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Evaluation of cocoa introductions (*Theobroma cacao* L.) on Ddamba island, Mukono district

Wetala, M.P.E. Kucel, P Hakiza, G.J. and P. Aluka
National Agricultural Research Organisation (NARO)
Coffee Research Institute (CORI), P.O. Box 185, Mukono, Uganda.

Abstract

Elite seed of Trinidad Selected Hybrids and Costa Rica introductions of cocoa were planted in 1987 and quarantined on Ddamba island in Lake Victoria, Mukono district. There was no consistent evaluation of these materials for the initial 10 years because of lack of funds. With availability of funds from USAID/ IDEA, cocoa research was revived at Coffee Research Institute (CORI) and the Ddamba materials evaluated from 1999 to 2001. At the beginning of the evaluation only 1 tree of Trinidad Selected Hybrids, 90 trees of Costa Rica introductions, and 164 trees of local materials were surviving. No new disease or insect pests were observed on the introductions but just like the locals, they were affected by the major diseases and *insect pests* found on cocoa in Uganda. The major diseases found were pod rot *(Phytopthora sp)*, and the insect pests were scales, mealybugs, aphids, lepidoptera, mites and vertebrate pests such as monkeys and squirrels. There were $1^1/_2$ times more trees among Costa Rica introductions bearing over 40 pods/tree as compared to the locals. However neither the parents nor the progeny of the introductions could be identified. Since it was apparent that the Costa Rica introductions might have good qualities, the seeds of these materials are being propagated in the nursery at the Coffee Research Institute.

Key words: *Ddamba island, Trinidad Selected Hybrids, Costa Rica introductions, pod rot, Quarantine, scales, mealybugs, aphids, lepidoptera, mites, monkeys, squirrels, local materials.*

Introduction

Since cocoa was introduced in Uganda in 1901, it has had ups and downs due to changes in world cocoa prices, field management levels, and damage from pests and diseases. After abandonment and replacement with coffee in 1924, cocoa was re-introduced in Uganda in 1956 by small-scale farmers to diversify foreign exchange earnings and increase farmer incomes in robusta coffee growing areas, using Upper Amazon hybrid seeds from Ghana. Research on cocoa between 1959 and mid 1970s generated production technologies that accompanied the development of the industry from the 1960s to mid 1970s, during which the area under cocoa increased from 461 ha in 1965 to 14,000 ha by 1978 (ADC/IDEA Project, Draft report, 1998). Maximum yields during this period were estimated to vary from 100 kg/ha at 3 years of age to 1000 kg/ha at 10 years. From the 1970s to early 1980s, there was political and economic instability with no active research in cocoa, which was partly reflected in the decline of the cocoa industry leading to neglect and abandonment of the fields. Attempts to revive the industry in mid 1980s among other things involved the importation of elite seed of cocoa that was quarantined on Ddamba island for surveillance of new pests and diseases. There was however no follow-up of these materials because of lack of funds.

There are 8,450 farmers growing cocoa on an estimated 10,000 ha of which 7,000 ha are productive. Cocoa production is mainly on smallholder farms averaging 0.5-2 hectares and two large estates (Kijjude and Magulu). The major growing districts are Bundibugyo, Mukono, Mayuge, Iganga, Jinja, Kamuli, Hoima, Luwero, Mpigi, Masindi, and Kibale. The production of cocoa in 1998 was reported to be 2,800 metric tons valued at US $ 4 million. It is a source of income to many Ugandans involved in its production and trade. Farm gate prices for grade I beans in 2001

were shs. 800/kg. The estimated national yield of cocoa is generally low, varying from 100 kg/ha to 600 kg/ha of dry beans. This is mainly due to the neglect of old farms, poor agronomic practices, varieties of low production potential and lack of control of major pests and diseases.

Since the outbreak of the coffee wilt disease *(Tracheomycosis xylariodes)* in Uganda in 1993, all traditional robusta coffee producing districts, some of which are also cocoa producers have been affected by the disease with district incidences varying from 0.1 to 70% (Uganda Coffee Development Authority Annual Report, 1999/2000). There is thus urgent need to improve the production of coca in quantity and quality both in its own right and as a fall back position in the wake of the coffee wilt epidemic

Under funding from Agribusiness Development Centre (ADC), Uganda's Investment in Developing Export Agriculture (IDEA), research on cocoa was revived at CORI in 1999. The major objective of cocoa research is to generate and transfer technologies for increasing the production of cocoa through improved varieties, integrated pest management and adoption of cocoa rehabilitation practices.

