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Research Paper

Leaf and tuberous root yields of cassava (*Manihot esculenta* Crantz var TME 419) in relation to the number of stems per strain at Gbadolite in the Democratic Republic of Congo

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Abstract
The aim of this study was to verify the influence of stem number on cassava tuberous root yield in Gbadolite, North Ubangi province, Democratic Republic of Congo. The biological material used for this study was cassava cuttings from a farmer's field of cultivar TME 419 (Obama). The experimental set-up used was that of randomized complete blocks arranged in 3 repetitions and 4 treatments, including T1: a strain with a single stem; T2: a strain with two stems; T3: a strain with 3 stems and T4: a strain retaining four stems. The 25 cm cuttings were planted at spacings of 1 m x 1 m. In this study, cassava produced 27.7 t/ha; 40.7 t/ha; 38.7 t/ha and 45.7 t/ha respectively for 1-stem, 2-stem, 3-stem and 4-stem stumps. Keeping at least two stems is still the best way to produce cassava leaves and tuberous roots under cultivation conditions.

Key words: ***Stems, roots, leaves, cassava, Gbadolite and Democratic Republic of Congo.***

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I. Introduction

Cassava (Manihot esculenta Crantz) is a tropical plant cultivated mainly for its starch-rich tuberized roots (IITA, 1990).In sub-Saharan Africa (Raffaillac, 1997), it accounts for around a third of total staple food production (Djoulde, 2005), and is the third most important source of calories after rice and maize. Cassava is a recognized and inexpensive source of abundant food energy.The parts consumed are the tubers (roots) and leaves.It is also grown mainly for its starch-rich tuberous roots (Kouadio et al., 2014).

Roots and tubers, notably cassava, sweet potato, yam and potato, are among the most important primary crops. They have long been the main source of food and nutrition for most of the world's poorest and most undernourished populations. They are generally valued for their stable yields (Lawrence et al., 2006).

Cassava roots provide over 50% of the calorific needs of African populations, while its leaves are a relatively protein-rich vegetable.Out of 100 grams of edible parts, its leaves contain 8 grams of protein. It is for this reason that its vegetables are appreciated in many African countries, and this gives it an important role in curbing the African food crisis.They represent an abundant and inexpensive source of vitamins A and B (Bordate, 2004).

Cassava is both the main and most widespread staple crop and source of income for around 70% of the population throughout the Democratic Republic of Congo. It covers more than half of the area under cultivation and is consumed on a permanent basis by more than 70% of the population for its roots and by around 80% for its leaves, which constitute one of the country's main vegetables after Nigeria, the Democratic Republic of Congo (Mutchapa et al., 2018).

In North-Ubangi in general, and Gbadolite in particular, cassava in its various forms of consumption plays a part in the staple diet of the Congolese population, gradually taking the place of various starchy foods, to such an extent that cassava currently constitutes, along with bananas, the staple hydrocarbon food of most peoples in forest areas and even bordering regions, being the first commodity most consumed in Litean households (Janssens, 2001; Molongo et al.,2015; Magbukudua et al., 2015; Kwa and Temple, 2019).

In Gbadolite, taking into account the socio-economic importance of the crop in this agricultural region, where crop management is a thorny problem.Several studies have been carried out on cassava, with the exception of the influence of the number of stems per stump on leaf and root yield.

Thus, this study seeks to answer the main question: are leaf and tuberous root yields proportional to the number of stems per strain?Specifically, can the average tuberous root length also be proportional to the number of stems? Is there a significant difference in yield at the $p < 0.05$ threshold?

Overall, this investigation tests the hypothesis that, if cassava leaf and tuberous root yields would be proportional to the number of stems per strain. And specifically, the average length of tuberous root would also be proportional to the number of stems. If there was a significant difference between yields at $p < 0.05$.

The overall aim of this study was to observe the influence of stem number per strain on cassava leaf and tuberous root yields. The specific objectives were to observe tuberous root length and to evaluate the difference in leaf and tuberous root yields between treatments at $p < 0.05$.

II. Materials and methods

Environment

The present study was carried out in Gbadolite, in the Pangoma district, Plateau des Professeurs (50 villas).Coordinates.The geographical coordinates in GPS of the experimental field are as follows: Latitude North 40°15'42.47"; Longitude East 20°59'5.87" and Altitude: 398.45 m.

