The Selection of Cocoa Pods for Raising Seedlings

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Introduction

The normal practice when raising seedlings for commercial cocoa is to use beans collected from mature ripe pods (6). The rationale behind this practice is not very clear as there is very little experimental evidence in literature to support it. However, it might not be unrelated to the traditional practice of selecting only mature ripe pods to supply beans for processing into commercial cocoa. It might therefore have been a matter of practical convenience for growers to simultaneously select beans for raising seedlings from the same pods. The bean quality requirements for raising seedlings are however not necessarily identical to those required for good fermentation and processing quality. While for the latter it is only essential that the beans develop up to a stage that would, after fermentation and drying, produce a well formed nib with certain acceptable qualities (7, 8), the main requirement for the former is that beans should be mature enough to be viable and be capable of producing adequately vigorous seedlings. The practice of selecting mature ripe pods for raising seedlings may also have been based on the assumption that only such pods can supply beans that would produce the most vigorous seedlings. In this respect, there was an indication from an earlier study that the maturity of the pod affects the vigour of seedlings produced (1) but there was no evidence to conclusively support such assumptions.

Observations made on Amelonado cocoa in 1966 (1) and subsequently on F_3 Amazon have shown that visual estimation of pod maturity using pod size and colour could be misleading because of the variation in size (Plate 1) and pod colour that occurs within pods of the same age even when they are from trees of the same parentage growing in close proximity in the field (2, 4). Pod age calculated from the time after pollination has therefore been considered a better estimate of maturity. Consequently, hand pollinated pods were used in more recent studies. Pods were harvested at 2 week intervals and beans were sown in 25·4 × 12·7 × 5·1 cm, 0·005 cm gauge black polythene pots.

Pods of the following crosses were used in 3 recent experiments also reported here:

Experiment 1: $C_{77} \times C_{23}$

Experiment 2: $C_{67} \times C_{77}$

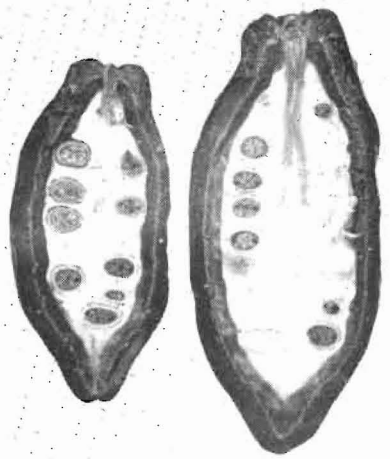
Experiment 3: $C_{77} \times C_{23}$, $C_{67} \times C_{77}$ and $C_{75} \times C_{14}$ mixture.

Clones C_{67}, C_{75} and C_{77} are upper Amazon selections while C_{23} and C_{14} are local Trinitario selections referred to earlier by Toxopeus in his reports on

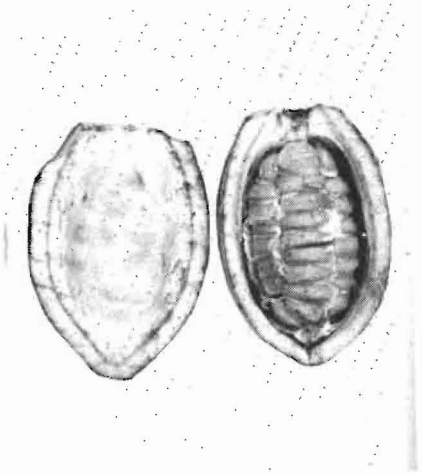
establishment ability of cocoa clones (10, 11). Three crosses were necessary in Experiment 3 to provide adequate materials for that part of the study.

Observations were made on mucilage content, bean development and viability while records of leaf number, seedling height and leaf area were taken at the end of 22 weeks' nursery period.

This paper discusses the unreported results obtained from the above experiments and also summarises results previously obtained on the same subject at the Gambari Experiment Station of the Cocoa Research Institute of Nigeria.



Longitudinal selections of 119 day old immature pods of Amazon cacao variety obtained from the same tree, showing variations in pod size and beans "cemented" together by the pulp.



Open pods of Amazon cacao showing beans, very distinct and only loosely bound together by mucilage at 166 days old (left), beans less distinct and still tightly bound together at 152 days old (Right).

Mucilage and bean development

Observations made over the years have indicated some general trends in the development of the cocoa bean and transformation of the surrounding pulp into mucilage (Table 1). Until a cocoa pod attains a certain stage of maturity, it contains only a compact white pulpy non-mucilaginous mass, within which the outlines of the future beans are still difficult to detect. In fact, up to about 105 days from pollination the pulpy material surrounding the beans remains in this condition which therefore makes individual "beans" impossible to extract manually. These beans later fill up but are still difficult to separate from the cementing pulp (Plate 1). As the pod matures, the pulp becomes mucilaginous and the beans become distinct and easier to extract (Plate 2). At this stage the

mature pod may vary in age from 147–175 days after pollination, the rate of development depending on the prevailing climatic conditions, the cultivar, the soil and other factors.

Table 1.
Pod bean and mucilage development at different stages after pollination

Time after pollination (days)	Observations
1. 105–110	Pods light green; beans flat with very little cotyledon development, all tightly packed together in a pulpy mass and difficult to separate or extract from the pods.
2. 119–124	Pods still green but bigger; beans with only moderate cotyledon development, in jelly-like form; beans tightly packed together and difficult to separate.
3. 133–138	Pods deeper green and bigger; beans a little plumper, but with only partially developed cotyledons, less tightly packed together as surrounding pulp becomes mucilaginous.
4. 147–152	Pods varying in colour from deep green to light yellow; beans plump with fully developed purple cotyledons, loosely packed in mucilaginous pulp and easier to separate.
5. 161–166	Pods all vary from fairly to fully ripe yellow in colour; beans are plump, with thick purple cotyledons and easily separated manually.

