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Evaluation of Some Growth and Yield Traits of Nine Cultivars of White Guinea Yam (*Dioscorea rotundata* poir.)

***Okon J. Ekwere, Arit O. Efretuei, Patrick I. Udounang and Fidel E. Akpaninyang**

Department of Crop Science, Akwa Ibom State University, Obio Akpa Campus, Oruk Anam, Nigeria

*Corresponding author: okonekwere@aksu.edu.ng: Tel: 234-08035492153

Abstract

White guinea yam is a chief source of carbohydrate in West Africa. Knowledge of the relationship between its agronomic traits and tuber yield can contribute to improving management practices and selecting the right cultivars for optimum yield. Field experiments were conducted during the 2021 and 2022 early cropping seasons at the Teaching and research farm of the Akwa Ibom State University, Obio Akpa Campus, to study the agronomic and yield traits of some white guinea yam cultivars. The experiment consisted of eight cultivars of the white yam (TDr 0900135, TDr 0900295, TDr 1401593, TDr 1401785, TDr 1100180, TDr 110028, TDr 1401220 and TDr 8902265) and a local variety, Atam. The experiment was laid out in a randomized complete block design and replicated three times. The effect of cultivars on growth and yield parameters were determined using a one way ANOVA and the relationships between growth and yield parameters were determined using Linear regression and Pearson Correlation Coefficient. There were significant differences among the yam cultivars in number of leaves produced per plant, number of tubers per plant and fresh tuber yield (tons/ha). Cultivar TDr 8902665 and TDr 140220 performed better than other cultivars in yield (8.05 and 8.91 tons/ha in 2021 and 8.42 and 8.85 tons/ha in 2022). The local variety, Atam sprouted late and also produced a low yield (6.8 tons/ha) compared to most cultivars. Across cultivars, there was a positive relationship between leaf number and tuber yield and vine numbers and tuber length-leaf numbers could significantly predict tuber yield and no of vines, tuber length. Cultivars TDr 140220 and TDr 8902665 have shown potential to outperform the other cultivars tested in this study. Yam farmers may adopt these varieties for cultivation in this study area.

Keywords: Tuber yield, Yam, Tuber length, Leaf numbers, Cultivars

1.0 Introduction

White guinea yam is a tropical vine with large edible starchy tuber. It is native to tropical Africa where it is predominantly cultivated (Ikwelle et al., 2003). It is the world's most important root and tuber crop after potato, cassava and sweet potato. Yam is a major source of staple carbohydrate for over 60 million people in West Africa (FAO, 2015). It does not only serve as staple food, it plays an important role in the religion, tradition, culture as well as the local commerce of the people (Hahn et al., 1993). About 5 million hectares of yam is cultivated annually in about 40 countries in the tropical and subtropical countries of the world, with Nigeria as the world's leading producer (FAO, 2010). Nigeria produces about 1.813 million metric tons of yam tubers from 1.5 million hectares of land annually (Law-Ogbomo & Remison, 2008).

Yam is propagated vegetatively through the tubers which are cut into pieces or planted whole (Ekwere, 2019). It is widely believed however, that the growth and yield of yam is largely dependent upon the size and quality of the planting material, besides the availability of, and provision of the necessary agronomic conditions (Kalu, 1989). Ugwu (1990) stated that coefficient variations exist among yam genotypes and phenotypes, and that these together, were responsible for tuber yield; but it has been proven that the crops optimal yield can be affected by the environment. Ekwere et al. (2013) reported a reduction in yield due to inter-specific and intra-specific competition in the growth environment. In addition, low soil fertility has also been reported as a limiting factor on crop yield (Efretuei et al. 2023). Recent studies in Nigeria have shown that crop productivity (within an environment) can be improved with the use of precise agricultural technologies and the selection of the right cultivars (Akpan et al. 2022; Ekwere and Efretuei, 2020; Eseme et al., 2019; Jonah et al 2023). Vashi et al. (2018) found a positive correlation between growth attributes- tiller numbers, vine length, (influenced by a crop environment), and fresh weight of yam tubers.