Gbadolite is located in dense rainforest, Guinéo-Congolaise. According to the Köppen classification, the climate is type Aw2 (IPAGRI, 2015). The average annual temperature is 28°C and rainfall is relatively abundant, with an annual average of over 1,600 mm. Insolation is low with 45% total radiation (Ngbolua et al, 2014).

The soil is clayey-sandy. The vegetation used to be evergreen equatorial rainforest, but has been replaced by savannah due to human activity, with Imperatacylindrica, Penisetumspp, Chromoleanaodorata and Panicum maximum (Molongo et al., 2014).

Plant material

The biological material used for this study was cassava cuttings from a farmer's field of cultivar TME 419 (Obama).

Methods

The experimental set-up used was that of complete randomized blocks arranged in 3 repetitions and 4 treatments, of which T1: stump with a single stem; T2: stump with two stems; T3: stump with 3 stems and T4: stump retaining four stems. The 25 cm cuttings were planted at spacings of 1 m x 1 m.

Treatments are shown in Figure 1.

Figure 1: Number of stems per stump.

Observed parameters

Observations were made on:

- Recovery rate using the formula of Molongo et al. (2015);Regrowth rate (in %)= x=(Number of regrown plants)/(Total number of plants) x 100
- Diameter at collar using caliper ;
- Plant height using tape measure;
- Number of roots per stump by counting;
- Diameter of tuberous roots using caliper;

- Length of tuberous roots ;
- Fresh tuberous root yield (in t/ha) by extrapolation of plot yield.

Statistical methods

Data were analyzed using single-criterion analysis of variance and Tukey's test, using IBM SPSS Statistics 20 software.

III. Results and discussion

Resultsa.

Vegetative parametersMean diameters are shown in Table 1.Table 1. Vegetative parameters

Traitements Paramètres	T1	T2	T3	T4
Diameter at collar (in cm)	2,5±0,3[a]	2,9±0,2[a]	2,4±0,1[a]	2,8±0,7[a]
Plant height (in cm)	177±27,8 [a]	241,8±26,7 [b]	262,0±22,5 [b]	257,3±19,2 [b]
Number of roots per stump	5±0,06 [a]	6±1,2 [a]	6± 1 [a]	8± 0,6 [b]
Diameter of tuberous roots (in cm)	4,5±0,4 [a]	4,7±0,2 [a]	4,8±0,4 [a]	5±0,2 [a]
Length of tuberous roots (in cm)	38,8±6,6 [a]	36,5 ±5,4 [a]	42,7±12,5 [a]	46,7±11,6 [a]

Legend: T1: stump with a single stem; T2: stump with two stems; T3: stump with 3 stems and T4: stump with four stems.

It was observed that basal stem diameter varied from 2.4 to 2.9 cm under the conditions of this study, with a coefficient of variation of less than 30%; in other words, neck diameters were homogeneous across treatments. The analysis showed that there were no significant differences between treatments, which means that these subjects had a similar development over the course of the study.

Plant height ranged from 177 to 262 cm.It was observed that strains with at least two stems produced taller stems than those with one stem, as they competed for light due to their high number. The analysis showed that there was a significant difference between treatments; the Tukey test grouped them in such a way that three-stemmed, four-stemmed and two-stemmed subjects were similar in height but different to the one-stemmed; with a coefficient of variation below 30%, therefore; that they were homogeneous.

The number of tuberous roots per strain was proportional to the number of stems under Gbadolite conditions. The number of stems was between 5 and 8 per strain.The coefficient of variation showed that the subjects were homogeneous, but the single-criterion analysis of variance showed that subjects with 4 stems gave a higher number of tuberous roots than the other treatments.

In the course of this study, it emerged that the average diameter of tuberous roots was 4.5 cm; 4.7 cm; 4.8 cm and 5 cm respectively for strains with 1 stem; 2 stems; 3 stems and 4 stems.There were no significant differences between treatments in this parameter, with homogeneous parameters below 30%.

Average root length ranged from 36.5 to 46.7 cm. The number of stems remains one of the most important factors in stem length. This length certifies that the soil in this field was loose. The coefficient of variation was homogeneous in this agricultural area; statistical analysis proved that there were no significant differences between treatments.

Leaf yield in tonnes per hectare

Leaf yields in tonnes per hectare are shown in Figure 2.

