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Assessment of cocoa farmers' knowledge and preferences towards planting material in Cameroon

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A B S T R A C T

As part of the cocoa selection process, farmers' knowledge of their cocoa planting materials in two major cocoa growing areas of Cameroon has been considered in the present study. Two surveys were carried out in farmers' fields to assess the agronomic profile of their cocoa planting materials, their satisfaction from them, and their expectations from future newly released varieties. In the first survey, the purpose was to build a typology of cocoa plantations. In most of the 129 cocoa plantations studied, a strong relationship has been found between the performance of the farms (yield and low incidence of *Phytophthora* pod rot) and farmers' practices, such as the use of chemical control. This result suggests that the level of management of cocoa farms improved the yield more than the genetic origin of the planting material used on-farm in the study. In the second survey, the level of satisfaction of cocoa farmers with respect to their grown varieties and their preferred criteria in cocoa selection were determined. Out of 690 farmers interviewed, 87% were satisfied from the traditional varieties (TV), whereas only 39% of the producers were satisfied from the hybrid varieties (HV). An analysis of preferences towards the criteria of selection within each varietal type has revealed that farmers considered yield as the criterion to be improved in TV, whereas the resistance to *Phytophthora* pod rot remains the most challenging within the HV. The impact of other agronomic criteria in the varietal selection of cocoa in Cameroon is also discussed in the paper.

Introduction

Since its introduction in Cameroon, cocoa has became the most important crop of the farming systems found in the humid forest zones of the country (Coulibaly et al., 2002). In addition, cocoa is the principal source of income among the commercial crops (Duguma et al., 2001). During several decades, cocoa production in the country remained stable. The productivity was relatively low and varied considerably from

one agro-ecological zone to another (Varlet et Berry, 1997). The highest level of production of 225,000 metric tons was recorded during the 2012/2013 campaign (ICCO, 2014). This variation was a result of several factors, such as termination of state support to cocoa producers and the disappearance of the structures involved in technical assistance and funding to the cocoa sector (Alary, 1996; Varlet, 2000). However, other factors directly linked to the planting materials might also explain the low performances of cocoa in Cameroon. These include the ageing of cocoa trees as revealed earlier by Champaud (1966), and the lack of resistant varieties to cocoa pests and diseases such as *Phytophthora* pod rot (Ppr) and mirids. In Cameroon, the losses due to Ppr might reach 90% of the production in the absence of chemical control.

Cocoa is cultivated in more than 400,000 stands distributed through different agro-ecological zones of the country. Based on the history of cocoa introduction and selection in Cameroon, the planting materials found in these stands are divided into two groups: traditional varieties so-called "German cocoa" by the producers and the hybrid varieties. Traditional varieties are basically composed of Lower Amazon Amelonado types, and the hybrids contain germplasm from upper Amazon and Trinitario origin.

However, the farmers frequently use mature pods of their own plantations or those of their neighbors, in order to obtain the seeds prior to the establishment of new plantations or to replace dead cocoa trees. Consequently, the planting materials resulting from the selection carried out by the farmers became genetically complex compared to the one existed earlier. The mixture of the materials of different origins within the same plantation has favored the emergence of farms composed of heterogenic varieties. Nevertheless, farmers continue to differentiate their cocoa trees into the two groups of varieties mentioned earlier, based on the phenotypic traits of the pods.

As possible hypothesis, the evolution of the genetic composition of cocoa orchards has probably influenced the cultivated material, notably their yield end resistance to Ppr, mirids and other pests and diseases. In that context, a typology of existing cocoa plantations will help to better explain the variation usually found in the performances of the different cocoa plantations, with respect to the criteria of agronomic interest. In addition, regular selection of pods within cocoa plantations as a source of seeds will be done based on criteria with specific interest for the farmer. The identification of these criteria remains a great challenge for the success of future breeding activities.

Therefore, the objectives of the present study were to:
- characterized cocoa farmers based on their age and their level of education
- characterized cocoa farms based on few agronomic and varietal criteria
- evaluate the level of satisfaction of farmers with respect to the varieties available in their farms
- identify the preferences of farmers with respect to phenotypic criteria of cocoa, within the purpose of varietal selection

Materials and methods

Site of the study

The data of the study were collected during field surveys carried out in different cocoa agro-ecological zones of the country: the Southern region including three

administrative provinces (Centre, South and East provinces) and the Western region (South-west province and the Moungo sub-division in the Littoral province).