Developing appropriate genetic and crop management technologies for yield increase requires specific knowledge of how growth traits influences yield (Yahaya et al., 2015). Grafius (1959) stated that increasing the total yield is easier by improving its components. In a study of some growth attributes (length and number of vines, number of leaves, leaf size and number of roots per plant) and their interrelationship with yield, Maity and Chatteijee (1997) reported that growth attributes were observed to be closely connected with yield in sweet potato. Law-Ogbomo and Remison (2008) attributed a positive correlation of the harvest index of white guinea yam with fertilizer application rates, and went on to conclude that it was an indication of enhanced translocation of assimilates from source (vines and leaves) to the sink (tuber) resulting in greater bulking ability of the white guinea yam. However, Diby et al. (2011) found no correlation between the above ground organs dry matter and tuber dry matter increase, and therefore demanded explanation to understand the source (leaves) – sink (tubers) relationship in yam. This study was conducted to evaluate some growth and yield traits of nine cultivars of the white guinea yam.

2.0 Materials and Methods

Field trials were conducted at the Teaching and research farm of the Faculty of Agriculture, Akwa Ibom State University, Obio Akpa Campus, during the *2021 and 2022 early cropping* seasons to evaluate some agronomic traits and yield attributes of some cultivars of the white guinea yam. Obio Akpa is located on latitude $4^0 31^1$ and 50^0 30^1N, and longitude 8^0 30^1 $8^0 00^1$E, in the humid tropical rainforest zone of South Eastern Nigeria. It records an annual rainfall of about 2500 mm. The rainfall lasts between April and November, with a short dry spell in August which usually lasts for about two weeks (August break). The soil of the study area is predominantly sandy loam and acidic; temperature ranges between 22.5^0C and 30.7^0C; the relative humidity is about 78% (SLUS-AK, 1989).

The experiment consisted of eight cultivars of the white yam –viz- TDr 0900135, TDr 0900295, TDr 1100180, TDr 110028, TDr 1401220, TDr 1401593, TDr 1401785 and TDr 8902665 all sourced from the National Root Crops Research Institute, Umudike, Nigeria. There was also a local variety, Atam which is widely cultivated among the farmers in Obio Akpa Community. The yam setts (planting materials) weighed between 500 to 700g, and were planted at 1 m^2 corresponding to 10,000 stands per hectare. Each experimental unit measured 4 x 4 m and consisted of 25 stands of yam planted in five rows. The experimental units were separated from each other by paths wide as 1.2 m and the replicates were separated by a path measuring 1.5 m. The experimental design was randomized complete block design and replicated three times. Five plants from the inner rows were randomly selected from each experimental unit and tagged for the purpose of data collection. Data were collected on shoot emergence, number of leaves, vine length, number of vines/plant and fresh tuber yield. The data were analyzed using the analysis of variance in the IBM SPSS Statistic Software Version 22. Means which showed significant differences were separated using the Tukey Kramer Multiple Comparison Test. In addition, the relationship between yield and growth parameters was determined using linear regression and Pearson correlation.

2.1 Soil Analysis

Soil samples (0-15 cm) were taken, air- dried, sieved and subjected to analysis. Particle size distribution was determined by the Bouyoucos hydrometer method as described by Udo et al. (2009). Soil pH was measured electronically in 1:1.5 soil-water suspensions (Mclean, 1982). Soil organic matter was determined by the Walkley-Black wet oxidation method (Black, 1965). Phosphorous was determined by the Bray P-1 method (Olsen & Sommers, 1983). Exchangeable cations (K, Ca. and Mg) were extracted in 1M NH4OAC at pH 7. K and Na were determined on the flame spectrometer, while Ca and Mg were determined on the atomic absorption spectrophotometer. Effective cation exchange capacity (ECEC) was obtained by the summation of the exchangeable bases and the exchangeable acidity (Udo et al., 2009). Percentage base saturation was calculated as the ratio of exchangeable bases to the ECEC multiplied by 100.

