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PERFORMANCES OF NEW AFRICAN GERMPLASM OF THE YAM *Dioscorea cayenensis-rotundata* IN THE CARIBBEAN

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ABSTRACT

Three polycrosses of *D. cayenensis-rotundata* introduced from IITA (Nigeria) have been selected in Guadeloupe over six years, with the contribution of trials in Martinique, St. Lucia, St. Vincent and Grenada. Several clones appear more adapted to an industrial cultivation than local controls. The selection process and the main characters involved are described. Prospects for the use of this material and the following steps in this first breeding of the African yam in the Caribbean are discussed.

INTRODUCTION

Yam growing remains an important component of food crops in the Caribbean. However, it is confronted with a number of problems, among which the lack of genetical variability is of utmost importance. While efforts are now in progress to improve the very aptitude of *Dioscorea alata* to give seeds (IITA, 1985, Vijaya and Jos, 1986) for more than fifteen years a steady work has been done at IITA in view of selecting through hybridization new and better clones within the African yam *D. cayenensis-rotundata* (Sadik and Okereke, 1975; Wilson and Victor, 1980; Akoroda, 1983; Akoroda et al., 1984). We thought interesting to introduce sexual seeds from IITA in 1983 in order to increase our Caribbean germplasm and give answers to the problems arising from the prospects of industrialization of the crop (Degras, 1985). The main objective of this approach was to select clones with :

1. High productivity of white rhyzomes of high culinary quality
2. Adaptation to single harvest
3. Rhyzome structure, size and shape suitable for mechanical harvesting
4. Good yield without staking
5. Pest (nematode) and disease (virus, leaf spots) tolerance/resistance
6. Low or no season yield dependence

7. Drought and soil water excess tolerance

8. High reproductive ratio through vegetative and sexual process

The last objective stands as the starting point of the breeding program of cycles of introgression of new African germplasm in the old Afro-American germplasm of D. cayenensis-rotundata.

MATERIALS AND METHODS

Genetic resources

Unfortunately, IITA could not give more information on the material given (three polycrosses amounting to 843 seeds) than indicating its coming from hybridization out of previous selected hybrids obtained at IITA, not of primary crossings of traditional cultivars (personal communication from Drs. M. Alvarez, S.K. Hahn and M.O. Akoroda). So, a part of this research was devoted to the characterization of the different polycrosses, an objective which may contribute to the methodology of the selection and its bearings.

Main ecological traits of the experimental area

The selection was mainly conducted in Guadeloupe at the Domaine Duclos (Petit-Bourg), a high rainfall area of Caribbean forest climax. Figure 1 maps the five islands (Guadeloupe, Martinique, St. Lucia, St. Vincent and Grenada) of the network permitted by the EEC contract STD045A. Rainfall varied from about 2200 to 750 mm by vegetative cycle and soil from lateritic acid to calcareous basic soils. From the difference in latitude, $18^{o}$to 13^{o}N, it follows that the length of the day has a smaller variation and is shorter from Guadeloupe to Grenada.

Though they surely exist, no definite differences among the biotic ecological factors could be registered between the different locations. It can only be said that the nematofauna seemed to have been recently submitted to variations in relation to a rather explosive phase of infestation by Scutellonema bradys (Kermarrec et al., 1987) over Guadeloupe and Martinique, followed by a seemingly rapid regression in Guadeloupe (Kermarrec, 1990, personal communication) while Pratylenchus coffeae remains ubiquitous.