The southern zone (Fig. 1) was the major cocoa production basin in Cameroon until the end of the 1970s (Champaud, 1966). Cocoa is grown under heavy shade composed of forest and fruit trees, with low level of farm management and a limited use of pesticides (Losch et al., 1991). The yield per ha of dried cocoa varies between 100 and 500 kg/ha from one site to another within the region (Varlet et Berry, 1997). The soils are ferralitic, acid and clayed, with a red or yellow color. The rainfall regime is bimodal and characterized by an alternation of a wet and a dry season, with rainfall ranging between 1500 and 2000 mm over the year.

In the western region (Fig. 1), the pedo-climatic conditions are more favorable, and the level of shade in cocoa farms is relatively low and the use of chemicals is more intensive (Losch et al., 1991). The yields are therefore higher and may reach 600 to 1200 kg/ha. The soils are volcanic and fertile. The rainfall regime is monomodal and varies yearly between 2500 and 4000 mm, favoring the high incidence of Ppr.

Variables of the study

Two surveys were carried out in the southern and western regions:

- The objective of the first survey was to build a typology of cocoa plantations. In total, 129 plantations were visited and the data were recorded based on the variables defined in Table 1.

- In the second survey, the level of satisfaction of cocoa farmers with respect to their grown varieties and their preferred criteria in cocoa selection were determined. In total, 690 farmers were interviewed and the information was collected based on the variables presented in Table 2.

In the two surveys, the data related to the level of education (no education, primary, secondary, post-secondary) and the age of the farmers (<40, 41 - 50, 51 - 60 and >60 years) were also collected.

Methodology of the study

Survey 1: Typology of cocoa farms

In this survey, the different types of farms were identified as follows:

- Traditional varieties-based farms
- Hybrid varieties-based farms
- Mixed traditional and hybrid varieties-based farms

The farms were randomly selected within each region. In total, 55 and 74 farms were respectively selected in the southern and the western regions.

A principal component analysis (PCO) was generated using MINITAB-15 software (2007) in order to visualize the distribution of the types of plantations according to the agronomic variables. The same analysis was used with the purpose of determining the contribution of variables in the main axes of the PCO. Spearman correlations (1904) among agronomic variables were also calculated using MINITAB-15.

Survey 2: Level of satisfaction of the producers with respect to their grown varieties and identification of their preferred criteria of selection

In the second survey, a questionnaire was used during the discussions with cocoa farmers. In total 466 and 224 were

respectively interviewed in the southern and the western regions. A descriptive analysis of the data collected was done to determine the proportion of farmers satisfied by the performance of the traditional or hybrid varieties. In addition, the different criteria of cocoa selection were classified according to their importance as expressed by the farmers, in order to identify the desired type of varieties.

Result and Discussion

Age and level of education of the producers and their effect on farm characteristics

In the first survey, the producers were distributed according to their age and level of education. The proportions of producers distributed in the different classes of these two variables did not vary significantly. However, 46 producers aged above 60 years, corresponding to 35% of the total sample (Table 3). Most of the producers (73%) attended at least primary school, and 27% had secondary education.

In the second survey, the proportion for age level varied slightly, except among the producers aged less than 40 years (35% of the total sample). In addition, as in the survey related to the farms' typology, more than 65% attended primary school. Almost 35% had secondary education.

In the first survey, the age of the producers was linked to the level of education. However, the chi-squares of independence of each of the two producers' variables were not significant, when compared to the agronomic variables.

In the second survey, the age of the producers was also linked to their level of education. In contrast, there was no relationship between these two producers' variables and the other variables considered in that survey including the level of satisfaction with traditional (TV) or hybrid varieties (HV), and the varietal composition of the cocoa farms (presence of TV, HV or mixed TV+HV).

