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ORIGINAL ARTICLE

Fertilizer Treatment Effects on Yield and Quality Parameters of Sweet potato (*Ipomoea batatas*)

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ABSTRACT

Currently the world is moving towards organic production of crops for the discovered and envisaged advantages. Despite this, farmers are faced with the challenges of the bulkiness of organic fertilizer to be used and further gains that could be accrued from it even if sacrifice of using it is made. To be quite sure of the appropriate fertilizer type to be used in improving quality as well as the tuber yield of sweet potato, this work, therefore, evaluated the effectiveness of organic, inorganic and organo-mineral fertilizers on quality determinants of sweet potato as well as its tuber yield.

This experiment was carried out at the Teaching and Research Farm, University of Ibadan. The treatments applied were Pacesetter organic fertilizer at the rate of 3t/ha, inorganic fertilizer (NPK 15:15:15) at the rate 130kg/ha while organo-mineral fertilizer (comprising NPK 15:15:15 and Pacesetter organic fertilizer) was at the rate of 1.5t/ha and the control .The experiment was laid out in randomized complete block design (RCBD) with tree replications and the fertilizer treatments were applied at four weeks after planting. At maturity, destructive sampling was embarked upon and the sampled plants were partitioned into leaves and tubers. The fresh and dry weights of the samples were taken after which their proximate analyses were done to determine the levels of the quality determinants (moisture content, crude protein, crude fat, crude fibre, Vitamin A and ash content) in them. Final harvesting was done at the end of the experiment to determine the yield per treatments. The data collected were analysed using analysis of variance (ANOVA) with the aid GENSTAT 5 package and significant means were separated using Least Significant Difference (LSD) at 5% probability level.

The results indicated that all the above mentioned quality determinants of sweet potato leaves and tubers were not significantly increased by the fertilizer treatments used except for ether extract in the tubers which was significantly improved by organic fertilizer. Also, leaf and tuber dry matter production were not significantly increased by the applied treatments. However, inorganic as well as organic fertilizers significantly increased the final fresh tuber yield of the crop. It was also found that leaves of sweet potato had higher levels of quality indicators than the tubers except for energy content which was higher in the tubers.

It is, therefore, recommended that organic fertilizer and, to a lesser extent, inorganic fertilizer (NPK 15: 15:15) be relied upon to increase tuber yield of the crop. Finally, sweet potato should be produced with organic fertilizer since it is more advantageous and the inorganic fertilizer did not produce much higher than it did.

Key words: *Sweet potato, quality determinants, tuberous yield, morphological parameters, fertilizer treatments.*

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INTRODUCTION

Sweet potato (*Ipomoea batatas)* of the family Convulvulaceae originated in America (Mexico, Central America and Caribbean) and the North Western part of South America . Globally, it is among the important food crops in the world, after wheat, rice, maize, Irish potato, and barley. It ranks second following Irish potato in the world's root and tuber crop production and third after Irish potato and cassava in consumption in several parts of tropical Africa[1]. Its ability to feed man is based on the fact that it has the highest solar fixing efficiency primarily because of its capacity to produce dry matter for a long time. Moreover, it is adaptable to tropical and subtropical climates, tolerant to drought and grows under marginal condition of low fertility and pH.

Over the last few decades, consumers' demand for healthier food and government policies which focused on environmentally sustainable agricultural systems have both promoted a rapid expansion of organic farming. In this regard, potato (*Solanum tuberosum* L.) represents a major food crop in many countries where the demand for organic products is gradually increasing [2]. In line with this, it has become a widespread belief that organic farming improves the state of the environment, the health of people and increases the quality of food products [3][4]. The assertion that organic agriculture produces healthy food is based on higher concentrations of beneficial secondary plant substances in organically grown crops compared to non- organically grown ones [5]. Despite this, the existence of differences in the nutritional value of organic and conventional food products remains a crucial question without definite answer till date[6][7]. Valid nutritional quality comparisons between organic and conventional foods require that the plants be cultivated in similar soils, under similar climatic conditions, be sampled at the same time,pre-treated similarly and analysed by validated methods[8][7].

Although organic foods are generally considered healthier than conventionally-grown products, an improved nutritional profile of organic versus conventional crops has not been ascertained [9]. Furthermore, it is not known whether different cultivation systems may affect the nutrient composition of the final produce. Consequent upon this, a clear link between cultivation system and nutritional value of agricultural products remains missing [3][10]. Currently, research information about the differences in the quality of conventionally and ecologically cultivated potatoes is neither homogenous nor sufficient [11]. Also, in the opinion of the experts, the present knowledge is not sufficient to conclude that organically grown foods would have a positive effect on health [12]. The Swiss Association for Research and Nutrition concluded that from a scientific viewpoint, organic foods are neither healthier nor safer than conventional products. Even, some studies have shown that organically produced food may contain more fungal toxins that food produced by conventional methods[13]. In the same vein, many researchers have stated that organically grown crops contain fewer nitrates but higher concentrations of important nutritive substances [14][15[16][13]. Despite the report on slightly higher contents of minerals and trace elements in organically grown plants, the majority of evidence has revealed no significant differences among them [17][14][7].

