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# STUDIES ON EFFECTS OF MINERAL FERTILIZER, ORGANIC MANURE AND CULTIVAR ON THE YIELD AND STORABILITY OF YAM (*Dioscorea rotundata* Poir)

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**ABSTRACT**

Yam is an important staple food crop in the humid and sub-humid tropics. Despite inadequacies in supply and availability of fertilizer to boost yam production in Nigeria, there have been reports and arguments that yams grown with chemical fertilizer are susceptible to pathological deterioration in storage while those grown with organic manure store better and have longer shelf life. Therefore, two experiments were conducted to investigate this controversy. The first field experiments tested the responses of five yam cultivars; *Amula, Nwaopoko, Ezakwukpolo Danacha* and *Pepa* to fertilizer and organic manure treatments. Statistical differences were not detected in all cases of manuring treatment although tuber yield appeared less where no fertilizer or organic manure was applied. While organic manure appeared to have a better effect on tuber yield with *Danacha*, NPK fertilizer had better yield effect with *Ezakwukpolo, Amula* and *Pepa*. The second experiment tested the effect of manuring treatments on the storage life of the five yam cultivars. Dormancy period was extended in *Nwaopoko* cultivar when organic manure was used than when no manuring or NPK fertilizer was applied. Tuber weight loss varied significantly among cultivars with different treatments. Rotting was significantly higher in *Amula* with the application of NPK fertilizer compared with *Danacha, Nwaopoko, Ezakwukpolo* and *Pepa*. The combined effects of cultivar and manuring treatments on rotting incidence varied with cultivar type. For example, *Amula* cultivar had the highest rotting incidence with or without manuring treatments, whereas *Danacha* and *Ezakwukpolo* had statistically similar rotting incidence with any of the manuring treatments. In conclusion, evidences in this study show that post harvest losses of yam are, in part due to field management but mostly dependent on species and cultivars. *Nwaopoko* and *Danacha* cultivars had better keeping qualities than all other cultivars tested with or without manuring treatment. It is recommended that plant breeders should use the traits in these two cultivars to improve others.

**Key words**: Yam, storability, fertilizer, organic manure

## INTRODUCTION

Yam (*Dioscorea rotundata* Poir) is traditional crop of great importance in the yam belt of West Africa responsible for 96% of the global annual output of the crop (33 million metric tones) for which Nigeria alone accounts for 25.2 million metric tones [1]. The nutritional value of yam varies greatly between species and amongst varieties of the same species. Variations are also subject to other factors, such as cultivation methods, climate and soil characteristics, the stage of maturity reached by the tuber at harvest and length of storage or the processing technique used [2, 3].

The use of chemical fertilizer in yam production is common in the yam growing areas of Nigeria. This is especially true where long fallowing is no longer tenable as an integral part of the cropping system. The desire to use chemical fertilizer in yam production is prompted by the higher yield usually obtained from fertilizer plots [4, 5, 6].

Despite inadequacies in supply and availability of fertilizer to boost the production of yam in the country, there were reports that yams grown with fertilizer application were more susceptible to pathological deterioration during storage than those grown without fertilizer [2]. In a survey of yam storage practices carried out in southeastern Nigeria, it was reported that yam tubers grown with organic manure had longer shelf life than those treated with chemical fertilizer in the field [7]. It has also been reported that high nitrogen content in mineral fertilizer increased sprouting of yams in storage, although high potassium tended to suppress sprouting [8]. Other claims were that fertilization, while increasing the unit weight of the tubers on one hand; it brought about losses during storage [9]. All these claims did not take into consideration that there are many varieties, species and cultivars of yam, which may vary in their responses to field management or storage treatment.

In order to substantiate these claims by the farmers and workers in yam production, there was need to investigate the effects, particularly the two amendment practices and five cultivars on storability of yam. Consequently, the objective of the study was, therefore, to determine the effects of cultivar and field fertilizer and organic manure application on tuber yield and on post-harvest storage losses.