The general objective of the investigation was to evaluate new cocoa introductions on Ddamba island for growth characteristics, yield, and resistance to diseases and pests.

The Specific objectives of the investigation were to:

i. Identify the varieties of the introductions and describe their characteristics
ii. Describe the agronomic and field conditions of the cocoa.
iii. Assess the susceptibility of the introductions to insect and vertebrate pest damage.
iv. Assess the susceptibility of the introductions to both new and existing diseases.
v. Select promising materials for propagation in CORI nursery.

Materials and methods

Background information on the materials

The work was carried out in Ddamba one of the islands in Lake Victoria within Mukono district and about 30 km from Ggaba shoreline. All the cocoa materials were planted on the island in 1987. Field planting was done after selective felling of natural trees to create the required shade. The introductions were composed of Trinidad Selected Hybrids and Costa Rica varieties. The Costa Rica introductions were a progeny of elite seed from 5 clones but whose identity could not be established. Over 20,000 seeds of Trinidad Selected Hybrids were planted in the nursery and unknown number of seedlings planted in the field. By 1993, 20 plants of Trinidad Selected Hybrids were surviving in the field but by 1994 only 2 were left. Unspecified quantity of seed of Costa Rica varieties was planted in the nursery and the seedlings transplanted in the field. Local materials were selected from Mukono District Farm Institute although it is not certain on what basis such selection was made but presumably yield potential may have been a major consideration. The local materials were to act as controls in the evaluation process of the introductions. The seedlings of all the materials were planted in the field at 3 m within row and 3 m between rows. Each variety was planted in a separate block with the locals and Trinidad Selected Hybrids being adjacent to each other and 80 m from the Costa Rica varieties.

Although the spot maps for the planting of all the introductions were made only that of the Trinidad Selected Hybrids was available at the time of the investigation.

The present study

Between July 1999 and June 2001 six visits were made to Ddamba island by teams of breeders, agronomists, pathologists and entomologists from the Coffee Research Institute to evaluate the materials for agronomic characteristics, flowering intensity, and susceptibility to pests and diseases. Soil samples were taken from the cocoa fields and analysed at Kawanda Soil Laboratory. Mr. Kebba, the DAO Mukono, who planted the materials, guided the scientists in their first trip.

Results

Varietal types and growth characteristics

At the time of the first visit in July 1999 only one plant of Trinidad Selected Hybrids was still surviving.

Costa Rica varieties

There were 90 trees of Costa Rica variety with only 6 natural trees locally called Kaliba (Mangrove trees) still surviving as shade trees. The rest of the shade trees are reported to have been blown over by windstorms. This gave rise to a very light shade leading to rapid growth of weeds and dieback of cocoa branches. Premature pods from these materials had red/ purplish in colour and furrowed or were green and serrated with pointed tip.

The dominant number of main stems per tree was two, but occasionally three stems, indicating lack of pruning. The girth of the main stem measured as the circumference at ground level ranged from 17 to 40 cm but most trees measured 36 cm. There was generally one jorquette for each main stem at the height of 50 cm to 2000 cm but commonly at less than 1500 cm. About 40 % of the trees had two jorquettes per main stem, a further indication of lack of pruning. Over 85 % of the

trees were between 2.5 and 3.5 m in height with a few more than 6 m. Generally all the trees had sections covered with lichens which hindered the formation of flower cushions.

Local materials

There were 164 trees of local materials with well formed jorquettes .The majority of the trees had main stems varying from 27 to 33 cm in girth measured as circumference at the ground level. The dominant number of main stems per tree was two, but occasionally with three stems. The trees were between 3.7 and 5.7 m in height. Invariably there was one jorquette per main stem at the height 0.7 to 1.4 m.

