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STORAGE LIFE OF ELEVEN CULTIVARS OF WHITE YAM (*DIOSCOREA ROTUNDATA*) GROWN WITH OR WITHOUT NPK FERTILIZER AND THE RELATIONSHIP WITH RESIDUAL SOIL NPK

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ABSTRACT
A major constraint facing yam producers in southeastern Nigeria is poor storage of the tubers. Farmers in the area also opine that yams grown with mineral fertilizers tend to have shorter shelf life than those grown without mineral fertilizers. This study was undertaken to evaluate the effect of the applied mineral fertilizer on cultivar weight loss and the relationship between the weight loss and residual soil NPK. The selected (wound-free and about similar size) tubers were stored in a shaded but well ventilated traditional barn. Weight loss from tubers of eleven cultivars (ten cultivars were developed at IITA and the 11^th^ one was a local best, Cv. Nwopoko.) of white yam (Dioscorea rotundata) was monitored monthly for six months following harvest in November at Nsukka, southeastern Nigeria. The tubers were from plots that received 15:15:15 NPK fertilizer mixture and those that did not receive any fertilizer. The result showed that there was a significant difference (p<0.001) between the loss in weight in tubers from fertilized and unfertilized plots. The average monthly loss in weight was 44% higher in tubers grown with fertilizer than those grown without fertilizer. The highest and the least losses in weight were obtained from IITA cultivars TDr 93-46 and TDr 95-127 respectively, for tubers from fertilized and unfertilized plots, while loss by the local cultivar was the second highest in both cases. A correlation of the tuber weight loss with residual soil NPK was not significant, however, tuber yield from unfertilized plots significantly correlated with residual soil K. Similarly tuber yield from fertilized plots correlated with residual total N. Some of the cultivars whether grown with or without fertilizer stored better than others. Cultivar effect was significant on weight loss (p<0.001) and more pronounced than fertilizer effect by more than 200%.

Key words: yam, NPK fertilizers, shelf life, Nigeria

INTRODUCTION
Most of the soils in the tropics are known to be poor in fertility status (Okigbo, 1989); hence, there is the need to supplement the amount of nutrients for optimal crop performance. The poor fertility status is even more related to chemical than physical properties according to Fernandez and Sanchez (1990). Yams according to Obigbesan and Agboola (1978) are heavy feeders and thus constitute a heavy drain on the soil. They thus recommended that at least liberal dressing of mineral fertilizer is necessary for increased yields. Over 49% increase in tuber yield has been reported by Asadu (1989) from fertilized over unfertilized plots, thus supporting the use of mineral fertilizer in yam production. However, yam farmers often opine that the tubers produced with mineral fertilizers tend to have shorter shelf life than those produced without mineral fertilizers.

Loss of yam in storage may range from 30-66% of the total output in southeastern Nigeria (Ugwu, 1995). The causes of yam tuber loss in storage as shown in earlier studies have been associated with pests, diseases, damage during and after harvest (e.g. during transportation), temperature and humidity variations as well varietal differences. Data on how the yams were grown are often not available especially the use of fertilizers. This is acute with the use of fertilizers. This is because farmers in the area hardly use both the recommended type and rate as well as the same type and rate over the years due to lack of and/or high cost of fertilizers (Nweke et al., 1991). Good posth harvest keeping quality of yam tubers has been acknowledged as an essential attribute to target in breeding programme (Asiedu and Wanyera, 1995).

Weight loss is one of the severest indications of yam tuber deterioration which may be due to deleterious reactions (Osuji and Umezurike, 1985). Other reactions that result to deterioration may be due to protein hydrolysis and disintegration of the membranes of the tubers. Weight losses result from respiration (largely due to the oxidation of stored starch), desiccation and sprouting. Up to 35% of the total weight loss at 25°C may be due to respiration during sprouting and up to 30% immediately after harvest (Ikediobi, 1985). Coursey and Walker (1960) had earlier shown that about 10% of the dry matter of tubers could be lost through respiration over a five–month period while dehydration could account for up to 20% weight loss for the same period. The objective of this study was to evaluate the effect of applied mineral NPK fertilizer mixture on the shelf life of eleven cultivars of white yam and the relationship between the tuber weight loss and residual soil NPK

MATERIALS AND METHODS

Location

The study was carried out at the University of Nigeria, Nsukka (lat.6° 52'N; long. 7° 25'E) Southeastern Nigeria. Nsukka is within the yam zone of West Africa. The annual rainfall is about 1560mm while average minimum and maximum temperatures are approximately 25°C and 30°C respectively. The relative humidity is hardly below 60% except during the *hammatan* (December-January) when the atmosphere is noticeably very dry (Ofomata, 1975). The general average climatic elements as reported by Asadu (2002) for the specific location are shown in table 1.

