THE EFFECT OF DIFFERENT PARTICLE SIZES OF SAWDUST AND FOREST TOPSOIL ON GERMINATION, GROWTH AND DEVELOPMENT OF TWO COCOA VARIETIES IN THE NURSERY[1] /

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Resumen

En un experimento llevado a cabo por 24 semanas en un semillero, se observó el efecto de suelo húmico del bosque y aserrín de diferentes texturas sobre la germinación, crecimiento y desarrollo de dos variedades de cacao en el semillero. El único aspecto beneficioso de la mezcla aserrín/suelo fue que produjo una germinación más rápida que el suelo solo. En otras variables, como los parámetros morfológicos, producción de material seco, absorción de nutrimentos y promedio de crecimiento, las plántulas sembradas en suelo húmico sólo mostraron mejores resultados.

Las plántulas de F3 Amazon mostraron más vigor y mayores promedios que las de Amelonado en todos los parámetros estudiados, posiblemente debido a una producción más temprana de una zona efectiva de hojas. En los dos cultivares, la absorción de nutrimentos fue mucho mayor en las hojas, luego los tallos y las raíces en orden descendiente. Entre los elementos, K fue el mejor absorbido, seguido por N, Ca Mg y P, en ese orden.

Introduction

It is now an established practice to raise cocoa seedlings in the nursery Benstead (5) and Freeman (8) have shown that nurseries are essential insurance against germination failure Previously in Nigeria baskets filled with topsoil were used to raise cocoa seedlings in the nursery, but in recent years, perforated polythene bags have been substituted for baskets in response to the work of Gordon (10) The use of topsoil alone as a propagating medium has been questioned, as evidenced from the work of Atanda and Jacob (4), who found that cocoa beans planted in a sawdust/topsoil mixture germinated faster than in topsoil alone There has been a recent reduction in areas where topsoil can be obtained in cocoa growing areas of Nigeria, as a result of massive clearing of many virgin forests for food crop production This study was therefore designed to investigate whether topsoil alone or in combination with various types of sawdust of different particle sizes would affect germination, growth and development, and nutrient uptake of nursery seedlings of two cocoa varieties, F_3 Amazon and Amelonado.

Materials and methods

The experiment was carried out in 1984 with two varieties of cocoa, F_3 Amazon and Amelonado, which are the two predominant varieties in West Africa. The sowing media used were:

a) unsieved sawdust on topsoil
b) 4 mm mesh-sieved sawdust on topsoil
c) 2 mm mesh-sieved sawdust on topsoil
d) 0 6 mm mesh-sieved sawdust on topsoil and
e) topsoil alone

Black perforated polythene bags (25 cm x 16 cm x 5 cm) were used. For the sawdust treatment, each polythene bag was filled to three-quarters of its

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capacity with 2.5 kg of unsieved forest topsoil, and the remaining quarter was filled with sawdust. In the topsoil treatment, the bags were filled to within 5 cm of the brim. The nutrient status of the topsoil and the sawdust in given in Table 1

The 10 treatments (2 varieties x 5 growing media) were replicated four times in a randomized block design. Ten bags were used in each replicate, for a total of 400 bags. The experiment was set up at the Cocoa Research Institute of Nigeria (CRIN), the main Watson (16) and Radford (14) The nutrient uptake was determined from the product of dry weight and the percent of nutrient contents.

Sampling started one month after sowing and continued at a monthly interval. Six samples were taken throughout the experimental period of 24 weeks. Each time, the morphological parameters of height, girth and number of leaves were taken. The polythene bag containing each of the sampled seedlings was then torn away and the whole seedling removed with the roots intact. The roots were thoroughly washed with water and the seedling broken into leaves, stem and roots. The fresh weights of each organ was taken. Leaf areas were determined with a leaf area meter (Lamba Instrument Corporation Model L13100). All the plant parts were then dried to a constant weight at 100°C in a forced air draught oven for 36 hours. Growth analysis variables were computed on the basis of the formulae used by the nursery at Idi-Ayunre, under artificial shade with incident light intensity of about 20% full daylight accordings to Goodall (9). Seeds were selected from the middle portion of ripe cocoa pods, after they had been washed with dry sawdust to remove the mucilage covering them, and were sown on 23 January, 1984. They were watered immediately after planting and consequently every morning. Germination counts were taken every day for one month

Results

Germination

The mean days to germination in both varieties increased as the particle sizes of the sowing media decreased. Seeds planted in sawdust/topsoil germinated better than those planted in topsoil alone, as the mean days to germination in topsoil was higher than in all the sawdust/topsoil combinations. The fastest germination was obtained from seeds planted in the unsieved sawdust/topsoil. F_3 Amazon germinated faster than Amelonado in all media and had a higher percentage of germination (Table 2).