Field conditions

The Costa Rica introductions had lost most of their natural shade trees reportedly blown down by windstorms and weed infestation was heavy with the height of weeds reaching 60 cm. The major weed species were *Commelina benghalensis, Panicum maximum, Setaria homonyma, Monechma subsessile, Kyllinga spp, Paspalum conjugatum.* The local varieties had good natural shade, allowing transmission of about 50 % of the sunshine. Although there were similar weed species in the local materials, weed cover was low with most of the area being covered by litter from shade and cocoa trees.

Table 1: Incidence and severity of attack by pests on Costa Rica introductions in January 2000
(assessment was based on a sample of 10 affected areas for each variety)

Common name	Scientific name	Part attacked	Variety	Incidence %	Severity %
Scales	*Stictococcus sp*	Pods	Costa Rica Introductions	45	31.5
			Local materials	46	19.1
Mealybugs	*Planococcus and Pseudococcus*	Flowers	Costa Rica Introductions	50	37.6
			Local materials	12	8.6
		Pods	Costa Rica	18	11
			Introductions	2	0.5
			Local materials		
Aphids	*Toxoptera spp*	Flowers	Costa Rica Introductions	52	22.9
			Local materials	48	12.7
Lepidopteran	Not yet established	Pods	Costa Rica Introductions	4	1.5
			Local materials	4	1.5
Mites		Leaves	Costa Rica Introductions	6	1.2
			Local materials	6	1.2
Monkeys		Pods	Costa Rica Introductions	-	-
			Local materials	11	8
Squirrels		Pods	Costa Rica I introductions	6	13.4
			Local materials	3	6.2

The fields were initially rehabilitated by slashing the weeds and pruning cocoa, after which these activities were regularly maintained.

The soil texture for both sites was sand clay, generally acidic with a pH of less than 4.3 and with more than adequate levels of organic matter and phosphorus but insufficient levels of other nutrients. The site for local materials had generally lower levels of nutrients. There

was little difference in the nutrient levels between 0-20 and 20-40 cm depth.

Insect pest and Vertebrate damage

A summary of the insect and vertebrate pests attacking both the introduced and local materials on Ddamba Islands and their severity is presented in Table 1.

Scale insects of the genus ***Stictococcus*** were the most damaging pest attacking both mature and young pods, aggregating on the stalks and body grooves of young pods and mainly on the stalks of more mature pods. Cases of premature ripening of young pods following heavy attacks were common. They may also have been partly responsible for the numerous cases of abortion of very young fruits dried up on the trees. The rampant malformation of mature pods was clearly a result of attack by scales early in the development of the pods. On both mature and young pods, pods with deeper body grooves appeared to be more severely attacked. Their association with small black ants of the genus Mymicaria and the brown larger ones of the genus *Pheidole* most likely aggravated the attack by the scales. Although there were similar incidences of scales for both materials, the severity of attack was higher among the introduced materials.

Mites were recorded on some trees of both the introduced materials and local materials. These caused mottling of leaves and inward curling of the lamina. A close observation of inside the curls revealed the mites and their associated cobwebs.

Defoliation of various kinds was also observed on both the materials, although at insignificant levels in either case. This however did not rule out the presence of any serious defoliator since most of them, particularly lepidopteran larva are sporadic in occurrence and their significance will vary with season or time of the year assessment is carried out. Leaf eating beetles of various kinds were also believed to be part of the damage.

Light attack by leaf skeletonisers was evident in the local materials, particularly on trees under dense shade.

The most surprising aspect of the assessment was the absence of any evidence of mirid damage quite devastating on mainland cocoa. Both the introduced and local materials were free of any damage attributed to mirids.

Generally, the pest complex on the introduced and local materials on Ddamba Islands appeared less broad than what has been observed on local materials in several mainland areas including the Coffee Research Institute at Kituza. Apart from the observed uneven preferences for the materials by monkeys and squirrels the pest complex on the introduced materials appears to be similar to that of the local materials. It should be noted that a meaningful comparison of the materials is only possible with data extended over a period of time and based on peak incidence data for each pest. However, no pest of foreign origin was recorded on the local materials.

