International Journal of Agriculture Innovations and Research
Volume 3, Issue 2, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 25/09/2014 | Accepted on : 05/10/2014 | Published : 09/10/2014

Parental Diversity in Improved Populations of Oil Palm (*Elaeis guineensis* Jacq.) After Three Cycle of Reciprocal Recurrent Selection

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***Abstract* – The recurrent reciprocal selection scheme used in the oil palm genetic improvement in Cote d'Ivoire results on a decrease of the diversity in selected** genitor's **populations. To maintain parental diversity, introductions were made at different levels of selection cycles. Therefore parental diversity is essential to any objective oil palm breeding program. This study was used to determine among categorical variables classification criteria whose can put most prominently this parental diversity. Various indices and descriptors of diversity were used to appreciate parental diversity after three cycles of selection. These indices were based on Shannon-Weaver diversity index, Simpson diversity index and Hill diversity index. The criteria for categorical variables classification were based on production groups, origin and genealogy criteria. It appears that among all the criteria, the criterion concerning the genealogy of genitors was the criterion that puts most prominently parental diversity. The use of this categorical variable will maintain within improved genitors population high variability compared to commonly using agro-morphological variables.**

***Keywords* – Categorical Variables, Diversity Index, Oil Palm Breeding.**

I. INTRODUCTION

The oil palm breeding program in the Lame Research Center is based on a recurrent reciprocal selection scheme (RRS) [11]. A lot of genitors from several origins and parents were integrated at different levels into the RRS breeding scheme after three cycles of selection ([3], [16]). In this scheme, two complementary sets of populations A and B were used as a basis for mutually bred using stringent criteria to screen for elite-trees ([12], [9]). The A group is characterized by production of small number of big bunch and B group characterized by production of big number of small bunch. However, Gallais [11] demonstrated that continuing selection results on a decrease of the diversity in selected genitors populations. Diversity in parental population is critical for the best utilization of oil palm genetic resources. Thus, maintaining diversity in genitor populations as RRS goes on has been a concern related to this breeding scheme because of oil palm inbreeding sensitivity. Introductions of new materials into the RRS have been attempted to broaden diversity in new working populations [2]. Moreover selection has increasingly favored the use of categorical variables for the *a priori* classification of improved genitor populations in order to exploit an apparent diversity between-population ([2], [5], [15], [16]). Categorical variables used as textual data contain the most important part of information collected on genitors during selection. Those data information's result from categorical variables whose data values or category levels are equal or greater than two information. The objective of this study is to analyze the level of diversity expressed by several categorical variables using diversity index according to information collected on genitors during selection. An inventory of the improved genitors' populations was made throughout selection cycles. Those genitors were classified into different types using categorical variables describing parental diversity. Diversity was assessed by means of graphical and univariate methods analysis.

II. MATERIEL AND METHODS

2.1 Material

Improved genitor's inventory

Improved genitors were inventoried in three steps: The first step was consisted on determination of the genealogy of each genitor from the improved genitors' populations. The second step concerned temporary listing of offspring from the 1st, 2nd and 3rd RRS cycles using cross schemes of candidate genitors. Only descendants whose parents or grand-parents were involved in at least one cycle of the RRS were selected. Last step was consisted to check the genitors, their parents and grand-parents which still alive on the fields. Overall, 311 improved genitors were selected for the analysis of parental diversity.

2.2 Methods

2.2.1 Categorical variables, descriptors of parental diversity

Criteria for classification of genitors in several categories were based on production groups, origin and genealogy criteria (*Table 1*).

2.2.2 Indices, indicators of diversity

Diversity level in each class of genitors given by each categorical variable was assessed using the frequency formula as an index of diversity.

$$FMode = NMode / \sum Ni.$$

In this formula, NMode is the number of genitors of the richest modality and Ni the number of genitors of the i^{th} class.

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Table 1: Descriptors of parental diversity within improved genitor's populations

Descriptors of diversity	Abbreviation	Modality
Production group	Grp	02
Cycle of selection	Cycle	03
Type of hybrid combinaison	Type	311
Origin of the 1st female grand parent	Orgdpa1f	08
Origin of 1st male grand parent	Orgdpa1m	08
Origin of 2nd female grand parent	Orgdpa2f	08
Origin of 2nd male grand parent	Orgdpa2m	08
Progenies of 1st grand parent	Desgdpa1	34
Progenies of 2nd grand parent	Desgdpa2	32
1st grand parent female	Grdpar1f	32
1st male grand parent	Grdpar1m	29
2nd grand parent female	Grdpar2f	30
2nd male grand parent	Grdpar2m	24
Parental offspring	Descpar	107
Female parent	Parent1	80
Male parent	Parent2	77

The richness S in genitors of a given class is the count of genitors related to each modality within the class. The chart of the distribution associated with the frequency amplitude gives an estimation of the diversity level in each class. It also allows the comparison of richness of the modalities between classes of genitors. The higher a population's frequency amplitude, the least diversified it is.