Table 1. Nutrient status and physical properties of the sowing media.

	A	Sawdust			
Sowing Media	Total % N	Total % P	% K	% Ca	% Mg
Unsieved sawdust	0.003	0.039	0.5	0.015	0.001
Sieved sawdust, 4 mm mesh	0.006	0.052	0.6	0.016	0.002
Sieved sawdust, 2 mm mesh	0.006	0.052	0.6	0.014	0.001
Sieved sawdust, 0.6 mm mesh	0.007	0.059	0.6	0.015	0.002

	B	Forest Topsoil							
	pH	% sand	% Silt	% Clay	% N	% P	% K	% Ca	% Mg
Forest Topsoil	6.5	47.0	22.0	31.0	0.12	0.18	4.0	1.5	0.23

Morphological parameters

The overall means of the seedling height, girth and number of leaves per plant increased with time. At the final sampling, seedlings planted in topsoil alone significantly excelled in all these parameters F_3 Amazon gave significantly higher values of these parameters than Amelonado (Table 3) All these parameters were found to be highly correlated with one another (Table 4)

Table 2. Mean days to germination in F_3 Amazon and Amelonado grown in different sowing media.

	Unsieved sawdust on topsoil	4 mm mesh-sieved sawdust on topsoil	2 mm mesh-sieved sawdust on topsoil	0.6 mm mesh-sieved sawdust on topsoil	Topsoil alone	Mean
F_3 Amazon	8.9	10 5	11 1	11 2	13.1	11.0
Amelonado	10 5	11 8	11 4	13 5	16 7	12 2
Mean	9 7	11 1	11 3	12 4	14 9	

LSD (P = 0 05) Variety 0 89
Medium 1.04
Interaction 1 48

Table 3. Mean values for Girth (cm) height (cm) and number of leaves of F_3 Amazon and Amelonado grown in the nursery (24 weeks after sowing).

Varieties	Unsieved sawdust on topsoil			4 mm mesh-sieved sawdust on topsoil			2 mm mesh-sieved sawdust on topsoil			0.6 mm mesh-sieved sawdust on topsoil			Topsoil alone		
	Girth	Height	No. of Leaves	Girth	Height	No. of Leaves	Girth	Height	No. of Leaves	Girth	Height	No. of Leaves	Girth	Height	No. of Leaves
F_3 Amazon	0 63	27 6	14 0	0.58	20 1	10 5	0 50	25 9	13 0	0.68	21 8	10 5	0 68	30.9	14 3
Amelonado	0 48	19 1	11 0	0 53	17.0	13.8	0 50	17 9	10 0	0 53	15.1	7.0	0 60	17 1	11 8
S E	0 145	5.01	2 19	0.145	5 01	2 19	0.145	5.01	2 19	0 145	5.01	2 19	0 145	5 01	2 19

Table 4. Correlation matrix between some growth parameters in F_3 Amazon and Amelonado grown in the nursery for 24 weeks (n – 2 = 4).

	Seedling height	Stem girth	Leaf number	Leaf area
Seedling height	–			
Stem	0 99**	–		
Girth	0 97**	–		
Leaf number	0 93**	0 94**	–	
	0 93**	0 87**		
Leaf area	0 96**	0 96**	0 98**	–
	0 89*	0 89*	0 64	–

Note: F_3 Amazon/Amelonado

Dry matter production and distribution

The mean total dry matter yield of the seedlings increased with time, peaking at the final harvest. F_3 Amazon gave a higher yield of total dry matter than Amelonado throughout the experimental period. There were significant varietal differences at 12 and 24 weeks after sowing (Fig. 1). Moreover, at the final sampling seedlings of both varieties grown in topsoil had the highest total dry matter yield (Table 5).