3.0 Results

Results of the growth and yield parameters of the white yam are presented in Tables 3.2 and 3.3. Results indicated that there were significant differences in days to sprout emergence among the

white yam cultivars. Cultivar TDr 1401220 emerged much earlier than most cultivars in 2022 (Table 3.3). It emerged in 45.67 days after planting. In 2021, the cultivar TDr 8902665 emerged earlier than most cultivars: it emerged in 46.38 days. The local variety, Atam was the last to emerge each year (56.66 days in 2021 and 57.00 days in 2022). Cultivars which took longer days to emerge invariably produced lower yields, for example, Atam took 57.00 long days to emerge, it also produced a yield of 6.81 tons/ha which was significantly lower than 6 cultivars in 2022.
Number of vines per plant produced over the two planting seasons ranged from 1.13 to 1.93. In 2022, TDr 8902665, TDr 1401220, TDr 110028 and Atam were amongst the highest producers of vines, numbers ranging from 1.47 - 1.93, with TDr 8902665 peaking the list. In 2021, there

Table 3.1: Physico-chemical properties of the soil of the study area

Physical properties	
Sand (%)	79.2
Clay (%)	17
Silt (%)	3.8
Texture class	Sandy Loam
Chemical properties	
Soil pH (%)	4.9
Organic matter (%)	2.59
Total N (%)	0.1
Available P (mg/kg)	181
Exchangeable bases (c/mol/kg)	
Ca	1.28
K	0.05
Mg	0.32
Na	0.19
Exchangeable acidity (c/mol/kg)	1.4
Effective CEC (c/mol/kg)	4.04
Base saturation	94.72

was no significant difference in vine numbers between cultivars although TDr 8902665 was among the highest producers of vines. With leaf numbers, TDr 8902665 was also among the highest producer in 2021 (93.33) while the highest number of leaves in 2022 (92.33) were produced by TDr 1401220.

There were no significant differences in length of tubers among the yam cultivars in 2022. In 2021, TDr 8902665 produced the longest tubers (44.66cm) followed by TDr 11028 and TDr 110180, both of which produced tubers 43.0cm long. The shortest tubers (32.33cm) were however produced on cultivar TDr 1401220. TDr 1401220 consistently produced a high fresh tuber yield (8.91 tons/ha in 2021 and 8.85 tons/ha in 2022). The lowest (numerical) yield (6.81 tons/ha) was produced by Atam in 2022.

Results also indicate that there was significant positive correlation between fresh tuber yield and some agronomic traits of the white yam; tuber yield correlated positively with establishment percentage (r^2 = 0.98 in 2021, and r^2 = 0.37 in 2022), days to 50% emergence (r^2 = 0.71 in 2021, r^2 = 0.2 in 2022) and number of vines per plant (r^2 = 0.31 in 2021, and 0.43 in 2022). Linear regression revealed a significant negative relationship between tuber yield and the number of days to first sprout in 2021 (figure 3.1). The cultivars with shorter days to first sprout produced higher yields. Number of days to sprout significantly predicted tuber yield. $F, (1, 25) = 4.8$. $P = 0.038$. It accounted for 16.10% of variations in tuber yield with adjusted R = 12.8%;

Additionally, regression analysis indicated a positive linear relationship between tuber length and number of vines per plant in 2021 (Figure. 3.2). Number of vines significantly predicted tuber length $F (1,25) = 4.03$; longer tubers were commensurate with more vines per plant. Number of vines accounted for 15% variation in tuber length. Adjusted R = 11.60%. There was a positive linear relationship between number of leaves per plant and tuber yield in both 2021 and 2022. Number of leaves per plant statistically significantly predicted fresh tuber yield $F (1, 25) = 5.134$. $P = 0.032$, and was responsible for 17.1% of variation in tuber yield of yam in 2021 (Figure 3.3). In 2022, fresh tuber yield increased with increase in leaf number also (Figure 3.4). Number of leaves per plant also significantly predicted tuber yield $F(1,25)$ 8.950. $P = 0.006$. The number of leaves per plant were responsible for 26.4% of fresh tuber yield; plants that had more than 80 leaves were more likely to produce tubers up to, or above 8.0 tons/ha (Figure. 3.4).

4.0 Discussion

Results of the experiment indicated significant differences in growth and yield traits among the yam cultivars. Cultivar TDr 8902665 performed better than other cultivars in most growth and yield parameters considered in the experiment; it sprouted early, produced the high number of leaves, produced the longest tubers and also produced a high tuber yield compared to most cultivars. The local variety, Atam gave a low performance; it sprouted late and also produced a low yield compared to most cultivars.

