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Assessment of Lobé Oil Palm (*Elaeis guineensis* Jacq.) Population from Cameroon crossed with Deli Testors

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ABSTRACT

To broaden the genetic variability and especially to enrich agronomic qualities of oil palm (*Elaeis guineensis* Jacq.) populations of Group B used in the breeding scheme, a study was led on Lobé population, beforehand improved by PAMOL plantations of Cameroon. This evaluation was carried out in crosses with Deli testors derived from the second cycle of reciprocal recurrent selection scheme. The LM 2 T × DA 10 D and LM 2 T × DA 115 D crosses derived from the first breeding cycle were used as controls for the characterization of Lobé × Deli crosses. The bunch production components, vascular wilt susceptibility and vertical growth rate were used as criteria of evaluation. The Lobé × Deli crosses were characterized by bunch production lower than those of controls. These crosses had a higher vertical growth rate than those of controls. The Lobé × Deli crosses were susceptible to the vascular wilt. A study of general combining abilities made it possible to select one parent which cumulates maximum interesting characters. This parent had good general combining abilities for the precocity of bunch production, bunch production at the adult period and the vascular wilt tolerance. Prospects for utilization of this parent for the improvement of bunch production at young age and the diversification of sources of vascular wilt tolerance of populations used in the reciprocal recurrent selection scheme were discussed.

INTRODUCTION

The genetic improvement of oil palm (*Elaeis guineensis* Jacq.) in Côte d'Ivoire is based on a reciprocal recurrent selection scheme. This breeding strategy, adopted on the La Mé station since 1957, uses two groups of populations with complementary production components (Meunier and Gascon, 1972). The Group A is characterized by palms with a small number of large bunches (Deli) and Group B, the La Mé and Yangambi populations (West Africa), includes palms with a large number of small bunches. This selection scheme is comprised of several successive breeding cycles. Each cycle includes progeny tests (Group A × Group B crosses) to identify the best parents, which were then recombined within each group (within-group recombination) to make up the improved populations or basic populations for the next cycle.

The implementation of this breeding strategy made it possible to perform a progression of 60 % on the oil yield in 50 years of selection (Durand-Gasselin *et al.*, 2009). However, this progress was accompanied by a reduction of the genetic base of populations used (Cao, 1995). This situation can hamper genetic progress in the long-term. To widen the genetic base and especially to enrich agronomic qualities of populations of breeding scheme, it is necessary to use additional materials. These new materials are introduced into the reciprocal recurrent selection scheme during the within-group recombination phases (Jacquemard, 1995). These materials derived from surveys of wild oil palm groves and exchanges between research stations. Most often, these populations are evaluated before their introduction into the reciprocal recurrent selection scheme. It is in this

context that Lobé population, beforehand improved by PAMOL plantations of Cameroon was evaluated in crosses with Deli testors derived from the second cycle of reciprocal recurrent selection scheme. A wide range of agronomic traits of major importance for oil palm breeding was measured, in order to evaluate Lobé × Deli crosses: bunch production components, vertical growth rate and vascular wilt tolerance. This last selection criterion is very important in tropical Africa, where the disease may trigger substantial damages (sékou *et al.*, 2009). This paper describes the characteristics of Lobé × Deli crosses and searches out the best parents of Lobé population able to enrich agronomic traits of populations of Group B valued in the selection scheme.

MATERIALS AND METHODS

Materials

Planting material: Lobé population originated from Ekona region of Cameroon. It was beforehand improved by PAMOL plantations of Cameroon. It was introduced at the La Mé station between 1968 and 1970, in the context of a program of exchange of

planting materials, in the form of recombinations between the best parents of PAMOL plantation. Thirteen palms were chosen in these recombinations on the basis of heritable characters (bunch number, percentage of pulp on fruit and vertical growth) to represent this population. These palms were crossed with twenty-three Deli parents to produce forty Lobé × Deli progenies. The Deli parents were chosen in the second breeding cycle of selection scheme. Their agronomic traits being acknowledged, these parents were used as testors. The LM 2 T × DA 10 D and LM 2 T × DA 115 D crosses of the first breeding cycle of selection scheme were used as controls. These hybrids were largely diffused in the village and industrial groves in Côte d'Ivoire.

Study site: This study was conducted at the La Mé station of the CNRA (Centre National de Recherche Agronomique). It is located in the Gulf of Guinea (5° 26' N; 3° 50' W; 23 m). This station is located in ombrophilous zone of forest, under an equatorial climate of transition. This climate is characterized by four seasons. The two seasons of rains are dominant (March-June and September-November) and are intercalated by two dry seasons (December-February and July-August). The last 15 years of the station were characterized by an average annual pluviometry of 1600 mm, an average hydrous deficit of 307 mm and a monthly average temperature of 27 °C.

Methods

Experimental design: All palms of various Lobé × Deli progenies and controls were planted in two trials (LMGP 131 and LMGP 146). These trials were planted in 1994 for LMGP 131 and 1996 for LMGP 146 according to a Randomized Complete Block Design with 6 replications. Each experimental unit, according to trials is comprised of 10 or 12 palms (either 60 or 72 palms per progeny). These palms were planted at the standard density of 143 palms per hectare after the felling of an old palm grove.

