Value of geographical origin and parental genealogy in the Selection of Oil Palm *(Elaeis guineensis* Jacq.*)* in Côte d'Ivoire

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ABSTRACT

*In genetic improvement of oil palm (*Elaeis guineensis *Jacq.), categorical variable represented a main part of information used to determine differentiation among populations of genitors selected from the reciprocal recurrent selection program (RRS). The disjunctive power of these variables has been tested on 134 genitors selected from populations of the first, second and third cycle of RRS. The categorical variables used to differentiate these populations are those that permitted to have some information on the geographical origins and the parental genealogies of those genitors. The factorial analysis of those categorical variables, permitted to assess the disjunctive power of each of the two main criteria of divergences of selected genitors' populations. The criteria "geographical origin" represented 14% of total disjunction expression of selected parents' populations. The criteria "parental genealogy" represented 70% of total disjunction expression of selected parents' populations. The use of these two criteria can constitute one fine alternative to the use of molecular data in diversity studies of selected oil palm populations.*

Keys word: Oil palm, selection, categorical variable, disjunction of population

INTRODUCTION

Since 2007, the palm oil production exceeds that of soybean oil (FAO, 2009). In Côte d'Ivoire, the good performance of oil palm (*Elaeis guineensis* Jacq) results from the selection of genitors based on a reciprocal recurrent selection (RRS) programme (Gascon and Meunier 1972). In this programme, genitors' populations (here referred to as populations) from various geographical origins were identified by different research centres members of CIRAD "network". The diversity of these populations was evaluated using agro-morphological criteria (Adon 1995, Cao 1995, Bakoume *et al.* 2001) and molecular criteria (Barcelos 1998, Billotte *et al.* 2001, Hayati *et al.,* 2004, Bakoume *et al,* 2007, Allou *et al.* 2008). However, when breeding populations were derived from similar geographic origins with identical agronomic performances, disjunction among of such similar populations exclusively on the basis of agro-morphological criteria was almost undoable. Given the relative high cost of molecular markers techniques, some oil palm breeders have adopted the use of categorical variables (Hartley 1967, Allou 2008). Those categorical variables were

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obtained from genealogical and geographical variables (Durand-Gasselin *et al.* 1999, Durand-Gasselin *et al.* 2000). These criteria represented an important part of the information used to differentiate the selected populations. The use of information based on the level of differentiation expressed by each categorical variable would be empirical without an evaluation of the power of the categorical variables in the disjunction among selected populations. The objective of this study is to evaluate, through factorial analysis, the power of few categorical variables in differentiating breeding populations selected after three cycles of oil palm selection in Côte d'Ivoire.

MATERIAL AND METHODS

Plant material

One hundred thirty-four (134) genitors characterized by a small number of large bunches were selected from 14 populations. These breeding populations were derived from crosses between oil palms from African (Angola, Dabou) and Asian (SOCFIN) research programmes. They include two (02) populations from the first cycle of selection, 4 the second cycle, and 8 from the third cycle (Table I).

Methods

Development of categorical variables

Two common criteria for oil palm selection in Côte d'Ivoire were used to develop the categorical variables. The first is the "geographical origin" which establishes differences among differentiates genitors on the basis of the origin of their grandparents. The second is the "parental genealogy" which differentiates genitors on the basis of their filiations (Table II). For each categorical variable developed, information gathered from a genitor is as qualitative alphanumeric data type, which specifies its membership in a category group of selected genitors. Each data was then codified from 100 to 100 + (n-1), where *n* is the total number of categories of genitors revealed by the categorical variable used.

Statistical Analysis

The programme STATISTICA version 5.1 (StatSoft 2001) was used to perform the Principal Component Analysis (PCA) in view of estimating the disjunctive power of the two variables (Leroux-Scribe 1997) and for each variable, the weight of their major components (Jobson 1992). It also allowed carrying out a Hierarchical Cluster Analysis (HCA) in order to assess the disjunctive power of each of the components of the "parental genealogy" using the eight populations selected from the 3rd cycle of RRS (Lebart *et al.* 1997).

