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Influence of Bulb Size on Macabo (Xanthosoma sagittifolium (L.) Schott) Propagation by the Kisangani PIF Method

Tshipamba T. O[1], Mubenga K[2], Mukandama N. J-P[2] and Okungo L. A[3]

[1] La Sapientia Catholic University of Goma in the Democratic Republic of Congo.

[2] University of Kisangani in the Democratic Republic of Congo.

[3] Institute Faculty of Agricultural Sciences of Yangambi (IFA / Yangambi) in the Democratic Republic of Congo.

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ABSTRACT

Macabo (*Xanthosoma sagittifolium* (L.) Schott.) May be a solution to the problems of hunger, inadequacy and food insecurity faced by several developing countries like DR Congo, because it is adapted to tropical equatorial and tropical climates.However, its large-scale cultivation encounters a problem of lack of propagating material in quality and quantity sufficient for the extension of the culture related to its mode of multiplication and growth. Indeed, the pronounced dominance of the terminal bud inhibits the development of lateral buds. To try to solve this problem, a study was carried out by experimenting the PIF method in Kisangani. It consisted in evaluating the rejecting power of *X. sagittifolium* bulbs planted on three different substrates, notably sawdust, charcoal (bio-char) and rice husks. The parameters observed were respectively the recovery rates of the mother bulbs, the number of offspring formed and weaned. The results obtained showed that: 1. The recovery rate of mother bulbs was 100% irrespective of the treatment; 2. After 24 weaning, a 9.6 cm diameter bulb produced 32 and 34 3 cm diameter shoots respectively for sawdust and bio-char, and 32 x 2.9 cm diameter shoots with bulb 8.8 cm in diameter for rice balls. These numbers of offspring do not differ statistically; 3. There is a positive correlation between the size of mother bulbs and the number of offspring formed (Y = -32,057 + 6,926X with r = 0,521) and secondly between the size of mother bulbs and the vigor of the offspring formed (Y = 1,300 + 0,182X with r = 0,560). These results show that the number of offspring formed increases with the size of the mother bulbs and their vigor also depends on it.

1. Introduction

Food scarcity is a scourge that affects many developing countries such as DR Congo. The performance of the agricultural sector in the DRC remains very low, agricultural land actually developed represents less than 10% of the country's area. In addition, agricultural production is declining while agriculture accounts for about 45% of the country's GDP and is the main source of income and employment for more than half of the population (Ministry of French Cooperation, 2008). One of the solutions would be the promotion and development of crops adapted to the ecological conditions of the environment, with a high production potential and with fewer phytosanitary problems (Okungo, 2008). As such, tuberous roots and tubers need to be given careful attention because they are adapted to equatorial, humid tropical climates and have a carbohydrate and protein content that can equal or exceed that of cereals (Messiaen, 1989). Among these plants, the X. *sagittifolium* deserves a place of choice. Indeed, this plant has some interesting characteristics justifying its choice. These include its ecological adaptation, its hardiness to diseases and bio-aggressors and its chemical composition (Ministry of French Cooperation, 2006).

Xanthosoma sagittifolium (L.) Schott is richer in protein than sweet potato, cassava, potato and yam. It doses 2 to 4% of proteins and its carbohydrates are of good digestibility due to the small size of starch seeds (Agueguia et al, 2007). In addition, Macabo is adapted to the agro-ecological conditions of the humid tropics where it can give an acceptable yield even in soils unfit for other crops. Indeed, one hectare of Macabo produces 25 to 30 tons under normal conditions. Yields of 40 to 50 tonnes / ha are possible (Van Den Put 1981, Messiaen 1989, Janssens 2001, Carburet et al 2007).

The peeled, dried and ground tubers give a flour that can be used in the production of bread mixed with wheat flour to a proportion of 20% (Ministry of French Cooperation, 2006). Macabo tubers (X. *sagittifolium*) are richer in dry matter than other root and tuber crops. This content varies according to the varieties and is of the order of 35-45% (Agueguia et al., 2007). Leaves still harvested provide a delicious vegetable (Messiaen, 1989). They are also an excellent source of vitamin C (Janssens, 2001). Moreover, the X. *sagittifolium* quickly produces large canopies that completely cover the soil (Ministry of French Cooperation, 2006). The Word Vision-funded survey (Jenga Jamaa II) found that Macabo had replaced banana and plantain with up to 10% of Kalehe's

Tele:
E-mail address:oliviertshipamba81@gmail.com.

