2017 International Symposium on Cocoa Research (ISCR), Lima, Peru, 13-17 November 2017

# Comparative assessment of agronomical performances of six commercial cocoa varieties in on farm progeny trials in Cameroon

O. Sounigo[1], L. Feumba de Tchoua[2], R. Bourgoing [1], F. Nsouga[2], D. Abolo[2], I.B. Efombagn[3], C. Cilas[1]

1 = CIRAD Montpellier France
2 = IRAD Nkolbisson, Cameroon
3 = IRAD Ekona Cameroon

## ABSTRACT

A long term participatory breeding program was launched in Cameroon in 2004, as a key component of a worldwide cocoa breeding project, funded by CFC. One activity within this program has consisted in setting up on farm progeny trials in order to assess the performances of commercial cocoa varieties, when tested in on farm conditions.
2,337 cocoa trees, belonging to six commercial varieties (six full-sib progenies issued from bi-clonal seed-gardens) were assessed in 11 progeny trial plots, set up in 2006, in two villages of Cameroon. Cocoa yield data recorded during the period from 2011 to 2015 were analyzed and showed significant differences among progenies, ranging between 730 and 1,285 kg cocoa/ha/year.
In addition, 681 cocoa seedlings issued from seed-gardens (CV), have been planted simultaneously with 234 seedlings issued from pods collected in farmers' plots, in six progeny trial plots set up in 2007 in three villages of Cameroon.
149 of these farmers' seedlings were issued from pods collected on cocoa trees belonging to the traditional amelonado variety (named german cocoa) (GC), while 85 others were issued from pods collected on trees belonging to commercial varieties (half-sibs issued from commercial varieties) (FV). Under the conditions of our trial plots (no permanent shade during the first ten years, because of the simultaneous planting of cocoa and shade trees), GC trees yielded significantly less (250 kg/ha/year) than FV (650 kg/ha/year) and CV trees (between 600 and 800 kg/ha/year).
The impact of these results on the future release of commercial cocoa varieties in Cameroon is discussed in this paper.

## INTRODUCTION

In Cameroon, cocoa farmers' plots have been set up using three types of varieties: 1) commercial varieties (CV) (progenies released from seed-gardens established by official extension agencies since the early 1970s), 2) "modern" farmers' varieties (progenies issued from pods harvested on cocoa trees in farmers' cocoa plots formerly established using CV, 3) traditional cocoa varieties (german cocoa = amelonado). In order to assess the performances of the three types of varieties, on farm trial plots were set up in the frame of a large program of cocoa participatory breeding, started in 2006. The results from eleven on farm trial plots set up in 2006, and allowing the comparative yield assessment of six CV, are shown in this presentation, as well as the results from six on farm trial plots, allowing the comparative yield assessment of the three types of cocoa varieties.

## MATERIAL AND METHOD

### Sites of the study

The trial plots were set up in four villages, located in three areas of the central region of Cameroon. Information about the sites are in the table below

| Village | Bakoa | Kedia | Edou | Lekie Assy |
|---|---|---|---|---|
| Administrative district | Mbam et Inoubou | Mbam et Inoubou | Mefou et Afamba | Lekie |
| Landscape | Forest/savanah | Forest/savanah | forest | forest |
| Annual rainfall (mm) | 1,300 | 1,280 | 1,470 | 1,280 |

| Rainfall (days) | 84 | 85 | 90 | 84 |
|---|---|---|---|---|
| Type of soil | SAND/silt | SAND/clay | CLAY/sand | SAND/clay |
| PH | 6.71 | 6.01 | 5.18 | 5.75 |
| organic matter/clay ratio | 0.16 | 0.12 | 0.1 | 0.07 |

**Plot management**
Cocoa seedlings were planted on plots (on savannah or fallow), designed in order to maximize farmers' income through crop diversification, with a minimal environmental impact (no deforestation) (Bourgoing et Todem, 2010).
The plots were completely cleared prior to setting up and two types of shade were applied:

- **Temporary shade:** maize (during the first two years) and plantain (during the first four years)
- **Permanent shade:** provided by fruit, coconut or oil palm trees, planted simultaneously or one year after the cocoa trees, thus starting to provide shade six years after plot setting-up

**Compared varieties:**
**Plots set up in 2006**
Six CV were compared in eleven on farm trial plots, set up near the villages of Kedia and Bakoa.
The six assessed CVs are issued from pods collected in six biclonal seed-gardens located at the SODECAO stations of Nkoemvone and Mengang. The pods are issued from the following crosses (numbers of trees in brackets):

1. IMC 67 x SNK 109 + reciprocal (519), 2. IMC 67 x SNK 64 (464), 3. SCA 12 x SNK 16 and reciprocal (379), 4. T 79/501 x SNK 109 + reciprocal (428), 5. T 79/501 x SNK 13 (208) and 6. UPA 143 x SNK 64 (339).