Measured parameters

Bunch production components: The bunch production was observed palm by palm for 7 years from the start of bearing (3 years after planting). Bunches were collected on each tree at a frequency from 2 to 3 times per month. The bunch number (BN) and total bunch weight or yield bunch (TBW) were recorded with each harvest. These observations cumulated on each crop year made it possible to determine the average bunch weight (ABW). The bunch production components of the first 3 years (3 to 5 years) correspond to the young age and the following 4 years (6 to 9 years), the adult stage.

Vertical growth rate: The height of stem (H) was measured at 16 years or 18 years (according to the trials) on each straight and healthy palm, starting from the axil of frond 33 to the ground level. The vertical

growth rate was calculated from the formula of Jacquemard (1980):

$$Vc = H / (N - P0)$$

Vc: vertical growth rate (cm/year)

N: tree age expressed in years and tenths of years

P0: the age of imaginary take off from the soil of leaf 33 of an oil palm, after which the speed of growth is constant (estimated at 3.5 years)

$$I = \frac{P.100 \text{ wilt} - \text{infected plant of a progeny}}{P.100 \text{ wilt} - \text{infected plant in all progenies in the test}} \times 100$$

The wilt index of each Lobé parent (*I_p*) was obtained starting from the mean index of progenies of this latter. A progeny or a parent with wilt index less than 100 is known as tolerant to vascular wilt. It is susceptible in the contrary case.

Statistical analyses: The progenies data were attributed to various crosses from which they result. The descriptive statistics parameters (average and coefficient of variation) and analyses of variance followed by the test of mean comparisons of Newman and Keuls to the risk of 5 % (Dagnelie, 1998) were used on parameters measured to compare Lobé × Deli crosses to the two controls. The mating systems used to provide progenies tested in the two trials consisted of incomplete factorials with several Lobé parents crossed only once. Moreover, Deli testers which were used in the various crosses are not all identical from parent Lobé to another parent Lobé. Aware of these situations, it is not possible to compare statistically general combining abilities (*gca*) of Lobé parents. The control cross LM 2 T × DA 10 D being planted in the two trials and even in all genetic trials at the La Mé station, it was used to provide a link between the different trials. Thus, for a given character, a classification of performances of Lobé × Deli crosses was carried out in order to identify parents having good *gca*. A parent had a good *gca* when crosses carried out from this one were better classified and the performance of each one of them was higher or equal to that of LM 2 T × DA 10 D control. The classification

Vascular wilt susceptibility: Each progeny was represented by 160 seedlings arranged in main plots of 20 seedlings in 8 blocks. The preparation of the inoculum, its application in the pre-nursery at 2-leaf stage and the identification of wilt-infected plants were carried out according to the method of Renard *et al.* (1972). However, the stock monospore 179 was used for the preparation of the inoculum. The assessment of vascular wilt susceptibility of each progeny was carried out starting from its index (*I*) which was derived from the following formula:

was applied after the test of Newman and Keuls at 5% likelihood. The analyses were carried out with the Genstat software 10.1 (Lawes Agricultural Trust, 2007).

RESULTS

Characteristics of Lobé × Deli crosses

Bunch production components at the young age:

In the two trials, Lobé × Deli crosses were characterized by a small bunch number (BN) compared to controls (Fig. 1 and 2). Their average bunch weight (ABW) was at the same level as those of controls. The bunch production or bunch yield (TBW) of these crosses was lower than those of controls. In the LMGP 131 trial, this small bunch production was estimated at 97% of LM 2 T × DA 10 D and at 68% of LM 2 T × DA 115 D. To the level of the LMGP 146 trial, it corresponded to 94% of LM 2 T × DA 10 D and to 85% of LM 2 T × DA 115 D. The variability was substantial between crosses of the LMGP 131 trial for the bunch production. The control LM 2 T × DA 10 D, LM 10975 T × LM 8933 D, LM 10964 T × LM 10824 D and LM 10975 T × LM 10818 D Lobé × Deli crosses, presented largest yield bunch (Table 1). These crosses differed significantly from LM 2 T × DA 10 D control. LM 10963 T × LM 7116 D got the smallest value of bunch yield.

Figure 1: Distribution of bunch production components at the young age of controls and Lobé × Deli crosses of the LMGP 131 trial (BN: Bunch number, ABW: Average bunch number, TBW: Total bunch weight).

Figure 2: Distribution of bunch production components at the young age of controls and Lobé x Deli crosses of the LMGP 146 trial (BN: Bunch number, ABW: Average bunch number, TBW: Total bunch weight).

Table 1: Classification in homogeneous groups of bunch productions at the young stage of controls and various Lobé x Deli crosses of the LMGP 131 trial.