485,320 inhabitants as a source of income (Njingulula et al. 2013).

Despite these advantages, the large-scale cultivation of X. *sagittifolium* encounters a problem of lack of propagation material in quality and quantity sufficient for the extension of the crop. This is explained by the mode of growth of the plant for which the pronounced dominance of the terminal bud inhibits the development of lateral buds (Van Den Put, 1981, Okungo, 2008). As a result, the multiplication rate is low, since a mature crop usually yields only one cuttings. The same number of cuttings are returned each year and the cultivated area generally remains the same for each growing season (Messiaen 1989, Okungo 2008).

The vegetative propagation method called PIF (Plants from Stem Fragments) was developed to regenerate hard-to-propagate plants. It allows, in a propagator, to activate the latent buds and to rapidly produce above ground a large amount of healthy planting material. This method is currently used successfully for the regeneration of banana trees. Sawdust is the most used substrate (Kwa Moïse, 1998). However, this substrate has the disadvantage of undergoing the attack of termites which destroy at the same time the roots of the bulbs and reduce their longevity in the regeneration compartments (Okungo, 2012).

With regard to X. *sagittifolium* , the PIF method has not yet been used for the production of the material. Thus, the main objective of this study was to evaluate the rejecting power of X. *sagittifolium* bulbs under three different substrates, including sawdust, charcoal and rice husks, and the relationship between existing between the size of bulbs and the number and vigor of offspring. It was understood that the shedding power of bulbs and the vigor of shoots would vary depending on the size of the bulbs and the substrate tested.

2 Material and Methods

2.1. Field of study

The present research was carried out within the parish Saint Joseph Artisan of the Archdiocese of Kisangani located in the school district in the municipality of Tshopo. The experimental site is located 397m above sea level, 00 ° 31'52.4 " North and 25 ° 10'57.3 " East.

The map of the experimental site is shown in Figure 1 below:

The climate of Kisangani is type Af of the Köppen classification. It is a hot and humid equatorial climate. The average daytime temperature oscillates around 30 ° C and that of the night is 20 ° C.

On average, there is 1885 mm of water per year. The rains are divided into two rainy seasons: the small one spreads from March to June and the big one from September to November.

The annual insolation is 1972 hours and the relative air humidity varies between 80 and 90% (Van Wambeke and Libens, 1957, Litucha et al., 2015, Okungo et al., 2017).

2. Equipment used

During the course of this study, the Macabo bulbs (X. *sagittifolium*) were used as propagation material. The variety used has the following morphological characteristics: green leaves, petioles and purple tubers.

2.3. Methods

2.3.1. Propagator

The superstructure of the propagator was built from local materials including sticks, bamboo and formwork boards. The dimensions of the propagator were 4 m long, 3 m wide and 2 m high. Then, this superstructure was covered with a transparent plastic sheeting to retain heat. To reduce the high brightness, a layer of palm leaves was spread over the tarpaulin. Inside the propagator, three regeneration compartments were constructed to dimensions of 2 m long, 1 m wide and 0.30 m deep.

Each compartment was filled with one of three selected substrates and 30 bulbs were placed in each of them. A total of 90 bulbs were used for this study.

The experimental device used was that of device non-randomized trials, specific case of standard device with slight modification relative to the disposition of witness compared to other treatments.

Prior to placement, the *X. sagittifolium bulbs* were stripped and decapitated. Then, they were allowed to stand in a shady place for a week to promote recovery. The decapitation of the bulbs eliminates the dominance of the apical bud, which removes the dormancy of the lateral buds.

