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Effect of the Degree of Maturity of Cocoa Pods (Theobroma cacao L.) on the Germination Capacity of the Beans and the Growth of Seedlings in the Nursery in Kisangani

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***Abstract*—** *In order to evaluate the effect of the degree of maturity of cocoa pods on germination capacity and growth in the nursery, a study was conducted using a randomized complete block design with three replications of three treatments each. The treatments were defined according to the degree of maturity of the pods as follows: pod beans at the beginning of maturity (T_1), moderately ripe (T_2) and fully ripe (T_3). After germination and emergence, the weight growth of seedlings of the different treatments was evaluated at 5 months.*
The results obtained were as follows:
- The emergence rate was respectively 83.33% for T_1; 93.33% for T_2 and 100% for T;
- The average diameter at the neck was 5.63 ± 0.5 cm for T_3, 5.43 ± 0.5 cm for T_1 and 5.3 ± 0.6 cm for T_2;
- The mean seedling height was: 36.50 ± 4.7 cm for T_3; 38.87 ± 3cm for T_1 and 40.80 ± 4.7 cm for T_2;
- The average number of leaves was for T_1 13±0.75 leaves and for T_3 and T_2 15±3 leaves;
- The average leaf area at 5 months was respectively 156.93 ± 56 cm2 for T_1; 167.10 ± 15 cm^2 for T_2 and T_3 175.47 ± 33 cm^2 for T_3.
The overall results show that the three categories of pods can be used in the production of quality cocoa seedlings. However. Fully ripe pods gave a 100% emergence rate and slightly larger leaves. Statistical analysis of the results showed that there were no significant differences between the three categories of pods.

***Keywords*—** *Ripeness, pods, beans, germination capacity, growth, nursery and Kisangani.*

I. Introduction

The cocoa tree is classified among the industrial plants used by the population for their numerous virtues as well from the food, socio-economic, pharmacopoeia point of view (case of the Aztecs that they considered it as a food of wine of the King) Matamayor et al. (2002). The beans are used to make a nourishing drink, industrial and are used to manufacture fertilizers, pharmaceutical products and soap (Hubert 1984; Janssens, 2001 and Memento, 2010). Currently in the DRC, the cultivation of cocoa is not applied almost everywhere, almost all plantations are abandoned and aged although some individuals. The edaphoclimatic conditions of the DRC allow the extension of this culture on vast areas. In addition, cocoa can be produced in the entire northern part of the country, in the dismembered eastern province and part of North Kivu, mainly in the territory of Beni. Cocoa production and exports have declined sharply in recent decades. Production has declined from about 30,000 tons in 1970 to about 10,000 tons or even 5,000 tons today according to official statistics, the difference being exported as contraband (Kasonia, 2012). To succeed in this revival, it is more than important to have quality and efficient planting material. It should be noted that the best cocoa pod for germination and multiplication is the one that reaches its physiological and morphological maturity. Currently, the research and mastery of adequate and adapted cultivation techniques are important to ensure a good revival of the crop. In order to make the seedlings available, the most common method is generative, using ripe pods. However, there are different degrees of maturity of cocoa pods on the plant. Thus, we wanted to determine the influence of the degree of maturity of the pods on the germination capacity and juvenile growth of the cocoa tree under the conditions of Kisangani. The research question that we want to try to answer is the following: Could the degree or level of maturity of pods have an influence on germination capacity and juvenile growth of cocoa in the nursery?

Since the maturity of cocoa pods differs on the cocoa plant, it is believed that the germination capacity and growth of cocoa seedlings during the juvenile stage would vary according to the maturity of the pods used. Indeed, Vanden put (1981) and Janssens (2001), point out that cocoa beans rapidly lose their germination capacity once they are removed from the pods. This situation would be due to the stage of harvest in relation to the degree of maturity of the pods.

The present work seeks to identify the influence of the degree of maturity of the pods on the germination capacity and juvenile growth of cocoa seedlings in the nursery in Kisangani.

II. Environment, Materials and Methods

Environment

Kisangani, capital of the Tshopo Province, is located in the eastern part of the central Congolese basin at 0°31'N latitude and 25°11'E longitude, at an altitude of 396 m. Due to its

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geographical coordinates, Kisangani straddles the equator. Its average elevation is 396 m and varies from 37 m to 45 m (Arabian plateau in the southeast and the medical plateau in the west) and 46 m (Boyoma plateau in the northeast). According to the report of the Institut National de la Statistique (INS), the data on its total area varies from 1910 km² to 2109 km² (Nyongombe, 1995).

The city of Kisangani is located near the Equator and is characterized by a hot and humid climate, with high and almost constant temperatures throughout the year. From a thermal point of view, Kisangani is characterized by an almost constant megathermy: the temperatures are quite high and their variations are hardly noticeable, even negligible. The average temperatures oscillate between 23,5°C and 25,3°C, that is to say a weak annual thermal amplitude of 1,8°C and the average of the temperatures of the coldest month higher than 18°C (Upoki, 2001).