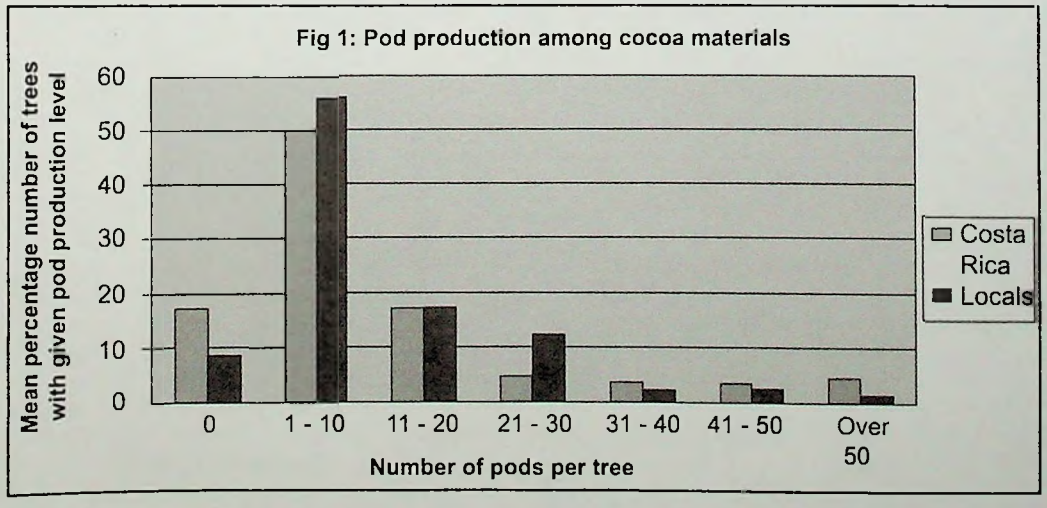
Disease status

The diseases that are found in Uganda but not observed on the island are:

i. Sudden wilting and death of trees confirmed from cocoa in two countries, Uganda and Brazil (Bahia) caused by Verticillium dahliae Kleb
ii. Collar Crack caused by Armillariella (Armillaria) mellea (Vahl ex F.) P. Karst.

Pod rot caused by Phytopthora, which is common in Uganda was also observed on the local and introduced materials.

The specific threats to Uganda cocoa are:



i. Viruses such as e.g. Swollen Shoot virus found in West Africa.
ii. Witches' broom *(Crinipellis perniciosa)*, which occurs throughout the Caribbean. It can be transmitted through infected seedling or bud wood.
iii. Ceratocystis wilt *(Ceratocysts fimbriata)* which is a less serious disease that witches broom.

Visual inspection of the foliage and trunk did not reveal presence of the above diseases. The plants are old and if they had come with any of the above diseases, affected plants would have exhibited symptoms a long time ago.

Flowering intensity

While the flowering intensity varied with the period, there were a higher proportion of trees with no flowering among the introductions than locals. The proportion of trees with low flowering intensity was similar for both varieties but generally there was a higher proportion of trees with fair to good flowering in the locals than in the introduced materials. There were less than 10 % of the trees with good or very good flowering intensity in both varieties.

Pod production

The percentage number of trees with different levels of pod production is shown in Figure 1 and Table 2. The percentage of trees without pods varied from 11 to 26 % for Costa Rica introductions and 2 to 15 % for the locals. The percentage of trees with less than average pod production (less than 20 pods/tree) was 78 to 94 % for Costa Rica introductions and 74 to 92 % for locals. Thus for both varieties only less than 26% of the trees had above average production. Generally there were a higher proportion of trees with very good production (over 40 pods/tree) for introductions or more than 1½ times the figure for locals. This is also borne out by the higher mean number of pods/tree for introductions compared to locals (Table 2). Hence although the introductions were not clearly identified they had a higher potential for higher yields than locals.

The characteristics of the pods harvested in June 2001 from 25 trees of the introductions (50% of the sample) are shown in Table 2.

Little can be said about the quality of the pods since dry bean weight was not determined. However good pods are expected to produce 30 to 40 seeds per pod. Based on this parameter about 7 trees or 14% can be assumed to produce potential good bean seed. However, these trees do not necessarily coincide with those giving high number of pods (>50 pods/tree). With improved insect pest management, the quality of seeds from the introductions could improve.

2000 seedlings from the Costa Introductions have been established at CORI.

Discussion

The cocoa introductions were imported with the understanding that they were elite seed and hence higher yielding than the local materials. The main objective of quarantining the new materials on Ddamba island was to observe for any pests and diseases that could have accompanied the planting materials. This study revealed that the materials were not affected by any new pest or disease but were susceptible to the pests and diseases found on the main land.