RESULTS

Proper values of the disjunctive variables and components

The PCA shows that the value of the variable "genealogy parent" is five times higher than that of the "geographical origin". On the first axis, the variable "parental genealogy" reveals 70% of difference among populations. The most expressive components of the variable in the differentiation observed are the "type of parental combination" (TYPE), the "lineage of grandparents" (DESGDPA1 and DESGDPA2), the "grandparents", (GRDPAR1F,

GRDPAR1M, GRDPAR2F and GRDPAR2M) the "lineage of parent" (DESCPAR) and the "parents" (PARENT1 and PARENT2). On the second axis, the “geographical origin" explains 14% of difference among populations. The most expressive component of this variable is the "origin of the first grandparents" (ORGDPA1F, ORGDPA1M, ORGDPA2F and ORGDPA1M).

Disjunctive power of geographical origin’s components

The breeding populations from the first cycle of RRS were separated into two categories on the basis of the “geographical origin" (Figure 1). The first category of disjunctive populations assembles genitors whose grandparents belong to Dabou origin. The second category of disjunctive populations regroups genitors whose grandparents are descendants from SOCFIN origin. The breeding populations from the second cycle of RRS have been separated into three categories. The first category of disjunctive populations is composed of single-origin progenies whose grandparents are from Angola origin. The second category is composed of single-origin progenies whose grandparents represent Dabou origin. The third category is composed of bi-origin progenies whose grandparents come from Dabou origin and from SOCFIN origin. The breeding populations from the third cycle of RRS were separated into four categories of disjunctive populations on the basis of the "geographical origin" including (i). single-origin progenies whose grandparents were all from Dabou origin, (ii) bi-origin progenies whose grandparents are from Dabou and SOCFIN origins, (iii) bi-origin progeny whose grandparents are from Dabou and Angola origins, and (iv) tri-origin progenies whose grandparents are from Dabou, SOCFIN and Angola origins.

Disjunctive power of parental genealogy’s components test

The HCA shows that populations can be grouped into seven points of inertia (Figure 2). Three levels of strong divergence are identified among the seven points of inertia. The first high-level of divergence is revealed by the component "parental progeny" (inertia point 2), the second by the component "first male grandparents" at the inertia point 4, and the third by the "first female grandparents" (inertia point 7). At this last point of inertia, the genitors whose first female grandparents are "AN" type (Angola origin) are distinguished from those whose first female grandparents are of "DA" type (Dabou origin). The use of the categorical variable "first female grandparents" as pedigree criteria revealed 60% of total differentiation among breeding populations of the 3rd cycle of RRS (Figure 3). At the point 4 of inertia, the genitors whose first male grandparents are "DA" type are distinguished from genitors whose first male grandparents are "SO" type. The selection criteria "first male grandparents" revealed 51% of total disjunctions. At the point 2 of inertia, populations are clustered into 14 categories on the basis of the "parental progeny". This parental genealogy’s component (parental progeny) reveals 27% of the total variability among populations.

DISCUSSION

The variable "geographical origin" has been widely used by oil palm breeders of palm oil, hence becoming essential criteria for selection of populations when the differentiation by agro-morphological variables is difficult. Indeed, Jacquemard *et al*. (1993) indicated that, in the RRS scheme, the separation of populations on the basis of their geographical origin can allow exploiting the greater source of genetic diversity of collection materials. This disjunction method was used a long time ago by Meunier and Gascon (1972) to improve oil palm populations. Therefore, the use of the "geographical origin" as a source of genetic