It has a climate of the Af type of the Köppen classification characterized by a low annual variation in temperature and precipitation. The monthly average varies between 42.6 mm (June) and 375 mm (October) with an average of 208.8 mm. This rainfall allows for

The soils of Kisangani are ferralitic of the ferra-soil type and belong to the oxisol order of the Soil Taxonomy, consisting of sand and clay and poor in nutrients and organic matter. They are deep, leached by rainwater and have a sandy-clay texture. This soil contains for 100g: 0,41 meq of exchangeable aluminium; 0,25 meq of exchangeable hydrogen; 7,75 meq of exchangeable bases; while the cationic exchange capacity amounts to 8,4 meq/100g. The clay fraction is very rich in kaolinite, the clear dominance of the latter reflects the state of extreme weathering of the Kisangani soil (Mambani et al., 2007).

According to Libini (1981), Kisangani currently offers a deeply reworked (modified) vegetation. Uncontrolled urbanization and the need for firewood have caused the forest, which was the indigenous vegetation of Kisangani, to give way more and more to savanna. This vegetation is of anthropic origin and is made up of grassy fallows or secondary forests. Hence, the savannah aspect of the present vegetation of the city.

Materials

The three categories of pods according to the degree of maturity were used as biological material. The seed was obtained from the National Institute for the Study and Agronomic Research of Yangambi. The technical materials consisted of polyethylene bags, machete, hoe, decameter and nylon thread, shade cloth, slat, caliper and tape measure;

Methods

The experimental design adopted was that of randomized complete blocks with 3 replicates of 3 treatments each. The treatments consisted of pod beans at the beginning of maturity (T_1), moderately ripe (T_2) and fully ripe (T_3). The experimental plots were 40 cm long and 30 cm wide or 1200 cm^2 in area, separated by 30 cm in all directions. The plots were under a 1.80 m high shade canopy measuring 240 cm long and 210 cm wide, i.e. a surface area of 50,400 cm2. Each plot contained 20 polyethylene bags as shown in photos 1, 2 and 3;

Photo 1: Early ripening pods (T_1)

Photo 2: Medium ripe pods (T_2)

Photo 3: Fully ripe pods (T_3)

After extraction of the beans from the pods, sowing was carried out in polyethylene bags filled with a mixture (50-50) of pig manure and forest soil at a rate of one seed per bag at a depth of about 3 cm. The seeds were sown so that the pointed end was on the surface of the substrate and the rounded end where the germ is located was at the upper level. This results in a sowing density of 20 seeds per plot, 20 bags of one seed per bag.

The maintenance work was carried out on the following interventions weeding, watering, the phytosanitary round, the reinforcement of straw for the shade.

The observations made during this study were mainly focused on the following parameters: emergence rate (germination capacity), diameter at the collar, number of leaves, leaf area and plant height. The emergence rate was evaluated by

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dividing the number of germinated seeds by the total number of seeds sown multiplied by 100. The number of leaves was counted; the leaf area was obtained by the product of the length and the great width affected by a corrective factor of 0.62. The latter was obtained by the gravimetric method. The diameter at the collar and the height of the plants were taken with a caliper and a metric tape respectively.

To calculate the mean, standard deviation and coefficient of variation as well as the analysis of variance the different formulas from the book of Dagnelie (1975) were used.

III. Results

Emergence rate (germination capacity).

Data on the germination capacity of seeds from pods of different degrees of maturity are given in Table 1.

TABLE 1: Germination rate (%)

Paramèter	T_1	T_2	T_3
Seeds sow	60	60	60
Germinated seeds	50	56	60
Rate (%)	83,33	93,33	100

The results in Table 1 show that germination capacity increases with the degree of maturity and varied according to the treatments used. It ranged from 83.33 to 100% for all treatments.

Nursery growth of the resulting seedlings.

Table 2 shows the mean values of collar diameter, height, number of leaves and leaf area of seedlings obtained at 5 months after emergence for various treatments.

TABLE 2: Average values of vegetative parameters at 5 months

Paramèters	T1	T2	T3
Diamèter at crown (cm)	5,4a	5,3a	5,6a
Plant height (cm)	38,9b	40,8b	36,5b
Nomber of leaves	13c	15c	15c
Leaf area (cm^2)	156,9d	167,1d	175,5d

The results in Table 2 show that all the growth parameters studied varied slightly with the degree of maturity of the pods. The average diameter at the neck of cocoa seedlings is in the range of 5.3 cm to 5.6 cm. The performance of the treatments according to seedling size is as follows: T_3 (36.50 cm) < T_1 (38.87cm) < T_2 (40.80 cm). The average number of cocoa leaves ranged from 13 to 15. The performance of the results is as follows: T_1 (13 leaves) < T_3 (15 leaves) = T_2 (15 leaves). The efficiency of the treatments according to the size of the leaves is presented in ascending order as follows: T_1 (156.93 cm) < T_2 (167.10 cm) < T_3 (175.47). Statistical analysis showed that the three categories of pods produced seedlings that did not differ for all the growth parameters studied, namely diameter at the collar, height, number of leaves and leaf area.