Yam tuber sampling

Three tubers of white yam (*Dioscorea rotundata*) were selected from each of the 11fertilized (rate 400 kg ha^{-1}, 15:15:15 NPK) and unfertilized plots established to evaluate the agronomic performance of 10 IITA and one local cultivars. A total of 66 tubers were selected. The ten IITA cultivars and the selected local best are listed below V1 = TDr 93-31, V2 = TDr 93-2,V3 = TDr 93-1, V4 = TDr 93-32, V5 = TDr 93-46, V6 = TDr 93-38, V7 = TDr 93-107, V8 =TDr 95-115, V9 = TDr 95-127, V10 = TDr 95-131, V11 = local *nwopoko*

The tubers were weighed immediately after harvest in November. They were then taken to a shaded and ventilated barn for storage. The tubers were placed at random on a raised rack in the barn. The weight of each was taken monthly for six months.

Soil sampling

With the help of soil auger, soil samples were collected at 0-20 cm depth closest to the point where the yams were harvested. The samples were air-dried and sieved with 2-mm sieve. Residual soil total nitrogen, available phosphorus and exchangeable potassium were determined from the soils following standard laboratory techniques. Total N was determined by the macro-Kjeldahl distillation method of Jackson (1962), available P (Bray II) was by the Bray and Kurtz (1945) method and exchangeable K was determined by the method described by Jackson (1962).

RESULTS AND DISCUSSION

In 1998 the mean tuber yield obtained (Table 2) from unfertilized plots (8.2 tha^{-1}) was less than that from fertilized plots (8.4 tha^{-1}) but the difference was not statistically significant. It is possible that the soil had adequate nutrients that did not elicit significant yield response to mineral fertilizer application in 1998.

This is often the case when a fallow land or a virgin forest is cultivated for the first time. The land was under fallow for at least 10 years before the trial was established. Tuber yields obtained (6.9 tha^{-1} from fertilized and 5.7 tha^{-1}from unfertilized plots) from the subsequent year (1999) confirmed this because there was a significantly ($p<0.001$) higher mean yield from fertilized than from unfertilized plots for the same location. The increase in yield was above 20%.

Table 1. General averages for climatic elements at Nsukka

Climatic element	Mean	Standard deviation	C.V. (%)	Number of years
Rainfall (mm)	1529	246.5	16.1	18
Relative humidity (%)	68.3	2.5	3.6	18
Minimum temperature (^oC)	20.4	1.4	6.8	14
Maximum temperature (^oC)	30.1	0.5	1.8	14
Sunshine hours	5.2	0.3	6.0	13
Evapotranspiration (mm day^{-1})	5.8	0.8	13.6	8

Source: Asadu (2002)

However, the residual content of soil NPK suggest that whatever nutrient that was applied as mineral fertilizer could have been absorbed by the yam possibly as luxury uptake which did not reflect significantly in the tuber yield in the case of 1998. Fertilizer effect on weight loss was not significant in 1999; hence comparisons were made using the 1998 data.

Both fertilizer and cultivar effects were significant ($p<0.001$) on tuber weight loss but only cultivar effect was significant ($p=0.05$) on residual total N (Table 3). This is an indication that the nitrogen applied through the mineral fertilizer was implicated in the weight loss and this varied according to cultivar. Tuber yield significantly ($p < 0.05$) correlated with residual exchangeable potassium for data from the unfertilized plots (Table 4). Again the yield only significantly ($p < 0.05$) correlated with residual total nitrogen for the corresponding data obtained from fertilized plots. The other relationships were not significant. The implication of this is that higher yield obtained from fertilized plots was probably due to higher N uptake from the fertilized plots.

The highest mean loss in weight was obtained from cultivar V_5 (TDr 93-46) while the lowest was obtained from cultivar V_9 (TDr 95-127) for samples from both fertilized and unfertilized plots (Table 2). This also shows that weight loss is related to cultivar differences.