It was also observed that cultivars that took longer days to emerge tended to produce lower yield. It is possible that plants that emerged late also initiated roots much later than others that emerged earlier, and therefore, could not benefit maximally from the early flush of essential soil nutrients, some of which are very mobile. Obio Akpa is located in the tropical rain forest which is characterized by sandy and acidic soils, heavy rain fall which causes leaching and fast declining soil fertility. Recent studies have confirmed low soil fertility at Obio Akpa (Ekwere & Efretuei, 2021). Akpan et al. (2022) stated that declining soil fertility is a major production constraint in Africa, and this is especially true of the tropical rain forest area of Nigeria.

Table 3.2: Growth and yield parameters of the white yam in 2021

Treatment	Days to 1st sprout emergence	Establishment (%)	No. of vines/plant	No of leaves/plant	Tuber length (cm)	Tuber circumference (cm)	Nos. of tubers/plant	Tuber yield (t/ha)
Atam	56.66^{a}	80.23	1.46	83.66^{b}	37.00^{c}	35.33^{b}	1.45^{c}	7.82^{bc}
TDR 0900135	47.33^{c}	88.16	1.40	70.24^{cd}	40.67^{bc}	34.27^{bc}	1.38^{c}	7.65^{c}
TDR 0900295	51.66^{b}	90.31	1.43	68.00^{d}	37.00^{c}	33.23^{bc}	1.18^{d}	7.65^{c}
TDR 1100180	49.33^{bc}	92.26	1.26	77.33^{bc}	43.00^{b}	35.66^{b}	1.35^{c}	7.95^{bc}
TDR 1100280	50.24^{b}	89.14	1.23	72.66^{c}	43.00^{b}	39.33^{ab}	1.76^{a}	8.01^{ab}
TDR 1401220	50.13^{b}	87.66	1.73	89.66^{a}	32.33^{d}	29.33^{cd}	1.78^{a}	8.91^{a}
TDR 1401593	49.31^{bc}	90.32	1.36	77.60^{bc}	39.00^{bc}	34.66^{bc}	1.18^{d}	7.55^{cd}
TDR 1401785	47.23^{c}	87.12	1.56	72.66^{c}	35.33^{cd}	31.36^{c}	1.28^{c}	7.05^{c}
TDR 8902665	46.38^{cd}	88.65	1.73	93.33^{a}	44.66^{a}	41.26^{a}	1.73^{b}	8.05^{ab}
P value	0.006	NS	NS	0.001	0.017	0.002	0.012	0.024

Table 3.3: Growth and yield parameters of white yam in 2022

Treatment	Days to 1st sprout emergence	Establishment (%)	No. of vines/plant	Nos. of leaves/plant	Tuber length (cm)	Tuber circumference (cm)	Nos. of tubers/plant	Tuber yield (t/ha)
Atam	57.00^{a}	88.67	1.81^{ab}	80.67^{b}	43.33	34.35	1.57^{abcd}	6.81^{e}
TDR 0900135	51.00 ^{bcd}	90.67	1.13^{d}	73.67^{bcd}	40.67	33.19	1.31^{cde}	7.92^{b}
TDR 0900295	49.00^{bcd}	84.00	1.33^{d}	79.33^{b}	38.13	32.63	1.13^{ef}	7.87^{bd}
TDR 1100180	52.33^{ab}	86.00	1.33^{d}	77.26^{bc}	35.34	30.10	1.32^{cde}	7.77^{bd}
TDR 1100280	51.67^{bcd}	91.33	1.47^{abc}	81.33^{b}	37.36	33.31	1.73^{ab}	7.45^{bcde}
TDR 1401220	45.67^{d}	87.67	1.87^{ab}	92.33^{a}	40.42	34.23	1.83^{a}	8.85^{a}
TDR 1401593	53.00^{ab}	87.33	1.37^{d}	66.33^{d}	37.67	36..37	1.17^{ef}	7.14^{bcde}
TDR 1401785	48.33^{abc}	88.67	1.37^{d}	88.33^{a}	33.42	37.67	1.26^{ef}	7.62^{bcd}
TDR 8902665	52.33^{abc}	84.00	1.93^{a}	88.67^{a}	42.33	36.24	1.64^{abc}	8.42^{ab}
P value	0.036	NS	0.017	0.001	NS	NS	0.004	0.001