diversification of oil palm material has often been used as a good way of assessing any new oil palm materials before their introduction into the SRR scheme. Adon *et al.* (1998) have used the material from Angola as a new source of diversity to diversify the current breeding populations. Molecular markers are the most recent tools used in the differentiation of populations when the technology is available. Hayati *et al.* (2004) performed a clustering of natural oil palm populations from different geographical origins using isozyme markers. The authors have shown, through a genetic diversity study, the existence of high molecular differences among 26 natural oil palm populations from 10 countries of West African and from one East-Asian country in respect with their geographical origins. Therefore, at the beginning of their implementation of certain breeding programmes, the exploitation of the "geographical origin" as a criteria for populations disjunction can be used temporarily given the costs required for generating and exploitation molecular data and most often the unavailability of molecular markers facilities (Bakoumé 2009, personal communication) However, our study also showed that the variable "parental genealogy" can be used to exploit disjunction among selected populations. It is five times more discriminating than the standard variable "geographic origin". Indeed, the use of categorical variables compiled from genealogical criteria remains the most effective way to establish better differences between selected genitors. According Durand-Gasselin *et al.* (2000), to better differentiate populations, the variable "parental genealogy" may be associated to the "geographical origin". Thus, in addition to the geographical origins of grandparents the authors took into account the "parental genealogy" to establish differences among populations from the 3rd cycle of selection. Using the "geographical origin" and "parental genealogy" allows to quickly differentiating populations with similar agronomic performances but different geographical origins of female grandparents. Categorical variables can help guiding the selection of certain populations not on the basis of their agronomic performance but on the knowledge of the molecular characteristics of the grandparents. This method of selection based on categorical variable may be proposed as an indirect method of selection if agronomic and molecular characteristics of the grandparents are very well known, and also if their geographical origin are known too. Statistical analysis of categorical variables related to parental genealogy has become indispensable to give a non-empirical basis for this method of indirect selection of parents in the absence of molecular markers.

CONCLUSION

The use of categorical variables as criteria for differentiating selected oil palm materials is efficient when taking into account the disjunctive power of each the two variables. In fact, exploitation of a disjunction established by geographical criteria is less expressive than that related to parental genealogy. The temporary adoption of any categorical criteria as an alternative to the use of molecular divergence must be submitted to a statistical analysis and be extended to all oil palm breeding populations in Côte d'Ivoire.

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TABLE I- LIST OF PARENTS SAMPLED FOR THE CATEGORICAL DIVERGENCE ANALYSIS.

Level of selection	Crossing realized	Selected population	Number of selected parents
1st cycle	Dabou*	DA	07
	SOCFIN*	SO	03
2nd cycle	Dabou × Dabou	DADA	26
	Dabou × SOCFIN	DASO	08
	SOCFIN × Dabou	SODA	
	Angola × Angola**	ANAN	09
			07
3rd cycle	(Dabou × Dabou) × (Dabou × Dabou)	DADADADA	19
	(Dabou × Dabou) × (Dabou × SOCFIN)	DADADASO	02
	(Dabou × SOCFIN) × (Dabou × Dabou)	DASODASO	06
	(Dabou × SOCFIN) × (SOCFIN × Dabou)	DASOSODA	05
	(SOCFIN × Dabou) × (Dabou × SOCFIN)	SODADASO	03
	(SOCFIN × Dabou) × (SOCFIN × Dabou)	SODASODA	06
	(Dabou × Dabou) × (Angola × Angola)	DADAANAN	17
	(Dabou × SOCFIN) × (Angola × Angola)	DASOANAN	02

* Basic population of the parents' origin

** The parents of Angola origin have been introduced into the oil palm genetic improvement program at the 2nd cycle of RRS

TABLE II- CATEGORICAL VARIABLE USED TO DESCRIBE DIFFERENCES BETWEEN POPULATIONS OF OIL PALM PARENTS.