The leaves had the highest proportion of dry matter, by comparison with the other organs. At the first sampling, the proportions of dry matter in the leaves, stem and roots of F_3 Amazon were 40%, 39% and 21% respectively. The corresponding figures in the Amelonado were 38%, 35% and 27%. At the final sampling, the proportion of dry matter in these organs in F_3 Amazon were 43% in the leaves, 31% in the stem and 26% in the roots. The corresponding figures for Amelonado were 43%, 35% and 22% (Figs 2 and 3).

Growth rates

The highest mean net assimilation rates (NAR) in both varieties were recorded between 8 and 12 weeks after sowing. F_3 Amazon recorded a higher overall mean NAR than Amelonado (0.0829 g/dm^2/wk and 0.0797 g/dm^2/wk respectively). However there was no significant varietal difference in NAR values throughout the experimental period (Table 6). The peak relative growth rate (RGR) value, like the NAR value, was also obtained between 8 and 12 weeks after sowing, with F_3 Amazon having a higher value. The leaf area ratio (LAR) decreased with the age of the seedlings in both varieties, with F_3 Amazon recording a significantly higher peak value (Table 6). The leaf area index (L) in both varieties increased with age, although there was a slight drop for Amelonado at 20 weeks after sowing. The peak L value for F_3 Amazon was 3.3, while the peak for Amelonado was 2.7 (Fig. 4). Seedlings grown in topsoil alone gave the highest value and had the highest number of leaves.

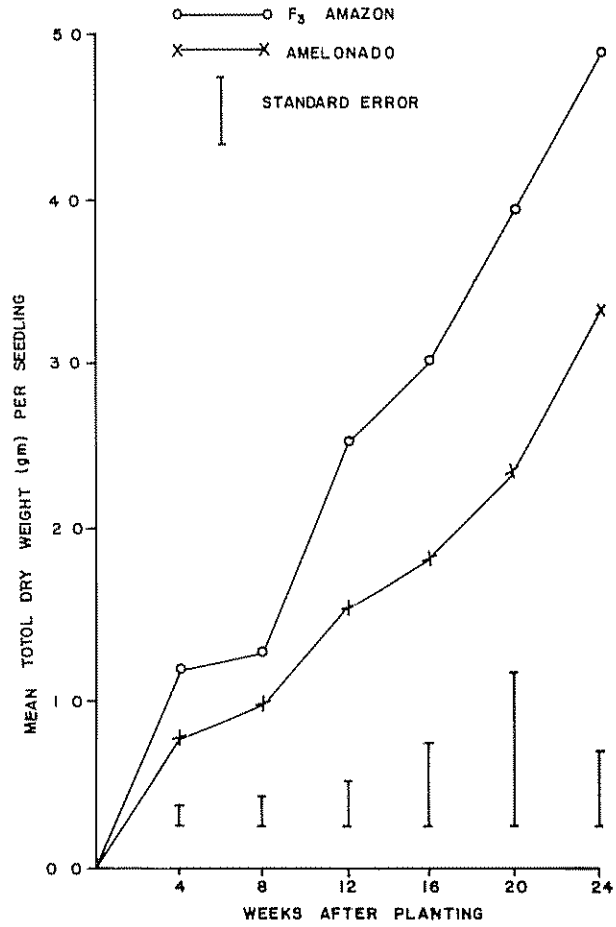

Fig. 1. Mean total dry weight (g) per seedling of F_3 Amazon and Amelonado for 24 weeks after planting.

Table 5. Mean total dry weight (g/seedling) of F_3 Amazon and Amelonado grown in the nursery (24 weeks after sowing).

