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Effect of Bean Location Level in the Pod on the Emergence Rate and Juvenile Growth of Cocoa Trees (Theobroma cacao L.) in Kisangani, Tshopo Province, DRC

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Abstract— *In order to determine the level effect of bean location in the pod on the emergence rate and juvenile growth of cocoa trees, a study was conducted using apical (T_1), median (T_2) and basal (T_3) beans. The trial was conducted in a randomized complete block design with 3 treatments and 3 replications. The parameters observed were essentially the emergence rate (germination capacity) and the juvenile growth of the seedlings. The results obtained were as follows:*

- *The emergence rate was 96.7% for T_1; 100% for T_2 and 95% for T_3 ;*
- *The average height and average diameter of seedlings were respectively 35.4 cm and 4.5 mm for T_1, 34.0 cm and 5 mm for T_2 and finally 34.6 cm and 4.5 mm for T_3;*
- *The leaf area and number of unfolded leaves were 112.6 cm^2 and 11 leaves, 115 cm^2 and 12 leaves, 108 cm^2 and 11 leaves for T_1, T_2 and T_3 respectively.*
- *The growth rate of most vegetative parameters was slightly more favorable for seedlings from the middle and apical part.*

The overall results indicated that all beans can be advantageously used for the production of quality seedlings although, the beans from the middle part give the slightly vigorous seedlings compared to the others.

Keywords— *Location level, pod, emergence rate, juvenile growth, cocoa tree.*

I. INTRODUCTION

The agricultural sector includes food crops and industrial export crops that bring in foreign currency to the country. The cocoa sector is going through a significant crisis due to numerous problems, in particular the degeneration of plant material, the ageing of plantations, the inadequate supervision of farmers, etc.

This is why its production has fallen to a derisory level and has significantly ceased to contribute to the state's foreign exchange resources, whereas a few decades ago, this agricultural export product was cited among the products that made a significant contribution to the state budget (FAO, 2001).

Cocoa beans are used to make a nourishing drink. They are used in various industrial processes, including the manufacture of fertilizers, pharmaceutical products and soap (Braudeau, 1969). Currently in the DRC, cocoa cultivation is almost not practiced, especially since almost all plantations are abandoned and have aged. This situation cannot be acceptable given that the edapho-climatic conditions of the DRC allow the extension of this crop over vast areas (Betau, 2017).

It should be noted that the revival and promotion of this sector requires, first, the rejuvenation of aged cocoa farms, whose production of good quality seedlings is important. The multiplication of cocoa by the generative way is generally done by all the beans contained in the pod, whereas there are different zones of beans according to their localization in the pod. It is in this perspective that we conducted this study, in order to identify the effect of the level of location of cocoa beans in the pod, on the rate of emergence and juvenile growth of cocoa trees in the conditions of Kisangani, whose research questions are oriented in the following way:

- Does the level of location of cocoa beans in the pod have an effect on the emergence rate and juvenile growth of cocoa trees?
- Would the emergence rate of apical, median and basal beans be different?
- What would be the juvenile growth of seedlings from each category of beans according to their location in the pod?

The aim of this work is to verify the behavior of different zones of cocoa beans, from the point of view of germination and juvenile growth of the plantlets obtained.

II. MATERIALS AND METHOD

2.1. Environment

Our study was conducted at the IFA experimental site located on Avenue Abbé Munyororo, in the Plateau Médical district of the Commune Makiso in Kisangani.

The city of Kisangani is located in the northeast of the Congolese basin in the province of Tshopo. Its average geographical coordinates are: 25°11' longitude East, 0°31' latitude North and altitude between 389 and 400 m. The relief is dominated by a combination of plateaus and plains intersected by numerous streams and rivers (Gross 1967 cited by Mulongo, 1995).

The Kisangani region is entirely within the equatorial type zone. Thermal fluctuations in this region range from 20 to 30°

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C with an average around 25° C. The average monthly relative humidity is 84% (Kamabu and Lejoly, 1994 in Makelele, 2008). The average annual rainfall is high at 1728.4 mm. While the maxima are 1915.4 mm and the minima are 1417.5 mm.

