Selection of new varieties of cocoa (*Theobroma cacao* L.) adapted to the effects of climate change in Côte d'Ivoire

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Context and justification

World production and quality of cocoa will be gradually affected by climate change according to the results of investigations by **Medina and Laliberté (2017).** In Côte d'Ivoire, this phenomenon is particularly evident in the lengthening of drought periods, which seriously affects the establishment and productivity of orchards, as well as the quality of products. To meet this challenge, breeders must maintain or improve tree productivity and bean technological quality. With this in mind, WCF and ECA-CAOBISCO supported an initiative through Bioversity International entitled "An integrated approach to improving the efficiency and resilience of cocoa trees to climate change through better use of cocoa genetic resources". This work aims to select new varieties of high-performance cocoa trees adapted to different agro-climatic zones of Côte d'Ivoire.

Fig. 1: Negatives effects of drought on orchard establishment and product quality (Bouaflé area in Côte d'Ivoire)

Plant Material

Study Zones

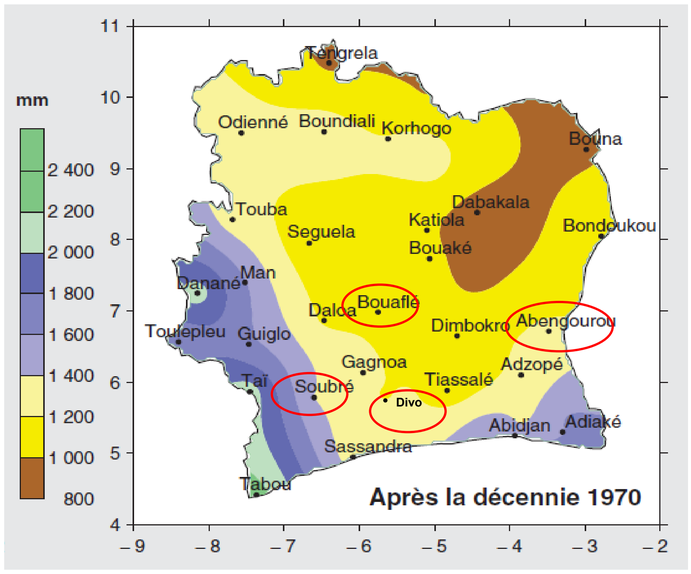

Fig. 2: Areas of implementation of the trial plots

Planting material

The planting material, planted in two plots per zone, is made up of 15 CNRA families (F1 to F15) common to each agro-climatic zone and 10 to 15 free progenies, selected in each zone by cocoa producers for their superior agronomic and technological performance.

Methods

The experimental design, which is based on the previous achievements of the CFC/ICCO/Bioversity (2004-2009) and FIRCA (2008-2011) projects, includes two agro-climatic zones with a rainfall deficit (Bouaflé and Abengourou) and two wetter zones (Divo and Soubré).

The parameters studied concerned i) production potential from 2015 to 2018 (**TOTCAB**), ii) adult vegetative vigor measured by trunk diameter at 30 cm from the ground (**DIAM**), iii) bean size evaluated by the weight of 100 dry cocoa beans (**P100FM**), and iv) field resistance to black pod-rot (caused by *Phytophthora* spp.), evaluated by % rotten pods (**TCP**).

Results

❑ *Analysis of the variance of the parameters studied*

Results showed that, with the exception of field resistance to black pod-rot, a highly significant zone x family interaction (probability < 0.0001) was observed for the studied parameters (**Table 1**). A similar result had been obtained for resistance to black pod-rot by **Nyassé *et al***. (2007) in Cameroon.

Table 1: Analysis of variance of the production potential, the adult vegetative vigor, the grain size and the field resistance to black pod-rot from 15 hybrid families planted in four cocoa production areas

	DIAM (cm)			P100FM (g)			TOTCAB			TCP (%)		
Sources	DDL	F	Pr > F	DDL	F	Pr > F	DDL	F	Pr > F	DDL	F	Pr > F
Zone	3	96	< 0,0001	2	46	< 0,0001	3	64	< 0,0001	2	47	< 0,0001
Famille	14	5	< 0,0001	14	16	< 0,0001	14	4	< 0,0001	14	2,4	0,004
Zone x Fam.	40	2,4	**< 0,0001**	26	9	**< 0,0001**	40	4	**< 0,0001**	20	0,9	**0,53**