IV. Discussion

The efficiency of the treatments with respect to germination capacity was as follows T_1 (83.33%) < T_2 (93.33%) < T_3 (100%). We note that whatever the degree of maturity, the beans from the pods have an interesting and good germination capacity and there are no significant differences between the degrees of maturity of the pods. Indeed, Mbolo (1990) and Okungo (2018) state that good quality seeds should have a germination rate of at least 80%. All pods gave a germination rate above this value. Kunzu (2010), obtained in the baskets 96.8% germination. It is therefore noted that cocoa beans germinate easily regardless of the conditions and the substrate. These results invalidate our hypothesis concerning the variation of germination rate according to the degree of maturity. According to the trial conducted by Ayi (2017) in Togo,

The best germination rate was observed at 10 days after emergence in both types of pots (cocoa and coffee bags), and averaged 95 ± 3.8% and 96 ± 3.3% respectively. There were no significant effects of the two types of pots on seedling recovery (90 ± 7% for cocoa bag and 91 ± 6% for coffee bag) while the sowing methods showed a negative impact of the delay in transplanting cocoa seedlings. Cocoa seedlings emerged on average 84 ± 9.2% in coffee bags and 82 ± 12% in cocoa bags. All these results show that the germination capacity of cocoa seeds is always high.

It can therefore be noted that the size of the seedlings seems to be independent of the degree of maturity of the pods used. We believe that the performance of the treatments is generally attributable to the individual abilities of the seedlings rather than the degree of maturity of the pods. At 5.5 months after sowing Ayi (2017), found that seedlings in coffee bags were moderately taller than those in cocoa bags with heights of 26.9 ± 3.6 cm and 25.2 ± 5.6 cm, respectively. The plants that reached the best heights at the end of the trial were produced by direct seeding in coffee bags and transplanting of seedlings into cocoa bags at 10 days after emergence (30.5 ± 2.4 cm and 30.3 ± 3.3 cm, respectively). This effect is due to the interaction between bag type and seeding method. These heights are lower than those found in our trial (36.50 ± 4.7 to 40.80 ± 4.7 cm) think we the experimental conditions of each trial.

The results showed that there were not large enough differences between the treatments. The performance of the results is as follows: T_3 (5.63 ± 0.3 cm) > T_1 (5.43 ± 0.5 cm) > T_2 (5.3 ± 0.6 cm) These results allow us to note that the degree of maturity of the pods has no influence on the vigor of seedlings. The stem neck circumference of cocoa plants in both types of bags was influenced by the sowing methods during the trial. At 1.5 months after sowing, direct seeding produced the best seedlings with an average circumference of 1.3 ± 0.1 cm, while at 3.5 months the best seedlings were produced by transplanting with a circumference of 1.8 ± 0 cm in the coffee bags, Treatments with transplanting 10 and 15 days in coffee bags (with a significant difference for the types of bags gave the best cocoa plants with a circumference of 2.0 ± 0.1 cm and 1.9 ± 0.2 cm, respectively (Ayi, 2017). These girths give diameters far inferior to ours. These differences are attributable to the age of the seedlings, as our seedlings were about 5 months old, while in the case of this author, the measurements were made at 1.5 months, and to the experimental conditions.

Our results corroborate with those of Ayi (2017) in Togo, although we had an average of 13 ± to 15 ± leaves per plant. Indeed, he found that the number of leaves on the cocoa plants averaged 12 ± 1 leaves at the end of the trial. There was no significant difference in the number of leaves at 5.5 months

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after sowing. The quantities of soil substrate and sowing methods had no effect on the production of leaves on cocoa plants at 5.5 months.

Statistical analysis of all the parameters studied showed that there were no significant differences between the three categories of pods. These results reflect the advantages of the growth of plants that emerged or resumed at the same time, Malziak (1982) and Cuisance (1984) emphasize that there is a uniformity and homogeneity of growth in seedlings obtained at the same time under the same conditions.

V. Conclusion

The aim of this work was to evaluate the effect of pod maturity on the germinative capacity and juvenile growth of cocoa seedlings in Kisangani. Thus, a trial was conducted in a randomized complete block design with 3 treatments and 3 replications in the Faculty of Agricultural Sciences of Yangambi. The treatments were defined as follows Beans from pods at the beginning of maturity (T_1); beans from pods at medium maturity (T_2) and finally beans from pods at full maturity (T_3). At the end of this investigation we obtained the following results: The emergence rate (germination capacity) was 83.33% for T_1; 93.33% for T_2 and 100% for T_3. The average diameter at the neck of the seedlings at 5 months was for T3 5.63 cm; for T_1 5.43 cm and for T_2 5.3 cm; the average height of the seedling was: 36.50 cm for T_3; 38.87 cm for T_1 and 40.80 cm for T_2; the leaf area at 5 months was 156.93 cm^2 for T_1; 167.10 cm^2 for T_2 and 175.47 cm^2 for T_3 and the average number of cocoa leaves was the following T_1 (13 leaves) T_3 (15 leaves) = T_2 (15 leaves).

The overall results show that all three categories of pods can be used without many problems in the production of quality cocoa plantlets.

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