2.2 Materials

2.2.1. Biological materials

The seeds used were from pods collected at INERA-Yangambi at the National Cocoa Research Program. The pods were of the Amazonian Forastero variety group. Specifically the variety Amelonado, having the oval shape of pod, with shallow groove (Igbabona, 2017)

2.2.2. Non-biological materials

The non-biological materials used in this study consisted of, among others:

- Knife: to separate different areas of beans after shelling ;
- Pulling meter: to measure each bean area ;
- Precision scale: to weigh each bean area after shelling.

2.3 Methods

2.3.1. Experimental set-up

The experimental set-up adopted is that of randomized complete blocks with three treatments and three repetitions. The treatments consisted of apical beans, median beans and basal beans. The experimental plots were 40 cm long and 32 cm wide, i.e. 1280 cm² of surface, separated from each other by 30 cm in all directions. The plots were under a combrier with a height of 1,80m, with 240 cm length and 216 cm width, covering the total area of 51.840 cm² (5,2 m²). Each plot contained 20 polyethylene bags of 8cm diameter and 20 cm height.

T_1 = Apical beans; T_2 = Median beans and T_3 = Basal beans.

2.3.2. Definition of each zone of beans in the pod

After shelling, we defined each zone of beans in particular (Apical, Median and Basal) by determining the total length of beans (in cm) as a whole (in ears) and then separate them using a sharp knife with three parts, as shown in Figure 2 below.

Fig. 1: Determination of each bean zone.

The average weights of each bean were determined by dividing the total weight of a bean zone by the total number of beans in the same zone and are presented in Table 1.

TABLE 1: Presentation of the average weight of each bean

Apical beans (g)	Median beans (g)	Basal beans (g)
4 ,76	5,12	3,85
5,01	5,30	3,52
4,11	5,04	3,43
4,36	5,26	3,25
4,18	4,82	3,26
∑ 22,42	**25,54**	**17,31**
$\bar{X}$ 4,48	**5,12**	**3,46**

2.3.3. Observed parameters

The parameters studied in this experiment were: (1) bean weight for each pod area; (2) emergence rate; (3) plant height; (4) number of leaves formed; (5) leaf area; and (6) growth rate.

Seed emergence rate was determined by simple counting. It is obtained by dividing the number of plants obtained by the number of seeds sown, multiplied by 100%. The emergence started from the 9th day after sowing and continued until the 15th day.

As for the height of the plants, the leaf area, the number of formed leaves were taken, on the 30th day after sowing for the first time and continued progressively every 4 weeks, to stop at the 90th day, that is to say 3 months.

The growth rate was determined three months after sowing. It is obtained by subtracting the last growth by the initial growth then, dividing by the same initial growth and multiplying it by 100 to express it in percentage.

2.4. Statistical analysis

To find the mean, standard deviation, coefficient of variation and analysis of variance (ANOVA), we used the different formulas of Dagnelie (1975).

The coefficients of variation was determined by the following relationship:

$$CV(\%) = \frac{S}{\bar{X}} \times 100$$

Where:

- CV: Coefficient of variation,
- S : Standard deviation
- $\bar{X}$: Mean

In this relationship we retain:

- ✓ CV < 30 % : homogeneous distribution
- ✓ CV > 30 % : heterogeneous distribution.

For the analysis of variance, we retain:

- ✓ Fcal > Ftab : significant difference
- ✓ Fcal < Ftab : no significant difference

III. Results and Discussion

3.1 Emergence rate

The germination capacity data at 15 days after sowing are presented in Table 2 below.