Crosses	TBW 3-5 years (kg/tree)	Cross origins
LM 2 T x DA 115 D	54.08a	Control
LM 10975 T x LM 8933 D	50.99ab	Lobé x Deli
LM 10964 T x LM 10824 D	50.66ab	Lobé x Deli
LM 10975 T x LM 10818 D	49.52abc	Lobé x Deli
LM 10970 T x LM 9363 D	48.07abcd	Lobé x Deli
LM 10964 T x LM 8929 D	45.38abcde	Lobé x Deli
LM 10963 T x LM 10815 D	44.44abcde	Lobé x Deli
LM 10975 T x LM 7032 D	41.97bcdef	Lobé x Deli
LM 10963 T x LM 9349 D	41.23bcdefg	Lobé x Deli
LM 10967 T x LM 7032 D	40.43bcdefg	Lobé x Deli
LM 10971 T x LM 7057 D	40.21bcdefg	Lobé x Deli
LM 10969 T x LM 7070 D	39.62cdefgh	Lobé x Deli
LM 10973 T x LM 7034 D	39.38cdefgh	Lobé x Deli
LM 10967 T x LM 10715 D	38.54cdefghi	Lobé x Deli
LM 2 T x DA 10 D	38.05defghij	Control
LM 10969 T x LM 10824 D	37.60defghijk	Lobé x Deli
LM 10973 T x LM 7114 D	37.54defghijk	Lobé x Deli
LM 10963 T x LM 7032 D	37.11defghijk	Lobé x Deli
LM 10970 T x LM 8929 D	36.09efghijk	Lobé x Deli
LM 10971 T x LM 9807 D	35.30efghijk	Lobé x Deli
LM 10974 T x LM 9791 D	34.9efghijk	Lobé x Deli
LM 10969 T x LM 8929 D	34.29efghijk	Lobé x Deli
LM 10974 T x LM 7047 D	31.86fghijk	Lobé x Deli
LM 10972 T x LM 7070 D	31.56fghijk	Lobé x Deli
LM 10963 T x LM 8960 D	31.06fghijk	Lobé x Deli
LM 10963 T x LM 7047 D	30.01fghijk	Lobé x Deli
LM 10969 T x LM 7116 D	29.72fghijk	Lobé x Deli
LM 10972 T x LM 7047 D	29.33ghijk	Lobé x Deli
LM 10967 T x LM 9818 D	27.86hijk	Lobé x Deli
LM 10974 T x LM 9807 D	26.60ijk	Lobé x Deli
LM 10963 T x LM 7089 D	26.54ijk	Lobé x Deli
LM 10970 T x LM 9807 D	25.91jk	Lobé x Deli
LM 10963 T x LM 7116 D	25.45k	Lobé x Deli

Legend: TBW: Total bunch weight. Values followed by the same letter are not statistically different according to Newman-Keuls test at 5% threshold.

Bunch production components at the adult stage:

Lobé × Deli crosses were also characterized by a small bunch number compared to controls at the adult stage (Fig. 3 and 4). Their bunch was as large as those of controls. The bunch production of these crosses was lower than those of controls. At the level of LMGP 131 trial, it was estimated at 88% of LM 2 T × DA 10 D and at 83% of LM 2 T × DA 115 D. Concerning LMGP 146 trial, it corresponded to 85% of LM 2 T × DA 10 D and to 83% of LM 2 T × DA 115 D. In the LMGP 131 trial, the two controls (LM 2 T × DA

10 D and LM 2 T × DA 115 D) and Lobé × Deli crosses such as LM 10963 T × LM 10815 D, LM 10964 T × LM 10824 D, LM 10973 T × LM 7114 D, LM 10973 T × LM 7034 D, LM 10969 T × LM 10824 D et LM 10975 T × LM 8933 D not differed significantly for bunch yield (Table 2). Regarding LMGP 146 trial, the control LM 2 T × DA 115 D characterized by the largest bunch yield, differed significantly from all Lobé × Deli crosses (Table 3). The control LM 2 T × DA 10 D not differed significantly from LM 10965 T × LM 8933 D.

Figure 3: Distribution of bunch production components at the adult stage of controls and Lobé × Deli crosses of the LMGP 131 trial (BN: Bunch number, ABW: Average bunch number, TBW: Total bunch weight).

Figure 4: Distribution of bunch production components at the adult stage of controls and Lobé × Deli crosses of the LMGP 146 trial (BN: Bunch number, ABW: Average bunch number, TBW: Total bunch weight).

Table 2: Classification in homogeneous groups of bunch productions at the adult stage of controls and various Lobé × Deli crosses of the LMGP 131 trial.

Crosses	TBW 6-9 years (kg/tree)	Cross origins
LM 10963 T × LM 10815 D	112.30a	Lobé × Deli
LM 2 T × DA 115 D	108.08a	Control
LM 10964 T × LM 10824 D	103.64ab	Lobé × Deli
LM 10973 T × LM 7114 D	101.83abc	Lobé × Deli
LM 2 T × DA 10 D	101.24abc	Control
LM 10973 T × LM 7034 D	100.83abc	Lobé × Deli
LM 10964 T × LM 8929 D	100.16abcd	Lobé × Deli
LM 10969 T × LM 10824 D	100.02abcd	Lobé × Deli
LM 10975 T × LM 8933 D	99.05abcde	Lobé × Deli
LM 10975 T × LM 10818 D	93.05bcdef	Lobé × Deli
LM 10969 T × LM 8929 D	91.40bcdef	Lobé × Deli
LM 10974 T × LM 9807 D	91.25bcdef	Lobé × Deli
LM 10971 T × LM 7057 D	91.13bcdef	Lobé × Deli
LM 10971 T × LM 9807 D	90.95bcdef	Lobé × Deli
LM 10975 T × LM 7032 D	89.68bcdef	Lobé × Deli
LM 10969 T × LM 7070 D	88.48bcdef	Lobé × Deli
LM 10970 T × LM 8929 D	88.21bcdef	Lobé × Deli
LM 10963 T × LM 8960 D	88.07bcdef	Lobé × Deli
LM 10963 T × LM 9349 D	87.98bcdef	Lobé × Deli
LM 10967 T × LM 10715 D	86.86cdef	Lobé × Deli
LM 10974 T × LM 9791 D	86.42cdef	Lobé × Deli
LM 10963 T × LM 7032 D	86.31cdef	Lobé × Deli
LM 10970 T × LM 9363 D	85.91cdef	Lobé × Deli
LM 10974 T × LM 7047 D	85.27cdef	Lobé × Deli
LM 10963 T × LM 7047 D	84.73cdef	Lobé × Deli
LM 10970 T × LM 9807 D	83.59def	Lobé × Deli
LM 10972 T × LM 7047 D	82.67ef	Lobé × Deli
LM 10963 T × LM 7116 D	81.68f	Lobé × Deli
LM 10963 T × LM 7089 D	79.51f	Lobé × Deli
LM 10972 T × LM 7070 D	79.07f	Lobé × Deli
LM 10969 T × LM 7116 D	78.69f	Lobé × Deli
LM 10967 T × LM 9818 D	77.48f	Lobé × Deli
LM 10967 T × LM 7032 D	76.04f	Lobé × Deli