Typology of cocoa farms and agronomic performances of the cultivated varieties

Relationship between agronomic variables

The relationship among agronomic variables of the plantations was determined by the chi-square of independence. From the 21 independence tests realized, about 13 variables were significant at 5%-level (Table 4). A significant value of the chi-square suggested that the two compared variables were related. Therefore, the age of the plantations (PANTAGE) depended on the source of planting material (PLANTSOURCE) and the type of plantation (PLANTTYPE).

The yield (YLD) was depended also on the size of plantation (PLANTSIZE), the density (PLANTDENS), the efficiency of chemical treatments (CHIMEF) and the yield losses due to Ppr (Table 4).

The level of losses due to Ppr (PprLOS) was depended on the efficiency of the chemical treatments and the type of plantations (r=0.35) (Table 4).

A factorial analysis of correspondences (FAC) was done using the agronomic variables and the plantations distributed according to their type (PLANTTYPE; Fig. 2.2). The FAC has shown that a spatial structure exists according to the type of plantations (TV; HV; TV+HV). The TV-based plantations were older and the HV-

based plantations were more susceptible to Ppr. In the plantations composed of both type of varieties, the yield (YLD) increased with the efficiency of chemical control and the size of plantations.

The contribution of different variables in the five first axes of the FAC was studied (Table 5). The first axes represent the greater proportion of the total variability detected by the FAC. In the first axis that explained 24.7% of the total variability, the variables contributing more were the type of plantations (PLANTTYPE), the efficiency of chemical treatments (CHIMEF), the losses due to Ppr (PprLOS) and the yield (YLD). In contrast, in the second axis that explained 17.4% of the total variability, the age of plantations (PLANTAGE) was the only contributing variable (Table 5). In total, the first five axes explained 77.8% of the total variability, including the 42.1% for the two fist axes.

Distribution of type of plantations according to agronomic variables

The distribution of the plantations according to agronomic variables is presented in Table 6. Very few TV and HV-based plantations were found in the Western region. In the two agro-ecological zones, most of the TV-based plantations were older than the HV-based plantations. The yield of the plantations was low in the two types of varieties. In contrast, within the plantations composed of both types of varieties mostly situated in the western region, the yields were relatively higher because of the efficiency of chemical treatments, fertility and rainfall. The proportions per level of the variables PLANTSIZE, PLANTDENS, CHIMEF, YLD and TREESIZE did not differ significantly between TV and HV-based plantations (Table 6).

Level of satisfaction from cultivated varieties and criteria of selection preferred by the producers

Producers expressed different interest according to the type of cultivated varieties in their plantations. Over the 690 farmers interviewed, 87% were satisfied from the TV and 13% were unsatisfied (Fig. 1). In contrast, only 39% of the producers were satisfied from the HV. In the Western region, the percentage of farmers unsatisfied from the HV was as high as that of the producers satisfied from the TV. In the Southern region, the producers were also more satisfied from the TV than the HV, but at a lower percentage when compared to the Western region.

In the analysis of preferences towards the criteria of selection within the two types of varieties, the characteristics (criteria) of the tree, the pods and the beans were classified based on the order of preference (Fig. 2). During the interviews, the producers had the possibility to choose more than one criterion at the same time. In the TV, the number of pods (TV-PN) was the first criterion preferred by the producers when they select pods in their plantations to obtain seeds. In contrast, the resistance to Ppr was the first criterion of selection within the HV. Based on order of preference, the criteria were classified as follows:

- Traditional varieties (TV) : TV-PN > TV-PS > TV-BS > TV-RPpr > TV-RM > TV-RDB > TV-TS > TV-PC;

- Hybrid varieties (HV) : HV- RPpr > HV-PN > HV-RM > HV-PS > HV-BS > HV-PC > HV-RDB > HV-TS.