Cultivation practices

Each site of the network followed its own usual cultivation practices, this diversity contributing to the objective of agronomical flexibility of the selected clones. Thus, in St. Lucia, nematicide was applied to the rhyzome sets. In Grenada fungicide was applied on the foliage. Even a double harvest

The Eastern Caribbean Islands

SITES OF THE NETWORK FOR EXPERIMENTATION OF YAMS

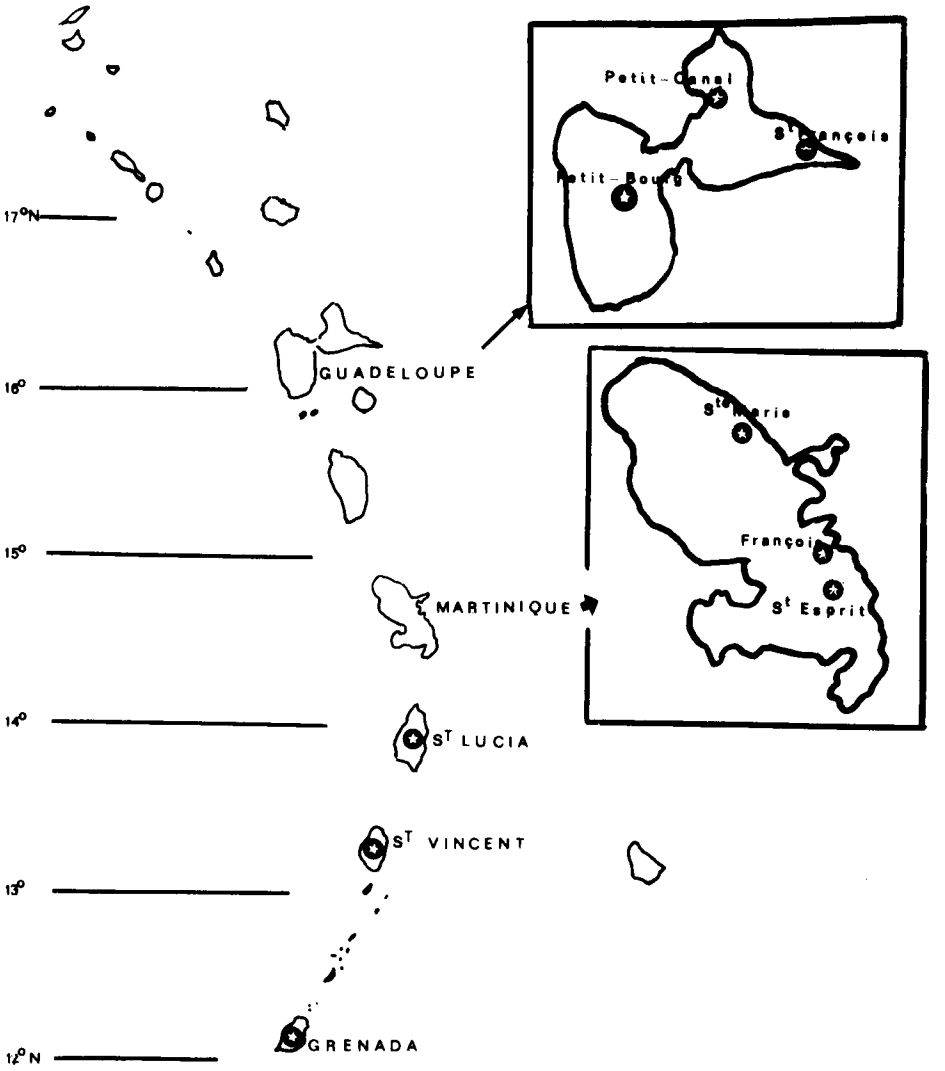

Fig. 1. The Eastern Caribbean Islands, site of these studies.

instead of single harvest occurred, once, in a location of Martinique. But in most cases mechanical ridging, preemergent herbicides, mineral fertilization, no-staking and manual single harvest were used.

The process of selection

Among the general objectives only a part was formally sought during this first cycle of selection. A number of criteria were applied along with a series of selection pressures. They are presented altogether in Table 1 with their order of priority as used over each growing season.

Some comments can be added here.

Productivity is the potential maximum yield of fresh rhyzome for one year. Approximates are given by the different weights and specifications of harvest available over the successive years.

Quality is considered as the highest grade for marketable rhyzome in appearance, handling, and consumer acceptance.

Resistances is rated from low or acceptable level of parasitism and/or damage from parasitism.

Ecological adaptation is expressed by the widest area with good yield over contrasted seasons and locations.