## MATERIALS AND METHODS

### Field Experiments

Two experiments were performed, one in the field and the other in the yam barn. The field experiment and the storage trials were carried out at the National Root Crops Research Institute (NRCRI) Umudike research farm and the modern storage barn, respectively. Umudike is in Nigeria, and is situated on latitude 05$^{0}$ 29’N longitude 07$^{0}$ 33’E in the Tropical rain forest zone and at 122m above sea level.

The yam cultivars were obtained from four major yam producing States in Nigeria – namely Enugu, Benue, Delta and Nassarawa States [10]. The cultivars were

Nwaopoko, obtained from Enugu state, Pepa from Lafia in Nassarawa state, Ezakwukpolo from Agbor in Delta state, Danacha from Katisna-Ala and Amula from Zaki-Biam, both in Benue state.

The field experimental design was a split plot in a randomized complete block design with four replications. Each replicate was divided into five main plots each of which was again divided into three subplots. The plot size was 2m x 12m and block size was (6m x 60m) with a pathway of 1.0m between blocks. Yam cultivars constituted the main plot treatment while N P K fertilizer, organic manure and control were the sub plot treatments.

The land was ploughed and harrowed. Stumps of grass (*Panicum maximum*) and shrubs were removed manually to get a clean seed bed. Ridges (1m wide and 60cm high) were made and bonds were constructed between plots to check flood erosion. The five yam cultivars: Nwaopoko, Pepa, Amula, Danacha and Ezakwukpolo were cut into setts and each sett weighed approximately 100g. The setts were treated with yam minisett dust, which was composed of nematicides, fungicides, bactericides and insecticides to protect the setts against insects, nematodes, bacteria and fungi respectively in the soil. The yam setts were planted on the crests of (1 x 0.6m) ridges at one meter apart, giving a plant population of 10, 000 plants per hectare. The organic manure (cow dung) was applied in bands on both sides of the ridges 2-4 days after planting to the appropriate plots. It was applied at the rate of 5.4 tonnes $ha^{-1}$ [11]. Two months after planting, a single dose of $N_{90}$ $P_{10}$ $K_{20}$ was applied based on the recommended optimum for yam production [11]. Staking was done at 4-6 weeks after planting (WAP) when almost all the yam setts had emerged from the soil and vines long enough to train on the stakes. Stakes were arranged in alternate furrows so that vines from 4-6 stands of yam taken from adjacent ridges were trained to climb the stake. Two weeding operations were performed. The first was one week before fertilizer application, 7 WAP, and the second was at 16 WAP. Shoot emergence scores were taken at 4, 6 and 8 WAP. Shoot vigour assessment was done on a 3 point hedonic scale where 1 = low, 2 = moderate and 3 = high. The tubers were harvested for yield determination after 8 months and thereafter, healthy looking tubers without cuts or bruises during harvest were selected for the storage experiment.

**Storage conditions**

The fresh yam tubers were stored in an improved yam barn. The roof of the improved barn was made of corrugated aluminum sheets with ceiling of bamboo and raffia mats. The sides of the barn consisted of a dwarf wall (1m high) made of cement blocks and a wire netting extended from the top of the dwarf wall to the roof of the barn. This feature enhanced air circulation and excluded rodents. Inside the barn, wooden shelves were constructed on which the tubers were placed. Dry and wet bulb thermometer were installed for monitoring temperature and relative humidity

**Measurements**

Temperature and relative humidity (RH) of the storage environment were monitored at 10.0 am and 4.0 pm daily using a thermocouple. Sprouting was evaluated visually

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for presence or absence of sprouts and recorded daily. The duration of complete dormancy was determined as defined by Ireland and Passam [12], which was given as the number of days from the start of the storage to the first visible sign of sprouting. The sprout lengths were measured with tape rule and removed when they attained 1.5m. They were cut at the base and weighed. Sprout relative weight (%) was obtained thus: $\frac{\text{Fresh sprout weight x 100}}{\text{Fresh tuber weight}}$

Weight loss was determined by the difference between the initial weight and successive weights divided by the initial weight, and multiplied by 100 to get the percentage weight loss Percentage rot was obtained by dividing the number of tubers that rotted with the total number of tubers stored multiplied by 100.