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TABLE 2: Emergence rate

Parameters \ Treatments	T_1	T_2	T_3
Number of seeds sown	60	60	60
Number of seeds emerged	58	60	57
Seed emergence rate %	96,67	100	95

T_1 = apical beans; T_2 = median beans and T_3 = basal beans

Table 2 shows that the emergence rate varied according to the treatments used, ranging from 95 to 100% for all treatments. As we can see, T_2 was characterized by the highest germination capacity. The efficiency of the treatments is as follows: T_2 (100%) > T_1 (96.67%) >T_3 (95%). We note that, whatever the level of localization, the beans from the median zone of the pod have an interesting and good germination capacity. Indeed, Mbolo (1990) states that good quality seeds should have a germination rate of at least 80%. All pod areas yielded a germination rate above this value. Mananga (2018), working on the influence of pod maturity, found the same trends with emergence rates ranging from 83.3 to 100%. These results invalidate our hypothesis regarding the variation in emergence rate with the level of bean location in the pod. All these results show that the germination capacity of cocoa seeds is always high.

3.2. Height of seedlings

3.2.1. Evolution of height over time.

Figure 2 below shows the evolution of seedling height over time.

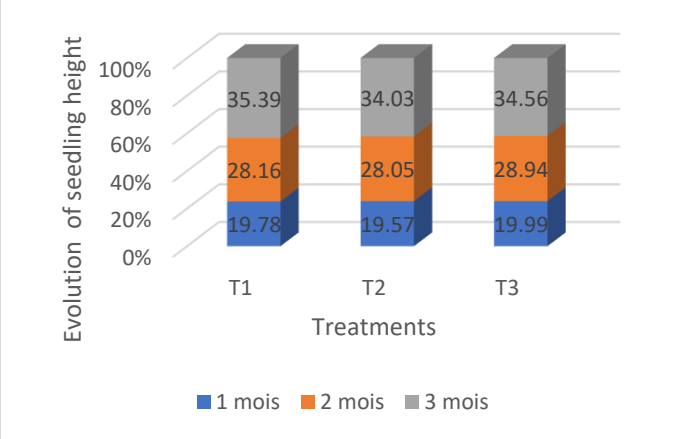

Fig. 2: Average evolution of height (cm) from 1 to 3 months

From the analysis of these results, we note an increase in the size of the seedlings from the first to the last sampling with a slight performance of T_2 (seedlings from apical beans). These differences are attributable to the individual abilities of the seedlings. Growth is a function of time and therefore variable over time. Growth is the enlargement of cells (Mazliak, 1982 and Hubert, 1984).

3.2.2 Average height

Data on the average height of cocoa stems under various treatments are presented in Table 3.

From the examination of the results in Table 3, it is clear that on average the height of the cocoa plant stem varied according to the blocks and treatments used during our investigation. The performance of the results is as follows T_1 (35.39 cm) > T_3 (34.56 cm) > T_2 (34.03 cm). We note that the size of the seedlings seems to be independent of the level of bean location used. We believe that the performance of the treatments is generally attributable to the individual aptitudes of the seedlings rather than to the level of bean location in the pod. These results corroborate those observed by Mananga (2018) and Bokongole (2018). The distribution of data around the mean is homogeneous for all treatments because, their coefficients of variation are less than 30%.

TABLE 3: Average height (cm) at 3 months under various treatments

Parameters \ Treatments	T_1	T_2	T_3
I	34,80	32,62	31,85
II	33,98	35,15	35,20
III	37,40	34,32	36,63
Sum	106,18	102,09	103,68
Average	35,39	34,03	34,56
Standard deviation	1,79	1,29	2,45
CV (%)	5,04	3,79	7,10

The results of the analysis of variance on seedling size under various treatments are presented in Table 4

TABLE 4: Summary of ANOVA for seedling height

SV	ddl	SCE	CM	Fcal	Ftab
Total	8	24,57	3,07		
Repeat	2	13,8	6,9	3,48	6,94
Treatment	2	2,84	1,42	0,71	6,94
Error	4	7,93	1,98		

After the calculation of the analysis of variance, it appears that there is no significant difference between treatments because (Fcal < Ftab). Regardless of the level of bean location in the pod, the size of the different seedlings is statistically similar.