Table.1 Survey 1: Variables used in the typology of cocoa plantations

Variable	Acronym	Category
Type of Plantations	PLANTTYPE	**1**=Traditional varieties (**TV**), **2**=Hybrid varieties (**HV**), **3**=Mixed **VT+VH**
Source of planting material	SPMat	**1**=Cocoa farms, **2**=Seed gardens
Age of Plantations	PLANTAGE	**1**=<10 years, **2**=10-30 years, **3**=30-50 years, **4**=>50 years
Size of Plantations	PLANTSIZE	**1**=<1 ha, **2**=1-3 ha, **3**=4-6 ha, **4**=7-9 ha, **5**=>10 ha
Efficiency of chemical control ** (Ppr and mirids)	CHIMEF*	**1**=low, **2**=average, **3**=high
Ppr losses	PprLOS	**1**=30%, **2**=30-50%, **3**=50-70%, **4**=>70%
Annual yield per farm (1 bag = 80 kg)	YLD	**1**=0-5 bags, **2**=6-15 bags, **3**=>15 bags per fam
Pruning	PRUNING	**1**=regularly, **2**=occasionally, **3**=No
Plant density (number of cocoa trees per Ha)	PLANTDENS	**1**=≤1000, **2**=≥1000 to ≤1300, **3**=≥1300

***** : CHIMEF was estimated based on the nature of chemicals used and the period of the application of the fungicides (Ppr) and the insecticides (mirids)

** : Based on farmers' estimations, the efficiency of the chemical control is expressed by the frequency and the period of fungicides and insecticides applications, as well as the nature of the chemical used.

Table.2 Survey 2: Variables used in the analysis of preferences by the producers with respect to the criteria of selection considered within their plantations

Type of Varieties	Criterion of selection	Acronym
Traditional varieties (TV)	Tree size	TV-TS
	Pod number	TV-PN
	Pod size	TV-PS
	Pod color	TV-PC
	Bean size	TV-BS
	Ppr Resistance	TV-RPpr
	Mirids resistance	TV- RM
	Die back resistance	TV-RDB
Hybrid varieties (HV)	Tree size	HV-TS
	Pod number	HV-PN
	Pod size	HV-PS
	Pod colour	HV-PC
	Bean size	HV-BS
	Ppr Resistance	HV- RPpr
	Mirids resistance	HV-RM
	Die back resistance	HV-RDB

Table.3 Distribution of plantations and producers based on geographic area, age and level of education of the producers

Survey	Variable	Level	Region		Total
			South	West	
1 (Typology of the producers and the plantations)	Age of the producers	< 40 years	13	17	30 (23.25%)
		41 -50 years	10	16	26 (20.15%)
		51 – 60 years	11	16	27 (20.95%)
		> 60 years	21	25	46 (35.65)
		Total	55	74	129 (100%)
	Level of education	Post secondary	0	0	0 (0%)
		Secondary	19	16	35 (27.13%)
		Primary	32	49	81 (62.80)
		None	4	9	13(10.07)
		Total	55	74	129 (100%)
2 (expectation of the producers)	Age of the producers	< 40 years	132	110	242 (35.08%)
		41 -50 years	120	54	174 (25.21%)
		51 – 60 years	113	29	142 (20.57%)
		> 60 years	101	31	132 (19.13%)
		Total	466	224	690 (100%)
	Level of education	Post secondary	8	10	18 (2.60%)
		Secondary	172	50	222 (32.17%)
		Primary	277	141	418 (60.57%)
		None	9	23	32 (4.63)
		Total	466	224	690 (100%)

Table.4 Chi-square of independence among the agronomic variables of the plantations

	TAIL PLANT	AGE PLANT	SM VEG	TYP PLANT	RDT	PF PERT	PCHIMEF	TAIL ARB
AGEPLANT	19.99[a]							
	0.22[b]							
SMVEG	9.57	45.56						
	0.65	*0.00*						
TYPPLANT	13.84	20.76	46.47					
	0.08	*0.00*	*0.00*					
RDT	24.75	1.55	5.19	3.01				
	0.00	*0.81*	*0.51*	*0.55*				
PFPERT	21.91	1.03	8.78	40.42	7.86			
	0.34	*0.90*	*0.88*	*0.00*	*0.09*			
PCHIMEF	8.04	1.37	1.76	23.65	15.31	42.27		
	0.42	*0.84*	*0.93*	*0.00*	*0.04*	*0.00*		
TAILARB	6.39	9.24	5.34	20.93	5.37	7.39	3.78	
	0.60	*0.32*	*0.25*	*0.00*	*0.25*	*0.11*	*0.43*	
DENSPLANT	5.71	9.24	3.50	3.05	11.41	4.17	9.25	4.81
	0.67	*0.32*	*0.54*	*0.54*	*0.02*	*0.38*	*0.05*	*0.30*