Varieties	Unsieved sawdust on topsoil	4 mm mesh-sieved sawdust on topsoil	2 mm mesh-sieved sawdust on topsoil	0.6 mm mesh-sieved sawdust on topsoil	Topsoil alone	Variety mean
F_3 Amazon	4.6	3.5	4.3	4.7	7.5	4.9
Amelonado	3.9	2.9	3.7	1.7	4.4	3.3
Medium mean	4.2	3.2	4.0	3.2	5.9	

S.E. Variety = 0.45
S.E. Medium = 1.30
S.E. Interaction = 1.84

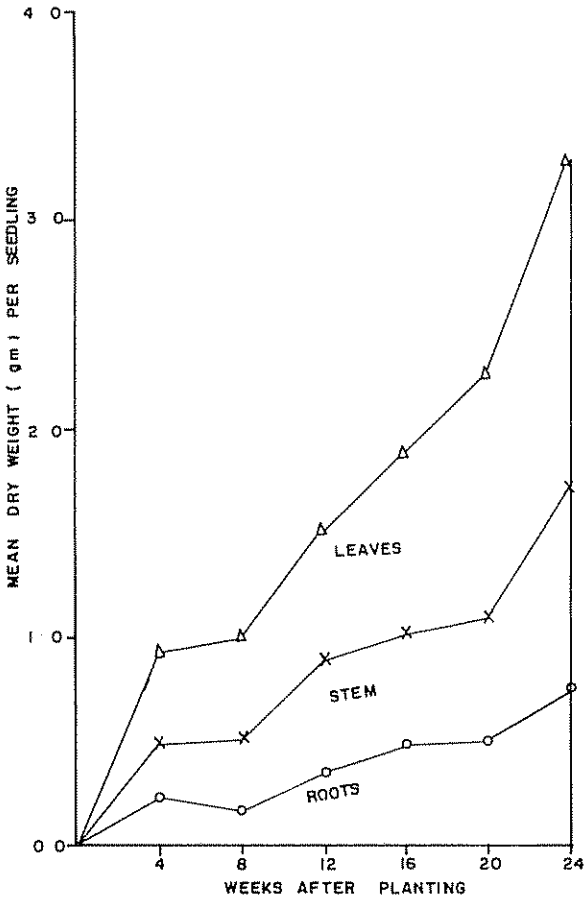

Fig. 2. Dry matter distribution in different organs of Amelonado seedlings for 24 weeks after planting.

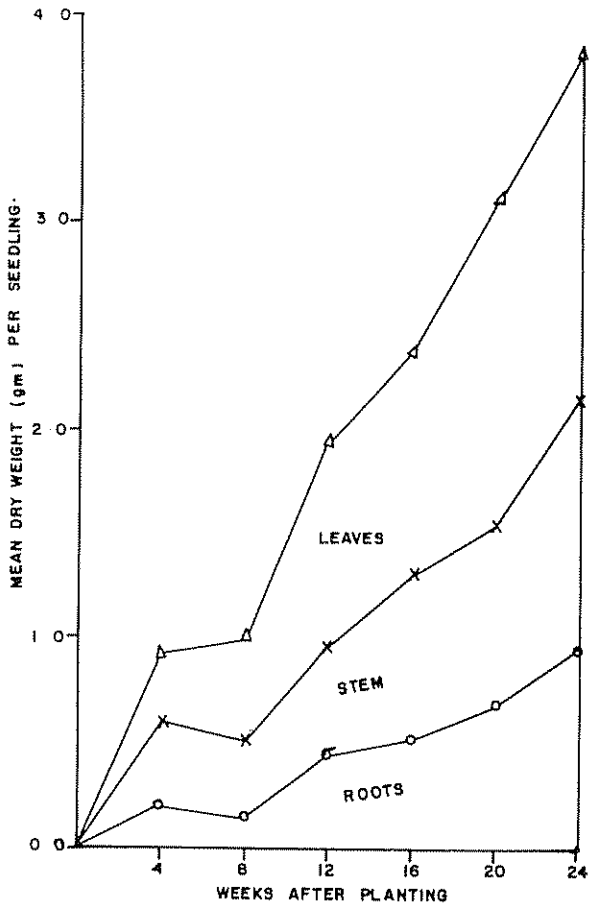

Fig. 3 Dry matter distribution in different organs of F_3 Amazon seedlings for 24 weeks after planting

Table 6. Mean values of Net Assimilation Rate, (NAR) Leaf Area Ratio, (LAR) and Relative Growth Rate (RGR) of F_3 Amazon and Amelonado during the first 24 weeks of growth.