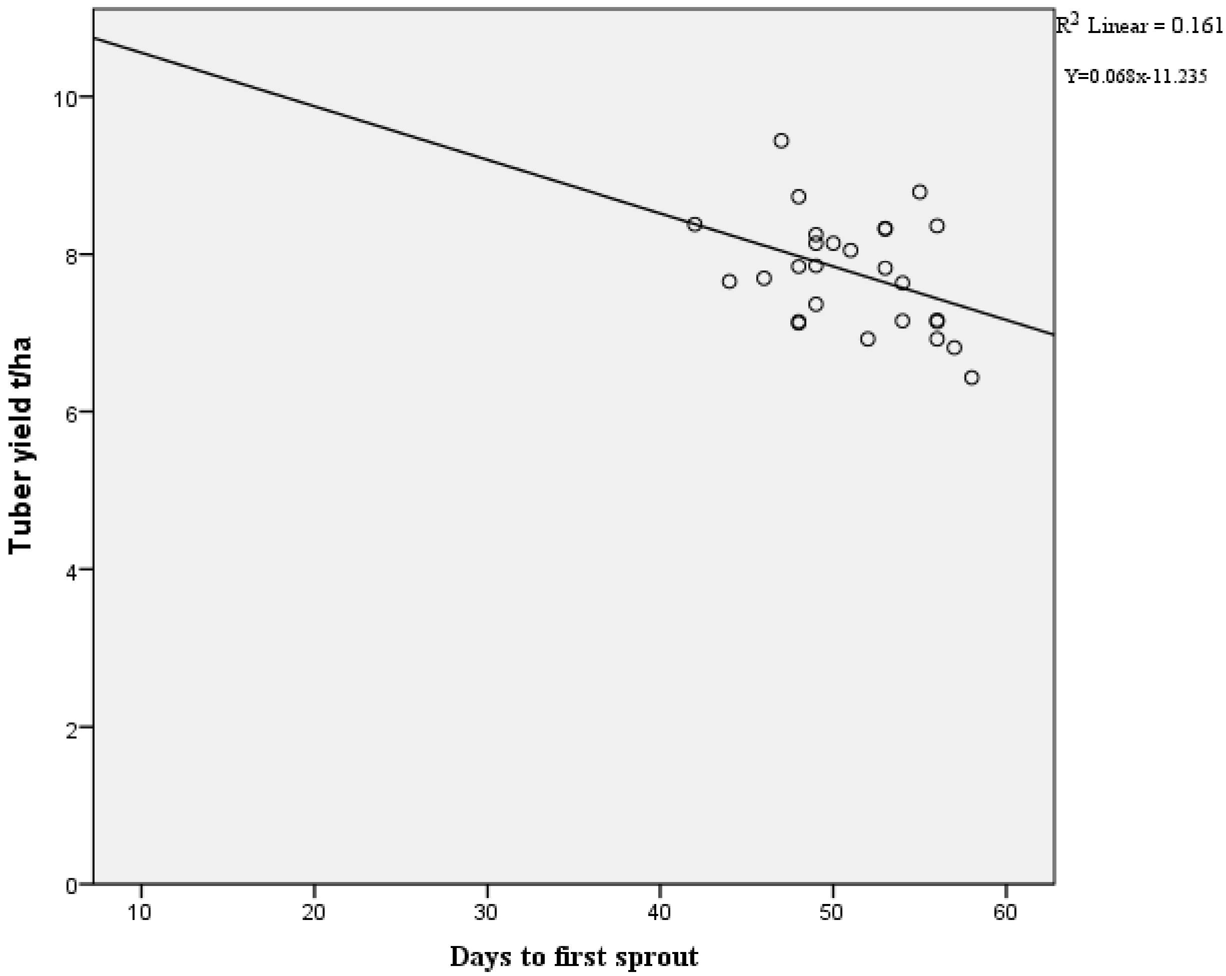

Figure 3.1. Scatter plot showing relationship between tuber yield and days to first sprout in 2021