Viability of the cocoa beans

Beans generally do not become viable until after a certain stage of maturity. In the agronomic sense, this means the beans will not germinate when sown in the nursery and so cannot be used to raise seedlings until after about 105 days (or 15 weeks) from the time of pollination; this period varying according to climatic and other factors stated earlier. The average maturity period for ripe cocoa pods at Gambari is about 161 days (or 23 weeks) from the time of pollination. Observations made so far in Nigeria have indicated that once cocoa pods have matured beyond about 140 days (about 20 weeks) from pollination, it should be possible to obtain anything between 75–100% germination. However, it is possible to raise seedlings from the developing embryo at stages before 105 days (15 weeks) by using tissue culture techniques.

One practical inference to be drawn from these observations is that mature green pods can supply viable beans that can be used to raise seedlings (2, 4). It is therefore not necessary to select only ripe pods for this purpose. Between 105 and 140 days from time of pollination, pods can supply a small proportion of viable beans. Similar observations on the viability of partially (not fully) mature cocoa beans have been made in other places (9).

Bean weight

Observations on the intact fresh beans made in an experiment carried out in 1975 showed that fresh bean weight tends to increase with increase in maturity up to a stage before declining, while the dry matter content increases all the way. In the study, fresh bean weight increased to a peak of 3·6 g at 138 days after pollination before declining while dry matter increased to 77·1% at 166 days (Table 2). It became apparent from this particular study that the developing cocoa bean contains practically no dry matter within the testa other than a translucent, almost colourless, jelly-like embryonic material until after about 105 days from pollination. This would explain why it was difficult to separate beans from the pulp at this stage.

Table 2
The influence of pod maturity on bean fresh weight (g) and dry matter content.

	Age of pods	Mean bean weight (g)	% dry matter
1	110 days	2·4	12·8
2	124 days	2·5	23·3
3	138 days	3·6	29·3
4	152 days	2·9	44·4
5	166 days	2·6	77·1

Foliage production

Results so far have shown that only seedlings raised from beans that were still very immature (i.e. those obtained at 105 and 110 days after pollination) produced fewer leaves than the more mature beans (Table 3). When the very immature treatment in Experiment 1, was excluded from subsequent experiments the variations observed earlier in foliage production were therefore considerably reduced (Table 3).

In Table 3, where the treatments covered a wide range of bean maturity the relationship observed between foliage production and bean maturity was more curvilinear than linear. This showed that there was nothing to be gained by raising seedlings with beans obtained from either very immature pods (about 105 days old) or fully ripe and overripe pods (about 175 and 189 days old respectively). A detailed analysis of the relationships between seedling growth parameters and bean maturity has been reported earlier (3).

Table 3.
The effects of bean maturity on leaf number per seedling at the end of the nursery period

Expt. 1	Days from pollination	105	119	113	147	161	175	189
	Leaf number	14·5	23·5	18·6	20·0	23·5	17·4	18·2
Expt. 2	Days from pollination	110	124	138	152	166		
	Leaf number	12·5	13·8	14·2	14·6	14·8		
		LSD (P = 0·05) 2·2						
Expt. 3	Days from pollination	120	134	148	162			
	Leaf number	16·1	16·7	16·2	15·4			
		LSD (P = 0·05) 1·8						

Seedling height

The influence of bean maturity on seedling height was similar to that on foliage only to the extent that the very immature beans also produced the shortest seedlings (Table 4). Otherwise seedling height tended to increase with increase in bean maturity. It is not however desirable that seedlings grow too tall at the end of the nursery period as robust seedlings with fairly good all round attributes should be preferable and easier to transport to the field.

Table 4.
The effects of bean maturity on seedling height (cm) at the end of the nursery period

Expt. 1	Bean maturity	105	119	133	147	161	175	189
	Height (cm)	33·7	51·2	56·9	58·4	63·4	56·0	65·9
		LSD (P = 0·05) = 15·3						
Expt. 2	Bean maturity	110	124	138	152	166		
	Height (cm)	25·3	29·5	30·6	34·1	32·8		
		LSD (P = 0·05) = 8·3						
Expt. 3	Bean maturity	120	134	148	162			
	Height (cm)	27·3	31·4	37·3	39·8			
		LSD (P = 0·05) = 5·6						

Leaf area and overall seedling vigour

The influence of bean maturity on leaf area per seedling was also similar to that of foliage production with the least mature beans producing seedlings with the lowest leaf area while the most mature beans produced no further increase in leaf area (Table 5). Considering the importance of leaf area in overall seedling vigour and the relationship which has been recorded between ability to develop leaf surface and productivity of the mature cocoa trees (5), seedlings raised from beans collected from immature unripe or partially ripe pods harvested at periods varying from 119–147 days from pollination should therefore constitute the best seedlings. This supports the earlier observations that fully ripe pods do not produce the most viable beans or the most vigorous seedlings.

Conclusion

Evidence obtained from these experiments has shown that the stage of maturity of cocoa pods has a measurable influence on the development and viability of the beans as well as on the growth of seedlings. About 105 days from pollination pods can supply viable beans. Beans from mature green pods or pods that are only partially ripe can produce seedlings which are as vigorous or more vigorous than those raised from ripe pods.

Table 5.
The effects of bean maturity on leaf area per seedling (cm^2) at the end of the nursery period – (Adenikinju, 1972)

Bean maturity (days)	105	119	133	147	161	175	189
Leaf area (cm^2)	761	1,561	1,402	1,469	1,241	1,226	1,246

LSD (P = 0·05) = 753·0

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