BirEx JOURNAL
Budapest International Research in Exact Sciences
Medical, Biological, Argiculture, Engineering
Science and other related areas
e-ISSN : 2655-7827
p-ISSN : 2655-7835
http://www.bircu-journal.com/index.php/birex

Influence of organic, mineral fertilizers and their combination on the Renewing Power of Macabo in Kisangani, DR Congo

Ramazani F. A[1], Ngama F[2], Okungo A. L[3]
[1]*Laboratory of ecophysiology and plant nutrition, IFA Yangambi,*
[2]*Laboratory of Virology and Phytopathology, Faculty Institute of Agricultural Sciences, IFA Yangambi, RD. Congo*
[3]*Laboratory of Ecophysiology and Plant Nutrition, IFA Yangambi*
lotokungo@gmail.com, faustinngama2@gmail.com, lotokungo@gmail.com

Abstract: *In order to help solve the thorny problem of low availability and propagation rate in Macabo (Xanthosoma sagittifolia (L.) Schott.), given that a planted cutting yields only one plant for a new plantation after cultivation and harvesting, a study was carried out in Kisangani using two types of manure. It consisted of assessing the effect of organic manure (pig dung and decomposed cow dung) and mineral manure (NPK), as well as their combination, on Macabo's capacity to produce ex-situ rejections. The parameters studied were, respectively, the recovery rate of the mother cuttings and the number of shoots produced during the first eight weanings. The results showed that: 1) The recovery rate of mother cuttings was 100% whatever the treatment; 2) After eight weanings, the organic and mineral manure combinations produced more shoots, with an average of 32 and 30 respectively for T4 (pig dung + mineral manure) and T5 (cow dung + mineral manure). These results indicate that the number of offspring produced does indeed depend on the manures used; 3) The average number of offshoots per plant decreased during weaning for all treatments. The results suggest that this technique can be advantageously used to produce quality planting material for this crop in quantity and in a short time.*
Keywords: *Organic and mineral fertiliser, rejection power and Macabo.*

I. Introduction

Faced with a growing population, the world is confronted with a number of problems, including food insufficiency, to name but one. This situation requires, among other things, effective and appropriate solutions from agronomic research.

Diversification of crops and growing methods is proving to be an appropriate solution to this situation. There are several types of crop: legumes, cereals, roots and tubers, etc. Root and tuber crops, including Macabo (Xanthosoma sagittifolia. (L) Schott), are adapted to the ecological conditions of the tropics (Vandenput, 1981; Gyansa, 1995; Janssens, 2001).

Macabo is considered to be a staple food in several countries and is the subject of particular research attention (Watanabe 2002). Thus, promoting its cultivation at the same time as other crops is important for achieving food self-sufficiency. This crop has greater production potential than sweet potato and manioc. In fact, one hectare of Macabo produces 25 to 30 tonnes under normal conditions, and it is possible to achieve yields of around 40 or even 50 tonnes/ha (Okungo, 2012). Macabo tubers contain easily digestible carbohydrates and are rich in dry matter (30-45%) (Agueguia et al. 2007).

Macabo is propagated asexually by cuttings. Lateral buds forming at the base of the stem, fragments of the corm or whole tubers can be used. Generally, growers use small tubers and seedlings obtained by fragmenting the apical part of a larger tuber.

Despite these advantages, one of the first obstacles to establishing a good crop is undoubtedly access to propagation material in sufficient and homogeneous quantities for large-scale propagation. The rate of multiplication is low, as a cutting planted after cultivation and harvesting yields only one plant for a new plantation. This means that the same number of

cuttings are used each year. Each growing season and the area cultivated each year remains the same due to a lack of propagation material (Okungo, 2017).

This means that methods and techniques must be found to solve the problem of the availability of propagation material. This situation is justified by the fact that the sexual reproductive system of Macabo is almost non-functional on the one hand, and that in cultivation Macabo does not produce shoots, generally as a result of the apical dominance imposed by the apical bud, on the other hand (Messiaen, 1989).

With a view to further improving production and the supply of planting material in sufficient quantity and uniformity, which is a problem for most farmers, the present study falls within the same framework and is intended to investigate the effect of organic and mineral fertilisers and their combination on the rejection capacity of Macabo (Xanthosoma sagittifolia (L) Schott) ex-situ in the town of Kisangani.