3.3 Leaf area

3.3.1 Evolution of leaf area over time

Figure 3 below shows the evolution of the leaf area over time

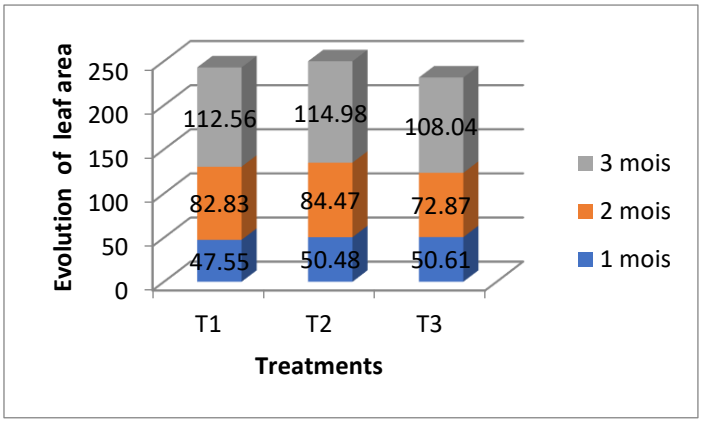

Fig. 3: Average evolution of leaf area (cm^2) from 1 to 3 months

It appears from Table 3, that the leaf area increased from the first sampling to the last, for all treatments. In relation to this

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parameter, we noticed that the beans from the median zone (T_2) are better compared to the others (Apical and basal) based on the last month.

3.3.2 Average leaf area

The data on the average leaf area under different treatments are presented in Table 5.

TABLE 5: Average leaf area (cm^2) at 3 months under various treatments

Parameters \ Treatments	T_1	T_2	T_3
I	115,48	113,62	104,26
II	110,26	115,16	112,34
III	111,94	116,16	107,52
Sum	337,68	344,94	324,12
Average	112,56	114,98	108,04
Standard deviation	2,66	1,28	4,06
CV (%)	2,36	1,11	3,76

The analysis of this table reveals that the leaf areas of the plants varied according to the blocks and the treatments used. The efficiency of the results is as follows T_2 (114.98 cm) > T_1 (112.56 cm) > T_3 (108.04 cm). These show that the beans from the median zone of the pod, give seedlings with a high leaf area compared to the other zones, especially apical and basal. Although there is a slight numerical difference between the averages but, they are homogeneous because, their coefficient of variation are lower than 30%. These results corroborate with those obtained by (Mananga, 2018) because, he found the distribution homogeneous for all treatments. The result of the analysis of variance, relative to the leaf area at 3 months, under different treatments are presented in Table 6 below.

TABLE 6: Summary of ANOVA for leaf area

SV	ddl	SCE	CM	Fcal	Ftab
Total	8	124,95	15,62		
Repeat	2	3,22	1,61	0,14	6,94
Treatment	2	74,44	37,22	3,15	6,94
Error	4	47,29	11,82		

After the ANOVA calculations, it appears from this table that there is no significant difference between treatments because F.cal < Ftab. The size of leaves at 3 months is similar for the 3 zones of beans located in the pod.

3.4 Number of leaves formed

3.4.1 Evolution of the number of leaves formed over time

Figure 4 below illustrates the average evolution of formed leaves

From the reading of figure 4, it appears that the average number of formed leaves, varied slightly according to the level of the localization of each zone of beans in the pod for the various treatments; from the first to the last observation. This is only normal because it obeys the law of growth.

3.4.2 Average number of leaves formed

Data on the average number of leaves formed under various treatments are recorded in Table 7.

From the results in Table 7, we see that the average number of cocoa leaves ranged from 11 to 12. The performance of the results is as follows: T_2 (12 leaves) > T_1 (11 leaves) = T_3 (11 leaves). As for the distribution of data around the mean, we noticed that there is homogeneity for all treatments. These low variations indicate that the number of leaves is a varietal character independent of the level of localization of each bean zone in the pod. Our results corroborate with those of Mananga (2018). Indeed, the latter had noticed that the average number of cocoa leaves is located in the range of 11 to 12 leaves per plant at 3 months and 13 to 15 leaves per plant at 4 months after sowing. The degree of maturity had no effect on the production of leaves on cocoa plants at 4 months.