Legend : TBW: Total bunch weight. Values followed by the same letter are not statistically different according to Newman-Keuls test at 5% threshold.

Table 3: Classification in homogeneous groups of bunch productions at the adult stage of controls and various Lobé × Deli crosses of the LMGP 146 trial.

Crosses	TBW 6-9 years (kg/tree)	Cross origins
LM 2 T × DA 115 D	116.74a	Control
LM 2 T × DA 10 D	113.75ab	Control
LM 10965 T × LM 8933 D	106.26bc	Lobé × Deli
LM 10965 T × LM 9807 D	104.53cd	Lobé × Deli
LM 10966 T × LM 8933 D	103.39cd	Lobé × Deli
LM 10965 T × LM 7047 D	99.70cde	Lobé × Deli
LM 5606 T × LM 9803 D	95.56de	Lobé × Deli
LM 10966 T × LM 7040 D	92.43ef	Lobé × Deli
LM 10964 T × LM 7083 D	92.08ef	Lobé × Deli
LM 5606 T × LM 7047 D	91.01ef	Lobé × Deli
LM 10972 T × LM 9791 D	84.80f	Lobé × Deli

Legend : TBW: Total bunch weight. Values followed by the same letter are not statistically different according to Newman-Keuls test at 5% threshold.

Vertical growth rate: The vertical growth rate of Lobé × Deli crosses was higher than those of controls (Fig. 5 and 6). For the LMGP 131 trial, this high growth was estimated at 110% of LM 2 T × DA 10 D and at 116% of LM 2 T × DA 115 D. On the level of LMGP 146 trial, it corresponded to 108% of LM 2 T × DA 10 D and to 123% of LM 2 T × DA 115 D. In this trial, the Lobé × Deli crosses such as LM 10965 T × LM 7047 D, LM 10964 T × LM 7083 D, LM 10966 T × LM 7040 D and

LM 5606 T × LM 7047 D not differed significantly from the two controls (Table 4). LM 10966 T × LM 8933 D, LM 10965 T × LM 8933 D and LM 10972 T × LM 9791 D crosses got largest value of vertical growth rate. Concerning LMGP 131 trial, 8 crosses whose vertical growths ranged from 45.69 cm/year to 48.70 cm/year were not significantly different from those of LM 2 T × DA 10 D (46.30 cm/year) and LM 2 T × DA 115 D (43.83 cm/year) (Table 5).

Figure 5: Distribution of vertical growth rates of controls and Lobé × Deli crosses of the LMGP 131 trial.

Figure 6: Distribution of vertical growth rates of controls and Lobé × Deli crosses of the LMGP 146 trial.

Table 4: Classification in homogeneous groups of vertical growth rates of controls and various Lobé × Deli crosses of the LMGP 146 trial.

Crosses	Vc (cm/year)	Cross origins
LM 10966 T × LM 8933 D	53.97a	Lobé × Deli
LM 10965 T × LM 8933 D	53.90a	Lobé × Deli
LM 10972 T × LM 9791 D	53.40a	Lobé × Deli
LM 10965 T × LM 9807 D	48.99b	Lobé × Deli
LM 5606 T × LM 9803 D	47.54bc	Lobé × Deli
LM 10965 T × LM 7047 D	45.04c	Lobé × Deli
LM 2 T × DA 10 D	44.75c	Control
LM 10964 T × LM 7083 D	44.70c	Lobé × Deli
LM 10966 T × LM 7040 D	44.55c	Lobé × Deli
LM 5606 T × LM 7047 D	44.24c	Lobé × Deli
LM 2 T × DA 115 D	39.33c	Control

Legend : Vc: vertical growth rate. Values followed by the same letter are not statistically different according to Newman-Keuls test at 5% threshold.

Table 5: Classification in homogeneous groups of vertical growth rates of controls and various Lobé × Deli crosses of the LMGP 131 trial.