**Data analysis**

Analysis of variance (ANOVA) and General Linear model (GLM) were performed on all data collected using the Statistical Analysis System (SAS) package. Standard error of difference (s.e.d) and standard error of the mean (S.E.M) were used as the mean separation tools.

## RESULTS

Pepa and Nwaopoko cultivars had over 30% crop emergence from the soil at 4 weeks after planting (WAP) whereas other cultivars had generally less than 25% emergence (Fig. 1). Amula cultivar consistently had the least emergence up to the 8th week when all the plants nearly attained 100 % emergence.

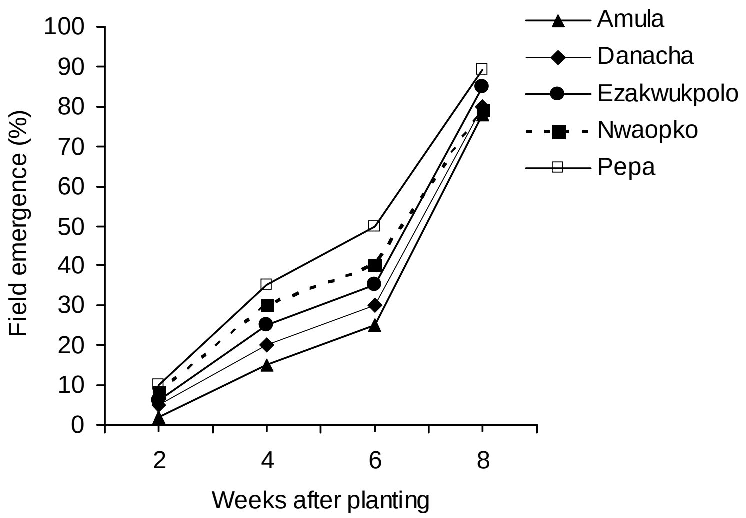


**Figure 1: Percentage field emergence of five yam cultivars with time**


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On average, manuring treatments did not have any significant effects on the plant vigour at 12 weeks after planting (Table 1). However, Danacha and Ezakwukpolo had higher plant vigour than others with respect to fertilizer application although the differences were not statistically significant. Similarly, higher plant vigour was obtained in Danacha alone when organic manure was applied compared to no manuring treatment.

Tuber yield at harvest was significantly higher among Danacha and Ezakwukpolo compared with Nwaopoko and Pepa cultivars where NPK fertilizer was applied (Table 2). The yield of Amula was also higher than those of Nwaopoko and Pepa although, differences were not significant.

The storage environment had lower temperature and higher relative humidity (RH) than the outside barn (Table 3). Relative humidity was always higher inside the barn especially in the evening time than the RH outside barn. In the storage, dormancy period in Nwaopoko extended when organic manure was applied than when no manuring or NPK fertilizer was used (Table 4). On the other hand, the application of organic manure appeared to have extended dormancy in Danacha while .Amula and Pepa were not affected in their dormancy by manuring treatments.

Tuber weight loss varied among the cultivars with Pepa having the lowest weight loss (35.8%) thus differing significantly (P = 0.05) from other cultivars except Nwaopoko (Table 5). On the average, tuber weight loss was not statistically different among Amula, Danacha and Ezakwukpolo cultivars. However, the application of fertilizer appeared to have increased weight loss in Danacha and Nwaopoko compared to where it was not applied, although difference was not statistically significant

Sprout relative weight also varied significantly (P = 0.05) among the cultivars (Table 6). Amula and Pepa exhibited the highest sprout relative weight loss when NPK fertilizer and organic manure were applied compared to the control. On average, Amula and Pepa produced highest sprouts followed by Ezakwukpolo, Nwaopoko and then Danacha. Across the treatments, NPK fertilizer exerted more effects on sprouting than organic manure and control, although the differences were not significant.