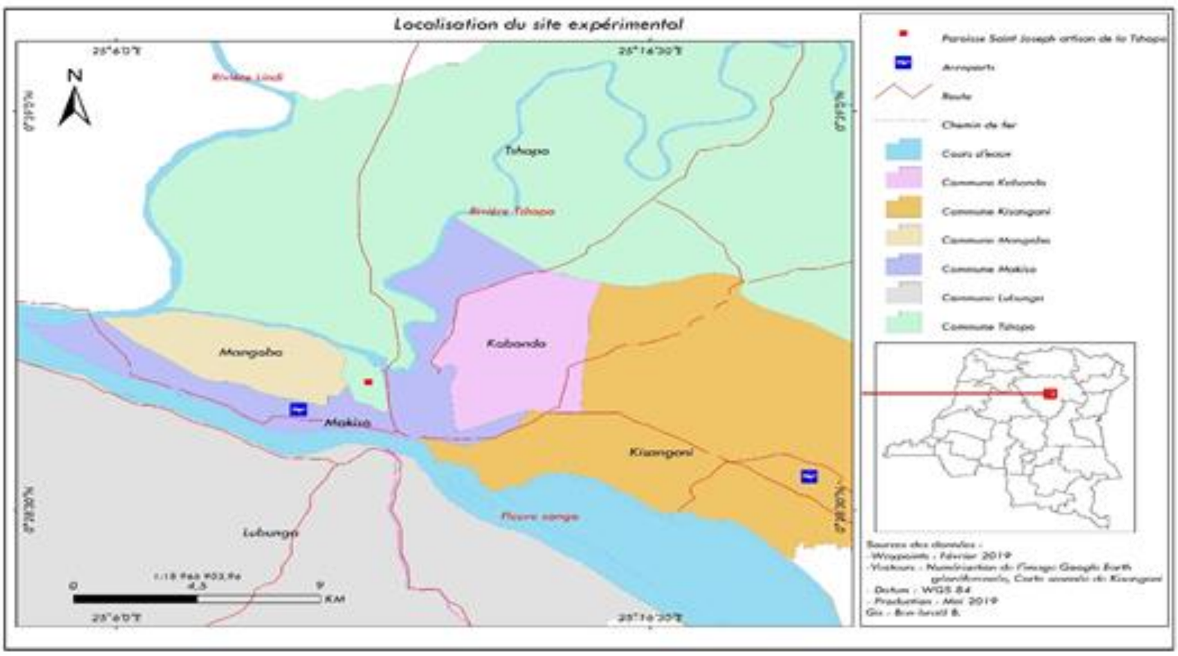

Figure 1. Experimental site map.

Maintenance care consisted of maintaining cleanliness in and around the propagator and watering the regeneration compartments daily to ensure substrate moisture.

Thirty days after the installation of the bulbs, the first offspring formed were weaned. Weaning continued at weekly intervals to avoid reestablishment of apical dominance of the dominant bud. To wean, a sharp and sharp knife was used. It was enough to exert a slight pressure on the offspring and it is separated from the mother's foot leaving a wound at the place where it was attached.

2.3.2. Observations

The main observations under study focused on:

The recovery rate of mother bulbs that was evaluated as a percentage (%), using the following formula: Recovery rate $= \frac{\text{number of bulbs having taken}}{\text{total number of bulbs planted}} \times 100$ and

The average number of trained offspring that were assessed by counting weaned offspring.

Then, the relationship between the average number of offspring formed and the mean diameter of mother bulbs was compared with the mean diameter of the offspring formed and the mean diameter of mother bulbs. The experiment covered the period from 04 September 2018 to 02 April 2019.

2.3.3. Statistical analyzes of the data

The data collected was analyzed primarily through variance analysis and regression analysis under SPSS 20.0 (IBM SPSS Statistic, 2011).

To establish the dependency relationship between the number of offspring formed and the diameter of the mother bulbs on the one hand and the other, between the offspring diameter and the diameter of the mother bulbs, the regression analysis was carried out.

3 Results

3.1. Recovery rate of mother bulbs

The results concerning the recovery rate of mother bulbs under various treatments are shown in Table 1.