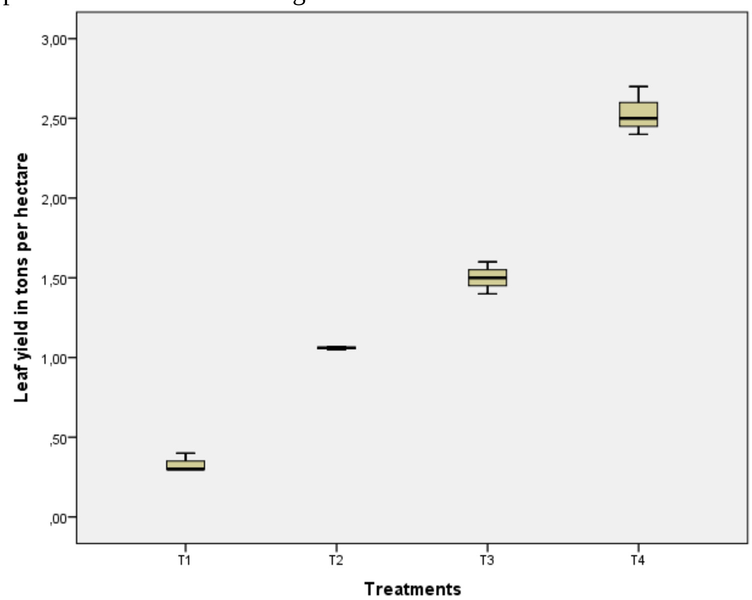

Figure 2: Leaf yield in tons per hectare.

It was observed that the treatments produced leaves in proportion to the number of stems, with 2.53 T/Ha, 1.50 T/Ha, 1.06 T/Ha and 0.33 T/Ha respectively for strains with 4; 3; 2 stems and 1 stem under Gbadolite conditions. This production is justified by the proportionality of the number of stems per strain capable of giving several branches and therefore likely to increase the production of this useful product. Statistical analysis concluded the following T1 T2 T3 T4; in other words, in terms of leaf production, the treatments differed from one another; but the best was the strain with 4 stems and then 3 stems.

Tuberous root yield in tonnes per hectare
The results in Table 6 have been extrapolated into tons per hectare and recorded in Figure 3.

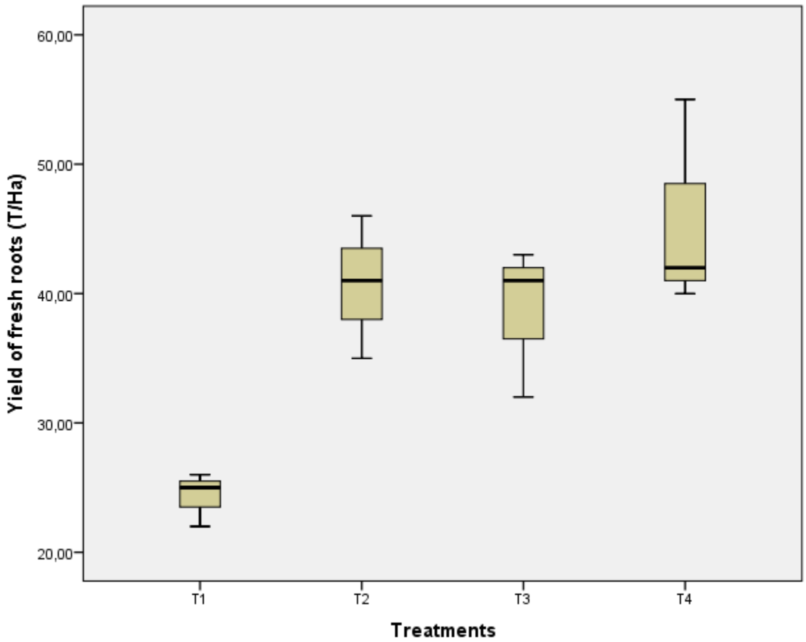

Figure 3: Yield in tonnes per hectare of tuberous roots.

It was observed that, depending on the treatments, cassava produced 27.7 t/ha; 40.7; 38.7 and 45.7 t/ha respectively for the one-stem, two-stem, three-stem and four-stem strains under the agro-ecological conditions of Gbadolite.
Single-criterion Analysis of Variance classification and Tukey test using IBM SPSS Statistics 20 software.The following decision was reached: T1 T3 T2 T4.This means that strains with at least 2 stems are more productive than cassava with one stem per strain. The best treatment was cassava with 4 stems per stump, but with similar production to cassava with two and three stems per stump.

IV. Discussion

This study shows that the average basal stem size was 2.5 cm, 2.9 cm, 2.4 cm and 2.8 cm for a strain with 1, 2, 3 and 4 stems respectively.These results suggest that the average stem diameter of the plants in this study varied between 2 and 3 cm (Vandenput, 1981).