Reproductibility is the level of propagation of the genotype through vegetative and/or sexual paths.

Cultural adaptation is related to the system chosen, traditional with staking and two harvests by hand, or modern without stakes and a single harvest.

The selection was conducted in field plots of varied sizes, with and without replications (see Table 1), depending on the different facilities offered by the different countries and stations.

RESULTS

1. Some common features of the polycrosses

No qualitative traits permitted discrimination between the three polycrosses. Only quantitative observations established that each can be ascribed predominantly to some area of the variability field of D. cayenensis-rotundata, all three exhibiting clones with traits of cayenensis (Lamark) and rotundata (Poiret) species as well as various interspecific combinations. However, considering the predominant frequency of

Table 1. Estimates of intensity of selection pressure on successive clonal cycles of polycrosses of D. cayenensis-rotundata from IITA, in the Caribbean

N.B. Estimates are obtained by the inverse of rank of importance of the criterion among those operating over the growing season and its post-harvest time: the less important is noted 1 and the most important 10, for instance.

Criterion	1984	1985	1986	1987	1988	1989	Total	
Productivity (rhyzome weight)								
Individual plant	4							
Sample		6						
Plot		5	10					53
Trial								
one location				9				
two/several locations				6	6	7		
Rhyzome quality (of the tuber)								
Tuber size and shape (*)	7		5	7	5		24	
Rhyzome cooking preference			3	x		x	3	
Disease and pest resistance								
Virus	5	8	8	8		1	30	
Fungi		7	7			3	17	53
Nematodes			6		x	x	6	
Ecological adaptation (narrow sense)								
Soil/climate		11		5	4	6		26
Cultural adaptation								
No-staking		10		4	7	8	29	
Root without prickle	6	3					9	91
Single harvest	8	9	9	10	8	9	53	
Mechanical harvesting (*)						*		
Reproductive ability								
Rhyzome storage	1	2	2	3	3	5	16	
Rhyzome multiplication ratio	2	4	1	2	2	4	15	31
Sexual reproduction	3	1	4	1	1	2	12	43

* Selection pressure for mechanical harvesting is done mainly through size and shape of rhyzome, which are prominent commercial and general quality criteria.

x No estimate.

white-fleshed rhyzomes, they can be classified as rotundata general parentage in the narrow sense.

This parentage does not exclude wide variation in flesh appearance and cooking properties of the rhyzome. A study done among a sample of 70 clones at the third clonal harvest is highly informative (Degras, 1987, Fig. 2).

All three polycrosses offer a wide extension of flowering period: in the first clonal cycle the onset of flowering was observed from the beginning of May to the end of June. No significative difference parted male from female on this point. It was not the same for rhyzome weight: the mean weight of female reached 2045g/plant, while the male reached 1853g/plant. Moreover, the non-flowering clones had a mean of 1096g/plant only, and the type of distribution of flowering and non-flowering plants in classes of weight was quite different (Fig. 3).

2. Some distinct peculiarities of the polycrosses

The difficulty of discrimination between the polycrosses rested upon the insufficient genotype expression at the seminal growing cycle, while, even with a very low selection pressure, in the first clonal cycle, and in the following cycles even more, the artificial genetical selection drift transformed the structure of the original populations.

At the seminal growing cycle, the leaf lamina shape varied from round-cordiform to hastate-cordiform, the differences of shape frequency being not significantly different among the polycrosses. At the first clonal cycle this trait permited to see in the polycross N 83-43 a relative higher frequency of the so-called cayenensis leaf type (Fig. 4), and conversely, a relatively higher frequency of the so-called rotundata leaf type in N 83=42. These population structures were confirmed by their flowering male/female ratio, at least when compared with the Caribbean cultivars (Degras, 1985): N 83-43 exhibited 17% of female clones only, while N 83-42 showed 47% of female clones.

The frequencies of classes of rhyzome length showed a higher percentage of long rhyzomes in N 83-42 (Fig. 5), which could be considered as a cayenensis trait. The fact that the distribution (not shown) of individual rhyzome weight was not different established that a fraction of the rhyzomes of N 83-42 was more slender for an equivalent weight than rhyzomes of N 83-43.