Crosses	Vc (Cm/year)	Cross origins
LM 10974 T × LM 9791 D	55.00a	Lobé × Deli
LM 10970 T × LM 9807 D	54.21ab	Lobé × Deli
LM 10970 T × LM 8929 D	54.11ab	Lobé × Deli
LM 10972 T × LM 7070 D	53.85abc	Lobé × Deli
LM 10970 T × LM 9363 D	53.75abcd	Lobé × Deli
LM 10967 T × LM 10715 D	53.46abcde	Lobé × Deli
LM 10963 T × LM 8960 D	53.45abcde	Lobé × Deli
LM 10967 T × LM 9818 D	52.74abcdef	Lobé × Deli
LM 10975 T × LM 8933 D	52.64abcdef	Lobé × Deli
LM 10973 T × LM 7034 D	52.58abcdef	Lobé × Deli
LM 10969 T × LM 8929 D	52.47abcdef	Lobé × Deli
LM 10972 T × LM 7047 D	52.46abcdef	Lobé × Deli
LM 10974 T × LM 9807 D	52.33abcdef	Lobé × Deli
LM 10975 T × LM 10818 D	51.37abcdefg	Lobé × Deli
LM 10971 T × LM 9807 D	51.32abcdefg	Lobé × Deli
LM 10963 T × LM 7032 D	51.07abcdefg	Lobé × Deli
LM 10973 T × LM 7114 D	51.02abcdefg	Lobé × Deli
LM 10967 T × LM 7032 D	50.97abcdefg	Lobé × Deli
LM 10963 T × LM 7089 D	49.94abcdefg	Lobé × Deli
LM 10963 T × LM 7047 D	49.90abcdefg	Lobé × Deli
LM 10963 T × LM 9349 D	49.20abcdefg	Lobé × Deli
LM 10964 T × LM 8929 D	49.19abcdefg	Lobé × Deli
LM 10971 T × LM 7057 D	49.06bcdefg	Lobé × Deli
LM 10963 T × LM 7116 D	48.7bcdefgh	Lobé × Deli
LM 10974 T × LM 7047 D	48.58bcdefgh	Lobé × Deli
LM 10975 T × LM 7032 D	48.08cdefgh	Lobé × Deli
LM 10969 T × LM 7070 D	47.93defgh	Lobé × Deli
LM 10963 T × LM 10815 D	47.72efgh	Lobé × Deli
LM 10969 T × LM 7116 D	47.61efgh	Lobé × Deli
LM 10969 T × LM 10824 D	47.29fgh	Lobé × Deli
LM 2 T × DA 10 D	46.30gh	Control
LM 10964 T × LM 10824 D	45.69gh	Lobé × Deli
LM 2 T × DA 115 D	43.83h	Control

Legend : Vc: vertical growth rate. Values followed by the same letter are not statistically different according to Newman-Keuls test at 5% threshold.

Susceptibility to vascular wilt: Lobé × Deli crosses were in average susceptible to vascular wilt (Table 6). However, approximately 41 % of these crosses were tolerant to this cryptogamic disease.

Table 6: Vascular wilt susceptibility of various Lobé × Deli crosses

Cross origin	Index	Tolerant crosses	I	Susceptible crosses	I
Lobé × Deli	109	LM 10964 T × LM 7083 D	38	LM 10963 T × LM 7047 D	101
		LM 10965 T × LM 8933 D	59	LM 5606 T × LM 9803 D	105
		LM 10965 T × LM 7047 D	60	LM 10972 T × LM 7047 D	110
		LM 10965 T × LM 9807 D	65	LM 10963 T × LM 9803 D	116
		LM 5606 T × LM 8933 D	67	LM 10963 T × LM 9349 D	121
		LM 5606 T × LM 7047 D	79	LM 10974 T × LM 9791 D	125
		LM 10966 T × LM 8933 D	81	LM 10972 T × LM 7089 D	128
		LM 10963 T × LM 7032 D	83	LM 10967 T × LM 9818 D	130
		LM 10965 T × LM 9807 D	84	LM 10967 T × LM 10715 D	132
		LM 10964 T × LM 7034 D	88	LM 10970 T × LM 9363 D	132
		LM 10963 T × LM 8960 D	92	LM 10970 T × LM 8929 D	132
		LM 10966 T × LM 7040 D	96	LM 10973 T × LM 11020 D	132
		LM 10964 T × LM 9890 D	97	LM 10971 T × LM 9807 D	133
				LM 10972 T × LM 9791 D	135
				LM 10967 T × LM 7123 D	137
				LM 10967 T × LM 8988 D	142
				LM 10974 T × LM 7047 D	145
				LM 10971 T × LM 11020 D	149
				LM 10967 T × LM 11020 D	183

Legend: I: vascular wilt index.

General Combining Ability of Lobé Parents

Bunch production: The LM 10964 T and LM 10975 T parents were characterized by the best general combining abilities (gca) for the precocity of bunch production (Table 7). These 2 parents provided in crosses with Deli testors, best rankings for bunch productions. The additional bunch productions at the young age of these crosses compared to LM 2 T × DA 10 D ranged from 10 to 34 %. However, the

performance of cross between LM 10964 T parent and the Deli testor LM 7034 D was low compared to LM 2 T × DA 10 D. At the adult stage, the LM 10964 T and LM 10973 T parents were characterized by the best gca (Table 8). The crosses of these 2 parents with Deli testors had bunch productions at the same level as that of LM 2 T × DA 10 D. However, the performance of cross between LM 10964 T parent and the Deli testor LM 7034 D was lower than that of LM 2 T × DA 10 D.