[a] : Chi-square value [b] : Probability

Table.5 Contribution of agronomic variables in the five first axes (FC1-FC5) of the plantations

Variable	FC1	FC2	FC3	FC4	FC5
PLANTSIZE	0.24	-0.05	-0.63	0.21	-0.39
PLANTAGE	-0.17	0.65	-0.08	0.06	-0.13
PLANTDENS	0.01	-0.09	-0.28	0.56	0.74
PLANTTYPE	0.48	-0.07	0.24	0.22	-0.02
SPMat	0.06	-0.69	0.04	-0.14	-0.12
YLD	0.40	0.05	-0.50	-0.12	-0.11
PprLOS	-0.45	-0.20	-0.03	0.35	-0.30
CHIMEF	0.47	0.14	0.20	-0.21	0.16
PRUNING	-0.27	-0.09	-0.40	-0.61	0.34

Table.6 Distribution of the types of plantations based on agronomic variables of the study

Variable	Level	Geographic area						Total (%)		
		South			West					
		TV	HV	TV+HV	TV	HV	TV+HV	TV	HV	TV+HV
PLANTAGE	**1**	0	3	0	0	1	3	0%	13.8%	3.9%
	2	4	15	0	0	3	30	16.7%	62.0%	39.5%
	3	4	3	3	0	1	22	16.7%	13.8%	32.9%
	4	15	3	3	1	0	15	66.6%	10.4%	23.7%
							Total	100%	100%	100%
PLANTSIZE	**1**	3	1	1	1	0	6	16.6%	3.5%	9.2%
	2	13	16	4	0	4	32	54.3%	68.9%	50%
	3	4	3	1	0	0	17	16.6%	10.3%	23.8%
	4	3	3	0	0	1	6	12.5%	13.8%	7.8%
	5	0	1	0	0	0	7	0%	3.5%	9.2%
							Total	100%	100%	100%
PLANTDENS	**1**	1	0	0	0	1	11	4.2%	3.5%	14.5%
	2	22	22	4	1	4	47	91.6%	89.6%	67.1%
	3	1	2	2	0	0	12	4.2%	6.9%	18.4%
							Total	100%	100%	100%
CHIMEF	**1**	4	6	2	0	2	3	16.7%	25.6%	6.6%
	2	18	18	4	1	2	37	79.2%	69.0%	53.9%
	3	1	0	0	0	1	30	4.1%	3.4%	39.5%
							Total	100%	100%	100%
PprLOS	**1**	9	1	2	1	1	62	41.7%	6.9%	84.2%
	2	9	18	2	0	3	3	33.3%	65.5%	6.6%
	3	6	5	2	0	1	5	25.0%	27.6%	9.2%
							Total	100%	100%	100%
YLD	**1**	15	6	5	1	1	3	66.6%	24.1%	10.5%
	2	5	15	2	0	3	35	20.8%	62.1%	48.7%
	3	3	3	1	0	1	30	12.5%	13.8%	40.8%
							Total	100%	100%	100%
PRUNING	**1**	11	11	1	0	3	11	45.8%	48.3%	15.8%
	2	9	12	4	1	2	58	41.7%	48.3%	81.6%
	3	3	1	1	0	0	1	12.5%	3.4%	2.6%
							Total	100%	100%	100%