This research is based on the following facts:

a. The effect of the various fertilisers on Macabo's suckering capacity is positive and depends on the type of fertiliser applied, given that each fertiliser has a different fertilising capacity to the others;
b. The rate of multiplication depends on the type of fertiliser applied.
c. The combination of organic manures (pig dung and cow dung) and mineral manures would be better than using them separately, since the combination creates synergy between manures and would be more favourable to the production of Macabo offshoots.

II. Research Methods

2.1 Environment

This study was carried out in the concession of the Institut Facultaire des Sciences Agronomiques de Yangambi, Kisangani site located in the Plateau Médical district of the Makiso commune. The town of Kisangani is located in the central basin and lies at an altitude of 369-400 m; 0°31‘ latitude North and 25°11’ longitude East in the north-eastern part of the D.R.C. The geographical coordinates of the experimental site taken with the GPS are as follows: Latitude North 0° 30‘ 46’‘; Longitude East 25° 9’ 53‘’ and at an altitude of 389.04 m.

Figure 1. shows the location of the experimental site.

Figure 1: *Map of the town of Kisangani and the experimental site*

The climate at the experimental site is that of Kisangani, which belongs to type Af of the Köppen classification. It is a hot, humid equatorial climate. The average daytime temperature is around 30°C and the average night-time temperature is 20°C. Relative humidity varies between 80 and 90%. Average annual rainfall is 1885mm. Rainfall is divided into two periods: the short period from March to June and the long period from September to November (Van Wembeke and Liben, 1957).

The soils of Kisangani are classified in the Lindian system (Upper Precambrian). The bedrock is made up of red sandstone, shale and quartzite, and the overburden consists of layers of clay and sandstone. The decomposition of the sandstones and shales has produced heavy clay soils with high water retention, while the overlying formations have led to the development of generally sandy soils (Cahen, 1954; Verbeeck, 1970).

2.2 Materials

For this study, the biological material consisted of cuttings of Xanthosoma sagittifolia (L) Schott (Macabo), commonly known as Mahole in the region.

The characteristics of the variety used are as follows:

a. Purple tubers, resistant to cooking;
b. Violet petioles;
c. Edible green leaves, an excellent leafy vegetable.

As fertilisers, two types of manure were used in our experiment: organic manure (cow dung and pig droppings in an advanced state of decomposition) and mineral manure (NPK17-17-17, Urea 46% N and KCl 60% K).

2.3 Methods

a. Experimental set-up and treatments.

In this work, we used an in-line treatment layout. Empty cement bags filled with black soil were used. Each treatment included 15 cuttings corresponding to the repetitions and each bag received one cutting. The trial included five treatments and a control consisting of Macabo plants grown without fertiliser. This is in fact the macro propagation of Macabo ex situ testing the influence of fertilisers. The treatments tested were defined as follows:

T0 = Control (no manure);
T1 = Decomposed pig dung;
T2 = Decomposed cow dung;
T3 = Mineral fertiliser;
T4 = Decomposed pig dung + Mineral fertiliser;
T5 = Decomposed cow dung + Mineral fertiliser.

Figure 2 below illustrates how the experimental field was laid out

Figure 2: *Experimental field (Photo Ramazani, 2023)*

b. Conducting the trial

1) Conditioning the material

After taking the cuttings, we took care to cut the leaves. And before planting, we measured the diameter of the mother bulbs using a caliper.

2) Site preparation

The experimental site was prepared by clearing, stumping, ploughing, filling the bags on the ground and burying the fertiliser a week before planting. We applied a dose of 6.5 kg/m2 for each organic fertiliser (Okungo, 2012) and a dose of 65 kg/ha of N, 50 kg/ha of P and 100 kg/ha of K (Vanden put, 1981).

3) Planting

The plants were planted in empty cement bags filled with good quality soil, with one cutting per bag.

4) Maintenance

Maintenance consisted of watering when it was not raining, weeding and hoeing the bags as the trials were carried out ex-situ.

Rooting

For our trial, recepage was carried out two months after planting, using a sharp knife that had been disinfected with 70% alcohol.

Two cross-shaped incisions were made at the site of the meristem to complete the elimination of the apical meristem and to prevent liquids (water and sap) from spreading over the wound. This could lead to contamination and rotting of the bulbs.