Table 2: Mean (SEM) of weight loss, residual total N, available P and exchangeable K in 1998

Source (Varieties)	Weight ($gmonth^{-1}$)	Residual total N x10 (%)	Residual available P ($mgkg^{-1}$)	Residual exch. K ($cmol\ kg^{-1}$)
V1	78.3(21.67)	9.3(0.25)	3.5(0.30)	0.13(0.005
V2	84.2(13..83)	9.1(0.10)	3.4(0.20)	0.10(0.00)
V3	73.3(3.34)	9.8(0.15)	3.8(0.55)	0.11(0.01)
V4	116.7(30.00)	9.8(0.05)	3.8(0.00)	0.11(0.00)
V5	224.2(24.7)	8.6(0.40)	3.5(0.30)	0.11(0.01)
V6	87.8(20.58)	9.1(0.65)	3.8(0.55)	0.11(010)
V7	98.8(22.08)	8.8(0.80)	3.8(1.10)	0.10(.00)
V8	103.3(36.67)	7.4(0.25)	3.5(0.80)	0.10(0.00)
V9	57.5(5.83)	8.1(0.20)	3.3(0.55)	0.11(0.01)
V10	95.8(12.50)	8.0(0.35)	3.2(0.00)	0.11(0.10)
V11	127.5(30.83)	8.2(0.10)	4.1(0.25)	0.13(0.00)
Fo	85.5(12.15)	8.7(0.70)	3.3(0.50)	0.11(0.01)
F1	123.1(15.39)	8.7(0.97)	3.9(0.52)	0.10(0.03)

Note: SEM = standard error of mean, V1 = TDr 93-31,V2 = TDr 93-2, V3 = TDr 93,1V4 = TDr 93-32, V5 = TDr 93-46, V6 = TDr 93-38, V7 = TDr 93-107, V8 = TDr 95-115,V9 = TDr 95-127, V10 = TDr 95-131, V11 = local *nwopok*

Table 3: Cultivar and fertilizer effects on tuber weight loss and residual total N in 1998

Source of variation	Df	Type III SS	Mean square	F-Value/ prob.level
		Weight loss		
Fertilizer	1	7776.81	7776.81	26.40***
Cultivar	10	39329.85	3932.98	13.35***
		Total N		
Fertilizer	1	$1.8x10^{-7}$	$1.8x10^{-7}$	0.01^{NS}
Cultivar	10	$1.1x10^{-3}$	$1.1x10^{-2}$	3.73*

NS= not significant, * = significant at 0.05, * = significant at <0.001 probability levels.**

Table 4. Correlation coefficients between tuber weight and residual soil total N, residual available P, and residual exchangeable K

Source of variation	N	Residual total N (%)	Residual available P ($mgkg^{-1}$)	Residual exch. K ($cmolkg^{-1}$)
Unfertilized	11	-0.072ns	0.514ns	0.744*
Fertilized	11	0.618*	0.061ns	0.275NS

NS* : Not significant and significant at 0.05 probability levels, respectively

A comparison using V_5 and V_9 shows that the differences between fertilized and unfertilized plots in weight loss were only 24 and 23 % respectively. On the other hand, the differences between V_5 and V_9 from unfertilized and fertilized plots were 289 and 292% respectively. This is seen from the actual values of the average monthly losses in weight by both varieties. Generally, weight loss from V_5 whether from fertilized or unfertilized plot was higher than both values obtained from variety V_9. Thus V_5 irrespective of the fertilizer treatment lost more weight than V_9. (Fig.1)

Except V_2 (TDr 93-2), all the mean values obtained from tubers from fertilized plots were higher than their corresponding values from unfertilized plots. Generally, the mean loss in weight from tubers obtained from fertilized plots was significantly ($p<0.001$) higher than that from unfertilized plots (Table 5). Earlier studies indicated that the factors that affect the loss in weight of yam tubers include physiological and biochemical reactions such as respiration and desiccation (Coursey 1967, Osuji and Umezurike 1985 and Okoli *et al.* 1985). Thus it is most likely that the higher values of weight loss from tubers obtained from fertilized plots was an indication that these processes went on at a higher rate in those tubers than in tubers from unfertilized plots. This also suggests that the tubers from fertilized plots deteriorated more than those from unfertilized plots, thus resulting in shorter shelf life of the former.

Table 5. Comparison of the mean loss in weight between tuber from fertilized and unfertilized plots

Source of variation	N	Mean (g $month^{-1}$)	SD	t-value/ significant level
Fertilized	11	123.1	51.0	-1.91***
Unfertilized	11	85.7	40.3	