**Plots set up in 2007:**
Three types of varieties were compared in six trial plots set up in Bakoa, Edou and Lekie Assy (numbers of trees in brackets):

1) Commercial varieties (CV): mixture of seedlings issued from pods harvested in the biclonal seed-gardens located at the SODECAO stations of Nkoemvone and Mengang (205), 2) traditional farmers' variety issued from pods collected in old on farm cocoa plots set up with amelonado type cocoa trees (german cocoa) (149), 3) Farmers modern varieties, issued from pods harvested in on farm plots set up with commercial varieties (85).
These three types of varieties were also compared to the two commercial varieties 2 (200) and 6 (276)(see parents in plots set up in 2006).

**Assessment**
Unripe but mature pods (NP) were counted every two months during the period 2011-15 on all the trees.
The average weight of dry cocoa per pod (BP) was assessed for each variety by weighting the fermented and dry cocoa from a sample of at least 50 pods, collected on at least 20 trees.

**Statistical analyses**
Potential yield (PYt) was calculated for each tree by the formula: PYt = NP * BP(g).
ANOVA were conducted in order to assess both plot and variety effects and their significance.
Newman-Keuls tests were performed in order to rank the varieties for PYt.
Then, PYt was used in order to estimate the level of yield of each variety per hectare (PYh) kg/ha/year, according to the formula: PYh = PYt /4 (nb of years of assessment) * 1,100 (usual cocoa density in Cameroon).
Finally, the actual level of yield per hectare was estimated for each variety, by the formula:
AYh = PYh * S (proportion of surviving trees)

**RESULTS**
**Plots set up in 2006:**
Plot and variety effects were assessed for PYt as well as their significance. are indicated in the table 1 below:

| | | **Potential yield per tree (PYt) during 2011-15 period (g)** | | | | **Potential annual yield per hectare (PYh) (kg cocoa/ha/year) )** | | |
|---|---|---|---|---|---|---|---|---|
| **Factor** | **F value** | **significance level** | **mean value** | **minimal value** | **maximal value** | **mean value** | **minimal value** | **maximal value** |
| **plot** | 30.3 | $p < 0.001$ | 4195 | 2815 | 6280 | 1154 | 774 | 1727 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **variety** | 31.6 | p < 0.001 | 4022 | 3275 | 5257 | 1106 | 901 | 1446 |

Significant effects were observed in the case of both plot and variety factors. A large difference between extreme yield values was observed between plots and between varieties.

The table 2 below shows the levels of yield and survival of the six commercial varieties assessed in the 11 trial plots as well as their ranking according to the Newman-Keuls at 5%.

| | **potential yield** | | **N.K 5%** | **% survival** | **actual yield** |
|---|---|---|---|---|---|
| **Variety** | g/tree (2011-15) | **kg/ha/year** | | | **kg/ha/year** |
| **IMC 67 * SNK 109 + Reciprocal** | 5500 | **1512** | a | 85 | **1285** |
| **IMC 67 * SNK 64** | 4379 | **1204** | b | 85 | **1023** |
| **T 79/501 * SNK 109 + Reciprocal** | 4159 | **1144** | c | 75 | **858** |
| **T 79/501 * SNK 13** | 3411 | **938** | c | 79 | **741** |
| **SCA 12 * SNK 16 + Reciprocal** | 3408 | **937** | c | 77 | **721** |
| **UPA 143 * SNK 64** | 3275 | **901** | c | 81 | **730** |

If survival rate did not vary largely among the assessed varieties, the level of yield showed a large level of variation, with the two varieties issued from crosses involving IMC 67 yielding more than one ton per hectare while the level of yield of the other varieties ranged between 730 and 858 kg per hectare.