According to Jean Prost (1980), recepage or decapitation is the practice of cutting the plant (Banana, Taro, Macabo, among others) at the point of insertion of the leaf apparatus in order to allow the dormant buds in the bulb to emerge.

Figures 3a and 3b below illustrate received plants, a clump of Macabo shoots and the experimental field before and after receiving.

Figure 3a: *Experimental field before and after harvesting (Photo Ramazani, 2023)*

Figure 3b : *Semis de macabo et touffe de pousses (Photo Ramazani, 2023)*

5) Le sevrage

Le sevrage est une technique qui consiste à séparer une pousse, une marcotte, un rameau, etc. de la plante mère (Jean-Prost, 1980).

Nous avons pratiqué le sevrage lorsque les pousses avaient une ou deux vraies feuilles. Ils sont alors caractérisés par une autotrophie totale. Un couteau pointu et tranchant a été utilisé pour le sevrage. Une faible pression est exercée sur le rameau pour le séparer de la plante mère, en laissant une plaie à l'endroit où il était attaché.

6) Observations

Au cours de nos investigations, les paramètres suivants ont été étudiés :

- Nombre de descendants par sevrage
- Changement de diamètre des pousses sevrées ;
- Hauteur des pousses sevrées.

Le nombre de pousses par plante et par sevrage a été évalué en comptant les pousses formées.

La hauteur des pousses a été mesurée à l'aide d'une latte graduée et le diamètre au collet des pousses formées et sevrées a été mesuré à l'aide d'un pied à coulisse.

Il est à noter que la collecte des données pour ces paramètres a débuté 21 jours après la réception, soit 3 semaines.

c. Statistical analysis of the data

Analysis of variance with one classification criterion was used. Past4.03.zip. 5 software was used to analyse the data from our trial. In addition, Excel software was used to help us create tables and databases based on the studies carried out, in order to facilitate the statistical analyses. In this study, we considered that if the coefficient of variance is less than 30%, the data are homogeneous or grouped around the mean, whereas if it is greater than 30%, they are heterogeneous. As for the correlation, it is either positive or negative depending on whether the value found is positive or negative.

III. Results and Discussion

3.1 Effect of treatments on changes in the number of offspring during weaning (1st to 8th weaning)

Figure 4 illustrates the evolution of the mean values of the number of offspring formed under various treatments from the 1st to the 8th weaning as a function of weaning.

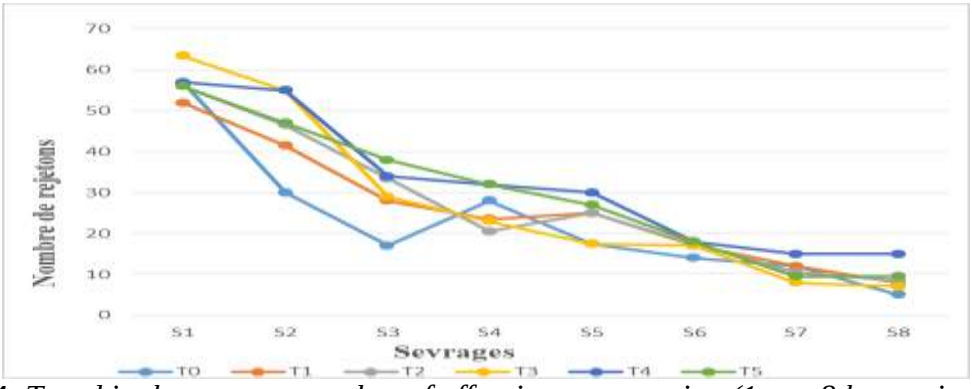

Figure 4: *Trend in the average number of offspring per weaning (1st to 8th weaning) for the different treatments.*

Figure 4 shows that the number of offspring weaned varied according to the treatments used and the weanings.

The combination of decomposed pig dung + mineral fertiliser (T4) had a more positive effect on offspring production than the other fertilisation formulas, followed by T5 (combination of decomposed cow dung + mineral fertiliser). For simple uses, treatment T3 (mineral fertiliser alone) performed better, producing slightly more offspring than T1 (decomposed pig dung) and T2 (decomposed cow dung), which received organic fertilisers alone. Mineral fertilisers act quickly, unlike organic fertilisers, whose elements are released gradually depending on the speed of decomposition. This justifies the superiority of treatments in which mineral and organic fertilisers were combined. Finally, seedlings received without fertiliser (T0) performed less well than seedlings received with fertiliser alone or in combination.