Table 7: General combining ability for bunch production at the young age of Lobé parents

Lobé parents	Trials	Deli testors	TBW 3-5 years Lobé × Deli crosses (kg/tree)	Ranking TBW 3-5 years	TBW 3-5 years % LM 2 T × DA 10 D
LM 10963 T	LMGP 131	LM 7032 D	37.11	16/31	98
	LMGP 131	LM 7047 D	30.01	24/31	79
	LMGP 131	LM 7089 D	26.54	29/31	70
	LMGP 131	LM 7116 D	25.45	31/31	67
	LMGP 131	LM 8960 D	31.06	23/31	82
	LMGP 131	LM 9349 D	41.23	8/31	108
	LMGP 131	LM 10815 D	44.44	6/31	117
LM 10964 T	LMGP 131	LM 8929 D	45.38	5/31	119
	LMGP 131	LM 10824 D	50.66	2/31	133
	LMGP 146	LM 7083 D	52.39	10/11	80
LM 10965 T	LMGP 146	LM 7047 D	64.79	3/11	99
	LMGP 146	LM 8933 D	67.30	1/11	103
	LMGP 146	LM 9807 D	59.55	7/11	91
LM 10966 T	LMGP 146	LM 7040 D	64.31	4/11	98
	LMGP 146	LM 8933 D	67.01	2/11	102
LM 10967 T	LMGP 131	LM 7032 D	40.43	9/31	106
	LMGP 131	LM 9818 D	27.86	27/31	73
	LMGP 131	LM 10715 D	38.54	13/31	101
LM 10969 T	LMGP 131	LM 7070 D	39.62	11/31	104
	LMGP 131	LM 7116 D	29.72	25/31	78
	LMGP 131	LM 8929 D	34.29	20/31	90
	LMGP 131	LM 10824 D	37.60	14/31	99
LM 10970 T	LMGP 131	LM 8929 D	36.09	17/31	95
	LMGP 131	LM 9363 D	48.07	4/31	126
	LMGP 131	LM 9807 D	25.91	30/31	68
LM 10971 T	LMGP 131	LM 7057 D	40.21	10/31	106
	LMGP 131	LM 9807 D	35.30	18/31	93
LM 10972 T	LMGP 131	LM 7047 D	29.33	26/31	77
	LMGP 131	LM 7070 D	31.56	22/31	83
	LMGP 146	LM 9791 D	61.31	6/11	94
LM 10973 T	LMGP 131	LM 7034 D	39.38	12/31	103
	LMGP 131	LM 7114 D	37.54	15/31	99
LM 10974 T	LMGP 131	LM 7047 D	31.86	21/31	84
	LMGP 131	LM 9791 D	34.90	19/31	92
	LMGP 131	LM 9807 D	26.60	28/31	70
LM 10975 T	LMGP 131	LM 7032 D	41.97	7/31	110
	LMGP 131	LM 8933 D	50.99	1/31	134
	LMGP 131	LM 10818 D	49.52	3/31	130
LM 5606 T	LMGP 146	LM 7047 D	56.49	8/11	86
	LMGP 146	LM 9803 D	63.48	5/11	97

Legend : TBW: Total bunch weight.

Table 8: General combining ability for bunch production at the adult stage of Lobé parents

Lobé parents	Trials	Deli testors	TBW 6-9 years Lobé × Deli crosses (kg/tree)	Ranking TBW 6-9 years	PR 6-9 ans % LM 2 T × DA 10 D
LM 10963 T	LMGP 131	LM 7032 D	86.31	20/31	85
	LMGP 131	LM 7047 D	84.73	23/31	84
	LMGP 131	LM 7089 D	79.51	27/31	79
	LMGP 131	LM 7116 D	81.68	26/31	81
	LMGP 131	LM 8960 D	88.07	16/31	87
	LMGP 131	LM 9349 D	87.98	17/31	87
	LMGP 131	LM 10815 D	112.30	1/31	111
LM 10964 T	LMGP 131	LM 8929 D	100.16	5/31	99
	LMGP 131	LM 10824 D	103.64	2/31	102
	LMGP 146	LM 7083 D	92.08	7/11	81
LM 10965 T	LMGP 146	LM 7047 D	99.70	4/11	88
	LMGP 146	LM 8933 D	106.26	1/11	93
	LMGP 146	LM 9807 D	104.53	2/11	92
LM 10966 T	LMGP 146	LM 7040 D	92.43	6/11	81
	LMGP 146	LM 8933 D	103.39	3/11	91
LM 10967 T	LMGP 131	LM 7032 D	76.04	31/31	75
	LMGP 131	LM 9818 D	77.48	30/31	77
	LMGP 131	LM 10715 D	86.86	18/31	86
LM 10969 T	LMGP 131	LM 7070 D	88.48	14/31	87
	LMGP 131	LM 7116 D	78.69	29/31	78
	LMGP 131	LM 8929 D	91.40	9/31	90
	LMGP 131	LM 10824 D	100.02	6/31	99
LM 10970 T	LMGP 131	LM 8929 D	88.21	15/31	87
	LMGP 131	LM 9363 D	85.91	21/31	85
	LMGP 131	LM 9807 D	83.59	24/31	83
LM 10971 T	LMGP 131	LM 7057 D	91.13	11/31	90
	LMGP 131	LM 9807 D	90.95	12/31	90
LM 10972 T	LMGP 131	LM 7047 D	82.67	25/31	82
	LMGP 131	LM 7070 D	79.07	28/31	78
	LMGP 146	LM 9791 D	84.80	9/11	84
LM 10973 T	LMGP 131	LM 7034 D	100.83	4/31	100
	LMGP 131	LM 7114 D	101.83	3/31	101
LM 10974 T	LMGP 131	LM 7047 D	85.27	22/31	84
	LMGP 131	LM 9791 D	86.42	19/31	85
	LMGP 131	LM 9807 D	91.25	10/31	90
LM 10975 T	LMGP 131	LM 7032 D	89.68	13/31	89
	LMGP 131	LM 8933 D	99.05	7/31	98
	LMGP 131	LM 10818 D	93.05	8/31	92
LM 5606 T	LMGP 146	LM 7047 D	91.01	8/11	80
	LMGP 146	LM 9803 D	95.56	5/11	84

Legend : TBW: Total bunch weight.