It is well established that high quality food can be produced using either organic or inorganic nutrient sources. If differences occur between crops produced with organic or inorganic fertilizers, they usually occur from differences in amount and balance of nutrients supplied [13]. Supporting this, a trial results have indicated that when the amount of basic nutrients (NPK) applied with organic and mineral fertilizers were equal, there were no significant differences in the biological yield and quality of a crop[18][19].

The use of fertilizer in increasing the quality parameters of sweet potato is highly demanded. This is because if breeding programme is used, the same result could be obtained but it takes a lengthy period for a single breeding programme to go to completion with high level of expertise of the experts in the field except if marker assistance is employed. Also, several research efforts have been directed at improving the yield of sweet potato in terms of tuber and leaf production but amazingly very few publications, if at all there is any, have been on comparative study of organic, complete inorganic and organo-mineral fertilizers in improving quality determinants of sweet potato . Despite the difficult in getting any difference between organically or conventionally produced crops as highlighted above, the world is currently moving towards organic production of crops for the discovered and envisaged advantages. With this drive, farmers are still faced with the challenges of the bulkiness of organic fertilizer to be used and further gains that could be accrued from it if sacrifice of using it is made. To solve this problem, the present work, therefore, evaluated the effectiveness of organic, inorganic and organo-mineral fertilizers on yield and quality determinants of sweet potato.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm, University of Ibadan, Oyo State(7.27^{o} N 3.5^{o}E) with a mean temperature range of between 22^{o}C and 38^{o}C and annual rainfall range of 1000mm to 1600mm. The pre-cropping soil analysis revealed that the soil was acidic and sandy-loam. It was low in carbon and nitrogen contents. The potassium and phosphorus contents were within their critical ranges.

Vines of sweet potato (Shaba variety) were cut into 25cm long pieces with at least two nodes per cutting for higher sprouting percentage. The vine cuttings were planted on ridges with spacing of 30cmx100cm to give 33,333 plants per hectare. The vine cuttings were planted at an angle of 45^{o}to the soil with two thirds of the vine in the soil for proper establishment. The experiment spanned between 22nd May and 27th November, 2007.

There were a total of four treatments including the control with each treatment was replicated three times. The experimental design was Randomised Complete Block Design (RCBD).The total number of plots was twelve. The treatments were designated as follows: T1-control, T2-organic fertilizer, T3-inorganic fertilizer, T4-organomineral fertilizer. The fertilizer materials used were NPK 15:15:15 at the rate of 130kg/ha for inorganic fertilizer treatment while fortified Pacesetter organic fertilizer at the rate of 3t/ha was used for organic fertilizer treatment. For organo-mineral fertilizer, it was compounded from NPK 15:15:15(two parts, on the basis of nutrient composition) and Pacesetter organic fertilizer (one part, on the basis of nutrient composition) at the rate of 1.5t/ha. The composition of the organo-mineral fertilizer was made like that to avoid bulkiness of the organic fertilizer .The fertilizer treatments were applied at four weeks after planting. Throughout the experiment, there was regular weeding of the experimental plots. Rouging was resorted to when vines had covered the ground to forestall harming them.

Data collection was centred on tuber yield, dry matter production and quality parameters of the crop: moisture content, ash content, ether extract, energy content, crude protein, crude fibre and vitamin A content of the tubers and the leaves.

At maturity (three months after planting), three representative plants were destructively sampled and separated into tubers, leaves and stems. The samples were then weighed fresh and dried to determine their moisture content. Proximate analysis was then carried out on the dried leaf and tuber samples using[20] method to determine percentage dry matter, ash, crude protein, crude fat, crude fibre, energy and the amount of vitamin A present in the samples. Final harvesting was done when the leaves had turned brown to determine the influence of the treatments on the tuberous yield of the crop under consideration. The collected data were analysed using Analysis of Variance (ANOVA) with the aid of Genstat 5 package while significant means were separated using Least Significant Difference (LSD) method at 5% probability level.

RESULTS

Effects of fertilizer treatments on quality parameters of sweet potato tubers

The peak moisture percentage from tubers was from inorganic fertilizer treated plots while the least was recorded from control plots. For percent ash production in the tubers, the highest was from both the control and organic fertilizer plot but the least was from organo-mineral fertilizer plots. In the case of percent crude protein in tuber, the highest was recorded from the control plots while inorganic fertilizer treated plots produced the least. For the ether extract, the highest percentage was found from organic fertilizer treated plots with the least from inorganic fertilizer treated plots. In crude fat production, the highest percentage was from the control plots while all the fertilizer treated plots (that is organic, inorganic and organo- mineral fertilizers) had the same percentage of 0.96 which is lower than the control. Vitamin A production was highest in the plots treated with organic fertilizer with the least from inorganic fertilizer plots. For energy content in sweet potato tubers, the highest was from inorganic fertilizer while control plots had the least. All the differences between different treatments in all the quality parameters of sweet potato tubers were not significantly higher in one than in the other except for ether extract from the organic fertilizer treated plots which was significantly higher than those of the control and inorganic fertilizer plots (Figures 1-7).