The results of the analysis of variance relating to the number of offspring weaned showed that there were no significant differences between the treatments tested (P-value = 0.9228).

The results in this figure also show that, in general, the average number of shoots per plant decreases during weaning for all treatments. We noticed that Macabo produces more offshoots per plant during its first weaning, then this number decreases progressively during the following weaning waves. This phenomenon is due to the fact that the mother bulbs lose their organic reserves accumulated progressively over time with age. In fact, the accumulated nutrient reserves are gradually depleted during weaning.

As for the distribution of data for this parameter, with the CV > 30%, heterogeneity was observed for all treatments. There was considerable variability in the number of offspring weaned during weaning for all the treatments compared.

3.2 Effect of manure type on changes in collar diameter of weaned shoots from 1st to 8th weaning (in cm)

Data on changes in the diameter at the neck of weaned offspring over the weaning period (1st to 8th weaning) are presented in the graph in figure 5.

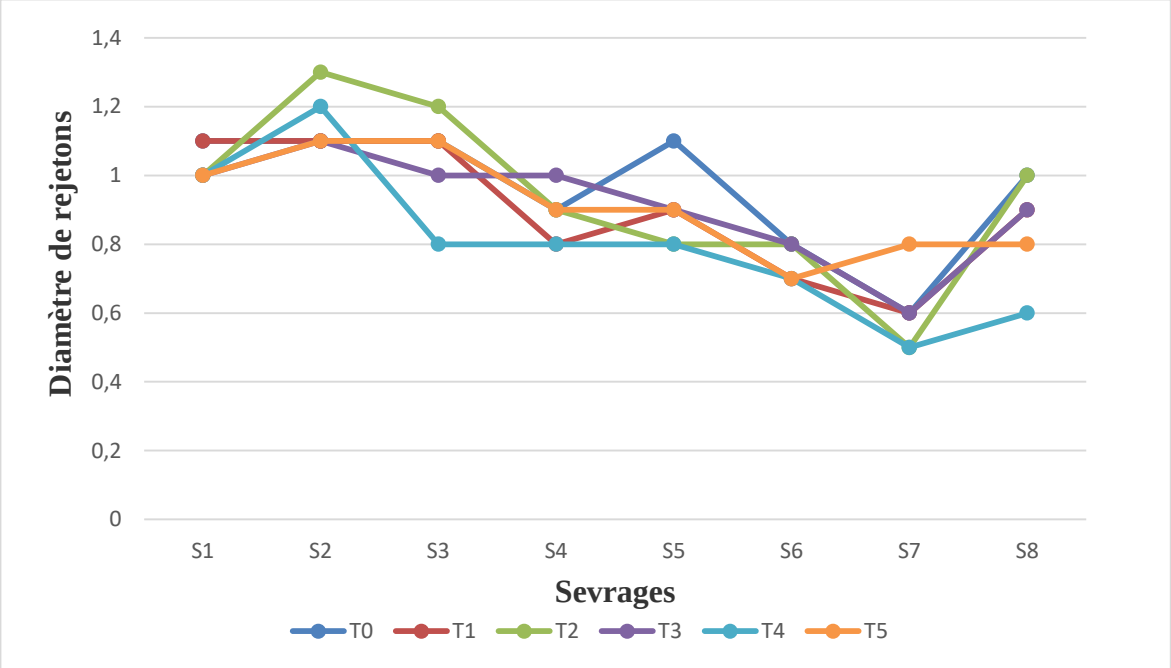

Figure 5: *Changes in neck diameter of weanlings from 1st to 8th weaning*

Examination of Figure 5 shows that the diameter at the shoot collar varied slightly according to the types of fertiliser tested. On average, shoot vigour varied from 0.5 to 1.3 cm. The fertilisers appear to have had a slightly more positive influence on shoot collar diameters, and generally in the same way.

Although there were numerical differences between the mean shoot diameters of the different treatments tested, the analysis of variance indicated that there were no significant differences between them from the point of view of the parameter examined (P-value = 0.6602).