❑ *Grouping of the 15 hybrid families by zone & by parameter evaluated*

With the exception of the TOTCAB parameters and DIAM in Soubré, the families were significantly different for all the parameters. In particular, the negative impact of drought on the weight of dry bean size has been highlighted (**Table 2.**)

Table 2: Comparison of 15 families of CNRA hybrids by zone & by parameter evaluated

	Zones sèches					Zones humides					
	Abengourou			Bouaflé		Divo			Soubré		Toute région
Fam.	DIAM (cm)	P100FM (g)	TOTCAB	DIAM (cm)	TOTCAB	DIAM (cm)	P100FM (g)	TOTCA	DIAM (cm)	P100FM (g)	TCP (%)
F2	15.62 a	165.16 a	60.8 a	14.3 b	131.0 abc	14,7 ab	190.2 a	_	22.1 a	130.3 bc	5.5 a
F14	15.37 a	127 bc	49.5 a	12.4 bc	119.1 abcd	15.8 a	155.8 b	_	22.0 a	111.3 bc	7.0 abc
F10	14.31 ab	115.33 cd	65.9 a	12.4 bc	146.9 abc	14.3 ab	122.6 cde	_	22.6 a	124.7 bc	7.6 abc
F8	14.03 ab	135 b	54.1 a	17.3 a	_	13.8 ab	126.1 cde		19.6 a	133.0 bc	12.5 c
F7	13.91 ab	125.35 bc	62.9 a	12.6 bc	100.6 abcd	_	_	89.0 b	16.1 a	116.7 bc	5.0 a
F9	13.52 ab	103.58 d	67.4 a	12.5 bc	104.3 abcd	9.9 c	107.7 e	34.7 b	21.5 a	123.7 bc	8.4 abc
F4	12.65 ab	79.33 e	54.1 a	13.3 bc	140.9 abc	13.3 ab	142.9 bcd	28.7 b	18.4 a	117.0 bc	6.7 abc
F15	12.43 ab	118.91 bcd	70.9 a	14.3 b	143.4 abc	15.3 ab	149.7 bc	_	19.4 a	131.3 bc	12.2 bc
F12	12.52 ab	124.02 bc	45.7 a	11.5 bc	35.3 d	13.8 ab	139.0 bcde	41.6 b	19.9 a	179.0 a	5.9 ab
F13	12.15 ab	115.33 cd	59.4 a	13.2 bc	190.0 a	12.7 b	131.4 bcde	89.2 b	15.1 a	117.3 bc	6.8 abc
F5	12.09 ab	104.83 d	44.0 a	10.3 c	89.4 bcd	14.4 ab	115.3 de	201.2 a	16.7 a	135.3 b	7.8 abc
F6	11.95 ab	114.41 cd	46.6 a	15.2 ab	61.2 cd	13.6 ab	130.9 bcde	60.6 b	16.7 a	121.7 bc	11.2 abc
F11	11.9 ab	127.83 bc	49.6 a	13.9 bc	104.3 abcd	_	_	_	19.0 a	112.0 c	8.3 abc
F3	11.45 b	112.66 cd	65.3 a	11.9 bc	176.6 ab	12.8 b	135.7 bcde	93.0 b	19.2 a	129.3 bc	10.0 abc
F1	10.82 b	126.5 b	59.9 a	13.0 bc	106.1 abcd	14.3 ab	162.3 b	_	15.1 a	130.3 bc	4.9 a
Moy.	**13.0 c**	**119.8 c**	**57.1 c**	**13.3 bc**	**117.8 a**	**13.9 b**	**137.0 a**	**79.5 b**	**19.0 a**	**127.5 b**	8.0
CV (%)	24.62	8.43	55.6	24.6	61.8	22.5	10.3	68.6	35.4	5.9	86.8
F	3.14	19.84	0.74	3.4	4.6	3.7	8.2	12.3	1.7	13.8	0.94
P	0.0002	< 0.0001	0.73	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.055	< 0.0001	< 0.0001

❑ *Rankings of the 10 best cocoa varieties including farmer selections for vigor, graininess, production potential & field resistance to black pod rot*

Table 3 showed that :