Effects of different fertilizer treatments on quality parameters of sweet potato leaves

The highest moisture percentage in the leaves of sweet potato was from inorganic fertilizer treated plot and the least from the control plots. For percent ash content, the peak was from inorganic fertilizer plots while the least came from organo-mineral fertilizer plots.In crude protein production, the highest percentage was realized from organo-mineral fertilizer treated plots, followed by organic fertilizer treated plots, followed by the control plots with lowest percentage recorded from the inorganic fertilizer treated plots. Ether extract had the highest percentage from inorganic fertilizer plots, followed by the control plots, followed by organic fertilizer plots and finally organo-mineral fertilizer plots with the least percentage. Ether extract had the highest percentage from the inorganic fertilizer treated plots, followed by the control plots with the least percentage from organo-mineral fertilizer treated plots. Vitamin A production was highest in the organo-mineral fertilizer plots while the least was from inorganic fertilizer treated plots. The energy content was at its peak in the leaves got from organic fertilizer treated plots while the least energy content was from inorganic fertilizer treated plots. All the differences recorded from all the quality parameters of sweet potato leaves were not statistically higher in one than in the other (Figures 8-14)

Effects of fertilizer treatments on dry matter production of sweet potato tubers

The percent dry matter yield in the tubers of sweet potato ranged from 34.30% to 37.48%. The least dry matter production (34.30%) was recorded from inorganic fertilizer treated plots while the highest (37.48%) was the result realized from the control plots. Although differences existed in the dry matter production from all the treatments, those differences were not statistically significant for any meaningful recommendation to be made (Table 2).

In the leaf dry matter production, the range was between 23.42% and 28.59%. The highest (28.59%) was also produced by the control plots while the least dry matter (23.42%) was still produced by plants treated with inorganic fertilizer. The differences here also were not significantly different in one treatment than in the other (Table 2).

In fresh tuber production, the production ranged between 5.43t/ha and 10.90t/ha. The least fresh weight (5.43t/ha) was from the control while the highest (10.90t/ha) was from the plots treated with organic fertilizer. Although all of them were above the production from the control, only the weight of tubers from inorganic fertilizer treated plots was significantly higher than the control (Table 4).

The fresh weight of leaves was between 0.99t/ha and 1.07t/ha. The least weights (0.95t/ha) were from both the control and organic fertilizer treated plots while the highest production 1.07t/ha was from organic fertilizer treated plots. All these weight differences were not significantly higher in one treatment than in the other (Table 2)