Rotting was significantly (P=0.05) high in Amula with the application of NPK fertilizer compared with Danacha, Nwaopoko and Ezakwukpolo (Table 7). Similarly, application of fertilizer increased rotting incidence especially in Amula compared to organic manure or control treatments. Statistical differences were not detected in all cases of manuring treatment although rotting appeared less where no fertilizer or organic manure was applied. Whether fertilizer or manure was applied or not, Amula had significantly higher rotting incidence than other cultivars. The combined effects of cultivars and manuring on rotting incidence varied significantly among the cultivars. For example, Amula cultivar had the highest rotting incidence when treated with manure or without whereas Danacha and Ezakwukpolo had statistically similar rotting incidence with any of the manuring treatments.

## DISCUSSION

The time of field emergence after sowing is important for uniformity of stands and eventual crop development, general performance and yield. Variability in field emergence existed among the genotypes used. Such variability probably, in parts, relate to the status of tuber with respect to the formation of the sprout buds on the tuber at the time of sett preparation and planting. It has been reported that the head portion of the tuber sprouted and emerged faster than the lower portion tuber setts [13]. Plant vigour differences among the cultivars might be related to time of field emergence as reported by Tschannen [13] that early emergence significantly affected vigour and final yield of yam. Higher plant vigour in organic manure and NPK fertilizer treatment plots than in no manuring treatment plots was a clear evidence of improved nutritional status of the soil as a result of appropriate doses of the treatment (soil amendments) in this study.

Tuber yield was higher with fertilizer and organic manure, yet yields were high enough where no fertilizer or organic manure was applied evidently due to high native fertility of the soil [14]. The combined effects of cultivar and manuring treatment on the yield varied among the cultivars. Ezakwukpolo cultivar gave the highest tuber yield when treated with NPK fertilizer while Pepa cultivar gave the least under the same treatment but when organic manure was applied to Danacha, the yield was greater than where NPK fertilizer was applied.

Storage of yams in barns has always aimed at modifying the temperature and relative humidity (RH) of the storage environment, which have been shown to influence storage life of yam [15]. The improved yam barn in which the present study was carried out had lower temperature and higher RH inside the barn than the outside barn environment. The barn had roof and insulated material as ceiling which probably helped to reduce the barn temperature while RH would result from moisture conservation due to less air movement inside the barn.

Post harvest losses of yam tubers in storage may be attributed to some field cultural practices which could be inappropriate rate of fertilizer or organic manure application but mostly the cultivar type and storage environment. The present study showed that the cultivars varied significantly in their dormancy periods. Although there were no clear statistical differences on effects of manuring on the dormancy period of yams, combined effects of cultivar and manuring were significantly different, suggesting that such differences in dormancy periods of yams were cultivar specific. This variation in dormancy period can also be explained in the light of earlier findings that dormancy in both potato and yam is under genetic control and both cultivar and species dependent [16, 17].

The changes in fresh weight of tubers were virtually unaffected by manuring treatments. However, weight loss was less among Nwaopoko and Pepa but higher than among Amula, Ezakwukpolo and Danacha. These observations suggest that differences in weight losses of tubers in the present experiment were related more to cultivars than manuring treatment. This result supports earlier findings by Girardin *et al.* [18] that the changes in fresh weight of tubers were highly dependent on species and cultivar. However, the present study slightly disagreed with the report by Dumont *et al.* [9] that fertilization, while increasing the unit weight of tubers also affected losses during storage depending on the species.

Tubers from no manuring treatment appeared to show reduced rotting in the present study compared to tubers treated with organic manure or NPK fertilizer. It is possible that tubers produced with fertilizer or organic manure led to greater succulence of tissue and to high nitrogen content, which increased sprouting of yam in storage [8]. Early sprouting and higher sprout relative weight noticed in Amula and Pepa cultivars probably led to increased rotting incidence as it had been reported that dormancy break and sprouting paved way for tuber senescence and pathogenic invasion and then rotting of tubers [16]. However, rotting incidence varied significantly among the cultivars. Evidence in this study showed that effects of either NPK fertilizer or organic manure on weight loss, sprouting and rotting of tubers in storage was partly dependent on cultivar, and perhaps soil fertility status. Similar to our finding in this experiment is the report by Adeniji [19] which held that inappropriate application of soil amendment might result in storage losses stating that N alone altered the taste of yam and texture but balanced fertilization with (NPK) had no negative effects. We therefore, recommend that appropriate application of fertilizer or organic manure as used in this study should be adopted since it has no adverse effect on the post harvest losses of yam in storage.