*** Significant at P < 0.001.

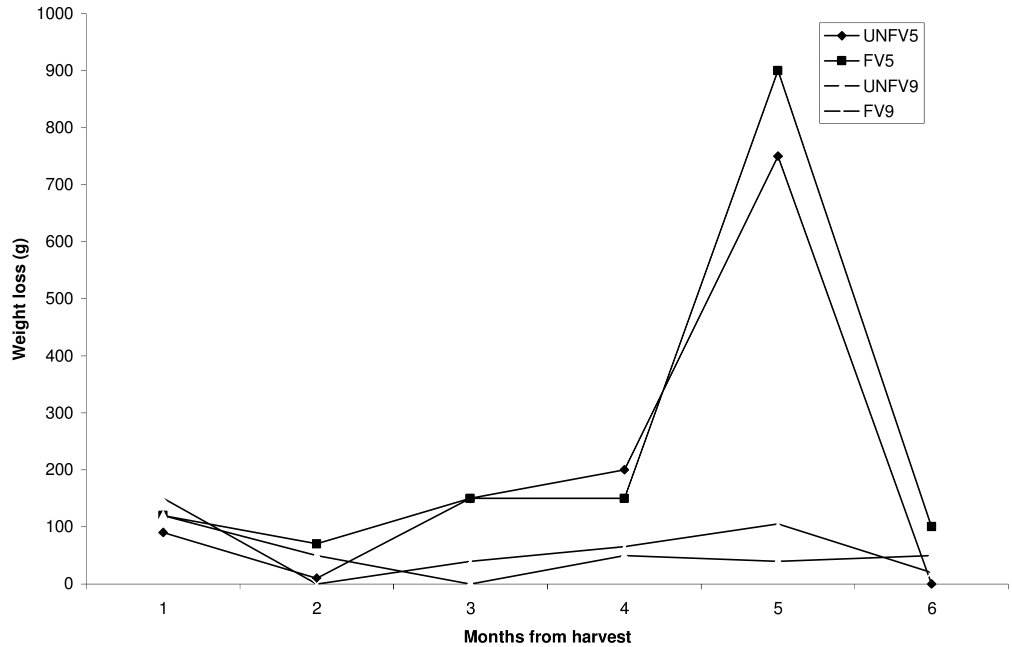

Fig1. Monthly average loss in weight by varieties 5 and 9 from both fertlized (F) and unfertilized (UnF) plots

This is supported by the significant correlation between tuber yield and total nitrogen in fertilized plots. The higher yield from the fertilized plots could have been associated with luxury uptake of N which in turn resulted in higher rate of deterioration (weight loss).

Another factor that could have accounted for the higher loss in weight of tubers from fertilized plots was higher infections by putrefying organisms especially those that cause the wet rot in tubers. This observation was noted in the barn during the period of the study. It is well known that high rates of N combined with P result in substantial increases in the population of the yam nematode (*Scutellema bradys*) in white yam (*Dioscorea rotundata*) and the injury/damage caused by nematode may aid fungi and bacteria which cause rots in yam in storage. Thus, the possible luxury uptake of applied N and P could have contributed to this loss in weight in tubers from the fertilized plots. This stresses the need for pre-planting soil test where mineral fertilizers have to be used. This is scarcely done by the poor rural farmers who constitute the major yam producers in Nigeria. Thus, their often-expressed view that mineral fertilizers tend to reduce the shelf life of tubers could emanate from luxury uptake of applied mineral nutrients.

It was also noted that the tubers from fertilized plots sprouted faster than those from unfertilized plots. It has been reported that sprouting also contributes to loss in the weight of yam tubers. In fact the loss in weight of yam tubers is greatest after dormancy is broken because according to Orkwor and Ekanayake (1998) sprouting is a very active and energy demanding physiological process that results in high losses in dry matter and moisture. Thus if dormancy period could be prolonged, a longer shelf life of healthy yam tubers could be achieved. It is possible that the imbalance between NPK absorbed by the yams and/ or their contents in the tubers are responsible for tubers from the fertilized plots sprouting faster. This is because Aduayi and Okpon (1980) have reported that the nitrogen content of tubers increases sprouting while P and K contents tend to suppress it. This implies prolonging the dormancy period. A long dormant period without loss of viability enables the tubers to be used in propagation and is a factor in the perenniality of yam (Passam 1982). Dormancy is known to be associated with low levels of glutathione in tubers (Campbell *et al.* 1962) and also with a group of growth inhibitors called batatasins (Ireland *et al.* 1981). Thus, it is possible that mineral fertilizer has influence on the contents of glutathione and the inhibitors. This, however, needs further evaluation.

CONCLUSION

The study showed that tuber weight loss could vary according to white yam cultivars when grown in southeastern Nigeria irrespective of whether mineral fertilizer was used or not. Again, cultivars grown with mineral fertilizer experienced significantly higher weight loss than those grown without fertilizer. The effect of cultivar variation was substantially higher than that of mineral fertilizer but the application of NPK 15: 15: 15 fertilizer mixture in yam production could result in reduced shelf life of tubers especially where there is no significant yield response to fertilizer application.

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