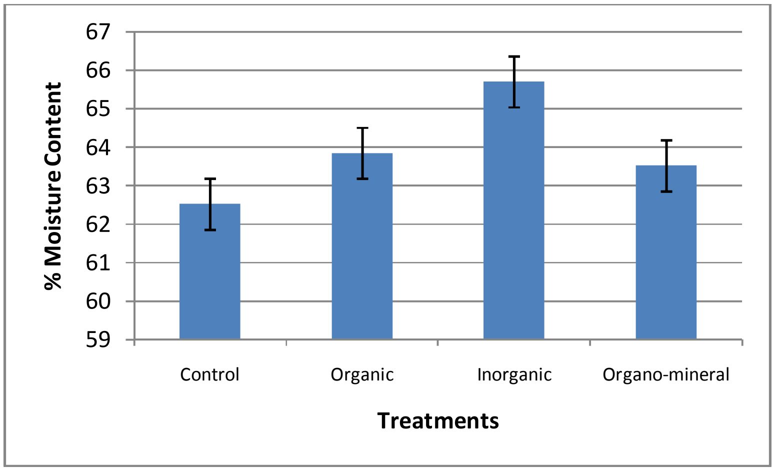

Fig 1: Effect of fertilizer treatments on tuber moisture content

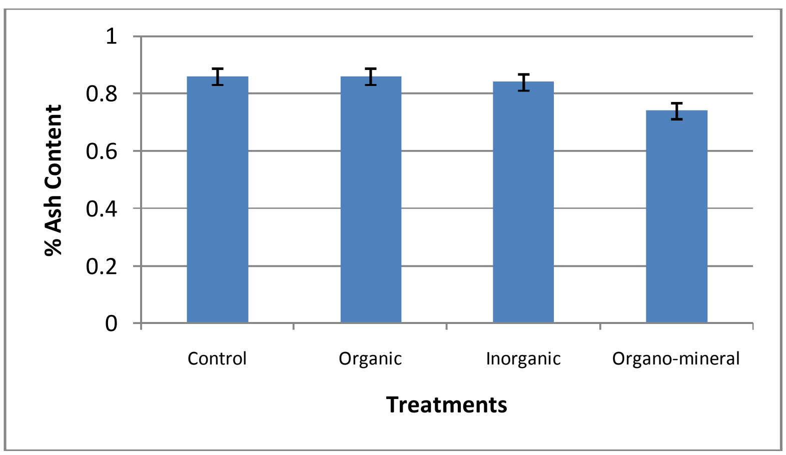

Fig 2: Effect of fertilizer treatments on tuber ash content

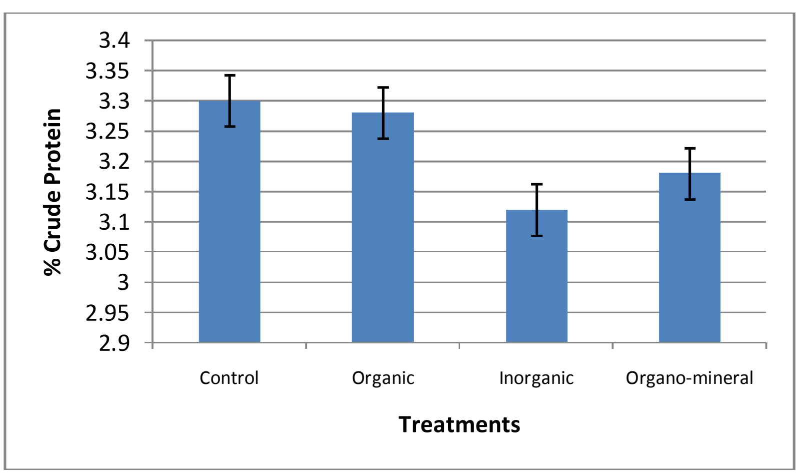

Fig 3: Effect of fertilizer treatments on tuber crude protein content

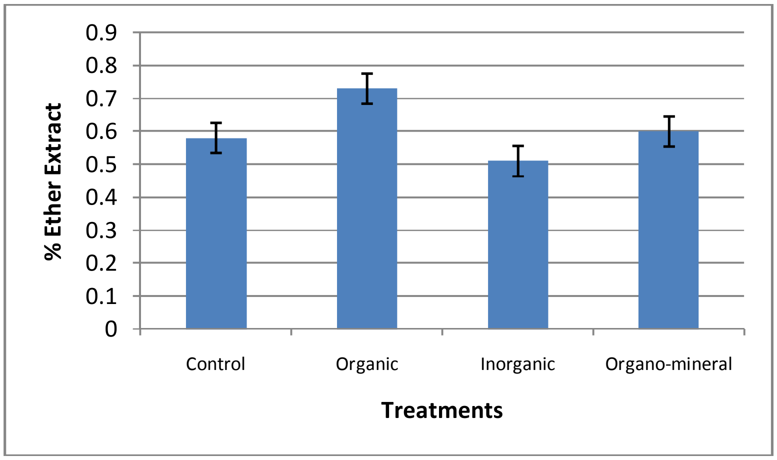

Fig 4: Effect of fertilizer treatments on tuber ether extracts content

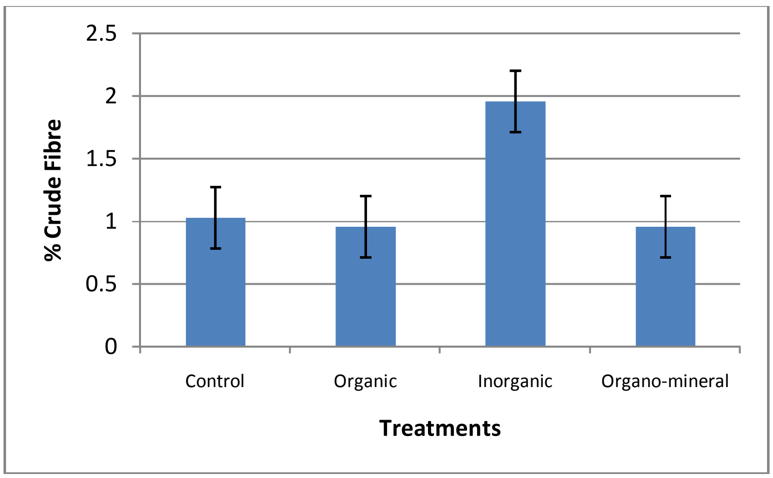