Interval (weeks)	F_3 Amazon			Amelonado		
	NAR $g/dm^2/wk$	LAR cm^2/g	RGR g/g/day	NAR $g/dm^2/wk$	LAR cm^2/g	RGR g/g/day
4–8 weeks	0.022	150.2	0.018	0.009	126.7	0.006
8–12 weeks	0.032	117.4	0.024	0.030	113.0	0.020
12–16 weeks	0.016	105.7	0.011	0.009	72.5	0.011
16–20 weeks	0.014	101.6	0.009	0.015	62.8	0.013
20–24 weeks	0.013	65.5	0.008	0.018	57.7	0.018
Total	0.097		0.07	0.081		0.068
Mean	0.019		0.014	0.016		0.013

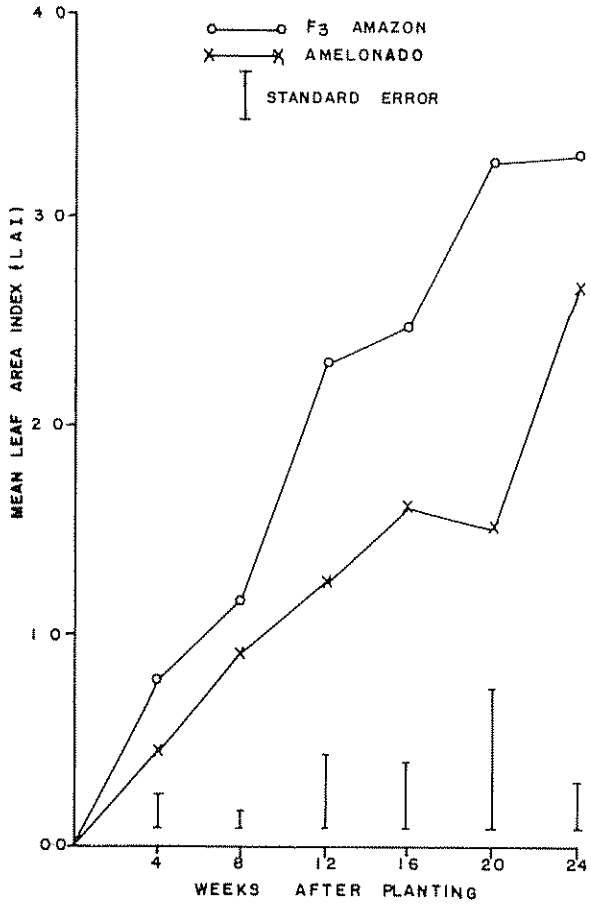

Fig 4 Mean leaf area index (LAI) of F_3 Amazon and Amalonado seedlings for 24 weeks after planting

Nutrient Uptake

F_3 Amazon variety recorded higher uptake of N, P, K, Ca an Mg than Amelonado Nutrient uptake in the leaves was highest, followed by that of the stem and the roots Uptake of potassium by the different organs of both varieties was the highest, followed by nitrogen, calcium, magnesium and phosphorus in that order Seedlings grown in topsoil alone had the highest uptake in both varieties (Table 7)

Discussion

The study reported here showed the overall superiority of sawdust on top of soil over topsoil alone This confirmed the work of Atanda and Jacob (4), who attributed this advantage to better drainage, good water potential and less "bean-medium" contact of the sawdust Also the study showed that the F_3 Amazon variety had higher a germination percentage and grew faster than Amelonado This difference in germination percentage may be attributed to the higher percentage of seed coat in Amelonado seeds as found by Atanda and Jacob (4) It is a well-documented fact that the seed coat exerts a tremendous effect on germination because it is impermeable to water and dissolved gases, particularly carbon dioxide, has high mechanical strength due to stratification, and is impermeable to chemical inhibitors Croucer and Barton (7) The particular factors militating against early germination of Amelonado seeds when compared with F_3 Amazon merits further investigation

In other measurements examined in this study, such as morphological parameters, dry matter production, growth rates and nutrient uptake, seedlings raise in topsoil alone were superior to seedlings raised in any sawdust/topsoil mixture This can be attributed to the low nutrient content of sawdust compared with topsoil

The consistently significant varietal differences observed in the experiment might be attributed to