Table 1. Recovery rate of mother bulbs

Treatment / Parameter	Sawdust	Bio-char	Rice Balls
Number of de bulbs planted	30	30	30
Number of de bulbs planted	30	30	30
Recovery rate (%)	100	100	100

The results in this table reveal that all planted bulbs have resumed normally for all treatments in general.

3.2. Effect of the substrate on the number of offspring formed per bulb

The results of comparing the number of offspring formed by parent bulbs on the different substrates are shown in Table 2.

Table 2. Analysis of the variance of the number of offspring formed on different substrates.

	SCE	df	MS	F	P-Value
Between Groups	105.867	2	52.933	0,200	0,819
Within Groups	23006.533	87	264.443		
Total	23112.400	89			

From the analysis of this table, it is observed that the comparison of the averages of three substrates tested with respect to the average number of offspring formed and weaned by the analysis of the variance gave the following result: p = 0.819. It emerges from this result that there are no significant differences between treatments from the point of view of production of offspring.

3.3. Relationship between the size of mother bulbs and the number of offspring formed

Table 3 illustrates the relationship between the size of mother bulbs and the number of offspring formed under various treatments.

Table 3. ANOVA of the size regression of mother bulbs and number of offspring formed.

Model	SCE	df	MS	F	P-Value
Regression	6272,188	1	6272,188	32,776	0,000
Residual Error	16840,212	88	191,366		
Total	23112,400	89			

An examination of this table shows that the comparison of the means of the mother bulbs and the number of offspring formed using the analysis of variance gave the following result: p = 0.000. It emerges from this analysis that there are very highly significant differences between these two parameters.

The correlation coefficient result shows that there is a positive relationship between the size of mother bulbs and the number of offspring formed (Y = -32.057 + 6.926X); this relationship is moderate (r (0.521) = 0.5) between the size of the mother bulbs and the number of offspring formed. The adjusted coefficient of determination ($R^2 = 0.263$) shows that the size of mother bulbs explains to 26.3% the increase in the number of offspring formed.

3.4. Relationship between pup size and strength of weaned offspring

Table 4 illustrates the relationship between pup size and the vigor of weaned offspring under various treatments.

Table 4. ANOVA of the regression of the size of the mother bulbs and the vigor of the offspring formed.

Model	SCE	df	MS	F	P-Value
Regression	4,321	1	4,321	40,138	0,000
Residual Error	9,475	88	0,108		
Total	13,796	89			

From the analysis of this table, it appears that the comparison of the means of the size of the mother-bulbs and those of the offspring formed and weaned with the analysis of variance gave the following result: p = 0.000. It emerges from this analysis that there are very highly significant differences between these two parameters.

The correlation coefficient result reveals that there is a positive relationship between the size of the mother bulbs and the vigor of the trained offspring (Y = 1,300 + 0,182X); this connection is of strong intensity (r (0.560)> 0.5) between the size of the mother bulbs and the vigor of the offspring formed. The adjusted coefficient of determination (R^2 = 0.305) shows that the size of mother bulbs explains to 30.5% the increase in vigor of the offspring formed.

4. Discussion of the Results

The results presented above show that the size of mother bulbs and the PIF method obtained in this study contribute effectively to the improvement of Macabo multiplication rate (*X. sagittifolium* (L.) Schott). The results obtained on the recovery rate of mother bulbs showed that all the planted bulbs took over and the recovery rate was 100%. Similar results have been obtained by Okungo (2008, 2012). Indeed, this author claims that Macabo's bulbs (*X. sagittifolium* (L.) Schott) normally resume without much difficulty, except in the case of prior attacks as pointed out by Van Den Put (1981) and Janssens (2001).

The study of the correlation between the size of mother bulbs and the number of offspring formed on the one hand and vigor of formed and weaned offspring on the other hand revealed that there is a positive connection between the two parameters. Large bulbs produce more offspring and good vigor compared to small bulbs. This shows that there is a relationship between the size of bulbs experienced in the production of offspring and the number of offspring produced and their vigor.

Therefore, the size of mother bulbs has a considerable influence on the production and vigor of trained offspring. This size depends on the amount of organic substances accumulated by the plant, especially carbohydrates. The number of offspring is a function of the number of buds present in the bulb in relation to its size (Okungo et al., 2017).