Fig 5: Effect of fertilizer treatments on tuber crude fibre content

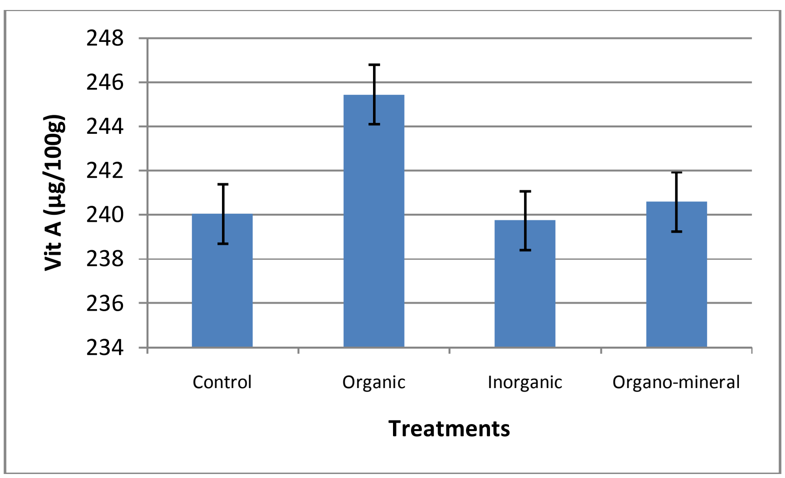

Fig 6: Effect of fertilizer treatments on tuber vit. A content

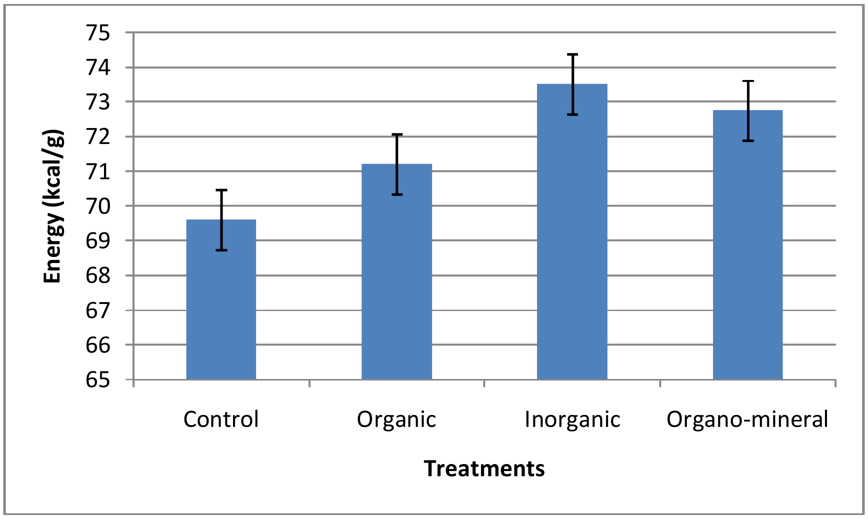

Fig 7: Effect of fertilizer treatments on tuber energy content

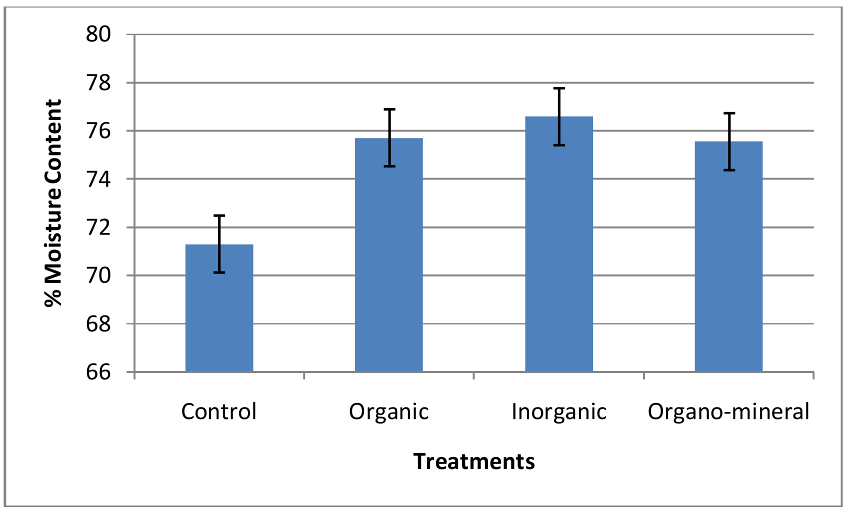

Fig 8: Effect of fertilizer treatments on leaf moisture content

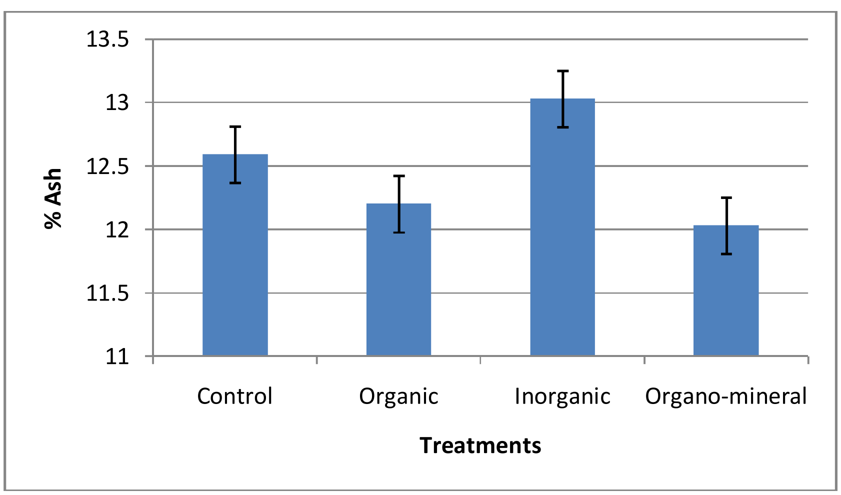

Fig 9: Effect of fertilizer treatments on leaf ash content