In conclusion, different cultivars of *D. rotundata* vary in their responses to manuring treatments and post-harvest behaviour. In this study, Nwaopoko and Danacha cultivars had better keeping qualities than all other cultivars tested with or without manuring treatment.

**Table 1: Effects of yam cultivar and manuring on field vigour at 12 weeks after planting**

| Manuring | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| | Amula (±0.0192) | Danacha (±0.0192) | Ezakwukpolo (±0.0192) | Nwaopoko (±0.0192) | Pepa (±0.0192) | Overall mean (±0.0333) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 2.1 | 2.6 | 2.6 | 1.9 | 2.1 | 2.3 |
| Organic manure | 2.0 | 2.8 | 2.1 | 2.0 | 1.9 | 2.3 |
| No manuring | 1.9 | 2.5 | 2.5 | 1.9 | 1.7 | 2.1 |
| Overall mean (±0.0333) | 2.0 | 2.6 | 2.4 | 1.6 | 1.9 | 2.2 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 0.42

s.e.d for comparing 2 manure means = 0.32

s.e.d for comparing 2 cultivar x manure means = 0.64

**Table 2: Effects of cultivar and manuring on yam tuber yield (t ha-$^{1}$) of *D. rotundata***

| | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| Manuring | Amula (±0.0190) | Danacha (±0.0190) | Ezakwukpolo (±0.0190) | Nwaopoko (±0.0190) | Pepa (±0.0190) | Overall mea (±0.0149) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 14.6 | 16.7 | 17.7 | 13.5 | 13.5 | 15.2 |
| Organic manure | 14.5 | 17.1 | 14.7 | 13.5 | 12.6 | 14.2 |
| No manuring | 13.8 | 16.7 | 15.9 | 12.5 | 12.5 | 14.3 |
| Overall mean (±0.0192) | 14.3 | 16.8 | 16.1 | 13.2 | 12.9 | 14.9 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 1.10

s.e.d for comparing 2 manure means = 1.20

s.e.d for comparing 2 cultivar x manure means = 2.21

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**Table 3: Temperature and relative humidity of the storage environment**

| | Temperature (°C) | | | | Relative humidity (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Inside barn | | Outside barn | | Inside barn | | Outside barn | |
| Period | am | pm | am | pm | am | pm | am | pm |
| Year 2006 | | | | | | | | |
| Jan | 29.6 | 31.1 | 32.0 | 34.0 | 80.2 | 92.1 | 76.2 | 57.5 |
| Feb | 27.1 | 29.8 | 31.4 | 33.8 | 80.4 | 89.2 | 74.8 | 60.0 |
| March | 28.9 | 30.9 | 30.6 | 34.0 | 89.3 | 92.4 | 76.0 | 57.4 |
| April | 29.1 | 30.6 | 30.4 | 33.7 | 79.9 | 82.6 | 84.2 | 66.8 |
| May | 30.1 | 30.4 | 29.6 | 32.2 | 86.2 | 91.2 | 82.6 | 70.0 |
| Jun | 27.6 | 29.8 | 28.9 | 30.1 | 76.0 | 80.0 | 80.1 | 72.4 |
| July | 28. | 26.4 | 30.0 | 30.4 | 78.0 | 81.3 | 79.2 | 68.9 |
| Year 2007 | | | | | | | | |
| Jan | 29.1 | 30.2 | 30.0 | 33.0 | 81.4 | 92.4 | 76.5 | 57.9 |
| Feb | 26.1 | 30.1 | 31.4 | 33.4 | 80.8 | 88.9 | 74.4 | 60.3 |
| March | 29.7 | 29.9 | 31.2 | 34.2 | 88.3 | 92.8 | 77.0 | 57.7 |
| April | 29.13 | 29.6 | 30.2 | 33.4 | 79.7 | 83.6 | 85.2 | 65.7 |
| May | 31.1 | 31.4 | 30.4 | 32.4 | 86.9 | 91.5 | 82.8 | 71.0 |
| Jun | 28.6 | 29.8 | 28.1 | 31.1 | 76.5 | 81.0 | 80.1 | 73.4 |
| July | 28.4 | 26.2 | 31.0 | 29.4 | 78.7 | 82.3 | 78.2 | 67.8 |