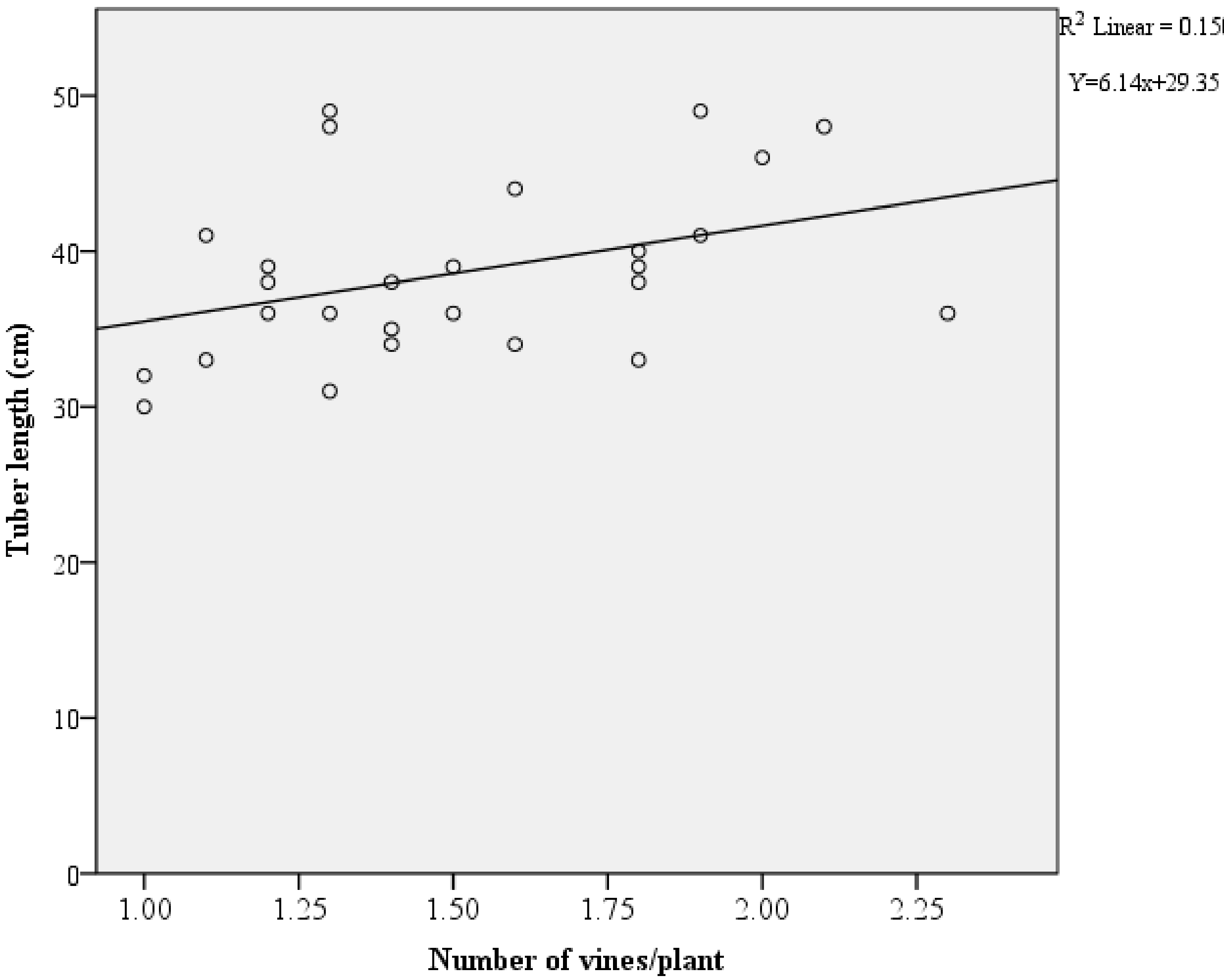

Figure 3.2: Scatter plot showing linear relationship between number of vines/plant and tuber length in 2021