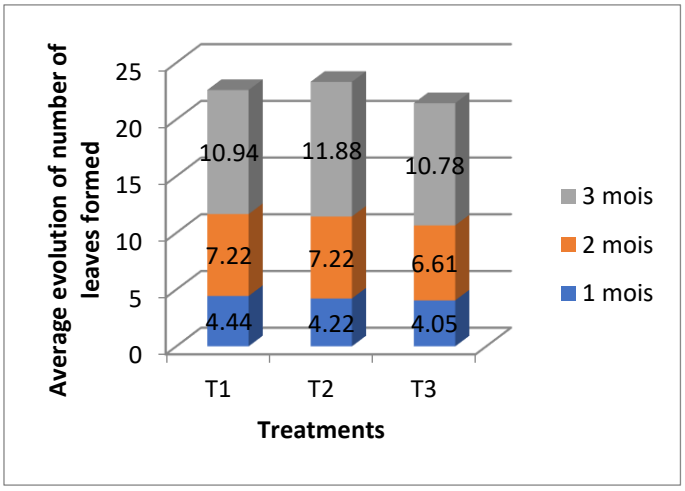

Fig. 4: Average evolution of formed leaves from 1 to 3 months

TABLE 7: Average number of leaves formed at 3 months after sowing

Blocks \ Treatments	T_1	T_2	T_3
I	10,33	12,33	10,17
II	11,17	12,00	10,00
III	11,33	11,33	12,16
Sum	32,83	35,66	32,33
Mean	10,94	11,89	10,78
Standard deviation	0,54	0,51	1,20
CV (%)	4,91	4,29	11,14

These numerical differences led to the analysis of variance, the results of which are reported in Table 8.

TABLE 8: Summary of ANOVA for number of leaves formed

SV	ddl	SCE	CM	Fcal	Ftab
Total	8	6,13	0,77		
Repeat	2	0,75	0,37	0,46	6,94
Treatment	2	2,15	1,07	1,32	6,94
Error	4	3,23	0,81		

After the ANOVA calculations, it appears from this table 8 that there is no statistically significant difference between the beans in the apical, medial and basal area of the pod because (Fcal < Ftab).

3.5 Neck diameter

3.5.1. Evolution of the diameter at the neck

The results in relation to the evolution of the average collar diameter of cocoa seedlings from different pod bean zones are presented in Figure 5 below.

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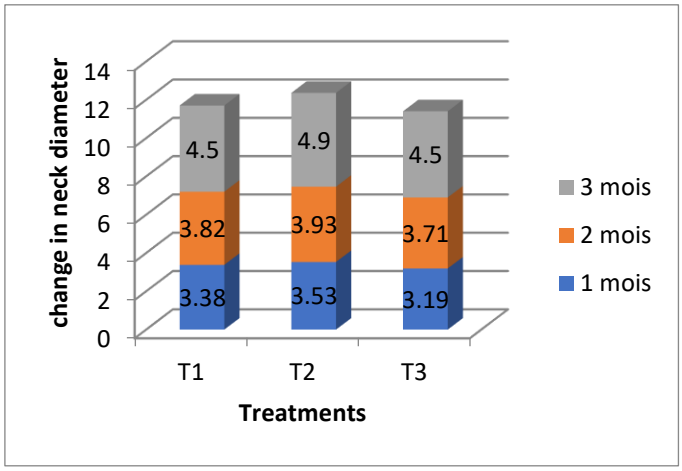

Fig. 5: Average evolution of the diameter at the neck (mm) from 1 to 3 months.

From the reading of figure 5, it appears that the vigour of the seedlings increased from the first to the last observation without noticeable difference for the different treatments tested, a weak performance of the seedlings from median beans (T_2).