Criteria of categorization	Describer used for categorical variable	Codification of variables	Number of categories used
Origin geographical	Geographical origin of the female 1st grandparents	ORGDPA1F	03
	Geographical origin of the male 1st grandparents	ORGDPA1M	03
	Geographical origin of the female 2nd grandparents	ORGDPA2F	03
	Geographical origin of the male 2nd grandparents	ORGDPA2M	03
Parental genealogy	Progeny of 1st grandparents	DESGDPA1	17
	Progeny of 2nd grandparents	DESGDPA2	15
	Genotype of female 1st grandparents	GRDPAR1F	14
	Genotype of male 1st grandparents	GRDPAR1M	11
	Genotype of female 2nd grandparents	GRDPAR2F	12
	Genotype of male 2nd grandparents	GRDPAR2M	09
	Progeny of parents	DESCPAR	55
	Female parent	PARENT1	40
	Male parent	PARENT2	34
	Type of parental combination	TYPE	14

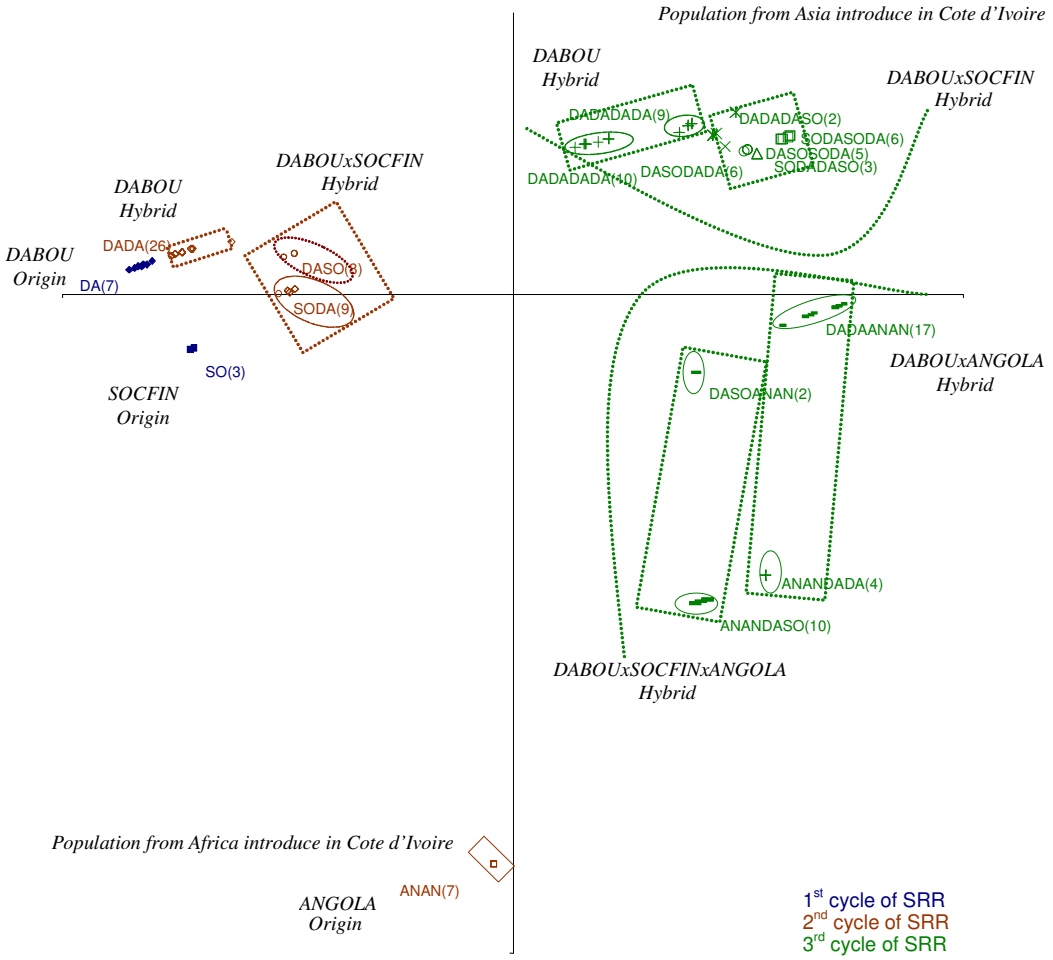

Figure 1. *Projection of selected parents into the plan 1-2 of the ACP; Axis 1 (Horizontal): genealogical variable, Axis 2 (Vertical): geographical variable*