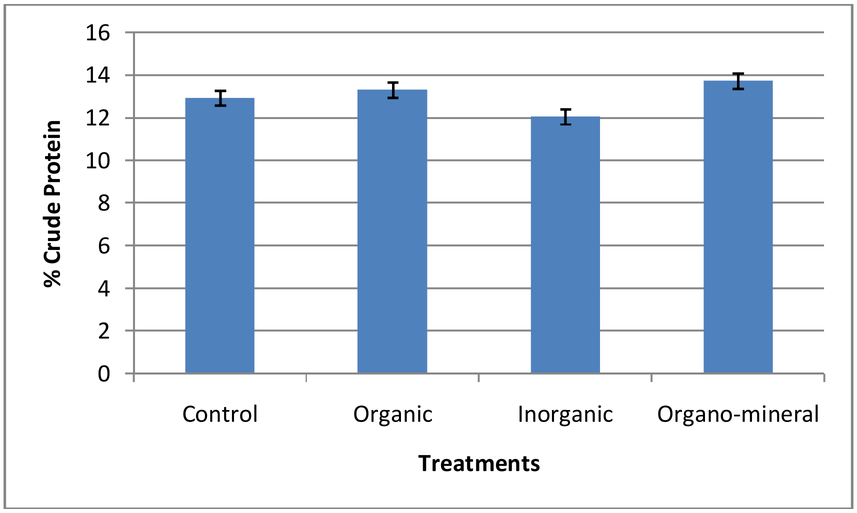

Fig 10: Effect of fertilizer treatments on leaf crude protein content

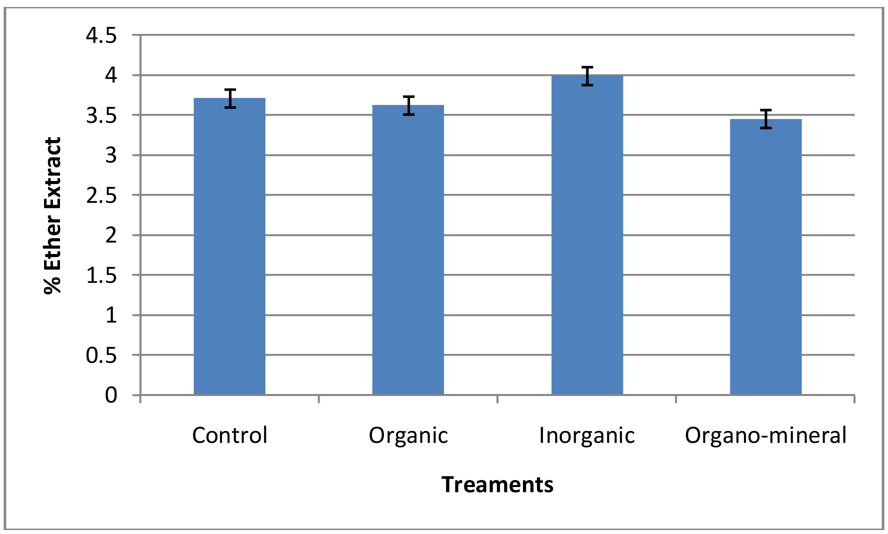

Fig 11: Effect of fertilizer treatments on leaf ether extract content

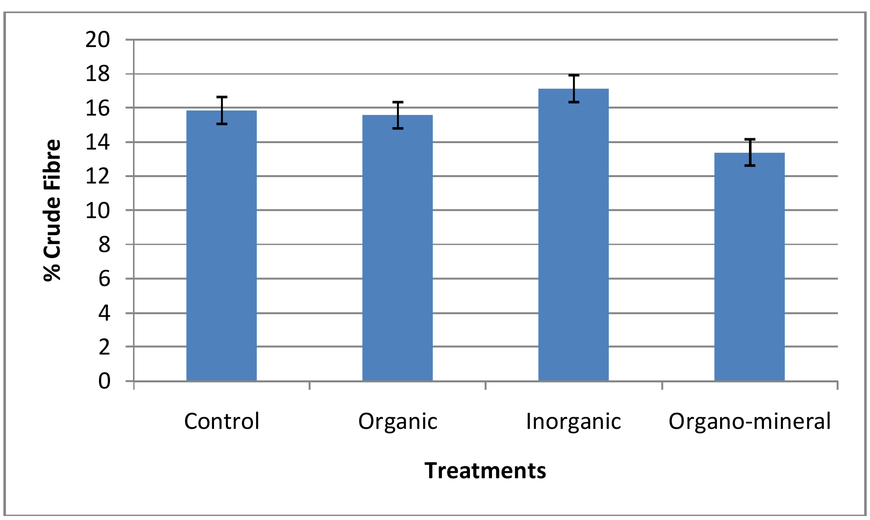

Fig 12: Effect of fertilizer treatments on leaf crude fibre content

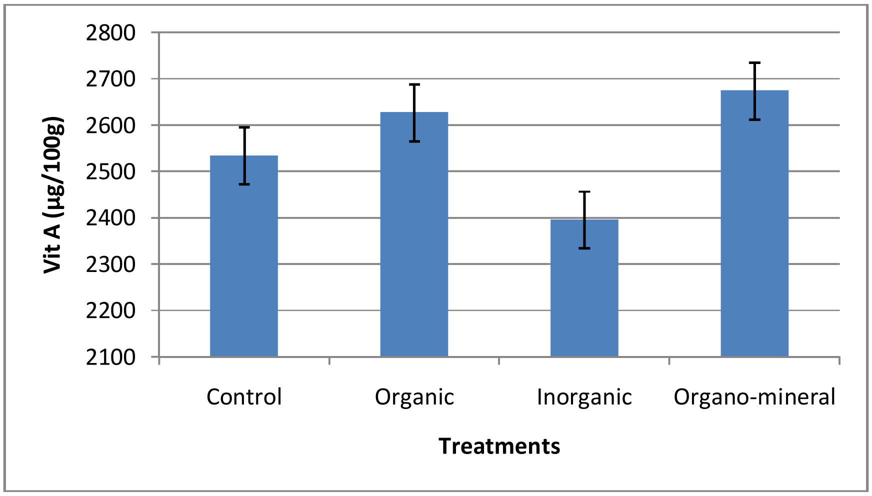

Fig 13: Effect of fertilizer treatments on leaf vit. A content

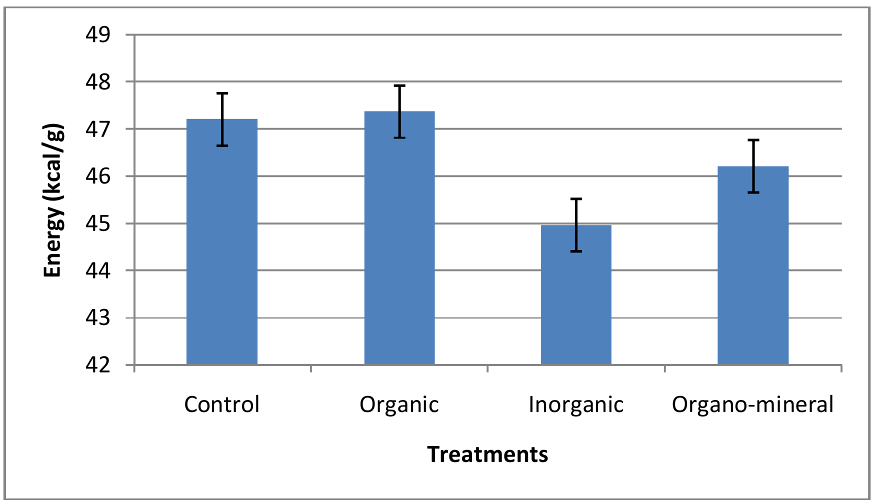

Fig 14: Effect of fertilizer treatments on leaf energy content

Table2: Effect of fertilizer treatments on yield parameters of sweet potato (tuber dry matter, leaf dry matter, fresh tuber yield and fresh leaf yield)

Treatments	%TDM	%LDM	FTY (t/ha)	FLY (t/ha)
Control	37.48	28.59	5.43	0.99
Organic	36.15	24.30	8.76	1.07
Inorganic	34.30	23.42	10.90	1.06
Organo-m	36.39	25.28	7.90	0.95
LSD (0.05)	ns	ns	3.47	ns

TDM = Tuber dry matter
LDM = Leaf dry matter
FTY = Fresh tuber yield
FLY = Fresh leaf yield