These results also show that the rejects produced are generally of the same size and can be used without many problems, as they are homogeneous. It should be noted that the vigour of the offshoots produced depends on the substances accumulated in the bulbs.

The T0 treatment (0.96cm) produced Macabo shoots with a slightly larger diameter. In descending order, the classification is as follows: T2 (0.94cm) > T3 (0.91cm) = T5 (0.91cm) > T1 (0.90cm) > T4 (0.80cm)

The poor performance of the T0 treatment compared with the other treatments is justified by the small number of rejects emitted compared with the others, which would lead to less competition. There was also a reduced shoot vigour during weaning, which was due to a reduction in nutrient reserves in the bulbs. due to the decrease in nutrient reserves in the bulbs with weaning.

3.3 Effect of manure type on height of weaned shoots (from 1st to 8th weaning).

Data on changes in height of weaned shoots from the 1st to the 8th weaning are Figure 6.

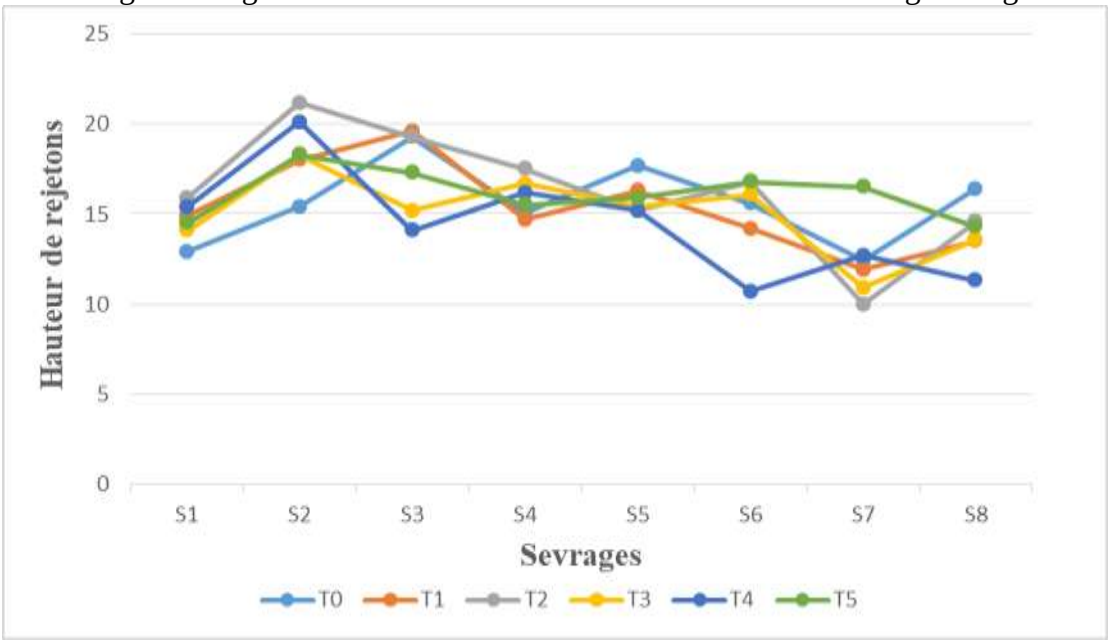

Figure 6: *Evolution of the height of weaned shoots from 1st to 8th weaning under various treatments.*

Looking at the results in Figure 6, we can see that the height varied in a sawtooth pattern from one weaning to the next and according to the treatments used. Treatment T2 (with 1.63 cm) was the best treatment, favouring the growth of Macabo offspring. The efficiency of the treatments was as follows: T5 (with 1.61cm) > T0 (with 1.56 cm) > T1 (with 1.54 cm) > T3 (with 1.50 cm) > T4 (with 1.45 cm). It was also found that the treatments containing cow dung had a greater influence on the height of offshoots compared with the other treatments.

We also found that the distribution is heterogeneous for all treatments as their coefficient of variation are greater than 30%.

Although there were numerical differences between the means of the different treatments, the analysis of variance indicated that there were no significant differences between them with regard to the height of offspring (P-value = 0.7059).