Vertical growth rate: The LM 10964 T and LM 10969 T parents provided the best gca for this character (Table 9). The crosses carried out with these 2 parents had best rankings. Their growth was at the same level as that of LM 2 T × DA 10 D (between 99 and 104 % of this latter). However, crosses between these 2 parents and the Deli testor LM 8929 D had growths higher than that of LM 2 T × DA 10 D (between 106 and 113 % of this latter). The LM 10970 T parent was characterized by the worst gca. In crosses with Deli testors, this parent provided additional growths ranged from 16 to 17 % compared to that of LM 2 T × DA 10 D.

Table 9: General combining ability for vertical growth rate of Lobé parents

Lobé parents	Trials	Deli Testors	Vc Lobé × Deli Crosses (cm/year)	Ranking Vc	Vc % LM 2 T × DA 10 D
LM 10963 T	LMGP 131	LM 7032 D	51.07	16/31	110
	LMGP 131	LM 7047 D	49.90	12/31	108
	LMGP 131	LM 7089 D	49.94	13/31	108
	LMGP 131	LM 7116 D	48.70	8/31	105
	LMGP 131	LM 8960 D	53.45	25/31	115
	LMGP 131	LM 9349 D	49.20	11/31	106
	LMGP 131	LM 10815 D	47.72	4/31	103
LM 10964 T	LMGP 131	LM 8929 D	49.19	10/31	106
	LMGP 131	LM 10824 D	45.69	1/31	99
	LMGP 146	LM 7083 D	44.70	5/11	100
LM 10965 T	LMGP 146	LM 7047 D	45.04	6/11	101
	LMGP 146	LM 8933 D	53.90	10/11	120
	LMGP 146	LM 9807 D	48.99	8/11	109
LM 10966 T	LMGP 146	LM 7040 D	44.55	4/11	100
	LMGP 146	LM 8933 D	53.97	11/11	121
LM 10967 T	LMGP 131	LM 7032 D	50.97	14/31	110
	LMGP 131	LM 9818 D	52.74	24/31	114
	LMGP 131	LM 10715 D	53.46	26/31	115
LM 10969 T	LMGP 131	LM 7070 D	47.93	5/31	104
	LMGP 131	LM 7116 D	47.61	3/31	103
	LMGP 131	LM 8929 D	52.47	21/31	113
	LMGP 131	LM 10824 D	47.29	2/31	102
LM 10970 T	LMGP 131	LM 8929 D	54.11	29/31	117
	LMGP 131	LM 9363 D	53.75	27/31	116
	LMGP 131	LM 9807 D	54.21	30/31	117
LM 10971 T	LMGP 131	LM 7057 D	49.06	9/31	106
	LMGP 131	LM 9807 D	51.32	17/31	111
LM 10972 T	LMGP 131	LM 7047 D	52.46	20/31	113
	LMGP 131	LM 7070 D	53.85	28/31	116
	LMGP 146	LM 9791 D	53.40	9/11	119
LM 10973 T	LMGP 131	LM 7034 D	52.58	22/31	114
	LMGP 131	LM 7114 D	51.02	15/31	110
LM 10974 T	LMGP 131	LM 7047 D	48.58	7/31	105
	LMGP 131	LM 9791 D	55.00	31/31	119
	LMGP 131	LM 9807 D	52.33	19/31	113
LM 10975 T	LMGP 131	LM 7032 D	48.08	6/31	104
	LMGP 131	LM 8933 D	52.64	23/31	114
	LMGP 131	LM 10818 D	51.37	18/31	111
LM 5606 T	LMGP 146	LM 7047 D	44.24	3/11	99
	LMGP 146	LM 9803 D	47.54	7/11	106

Legend: Vc: vertical growth rate.

Wilt susceptibility: The LM 10964 T, LM 10965 T, LM 10966 T and LM 5606 T parents were tolerant to vascular wilt (Table 10). In crosses with susceptible (LM 8933 D, LM 9791 D, LM 9803 D) and tolerant Deli testors (LM 7034 D, LM 7040 D, LM 7047 D, LM 7083 D, LM 9807 D and LM 9890 D), these 4 parents provided factors of tolerances to their progenies. The LM 10963 T, LM 10967 T, LM 10972 T and LM 10974

T parents were susceptible to this cryptogamic disease. These parents provided in crosses with susceptible (LM 8960 D, LM 8988 D, LM 9349 D, LM 9791 D, LM 9803 D, LM 9818 D, LM 10715 D and LM 11020 D) and tolerant Deli testors (LM 7032 D, LM 7047 D, LM 7089 D and LM 7123 D) factors of susceptibility to their progenies.