The Shannon-Weaver diversity index [4] was also used. The formula is as follows:

$$H' = -\Sigma ((Ni / N) \times log2 (Ni / N)).$$

Where Ni is the number of genitors in a given class, N is the total number of genitors sampled. H' is null (0) when all genitors of a class belong to the same modality. H' is also null when each modality in the class of improved genitors is represented by a unique genitor, all other improved genitors belonging to a unique modality. The highest H' value is reached when all genitors are equally distributed among all modalities of the class of the sampled genitors [14].

The Simpson index was used to estimate the probability of randomly picking two genitors in the same class [8]. The formula is:

$$D = \Sigma Ni (Ni-1) / N (N-1)$$

Where Ni is the number of genitors in a given class, N is the total number of genitors. The Simpson index is null when the probability is minimum and the diversity is maximum. The maximum Simpson index indicates maximum probability and the minimum diversity [6]. The Hill index was used to estimate the proportional abundance of improved genitors in each class [7].

The Hill index combines the indexes of Shannon-Weaver and Simpson [10]. Its formula is as follows:

$$Hill = (1/D)/eH'$$

Where 1/D is the inverse of the index of Simpson and eH' is the exponential of the index of Shannon-Weaver. The more the Hill index is close to 1, the lower the proportional abundance is. For ease of interpretation, the 1-Hill index is preferred. Thus, the equal distribution of improved genitors is good when 1-Hill = 1 (maximum diversity) and poor when 1-Hill = 0 (minimum diversity).

III. Results

The chart of the frequency amplitudes of the classes of improved genitors showed four diversity levels in the population of improved genitors (*Figure 1*). The first diversity level consisted of the "**production group**" and "**selection cycle**" classification criteria. The group B and the third cycle contained 56.7% and 61.15% of the improved genitors, respectively.

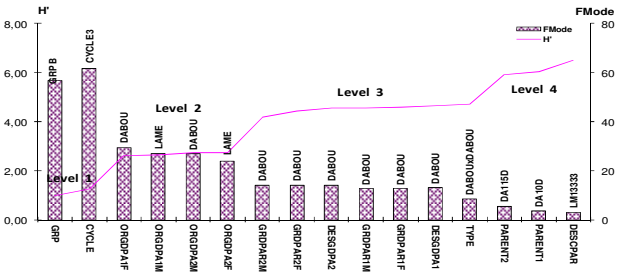

Fig.1. Level of diversity of genitors assembled into classes of genitors.

According to the Shannon-Weaver diversity index, the use of the "production group" and "**selection cycle**" criteria to classify the improved genitors is based on a very weak diversity level H' (*Table 2*).

Indeed, the probability of getting two improved genitors from the same production group is very high (D=0.51) for these criteria. Improved genitors are equally distributed between production groups A and B (*Figure 2*).

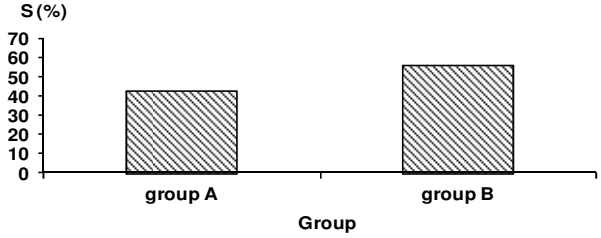

Fig.2. Abundance of improved genitors into the production groups A and B.

Table 2: State of the diversity of improved genitors based on the categorical variables

Categorical Variables	Diversity (H')	Probability (D)	Equitability (1-Hill)	Level
Grp	0,99	0,51	0,51	I
Cycle	1,24	0,49	0,41	
Orgdpa1f	2,61	0,19	0,61	
Orgdpa1m	2,63	0,19	0,62	II
Orgdpa2m	2,73	0,18	0,63	
Orgdpa2f	2,74	0,17	0,63	
Grdpar2m	4,19	0,07	0,77	
Grdpar2f	4,43	0,06	0,80	
Desgdpa2	4,54	0,06	0,81	III

The second diversity level was explained by the classification criteria ORGDPA1M, ORGDPA2F and ORGDPA2M. These criteria are all related to the geographical origins of the improved genitors. The origins Deli DABOU and BRT10 LAME are the most utilized among all origins introduced in the breeding scheme of oil palm in Côte-d'Ivoire (*Figure 3*).

The inventory analysis showed that 29.3 % of improved genitors are from DABOU origin and 26.7% are from LAME origin. When the "**geographical origin**" criterion is used to classify the genitors the diversity H' is twice higher than what is observed for the "production group" criterion is used (*Table 2*).

The probability two improved genitors belong to the same origin is low (D=0.19) for these criteria. According to the Hill index except both of these origins, the improved genitors from the other origins were equally utilized for the breeding of palm oil (*Figure 3*).