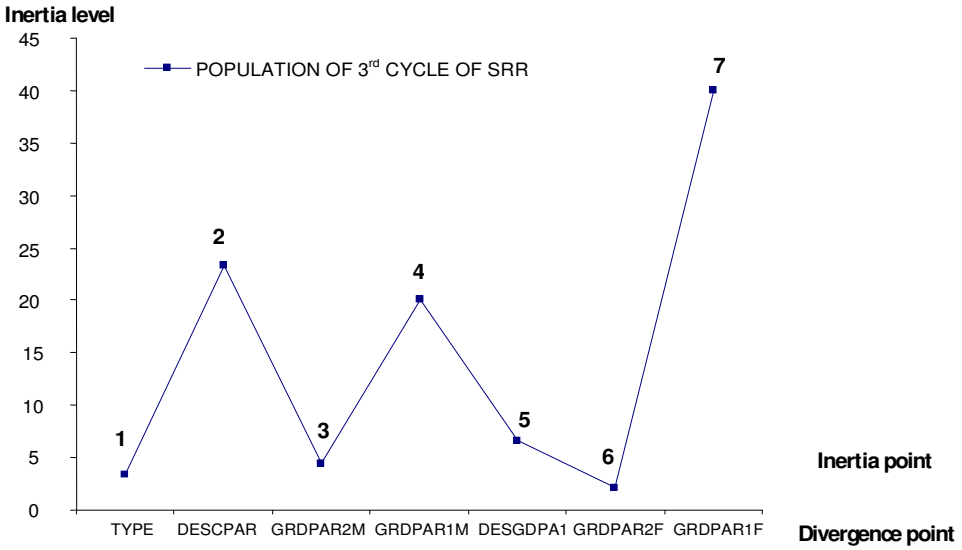

Figure 2. Evolution of inertia points after an automatic classification analysis of the populations of parents selected from the 3rd cycle of SRR of oil palm.

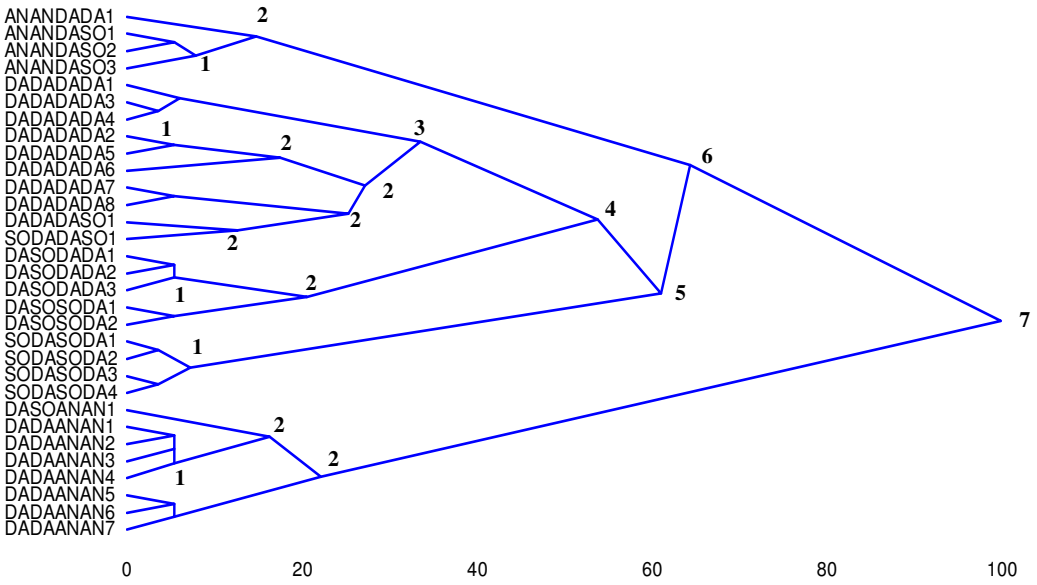

Figure 3. Ordering of populations from the 3rd cycle of SRR based on the level of categorical divergence expression

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