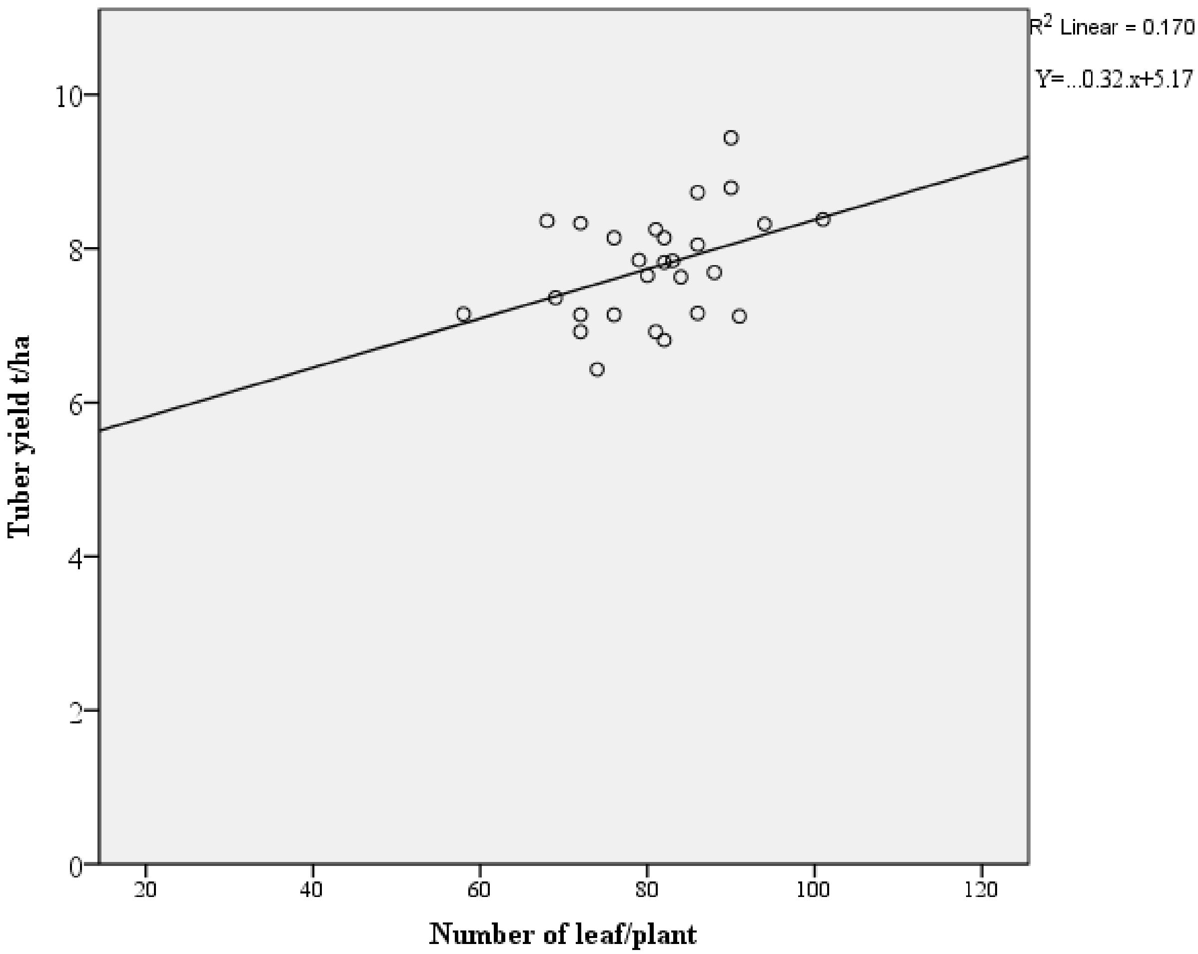

Figure 3.3: Scatter plot showing linear relationship between leaf number/plant and tuber yield in 2021