DISCUSSION

The quality parameters

It is evident from the results that the use of different fertilizer types could not be used in increasing the quality parameters of sweet potato tubers measured in the present work (moisture content, ether extract, crude fat, crude fat, crude protein, energy, and ash as well as vitamin A contents). It was not only in the use of organic fertilizer that no significant increase above the control was noticed but also in the use of inorganic fertilizer (NPK 15:15:15) as well as the use of complementary organic and inorganic fertilizers (organo-mineral fertilizer). Organic foods are generally considered healthier than conventionally-grown products. Nevertheless, an improved nutritional profile of organic vs. conventional crops has not been ascertained[9]. However the use of organic fertilizer could be further encouraged because the ether extract in the tuber was significantly increased above what was obtainable from the control. This goes in line with the present clamour for organic farming that is currently gaining acceptance of all and sundry in production agriculture. This ether extract (crude fat) is an indicator of energy production (twice that of carbohydrate), means of absorbing fat soluble vitamins, protector of delicate organs in the body as well as insulator against cold.

Furthermore, there is close relationship between the effects of the treatments applied on the quality parameters in sweet potato tubers and leaves. The increases noticed above the control treatments were not significantly higher for any meaningful recommendation from the results. Similarly, the differences that existed among the results from different treatments were not significantly higher in one than the other. This indicates that once a particular nutritional treatment fails to improve the nutritional quality in tubers, the results of the same parameters from the leaves of the same plant will follow suit. Despite this, ether extracts which was found to be increased in the tuber by the use of organic fertilizer at rate of 3t/ha was an exemption.

By and large, the magnitude of quality parameters in the leaves of sweet potato with or without fertilizer treatment was higher than what the tubers produced. This implies that the leaves of sweet potato are more nutritious than the tubers. This fact is relied upon by people who use sweet potato foliage as vegetable as is eaten in parts of Africa and the Philippines. This discovery is not absolute because the energy content of sweet potato tubers which was derived from its carbohydrate content was higher than its counterpart in the leaves of the plant. There is direct relationship between energy and starch as well carbohydrate content of the tubers. Therefore, the tuber is often used as a source starch in industries to manufacture adhesives, dextrin, paper and also cosmetics[21]. It is also, for the same reason, used industrially to produce glucose, syrup noodles and alcohol. It can also be used as animal feed or infant food [22]. Large quantities of sweet potato, mainly culls, are therefore used in some countries as a high carbohydrate feeding stuff for cattle, pigs and poultry [23]. They are, on the same grond, used occasionally as food for Tilapia in fish ponds.

The dry matter production was high in the leaves of the control plots (zero fertilizer treatment) because the fertilizer treated plots had higher moisture contents than found in the control plots. This was also the reason for what was got under tuber dry matter production. This is also true for root or tuber crops that when the yield is aided with fertilizer application the moisture content of the tuber increases because there is an inverse relationship between the two parameters. However, the dry matter production in the leaves is less than what was got from the tuberous roots. This was in line with the results of Indra and [24] who said that sweet potato, being an intermediate type, had accumulation of dry matter in vine (leaves and stem) and tuberous roots which increased throughout the growing period. However, the rate of dry matter (DM) production and its partitioning varied greatly during the growth period. The ratio of root and shoot increased up to 60 days after planting and, therefore, the dry matter accumulation in tuber exceeded that of vine with the commencement of tuber bulking. While there was decrease in vine weight towards harvest, the tuber weight increased linearly with the age of crop.

The highest and most significant tuber production was found from the plots treated with inorganic fertilizer which was as a result of high potassium content of the inorganic fertilizer used.Also comparative higher level of potassium was also found in the organic fertilizer under consideration too. The work of potassium in this situation is that it accelerates translocation of photosynthates from leaves to tubers by increasing its photosynthetic efficiency. This was in consonance with the findings of [25] that the yield of sweet potato is significantly depressed if potassium is missing. However, eliminating phosphorus does not affect the yield. It has been established that high K levels also increased leaf area duration and excessive leaf growth is suppressed, resulting in higher root yield. Furthermore, the key factors for increased sweet potato yield are the careful regulation of N levels and liberal supply of K to increase sink capacity and photosynthesis.

The dry matter production in both tubers and leaves, despite the use of different fertilizer treatments, was not increased significantly above the control. Also the differences in the results that existed between the treatments were not significantly higher in one than in the other. The roots produced higher dry matter than the leaves because the percent moisture content in the leaves was higher than that of the tubers.

The fresh weight of leaves produced from all the treatments did not correlate with the weight of fresh tuber produced. In the same vein, all the treatments applied failed to generate any statistically meaningful increase in leaf weight above the leaf weight from the control plots.

CONCLUSION

It is evident from this work that organic fertilizer and, to a lesser extent, inorganic fertilizer (NPK 15: 15:15) could be conveniently used to increase tuber yield of sweet potato. Finally, production of sweet potato will be better with organic fertilizer since it is more advantageous than the inorganic one and that inorganic fertilizer did not produce higher than it.

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