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**Table 4: Effects of yam cultivar and manuring on dormancy periods in (days) of yam in storage**

| Manuring | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| | Amula (±0.0194) | Danacha (±0.0194) | Ezakwukpolo (±0.0194) | Nwaopoko (±0.0194) | Pepa (±0.0195) | Overall mea (±0.0333) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 77.1 | 87.4 | 87.4 | 87.7 | 72.4 | 82.4 |
| Organic manure | 82.9 | 93.8 | 87.4 | 97.3 | 72.1 | 86.4 |
| No manuring | 76.9 | 94.9 | 79.8 | 87.8 | 72.8 | 82.4 |
| Overall mea (±0.0333) | 79.0 | 92.0 | 85.0 | 90.9 | 72.4 | 83.9 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 1.77

s.e.d for comparing 2 manure means = 1.37

s.e.d for comparing 2 cultivar x manure means = 3.06

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**Table 5: Effects of yam cultivar and manuring on sprout relative weight (%) of yam in storage.**

| Manuring | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| | Amula (±0.0199) | Danacha (±0.0199) | Ezakwukpolo (±0.0199) | Nwaopoko (±0.0199) | Pepa (±0.0199) | Overall mean (±0.344) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 38.8 | 43.2 | 40.3 | 41.3 | 31.9 | 39.1 |
| Organic manure | 39.9 | 39.1 | 39.0 | 37.2 | 38.2 | 38.7 |
| No manuring | 41.3 | 40.2 | 42.4 | 37.1 | 37.2 | 39.6 |
| Overall mean (±0.0344) | 40.0 | 40.8 | 40.6 | 38.5 | 35.8 | 39.1 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 1.50

s.e.d for comparing 2 manure means = 1.16

s.e.d for comparing 2 cultivar x manure means = 2.60

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**Table 6: Effects of yam cultivar and manuring on sprout relative weight (%) of yam in storage**

| Manuring | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| | Amula (±0.0198) | Danacha (±0.0198) | Ezakwukpolo (±0.0198) | Nwaopoko (±0.0198) | Pepa (±0.0190) | Overall mean (±0..0344) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 6.9 | 5.7 | 5.3 | 5.6 | 6.0 | 5.8 |
| Organic manure | 6.7 | 5.0 | 5.7 | 4.7 | 6.7 | 5.6 |
| No manuring | 6.3 | 4.6 | 5.6 | 5.3 | 5.4 | 5.4 |
| Overall mean (±0.0344) | 6.5 | 5.1 | 5.5 | 5.2 | 6.0 | 5.6 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 0.28
s.e.d for comparing 2 manure means = 0.21
s.e.d for comparing 2 cultivar x manure means = 0.48

**Table 7: Effects of yam cultivar and manuring on rotting (%) of yam in storage**

| | Yam cultivars | | | | | |
|---|---|---|---|---|---|---|
| Manuring | Amula (±0.0528) | Danacha (±0.0528) | Ezakwukpolo (±0.0528) | Nwaopoko (±0.0528) | Pepa (±0.0528) | Overall mean (±0.0915) |
| $N_{90}$ $P_{10}$ $K_{20}$ | 49.3 | 35.4 | 37.6 | 34.0 | 42.3 | 39.7 |
| Organic manure | 42.2 | 33.1 | 37.4 | 42.3 | 39.3 | 38.8 |
| No manuring | 44.2 | 30.1 | 37.3 | 34.8 | 33.3 | 35.9 |
| Overall mean (±0.0915) | 45.2 | 32.9 | 37.4 | 37.0 | 38.3 | 38.1 |

In parenthesis is the standard error of the mean = (±SEM)

s.e.d for comparing 2 cultivar means = 1.93

s.e.d for comparing 2 manure means = 1.50

s.e.d for comparing 2 cultivar x manure means = 3.35

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