The results obtained made it possible to verify our initial hypotheses. In fact, the size of mother bulbs and the PIF method make it possible to improve the multiplication rate of *X. sagittifolium* (L.) Schott with a view to extending the culture. By maintaining a high temperature in the propagator, the FIP promotes healing of wounds and bud bursting dormant side buds of the bulbs.

The regression lines obtained between the size of mother bulbs and the number of offspring formed on the one hand, and between the size of mother bulbs and the vigor of offspring formed on the other, indicated that there is a link between moderate intensity ($r = 0.521$ and $R^2 = 0.263$, $r = 0.560$ and $R^2 = 0.305$) respectively between the size of mother bulbs and the number of offspring formed on the one hand, and on the other hand between the size of bulbs-mothers and the vigor of offspring. Comparing our results with those obtained by Okungo et al (2017), we find that the size of the bulbs and the PIF method contribute significantly to the improvement of the production of the offspring in *X. sagittifolium* (L.) Schott. In fact, during their in situ trial, these authors had produced an average of 10 rejects with a 6.9 cm cuttings without weaning and 25 rejections on average with a 6.70 cm cutting after 6 weaning's. This low observed performance can be explained on the one hand by the method tested and on the other hand by the size of the bulbs used and the number of weaning performed. Recall that for our study, we experimented with the PIF method and the bulbs used averaged 9.6 cm (sawdust and bio-char) and 8.8 cm (rice husks) during the 24 weaning's. With this method, an elite foot gives 98 offspring after 24 weaning's (6 months). These offspring placed in the nursery reach the size of the mother bulb in 6 months and the 98 offspring can give 9,604 offspring in six months.

With regard to the different substrates used with regard to the number of formed and weaned offspring, the results recorded showed that they did not have a marked influence on the discarding power of *X. sagittifolium* (L.) Schott statistically; this is explained by the fact that the substrates used, especially sawdust and rice husks not yet decomposed, contributed initially only to the retention of the water of irrigation without releasing in the middle no nutrients (Okungo, 2012). In other words, these different substrates initially had as their main role, the retention of water necessary for a favorable humidity for bud burst (Margara, 1989). However, note that compared to averages, there was a slight performance of bio-char compared to other substrates because it contains ash. Indeed, Angladette (1966) confirms that plant ash is part of quick-acting mineral fertilizers unlike organic fertilizers whose mineral elements are released gradually according to the speed of decomposition.

5. Conclusion

The present investigation focused on the influence of bulb size on Macabo multiplication (*X. sagittifolium* (L.) Schott) by the PIF method in Kisangani. The experiment carried out consisted in evaluating the rejecting power of *X. sagittifolium* bulbs under 3 different substrates, notably sawdust, charcoal (bio-char) and rice husks, and the relationship between the size of bulbs and the number and vigor of offspring. The main observations made during this study were based on the recovery rate of mother bulbs and the average number of offspring formed; Next, the relationship between the average number of offspring formed and the average size of mother bulbs was established on the one hand, and the strength of offspring formed and the size of mother bulbs on the other hand. The recorded results can be summarized as follows:

1. The recovery rate of mother bulbs was 100% irrespective of the treatment;
2. After 24 weaning, a 9.6 cm diameter bulb produced 32 and 34 3 cm diameter shoots respectively for sawdust and bio-char, and 32 x 2.9 cm diameter shoots with bulb 8.8 cm in diameter for rice balls; These numbers of offspring do not differ statistically;
3. There is a positive correlation between the three parameters studied. The number of offspring formed increases with the size of the bulbs and their vigor also depends on them, although this number is not statistically different by comparing the different categories of bulbs according to their size.

These results show that bulb size and PIF method are one of the solutions in solving the thorny problem of low availability of propagation material in Macabo (*X. sagittifolium* (L.) Schott). This experiment has shown that the multiplication rate is significantly improved. It was 32 times for sawdust and rice husks, and 34 times for bio-char. It should also be noted that the PIF method is simple and adapted to the living conditions of the rural population, since it generally uses local materials.

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