This study shows that the plants reached an average height of 177 cm: 241.8 cm; 262 cm and 257.3 cm respectively for the stock with 1 stem; 2 stems; 3 stems and 4 stems.It was observed that, in addition to the stump with one stem, the other plants were at the interval of 2 to 6 m in height, values described by Van Den Abeele and Vandenput, 1956; Mahungu, 2014).The single-stem stump produced a smaller plant than the others, as the stems outnumbering the stump compete for light; by dint of needing this ecological factor, the plant tends to grow taller. In the agro-ecological conditions of Gbadolite, the TME 419 or Obama cultivar can reach over 2 m in height, despite the harvesting technique used.

We counted 5 tuberous roots on a stump with 1 stem; 6 tuberous roots on those with 2 and 3 stems on stumps with one stem, however 8 on the stump with 4 stems.The number of roots corroborates that found by Kouadio et al. (2014).

In view of these results, the number of stems varied between 4.7 cm and 5 cm; these values were lower than 5 and 15 cm; thus, a counter-performance (Favier, 1997).In other words, the cultivar has degenerated. It has been observed that the high number of tuberous roots reduces root size under cultivation conditions; most of these are thread-like.

This investigation revealed that cassava produced an average tuberous root length of 38.8 cm, 36.5 cm, 42.7 cm and 46.7 cm respectively for strains with 1 stem, 2 stems, 3 stems and 4 stems.In view of this measurement, these results are in line with cassava selection criteria, according to which the length of cassava tubers at maturity varies between 20 cm and 50 cm (Favier, 1997).

It was analyzed that leaf yields in tons per hectare ranged from 0.7 t/ha to 4.5 t/ha obtained from the monthly harvest, the bimonthly harvest; but lower by 7.6 t/ha to 13.6 t/ha obtained from the quarterly harvest, as the prolonged harvest is the basis of the yield increase (Dahniya, 1980; Ezumah, 1980 and Ambwa et al., 2022).

In this study, cassava yields using this technique were 27.7 t/ha, 40.7 t/ha, 38.7 t/ha and 45.7 t/ha for strains with 1, 2, 3 and 4 stems respectively. These yields were reported to be greater than 20 - 25 t/ha (Vandenput, 1981) but greater than or equal to 20 and 30 t/ha in uncontrolled conditions and 45 t/ha in controlled conditions for cultivar TME 419 or Obama (SENASEM, 2012).Yields greater than or equal to 26.7 t/ha; 27.4 t/ha; 41.3 t/ha; 34.6 t/ha and 40.8 t/ha were recorded respectively for subjects harvested at 9 months; 12; 15; 18 and 21 months in Gandajika (Mukendi et al., 2018); even at 11 and 26.8 obtained Kouadio et al. (2014).

Indeed, the strain with at least two stems gave a higher yield than the one with a single stem. This situation is justified by the fact that the crop has developed a wider leaf crown playing an important photosynthetic activity responsible for superior plant mineral nutrition for its physiology likely to promote growth, development and consequently yield.

V. Conclusion

The aim of this study was to observe the influence of the number of stems per strain on leaf and tuberous root yields of cassava (Manihot esculenta Crantz var TME 419) under the agro-ecological conditions of Gbadolite in the Democratic Republic of Congo.

Hypothesis testing by Analysis and Test revealed the following:2.53 T/Ha; 1.50 T/Ha, 1.06 T/Ha and 0.33 T/Ha were obtained respectively for strains with 4; 3; 2 stems and 1 stem under Gbadolite conditions.

Cassava tuberous root yields in tons per hectare were 27.7; 40.7; 38.7 and 45.7 respectively for the one-stem, two-stem, three-stem and four-stem strains under Gbadolite agro-ecological conditions. Yields were therefore proportional to the number of stems per strain.

Average tuberous root length was also proportional to the number of stems: 46.7 cm for roots with 4 stems per strain; 42.7 cm for roots with 3 stems; 38.8 cm for roots with 1 stem; and 36.5 cm for roots with 2 stems.

There was a significant difference in yield at $p < 0.05$.

In view of these results, cassava growers are advised to cultivate cassava in such a way as to obtain at least two stems per strain, in order to maximize production of leaves as a vegetable and tuberous roots as a staple food.

As the cassava study is of great socio-scientific value, the recommendations made here are of the utmost importance.

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