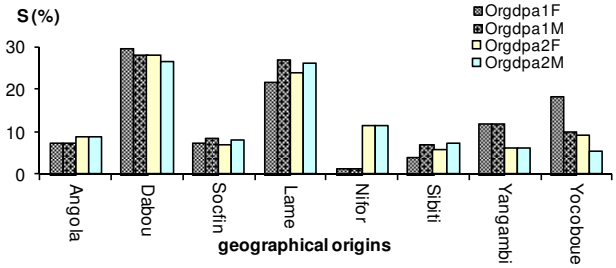

Fig.3. Abundance of improved genitors of the geographical origins.

The third and fourth levels of diversity were explained by criteria related to the genealogy of the improved genitors. In the third level, 13.8% of genitors have Deli DABOU as grand-parents. The "**grand-parents**" criterion used a diversity H' four times higher than the "**production group**" criterion (*Table 2*). The probability two improved genitors descend from the same grand-parent is much lower (D=0.07). According to the Hill index (*Table 2*) improved genitors from the less used grand-parent descents were equally used in the oil palm breeding program (*Figure 4*).

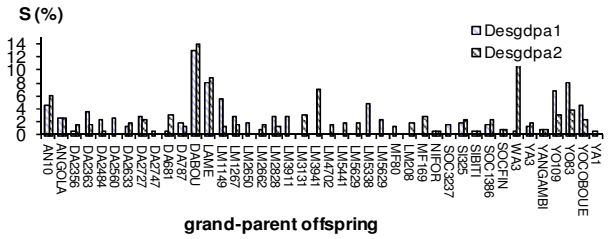

Fig.4. Abundance of improved genitors of the grand-parent offspring.

In the fourth level of diversity, study revealed that among the 107 parental offspring, 2.60% of them are from LM13008 parental offspring, 2.60% of genitors are also derived from LM13333 parental offspring and 2.60% of genitors are from AN10 (*Figure 5*). The genitors of 107 parental offspring originate from parental families LM13008, LM13333 and AN10 at the same 2.6% percentage. The "**parental family**" criterion displayed an H' diversity six times higher than the use of the of the "**production group**" criterion. Under this criterion, the probability two improved genitors originate from the same full-sib family is very low (D=0.02). Hill index showed that improved genitors originating from the less used numerous parental descents were equally utilized in the oil palm breeding program (*Figure 5*).

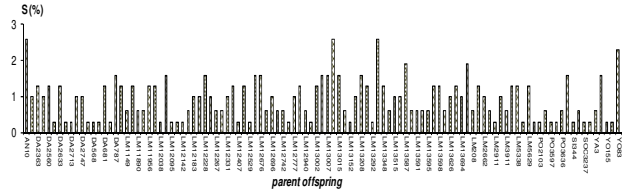

Fig.5. Abundance of improved genitors of the parent offspring.

IV. DISCUSSION

Categorical data have been widely used in the genetic breeding of oil palm. However, the classification criteria used to select improved genitors exploit only four levels of parental diversity. Adon *et al.* [2] attempted to diversify the oil palm vegetal materials by the introduction of Angola materials. In order to test the possibility of using "Angola" material as a source of germplasm diversification, they assembled 38 hybrid genitors into four types of parental combinations according to the third

level of diversity. All types were different from each other based on the origin of the male parent. These authors appropriately used the "male parent origin" as a source of diversification of the vegetal materials and they could therefore point out a higher genetic variation as a result of a higher diversity between parents. The classification strategy these authors used confirmed the fact that the utilization of a better diversity of the vegetal materials relies on the type of categorical variable used to differentiate them. Durand-gasselin *et al.* [15] assessed self-pollination and recombination offspring in order to design a strategy for the optimal utilization of recombination in a new cycle of selection. Hybrid populations were compared based on the "parental families". Thus, each population was identified by both its grand-parents Dura Deli and Tenera Lamé. In the strategy used by these authors two genitors slightly different for a given agronomical trait can still be used in recombination for another categorical trait discriminating them. The use of the "grand-parents" as source of diversification allows the exploitation of a higher parental diversity than the origin of the genitor. Indeed, there is much more diversity for grand-parents than for geographical origins for the same number of genitors. Delseny [6] suggested that categorical variables could be a powerful tool for prediction. Nevertheless they can be misused in samples adjustment process when no data related the textual statistics of the variable are available.

V. Conclusion

Parental diversity is essential to any objective oil palm breeding program. To keep it within breeding populations of oil palm improved genitors, categorical variables were used to determine the degree of variability of this population. Among the three categorical variables classification criteria, the classification test using genealogy criteria was the criterion that has most prominently this parental diversity. The use of categorical variables as classification criteria keeps within the improved genitors' population high variability compared to commonly using agro-morphological variables.

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