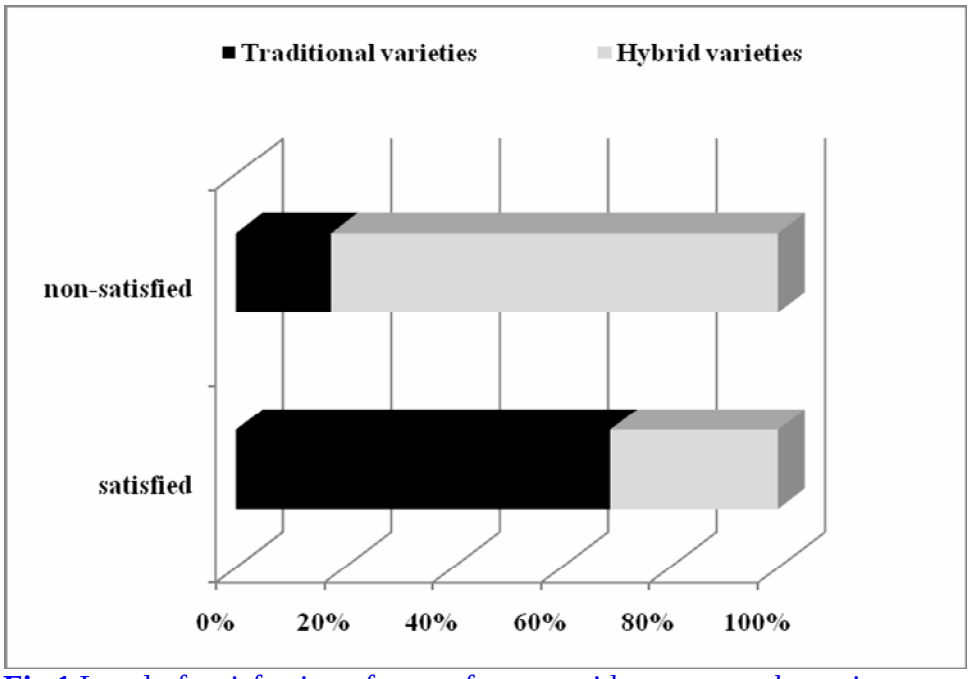

Fig.1 Level of satisfaction of cacao farmers with respect to the main grown varieties in their farms

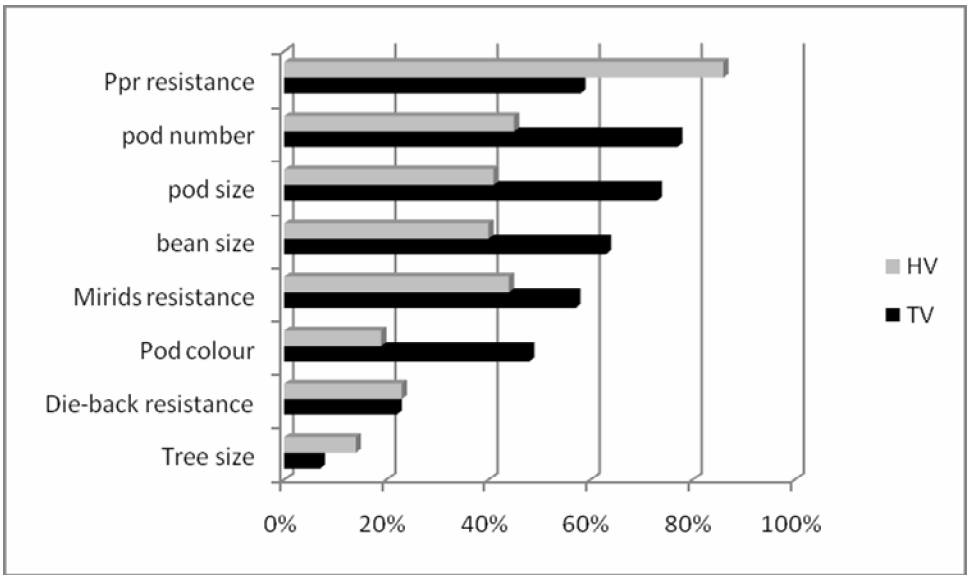

Fig.2 Criteria of preferences for the different agronomic traits as expressed by the farmers

Typology of the plantations

The results obtained have shown that the agronomic variables of the plantations were not influenced by the age and the level of education. Most of the producers have a minimum level of education and are aged less than 60 years. In both surveys, the age of the producers was correlated with their level of education, the younger producers being more educated. However, this situation did not have any consequence on

the selection of planting materials prior to the creation of new plantations, because the more educated farmers preferred the same planting materials as the less educated farmers.

In the plantations, few relationships were detected between agronomic variables of the study. The type and age of the plantations were closely related. The oldest plantations were mainly composed of traditional varieties or material collected from pre-existing plantations. In addition, most of the high yielding plantations were composed of both types of varieties. These mixed plantations are better yielding because they are mainly localized in the more productive Western region, characterized by favorable cocoa growing conditions. In this region, the use of chemical inputs in cocoa plantations was relatively high, and therefore contributed to reduced Ppr incidence and improved the yield. Other ecological factors contributed to the increase of yield in that region.

