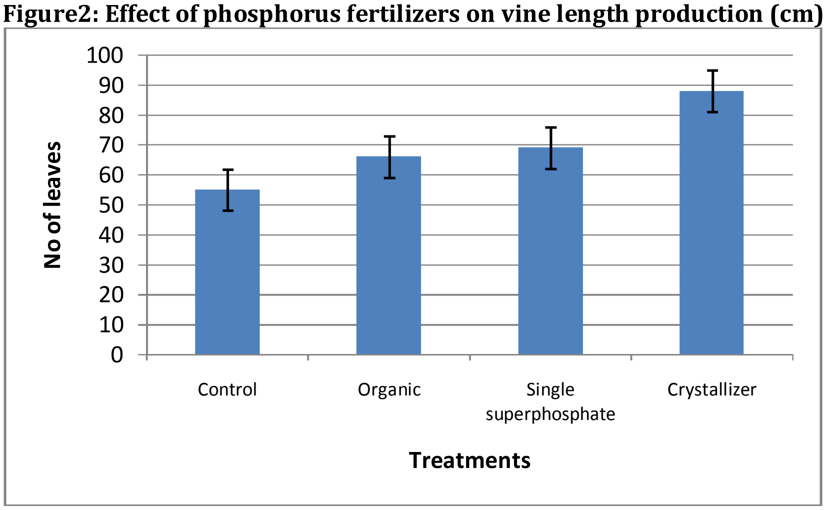

Figure 3: Effect of phosphorus fertilizers on sweet potato leaf production

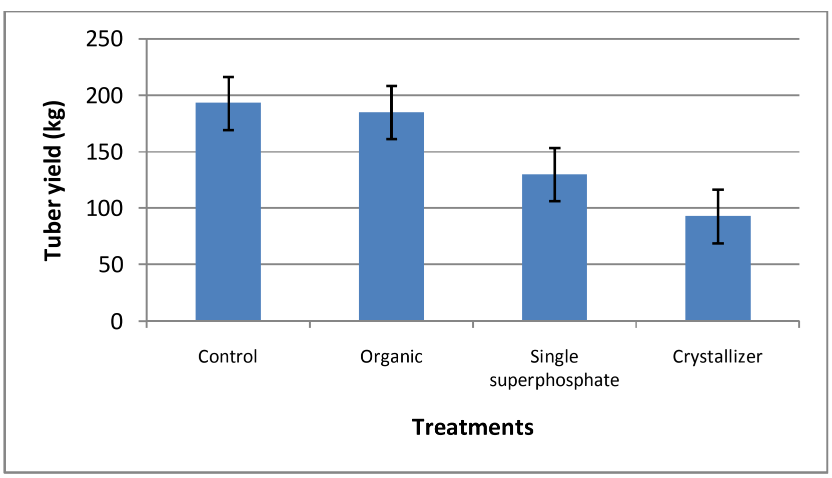

Figure 4: Effect of phosphorus fertilizers on tuber yield of sweet potato (kg/ha)

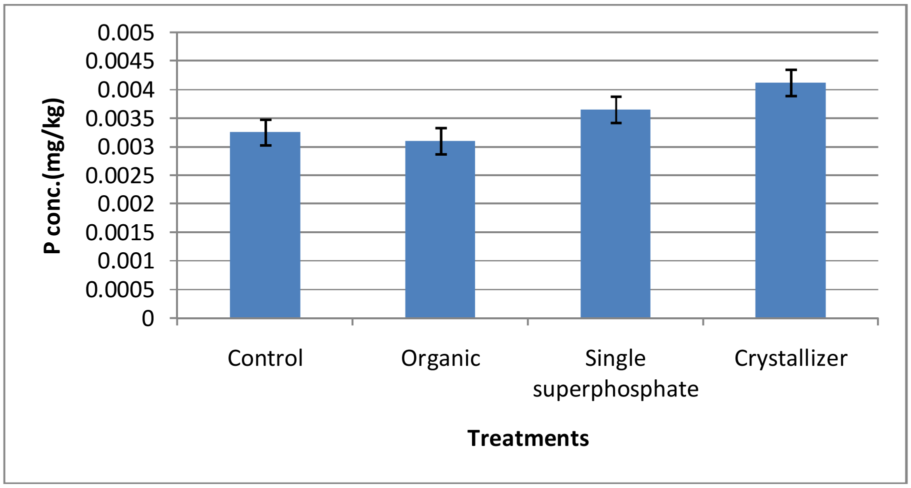

Figure 5: Effect of phosphorus fertilizers on leaf phosphorus uptake of sweet potato (mg/kg)

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. It is evident from this that single super phosphate (the highest phosphorus releaser) is a potential 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. [17] observed that despite higher amount of phosphorus released, recovery of P-fertilizer by crop uptake is about 15%-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. In most soils, in spite of the considerable addition of P-fertilizers, the amount available for plants is usually low since it is converted to unavailable form by its reaction with the soil constituents[10].

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. This implied that the more the phosphorus in the soil, the shorter the vine (vegetative parts). It could be said that lower level of phosphorus aided cell multiplication which consequently resulted in production of longer vines. On this,[10] 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. 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 and bulking which is the ultimate target of crop production. To further strengthen this, it has been discovered that leaves and other vegetative parameters were less increased by high phosphorus nutrition but low input of the nutrient was highly beneficial to the productivity of the plant under consideration [18]. Moreover, longer vine development resulted from application of higher proportion of farmyard manure in combination with lower proportion of P indicating that sweet potato benefited little from P to increase its canopy compared to the benefit that it derived from farmyard [19].

The effect of high P-releasing fertilizers on tuberous yield of sweet potato was completely different from the expected result (i.e. the more the phosphorus in the soil, the more the tuberous yield). This can be attributed to nutrient imbalance as a result of additional phosphorus nutrition through fertilizer application. Bulking of the tuberous root as well as grain filling in cereals require lots of potassium nutrition and not high level of phosphorus which if at all it is present, it should be at a minimal level. It has been revealed that high phosphorus level in the soil suppressed tuber development of sweet potato and other root and tuber crops [20]. The result also supported the assertion that very little mention has been made in literature on the use of phosphatic fertilizers to benefit sweet potato which was perhaps due to lack of yield response of sweet potato to phosphorus nutrition. Also, it has been found that phosphorus does not appear to be an important nutrient for sweet production although phosphorus is usually recommended in the fertilizer mixture. Moreover, [21] corroborated this with its discovery that elimination of phosphorus from the nutrition of sweet potato would not affect its yield in the least.

The level of vegetative growth (number of leaves and vine length) had been the significant reason behind the discrepancy in the level of phosphorus uptake. There was positive correlation between P uptake and the number of leaves produced by sweet potato plants. So, the fertilizer which aided higher leaf production directly encouraged the highest phosphorus uptake. In essence, when there is high vegetative production there will be effective absorption of available phosphorus in the soil and phosphorus fixation will be dramatically reduce.

CONCLUSION

It could, therefore, be said that crystallizer applied at the rate of 500kg/ha can be used for significant phosphorous uptake which equally leads to better quality sweet potato tuber production and appreciable vegetative growth. Also, when soil phosphorus is maintained as low as 6.80mg/kg high tuberous yield in sweet potato will be achieved.

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Citation of this article:

Isiaka Kareem . Growth, Yield and Phosphorus Uptake of Sweet Potato (*Ipomoea batatas*) Under the Influence Phosphorus Fertilizers. Res. J. Chem. Env. Sci., Vol 1 Issue 3 (August 2013): 50-55