- for each trait evaluated, there is as much plant material selected by research as plant material selected by producers among the best varieties selected.
- 9 free progenies were remarkable for their graininess, in particular in Abengourou where the drought has an impact on the size of marketable cocoa beans: **FRE_C (168,3 g), FRE_E (163,3 g), YAO_A (146 g), FRE_A (145 g), FRE_D (145 g), YAO_D (140,7 g), BAZ_E (140,7 g), TIG_D (140,3 g) et BAZ_D (140,3 g).**

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Table 3: Rankings of the 10 best cocoa varieties including farmer selections for vigor, graininess, production potential and field resistance to black pod rot

Zones sèches					Zones humides					
Abengourou (N = 45)			Bouaflé (N = 48)		Divo (N = 36)			Soubré (N = 45)		Toute région
Diam (cm)	P100FM (g)	TOTCAB	Diam (cm)	TOTCAB	Diam (cm)	P100FM (g)	TOTCAB	DIAM (cm)	P100FM (g)	TCP (%)
F2	FRE_C	BAZ_A	F8	F13	F14	F2	F5	LOUMA_D	F12	F34SS
F14	F2	F15	F26SS	F15	F33SS	F8SS	F26SS	LOUMA_B	OLLO_D	BIL_E
AKA_B	FRE_E	FRE_A	F1SS	F3	F15	F1	F3SS	LOUMA_A	DIARRA_E	F32SS
FRE_B	YAO_A	F1	F28SS	F10	F14SS	F14	F17SS	ZADI_B	OLLO_B	KOF_D
AKA_B	FRE_A	BAZ_E	F19SS	F4	F2	F28SS	F25SS	LOUMA_C	OLLO_E	F24SS
FRE_B	FRE_D	BAZ_D	F3SS	F5	F5	F6SS	F1SS	LOUMA_E	LOUKOU_E	F18SS
F10	YAO_D	F10	F6SS	F2	F1	F30SS	F16SS	ZADI_C	LOUKOU_A	BIL_D
BAZ_E	BAZ_E	BAZ_B	NAB_D	F8SS	F10	F15	F3	F10	F5	F17SS
F8	TIG_D	FRE_B	F17SS	BIL_B	F17SS	F7SS	F6SS	F2	F8	ADO_A
YAO_E	BAZ_E	F4	F9SS	ADO_D	F20SS	F9SS	F13	F14	OLLO_A	F6SS
15.6 - 9.0	168.3 -78.0	91 - 41.1	17.3 - 8.5	190.0 - 63.2	15.8 - 9.8	190.7 - 107.7	201.2 - 11.3	28.6 - 6.6	179.0 - 111.3	1.0 - 21.0

❑ *Frequency of appearance of each family of CNRA hybrids among the test best-ranked varieties for each trait*

- Six CNRA families ranked at least three times among the 10 best varieties, including farmers' selections for all the traits studied at the different test sites (**Table 4**): **F1, F2, F5, F10, F14 et F15.**

Table 4: Frequency of appearance of each family of CNRA hybrids among the 10 best-ranked varieties

Fam.	DIAM (cm)	P100 FM (g)	TOTCAB	TCP (%)	TOTAL	Fréquence d'apparition	RANG
F1	2	0	1	0	3	**3/9 (33.3%)**	5ème
F2	3	2	1	0	6	**6/9 (66.7 %)**	1er
F3	0	0	1	0	1	1/9 (11.1%)	
F4	0	0	2	0	2	2/10 (20.0 %)	
F5	1	1	1	0	3	**3/10 (33.3 %)**	5ème
F6	0	0	0	0	0	0/10 (0.0 %)	
F7	0	0	0	0	0	0/8 (0.0%)	
F8	2	0	0	0	2	2/8 (25.0 %)	
F9	0	0	0	0	0	0/10 (0.0 %)	
F10	3	0	2	0	5	**5/9 (55.5 %)**	2ème
F11	0	0	0	0	0	1/7 (14.3 %)	
F12	0	1	0	0	1	1/10 (10.0 %)	
F13	0	0	1	0	1	1/10 (10.0 %)	
F14	3	1	0	0	4	**4/9 (44.4 %)**	3ème
F15	1	1	2	0	4	**4/9 (44.4 %)**	3ème
TOTAL	15	6	11	0	32		

Conclusion & Perspectives

- The selection of six families of CNRA hybrids adapted to drought areas suggest spreading them to marginal areas to minimize the effects of drought on producers' incomes;
- Start cloning the female parents of the best free progenies selected in Abengourou for graininess and field resistance to black pod disease. These are potential progenitors for the improvement of characters.

References

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