An analysis of figure 7 shows that T2 caused the greatest growth in height (1.63 cm) of offspring weaned from the 1st to the 8th weaning.

Apart from the first weaning, there was a downward trend for all treatments. This is due to the reduction in reserves accumulated in the mother bulbs.

3.4 Discussion

The set of results presented above shows that the organic and mineral fertilizers as well as their combination experimented in this investigation improve the multiplication rate of Macabo (Xanthosoma sagittifolium (L.) Schott.).

The combination of pig droppings + mineral fertilizer (T4) and the combination of cow dung + mineral fertilizer were more efficient in the production of offspring than the separate application of manure.

By comparing our results with those in the literature, we note that the combinations of organic and mineral manure produced more offspring per weaning with an average of 32 and 30 respectively for T4 (decomposed pig droppings + mineral manure) and T5 (dung cows + Mineral manure) after eight weanings. Indeed, Okungo et al (2017), by studying the processes of recuperation and weaning as methods of rapid multiplication of propagation material in the Macabo (Xanthosoma sagittifolium (L.) Schott) in Kisangani, had found on average 22.0 rejects after four weanings for the variety with green leaves and purple petioles compared to 6 rejections for the variety with green leaves and green petioles. Our results show that the application of fertilizers improves the multiplication rate in Macabo and therefore, the possibility of increasing the number of weanings.

The performance of combinations of two types of fertilizers compared to other separate treatments is justified by the fact that in addition to the direct action exerted by mineral fertilizers, organic fertilizers provide the various mineral elements in very variable proportions depending on of their origins and their different forms (Angladette, 1966)

Furthermore, Okungo (2012) pointed out that with the breeding and weaning processes, an elite plant can give 34 suckers in three months. These suckers placed in the nursery reach the size of the mother plant in 6 months and the 34 plants can give 1,156 suckers in three months. So with around 9 mother cuttings (i.e. 8.5), we can have propagation materials for 1 ha/year, unlike the traditional method where we return to the same number of plants each year (Vanden Put, 1981).

Likewise, by comparing the results of this study to those obtained by Tshipamba (2022) by evaluating the PIF method in the conditions of Goma using bio-char (charcoal dust) as a substrate, it emerges that the latter produced fewer releases than those provided by this test, i.e. 32 compared to 22 (i.e. 21.93 ± 1.13).

These results may be due on the one hand to the varieties tested and the methods used, and on the other hand to the combination of fertilizers. Indeed, this trial used the purple variety by combining organic and mineral fertilizers as well as transplanting followed by weaning, while Tshipamba (2022) had experimented with the green variety using the PIF method and that of bulb fragmentation... Also, this author used charcoal dust as a physical support for the planted bulbs while we used arable soil placed in empty cement bags.

From the analysis of the figure relating to the average diameter at the collar under various treatments, it emerged that the vigor of the shoots varied slightly depending on the type of manure. The high values were found under the treatments containing cow dung

(0.94cm) and the control (0.96cm), while for pig manure (0.90cm), mineral manure and their combination gave lower values. By comparing the results of this test to those obtained by Okungo (2012) in Kisangani, some differences are observed because for the latter, organic fertilizers based on pig excrement and rice husk ash respectively gave the average diameters of 0.84cm, 1.46cm. Macabo plants under rice husk ash were more vigorous than those planted under pig droppings. These results can be explained by the fertilizing power of each type of fertilizer. Rice husk ash, like all plant ashes, is rich in mineral elements (Angladette; 1966).

V. Conclusion

The purpose of this test was to study the effect of organic and mineral fertilizers as well as their combination on the sprouting power of Macabo (Xanthosoma sagittifolia (L) Schott) ex situ in the conditions of Kisangani.

All the results obtained reveal that combinations of fertilizers constitute one of the solutions in resolving the thorny problem of low availability of propagation material in Macabo (Xanthosoma sagittifolium (L.) Schott.). These tests also showed that the multiplication rate is significantly improved. It was 32 times for the combination of organic manure based on pig excrement + mineral manure and 30 times for the combination of organic manure based on cow dung + mineral manure. The results obtained made it possible to verify our initial hypotheses. Indeed, the application of fertilizers makes it possible to improve the multiplication rate of Macabo with a view to extending the culture on the one hand and their combination further promotes the bursting of many dormant lateral buds into offspring.

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