3.5.2. Average diameter at the neck

Table 9 presents data on the average diameter at the neck of cocoa plants under various treatments at the end of the experiment.

TABLE 9: Average diameter at the neck (mm) at 3 months after sowing

Treatments / Blocks	T_1	T_2	T_3
I	4,9	5,0	4,5
II	4,5	4,9	4,7
III	4,3	5,0	4,3
Sum	13,7	14,9	13,5
Mean	4,57	4,97	4,50
Standard deviation	0,31	0,06	0,20
CV (%)	6,69	1,16	4,44

The results in Table 5 show that the average neck diameters of cocoa seedlings varied slightly between treatments and blocks. The average values obtained are in the range of 4.5 to 5 mm. The results showed that there was no significant difference between treatments. The performance of the results is as follows: T_2 (5mm) > T_1 (4.5mm) = T_3 (4.5mm). As for the distribution of the data around the mean, we noticed that there is homogeneity because the coefficients of variation of all the treatments are lower than 30%. These results allow us to note that the location of cocoa beans in the pod has no influence on the vigor of seedlings. Comparing our results, in relation to those obtained by Bokongole (2018) and Mananga (2018), it is revealed that there is a corroboration. The results showed that the degree of pod maturity and the types of substrate have no influence on the diameter at the collar of 3.5 and 4 months old cocoa seedlings.

Since numerical differences exist between treatments, we proceeded with the analysis of variance, the results of which are recorded in Table 10.

After calculating the analysis of variance relative to the diameter at the neck, it is clear that there are no significant differences between the treatments because Fcal < Ftab. It follows that the diameters of the different seedlings whatever the position of the beans in the pod, from the statistical point of view, there is no difference. A slight difference is noticed from the numerical point of view.

TABLE 10: Summary of the analysis of variance on the diameter at the collar.

SV	ddl	SCE	CM	Fcal	Ftab
Total	8	0,66	0,08		
Repeat	2	0,11	0,05	1,25	6,94
Treatment	2	0,38	0,19	4,75	6,94
Error	4	0,17	0,04		

IV. Conclusion

The objective of the present study was to evaluate the effect of the level of location of cocoa beans in the pod, on germination and juvenile growth of cocoa trees under the conditions of Kisangani. To achieve this objective, we installed a germinator-nursery following an experimental device of randomized complete blocks comprising 3 treatments and 3 repetitions in the enclosure of the Faculty Institute of Agronomic Sciences of Yangambi in Kisangani.

The first treatment was composed of apical beans (T_1), the second of median beans (T_2) and finally the third of basal beans (T_3). Observations were made on emergence rate, seedling height, leaf area, number of leaves formed and crown diameter. The results obtained showed that:

- The emergence rate was 96.66% for T_1; 100% for T_2 and 95% for T_3. Nevertheless T_2 is the best treatment compared to others;
- The average height of seedlings was 35.39 cm for T_1; 34.03 cm for T_2 and 34.56 cm for T_3;
- The leaf area increased from the first sampling to the last for all treatments was 112.56 cm^2 for T_1; 114.98 cm^2 for T_2 and 108.04 cm^2 for T_3
- The average number of leaves formed was 12 for T_2 and T_1 (11 leaves) = T_3 (11 leaves).
- The average diameter at the collar was 5 mm for T_2 and T_1 (4.5 mm) = T_3 (4.5 mm).

The results obtained show that the three bean zones within the pod can be used without much problem in the production of quality cocoa seedlings. Nevertheless, the middle zone was characterized by good emergence and juvenile growth of cocoa trees, slightly higher than the other zones (apical and basal).

V. Recommendations

In view of the above, we recommend the following:

- That this study be repeated in time and space to confirm or refute the trends;
- That the nurserymen generally use all the beans contained in the pod but, by throwing much more their devotion on the beans of the median zone (T_2), to relaunch this sector because, the germinative capacity and juvenile growth were more favorable in this zone than others notably apical (T_1) and basal (T_3).

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