These factors include soil fertility and low shade. The performances of the cocoa plantations may be further favored by the use of pesticides (fungicides and insecticides). However, variability between different genetic materials that are growing under the same ecology and chemical treatment, may also improve the yield in cocoa plantations as confirmed by Jagoret et al. (2008). The use of pesticides as major source of inputs in cacao plantations in Cameroon has already been mentioned by Kazianga (2002). The Factorial analysis of correspondences (FAC) done on the different types of plantations had shown that the traditional-based plantations were older, and those composed of both types of varieties (western region) were better controlled with pesticides, and therefore yielded better. The FAC indicates also that the hybrid varieties were more susceptible to Ppr.

According to Dand (1993), the yield of cocoa tree depends on the age, the type of material and quantity of inputs used. The geographical situation influenced the distribution of the different type of plantations. The mixed (hybrid-traditional) plantations received more inputs in the Western region and therefore produced the best yields. The cocoa plantations aged less than 30 years (that corresponds to the levels 1 and 2 of the variable PLANTAGE in our study) were generally known to be more productive, and the yields decrease later with the age. Previous work undertaken in Cameroon have confirmed that the yields decrease gradually when the plantations get older (Gilbert et al., 1999 ; Gokowski et al.,1998).

In contrast, in the mixed plantations, the performance in terms of yield depended also on the aptitude of planting material to resist to Ppr. As Ppr and mirids were concerned, the efficiency of chemical control, the type and age of plantations were also the factors that influenced more the performance of cocoa plantations. The uses of fungicides and insecticides influence further the level of losses than the origin of cultivated varieties that was not possibly good enough.

Level of satisfaction and criteria of preference of the producers

The results of our study showed that the cocoa producers were not satisfied from the hybrids cultivated currently in their plantations. The main reason of this non satisfaction is the susceptibility of hybrid to Ppr and mirids, in spite of their high yielding ability. This justifies the choice of Ppr resistance as the first preferred criterion of selection to be improved within hybrid

material according to the producers. However, other factors may explain the incidence of Ppr within hybrid-based or traditional-based plantations in Cameroon. This includes the shade for example (Kazianga, 2002). If the traditional varieties were preferred by most of the producers, their yielding potential was lower than the one of hybrid material. The number of pods produced per tree is therefore considered as the first criterion to be improved within traditional material.

Other factors that were less considered in the previous cocoa breeding programs have been proven as important for the producers in this study. These factors include mirids resistance, bean size, and the resistance to the so-called "die-back" phenomenon that might be a result of mirids damage, and expressed by regressive dry out of cocoa trees. Even if the Ppr has been identified as the major phytosanitary constraint of cocoa cultivation in Cameroon (Ruf, 1993), some studies carried out in few sites of production have identified mirids as a greater risk (Coulibaly et al., 2002 ; Amougou, 2005). In addition, during the selection of pods for planting materials, (Paulin et al., 2003) several producers from Southern Cameroon had favored other criteria such as pod color, size and shape, as well as their position on the trunk of the trees. The pods harvested on the trunk (generally more developed with big beans compared to those on the branches) produce vigorous seedlings in nurseries.

Conclusion

In our study, we found that the cocoa plantations in Cameroon are composed of varieties issued from the first introductions of cocoa (traditional varieties) and varieties issued from the selection on station (hybrid varieties). In several plantations, all these varieties are mixed, mostly in the western region. The yield and the resistance to disease and pests (Ppr and mirids) depend on the genetic material (origin and age) and the agronomic practices of the growers, particularly the management of phytosanitary constraints through chemical control. The producers expressed their preference to the traditional varieties because of their lower Ppr incidence, compared to the varieties issued from seed gardens (hybrids) which are more susceptible to diseases and pests, but high yielding. Therefore, they select consciously one varietal type according to limitations of the other varietal type in their farms. This experience of the producers influence their criteria of selection within each of the two varietal types found in their plantations. The same producers have already expressed an interest in other agronomic characters that have not been exploited before in breeding programs, such as resistance to mirids, and "die-back" as well as bigger bean size.

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