Table 7. Nutrient uptake in cocoa seedlings (g/plant) 24 weeks after sowing

	Nitrogen		Phosphorus		Potassium		Magnesium		Calcium	
Organs	F_3 Amazon	Amelonado	F_3 Amazon	Amelonado	F_3 Amazon	Amelonado	F_3 Amazon	Amelonado	F_3 Amazon	Amelonado
Leaf	0 033	0 023	0.0032	0 0022	0 06	0 04	0 011	0.009	0 023	0 015
Stem	0 011	0 006	0 0019	0 0014	0 036	0 024	0 010	0 007	0 016	0 009
Root	0 006	0 004	0 0012	0 0008	0 023	0 015	0 005	0 003	0 005	0 003
Total	0 05	0 03	0.0063	0 0044	0 12	0 08	0 03	0 02	0 04	0 03

the inherent genotypic properties of the varieties The rapid production of leaves by F_3 Amazon no doubt helped it to establish its photosynthetic apparatus earlier than Amelonado and made it less dependent on the seed endosperm at initial stages of growth The net result of this was that F_3 Amazon was able to surpass Amelonado in all the growth measurements examined Leaf number, in particular, has been found to be an important growth parameter in the development of nursery seedlings Adenikinju (1)

The study provided an opportunity to compare the growth rates of the varieties observed here with those found in other studies The overall NAR mean value obtained in this study was slightly less than the value obtained by Oyebade (13), but it added support to the prevailing opinion that NAR values of cocoa seedlings are low, as in other tree crops such as oil-paln Rees (15); Lucas (11) The peak relative growth rates (RGR) of the two varieties obtained in this study agreed with the earlier results obtained by Goodall (9) and Atanda (3), who suggested that the high value obtained between 10 and 15 weeks after sowing was associated with leaf flushing and full expansion of leaves In this study there was a sharp increase in the leaf area index between 8 and 12 weeks after planting in Amelonado The decrease in leaf area ratio (LAR) with time observed in the study was consistent with the findings of Oyebade (13), but in conflict with those of Atanda (3), who obtained peak LAR value at 15 weeks after sowing the apparent difference might be to the different locations of the experiments This experiment, like that of Oyebade (13), was sited at CRIN main station at Onigambari (Forest zone), while Atanda's (3) was sited at the Uhonmora substation (a derived savannah zone)

Little work has been done on the nutrient uptake of cocoa nursery seedlings for ease of comparison However, in oil palm nursery seedlings, Lucas, Ataga and Thomas (12) found that K uptake was highest, followed by N, Ca, Mg and P in that order A similar situation was observed in this study Also, Cooke (6) found that in adult coffee, the order of uptake from highest to lowest was K, N, P, while in tea the order was N, P, K There is a need for further investigation on the relative importance of these nutrients in cocoa nursery seedlings

Conclusion

The importance of raising cocoa nursery seedlings in a medium of sawdust on top of forest topsoil lies in the fact that cocoa beans planted in such a medium germinate faster than beans planted in topsoil alone However, for subsequent growth, seedlings raised in topsoil alone show better morphological parameters, higher growth rates, dry matter production and nutrient uptake The superior growth of F_3 Amazon over Amelonado can probably be attributed to inherent genotypic differences between the two varieties, which were manifested in the early establishment of bigger leaf area, higher photosynthetic capacity (L) and better photosynthetic efficiency (NAR)

The measurements of nutrient uptake suggest the need for further investigation on the nutrient needs of cocoa seedlings in a well-designed fertilizer experiment

Summary

A nursery experiment was carried out for 24 weeks using sawdust of different particle sizes added to topsoil, and using topsoil alone, to test the germination, growth and development of two cocoa varieties It revealed that the only beneficial effect of the sawdust/topsoil mixture was faster germination of cocoa seeds In other measurements, such as morphological parameters, dry matter production, growth rates and nutrient uptake, seedlings grown in topsoil alone gave better results

F_3 Amazon seedlings grew more vigorously and performed better than Amelonado seedlings in all the parameters examined, presumably because of the earlier establishment of effective leaf area by F_3 Amazon Nutrient uptake by the seedlings of both varieties was highest in the leaf, followed by the stem and then the roots Potassium uptake was the highest, followed by nitrogen, calcium, magnesium and phosphorus in that order

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