**Plots set up in 2007:**
Plot and variety effects were assessed for PYt as well as their significance are indicated in table 3 below:

| | | **yield per tree (g) during 2011-15 period** | | | | **estimated yield (kg cocoa/ha/year)** | | |
|---|---|---|---|---|---|---|---|---|
| **Factor** | **F value** | **significance level** | **mean value** | **minimal value** | **maximal value** | **mean value** | **minimal value** | **maximal value** |
| **plot** | 8.1 | p < 0.001 | 3515 | 2745 | 4506 | 967 | 755 | 1239 |
| **variety** | 31.6 | p < 0.001 | 3365 | 1797 | 4682 | 925 | 494 | 1288 |

Significant effects were observed in the case of both plot and variety factors. A large difference between extreme yield values was observed between plots and between varieties.

The table 4 below shows the levels of yield and survival of the five varieties assessed in the six trial plots as well as their ranking according to the Newman-Keuls at 5%.

| | **potential yield** | | **N.K 5%** | **% survival** | **actual yield** |
|---|---|---|---|---|---|
| **Potential yield** | g/tree (2011-15) | **kg/ha/year** | | | **kg/ha/year** |
| **IMC 67 * SNK 64** | 4682 | **1288** | a | 62 | **799** |
| **farmer modern varieties** | 3562 | **980** | b | 66 | **647** |
| **UPA 143 * SNK 64** | 3532 | **971** | b | 71 | **689** |
| **mixture of commercial varieties** | 3251 | **894** | b | 67 | **599** |
| **traditional farmers variety** | 1797 | **494** | c | 51 | **252** |

The survival rate was rather low for all the varieties, especially in the case of the traditional variety, showing a % of mortality close to 50%.
The level of yield was higher for the variety issued from the cross IMC 67 * SNK 64 and much lower in the case of the traditional variety.

**DISCUSSION**
The analysis of the data obtained from the on farm progeny trials, set up in absence of permanent shade, showed that:

- The level of mortality in our trial plots is rather high (between 15 and 50% depending on the variety and the plot). This can be explained by the lack of permanent shade combined to soils with a moderate to low fertility. However, a high level of mortality is also currently observed in traditional cocoa plots and explain the strategy adopted by farmers, consisting in planting the cocoa seedlings at very high density, in order to end up with a density of around 1,100 trees/ha after few years.
- The level of yield is highly variable (between 730 and 1285 kg/ha/year) among the cocoa varieties commercially released in Cameroon since the 1970s. A mixture of these commercial varieties shows a level of yield (599 kg/ha/year) similar to the one of modern farmers' varieties (FV) (647 kg/ha/year).
- However, the progeny issued from IMC 67 x SNK 64 proves to yield significantly more (799 kg/ha/year) than the FV. The progeny issued from IMC 67 x SNK 109 is thus also expected to yield more than the FV.
- The traditional variety ("german cocoa" = amelonado), shows very low performances in terms of survival and yield. These poor performances contrast with the high level of yield commonly observed for this variety, when it is cultivated in traditional plots, under strong shade conditions. This contrast shows the poor adaptation of the traditional variety to the absence of permanent shade.

From these data, a strategy based on several actions is proposed:

- Selection of the highest yielding commercial varieties (HYCV) among the fourteen ones, presently released to farmers. The eight commercial varieties, not mentioned in the present study, have been under assessment in on farm trial plots set up from 2011 and the selection of the highest yielding ones will start in 2020.
- Extension of the seed gardens for the large scale production of the HYCV, in order to increase their proportion within the mixtures of commercial varieties.
- Select new varieties from experimental plots recently set up on farm. 174 full-sib progenies have been currently assessed in on farm plots set up from 2008, and the selection of the highest yielding ones will start in 2018.

## LITTERATURE

Bourgoing R., Todem H. 2010. Association du cacaoyer avec le palmier ou le cocotier. Systèmes expérimentals en cacaoculture. Guide technique, Montpellier : CIRAD, 2010. 110 p.

Bourgoing R., Todem H. 2010. Association du cacaoyer avec les fruitiers. Systèmes expérimentals en cacaoculture. Guide technique, Montpellier : CIRAD, 2010. 82 p.

## SPECIAL THANKS

The Cocoa Participatory Breeding Program started in the frame of a CFC/ICCO/Bioversity project, and it continued thank to the funding of the following bodies/companies: Mars Inc., USDA and French Ministry of Foreign Affairs.