Lachenaud et al. (2000) named the selection criteria in the improvement cocoa trees as comprising juvenile growth (or vigour), adult vigour, the yield-vigour ratio, earliness of production, yield, average pod weight and losses due to pod-rot caused by Phytophthora spp. studied over a 10 year period. The study reported in this paper was carried out more than 10 years after the materials were planted and hence missing both the juvenile and the formative period during which assessments are most useful. During this period practically all Trinidad Selected Hybrids and a large proportion of the Costa Rica introductions were lost. Although the Costa Rica introductions could not be identified, being progenies of elite seed, it was hoped that they could be propagated by vegetative means or as a mixture of improved seed assuming the vigour was not lost. Although it was not possible to collect yields from the materials over a consistent period, because of poor accessibility, productivity estimates based on pod production indicated that the Costa Rica introductions had a higher proportion of higher yielding materials (those with more than 40 pods/tree) than locals although the identification of the progeny could not be established. The pod weight of the introduced materials was generally 30% of the weight of pods of the local Upper Amazon growing on the main land. This small size of pods could be due to poor field conditions such as lack of shade, lack of pruning for a long time and damage by insect pests. It is hoped that the seedlings established at CORI from the Costa Rica introductions will be issued to farmers as improved planting materials or kept as part of germplasm collection..

Table 2: Pod characteristics of the cocoa introductions at Ddamba

Tree number	No. of pods harvested	Length of pods (cm)			Circumference at widest thickness			Weights per pod (Gm)			Number of seeds per pod		
		Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
1	10	21.4	22	17	23.2	28	22	62.3	140	15	18.8	46	9
*2	2	18.5	19	18	24.7	26	23.5	140	140	140	34	34	34
*9	11	20.2	21	15	22.9	28	15.5	114.4	180	18	29.2	45	10
#10	2	22	24	20	28	29	27	130	160	100	31.5	40	23
12	6	18.3	20	17	24.2	27	20	116.7	160	80	34	40	27
#13	1	23	23	23	21.5	21.5	21.5	200	200	200	36	36	36
#17	1	24	24	24	31	31	31	20	20	20	41	41	41
18	1	23	23	23	25	25	25	60	60	60	11	11	11
*20	11	17	19	15	22.8	25	21	110	140	80	36	38	19
#22	1	14	14	14	24	24	24	140	140	140	32	32	32
23	12	19.5	22	15.5	23	25	19.5	88.3	140	60	22.3	29	10
*25	12	17.3	21	15	21.5	26	18	83.3	160	40	17.9	36	7
26	11	12.7	18	13	24.6	28	21.5	89.1	100	40	15.5	26	10
28	13	14.6	16.5	12	23.1	25.5	21	115.4	160	60	26	36	11
30	1	19	19	19	25.5	25.5	25.5	120	120	120	24	24	24
24	2	17.3	19	15	28	30	26	120	140	100	24	29	19
35	2	18.5	19	18	30.8	31	30.5	110	120	100	26	32	20
38	8	13.1	15	12	19.6	21.5	10	29.8	80	10	13.6	24	8
40	9	15.9	18	14	26.7	29	25	74.4	100	40	14.3	19	9
41	1	14	14	14	20.5	20.5	20.5	40	40	40	9	9	9
42	3	17	20	15	23.7	27	20	86.7	80	60	19.7	38	9
#44	1	19	19	19	28.5	28.5	28.5	140	140	140	30	30	30
45	8	18.7	19.5	16.5	27	28	25	97.5	140	40	20.9	28	12
#31	1	21	21	21	35	35	35	140	140	140	35	35	35
#47	6	18.8	21	18	26	29	20	123.3	160	80	31	38	16
Mean	18.3	18.3	19.6	16.9	25.2	27.0	23.1	102.1	124	79.5	25.3	29.5	21

* Trees with at least 50 pods/tree # Trees with apparent good seed bean production

Conclusion

The study showed the cocoa Costa Rica introductions did not harbour any foreign diseases or insect pests and appeared to have a higher proportion of trees with high potential yields than the locals. The introduced materials are being raised in the nursery at the Coffee Research Institute for further propagation in form of seedlings.

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