DISCUSSION

The study of Lobé population in crosses with Deli material showed that this population provides a low bunch yield compared to controls. This low bunch production is due mainly to their small bunch number because they have bunch as large as those of controls. The high bunch production of which this population made proof during the characterization carried out by Adon (1995) was not observed in crosses carried out with Deli material. However, substantial variability for this character made it possible to make an effective selection at the young age and at the adult period. Indeed, 3 crosses

significantly earlier than LM 2 T × DA 10 D controls were identified at the young age. On the level of the adult stage, 8 crosses at the same level that one or the two controls which are references for this character of first crosses cycle (Adon *et al.*, 1998) and even to 2nd cycle were identified. The vertical growth rate of Lobé × Deli crosses was estimated according to trials at 16 years or 18 years. The vertical growth rates of various crosses have been underestimated compared to the usual measurements carried out at 9 years or 10 years. Indeed, according to Jacquemard and Baudouin (1987), the rate of vertical growth gradually decreases from 10 years.

Table 10: Wilt susceptibility of Lobé parents.

Lobé parents	Deli testors	Deli testors indices	Lobé × Deli Crosses indices	Lobé parents indices
LM 10963 T	LM 7032 D	96 (1-1)*	83	103
	LM 7047 D	78 (3-0)	101	
	LM 8960 D	141 (1-6)	92	
	LM 9349 D	127 (0-2)	121	
	LM 9803 D	120 (1-6)	116	
LM 10964 T	LM 7034 D	96 (1-1)	88	74
	LM 7083 D	68 (4-1)	38	
	LM 9890 D	97 (1-0)	97	
LM 10965 T	LM 7047 D	78 (3-0)	60	67
	LM 8933 D	106 (2-2)	59	
	LM 9807 D	94 (2-1)	65	
	LM 9807 D	94 (2-1)	84	
LM 10966 T	LM 7040 D	91 (2-0)	96	89
	LM 8933 D	106 (2-2)	81	
LM 10967 T	LM 7123 D	81 (8-2)	137	145
	LM 8988 D	117 (2-4)	142	
	LM 9818 D	130 (0-1)	130	
	LM 10715 D	132 (0-1)	132	
	LM 11020 D	155 (0-3)	183	
LM 10970 T	LM 8929 D	131 (2-4)	132	132
	LM 9363 D	155 (0-2)	132	
LM 10971 T	LM 9807 D	94 (2-1)	133	141
	LM 11020 D	155 (0-3)	149	
LM 10972 T	LM 7047 D	78 (3-0)	110	124
	LM 7089 D	85 (3-1)	128	
	LM 9791 D	130 (0-2)	135	
LM 10973 T	LM 11020 D	155 (0-3)	132	132
LM 10974 T	LM 7047 D	78 (3-0)	145	135
	LM 9791 D	130 (0-2)	125	
LM 5606 T	LM 7047 D	78 (3-0)	79	84
	LM 8933 D	106 (2-2)	67	
	LM 9803 D	120 (1-6)	105	

Legend: *: The first value between brackets indicates the number of progenies of Deli testor with index less than 100. The second value indicates the contrary case

The rate of vertical growth of these crosses must be higher than those which were estimated starting from these two ages. However, all crosses being planted in the same conditions (in the same trial), comparisons

between them are still valid even if observations took place beyond 10 years. The Lobé × Deli crosses were in average susceptible to vascular wilt. In contrast, approximately 41 % of crosses were tolerant to this

cryptogamic disease. The transmission of tolerance factors being primarily additive Meunier *et al.*, (1979), these tolerant crosses are due to some Deli testers recognized for their tolerance to the disease (LM 7047 D, LM 7083 D), but also some Lobé parents which provided tolerance factors in crosses with susceptible Deli (LM 8933 D, LM 8960 D). The LM 10964 T parent had a good gca for the bunch production at the young age and at the adult stage. However, its performance in cross with LM 7038 D Deli tester was low compared to LM 2 T × DA 10 D. This low production which was observed is ascribable to LM 7038 D tester who is known to transmit a low bunch production to his progenies. On the basis of the vertical growth rate, LM 10964 T and LM 10969 T parents had good gca. However, their performance in crosses with LM 8929 D Deli tester was high compared to LM 2 T × DA 10 D. This high growth rate which was observed is ascribable to LM 8929 D tester who is known to transmit a high growth rate to his progenies. An analysis of selected parents for their good gca for all parameters measured showed that LM 10964 T parent cumulates the maximum of interesting characters. This parent has a good precocity for the bunch production, a good bunch production at the adult stage, an average vertical growth and is tolerant to vascular wilt. Its exploitation in the breeding scheme could guarantee in term (after its introduction into the reciprocal recurrent selection scheme), an improvement of the bunch production to the young age of planting material to provide to the village and industrial groves. It could also diversify the seeds destined for zones affected by the vascular wilt. Its introduction into the breeding scheme could also make it possible to improve the bunch production and diversify sources of vascular wilt tolerances of recurring populations of group B of recurrent reciprocal selection scheme.

CONCLUSION

On the basis of all parameters measured, Lobé × Deli crosses were characterized by performances lower than those of the controls. However, substantial variability for each parameter made it possible to identify crosses as powerful as or more powerful than controls. The study of general combining abilities of Lobé parents made it possible to select one parent which cumulates the maximum of interesting characteristics. The introduction of this parent into the breeding scheme will be able to make it possible to guarantee the improvement of the precocity of bunch production, bunch production at the adult period and the diversification of sources of vascular wilt tolerance of recurring populations of Group B of scheme selection.

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