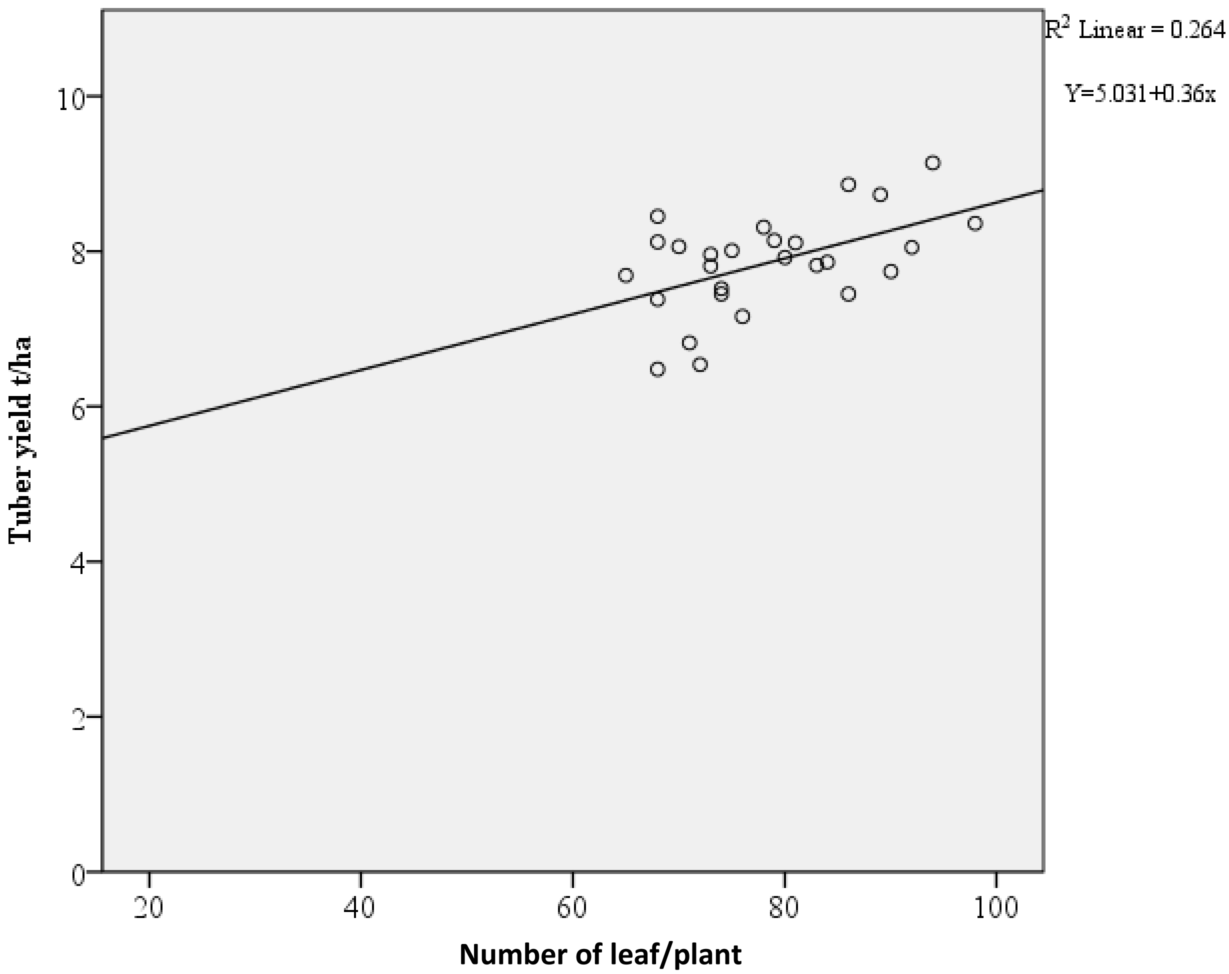

Figure 3.4: Scatter plot showing linear relationship between number of leaves/plant and tuber yield in 2022

There was a strong positive correlation between leaf production and tuber yield of yam; plants that produced more leaves tended to produce higher tuber yields. These results agree with Law-Ogbomo and Remison (2008) who stated that increase in total dry weight of yam tubers paralleled increase in leaf number. It is expected that increase in leaf number would enhance greater exposure of the leaves to sunlight, and the production of assimilates and translocation of same, from the sites of photosynthesis to the tubers – resulting in greater bulking ability of the white guinea yam.

The link between export of sugars from leaves and the corresponding demand by sinks have been examined as a possible target for improving plant productivity (Ainsworth & Bush, 2011). Results from this experiment suggests that increase in the number of leaves and vines of yam (which constitute the above- ground biomass) ensured better utilization of the solar radiation, resulting in the yield of longer tubers of yam.

5.0 Conclusion

Results of this experiment indicate that interrelationships exist between growth and yield traits of the white yam. White yam cultivars which emerged early in the season, tended to produce more vines and leaves. For all the yam cultivars tested in this experiment, there was a positive relationship between leaf number and tuber yield, as well as tuber length and number of vines. Cultivars TDr 140220 and TDr 8902665 have shown potential to outperform the other cultivars (with regards to tuber yield) tested in this study. Yam farmers may adopt these varieties for cultivation in this study area.

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