3. Differential size effects of the pressures of selection on the polycrosses

Figure 6 shows the different ratios observed over and within the polycrosses from the application of criteria under the different pressures of selection reached by the successive growing cycles.

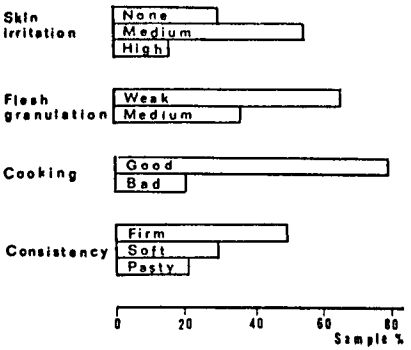

FIG. 2 . DISTIBUTION OF ORGANOLEPTIC TRAITS WITHIN 70 CLONES OF THE N- 83 POLYCROSSES

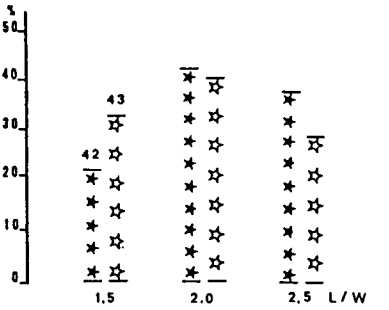

FIG. 4 . LENGTH (L) TO WIDTH (W) LAMINA RATIO DISTRIBUTION WITHIN TWO PROGENIES (42,43)

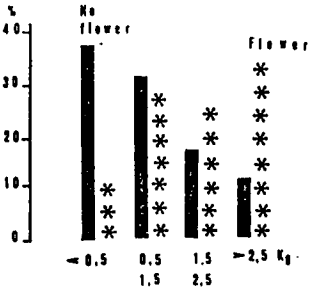

FIG. 3 . DISTRIBUTION OF TUBER WEIGHT WITHIN THE FLOWERING AND NO FLOWERING CLONES

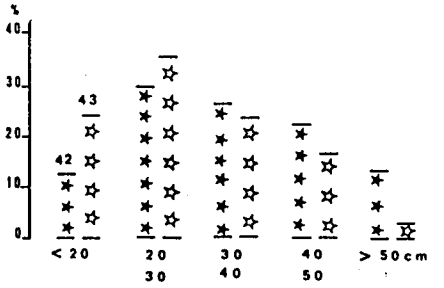

FIG. 5 . TUBER LENGTH DISTRIBUTION WITHIN TWO PROGENIES (42,43)

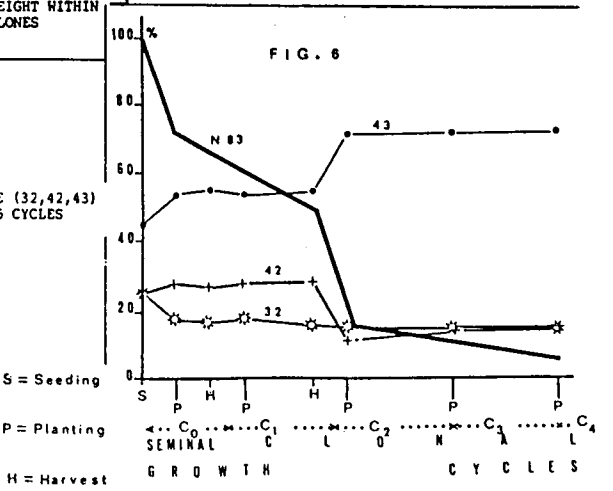

FIG. 6. TOTAL (N 83) AND RELATIVE (32,42,43) RATE OF SELECTION PRESSURE OVER 5 CYCLES

4. The new clones selected

These can be considered for two different purposes: as better agronomic material for farming, marketing and consumption, and as a genetic resource for advanced breeding programs.

About a dozen clones are on trial as new commercial cultivars in the experimental network in the OECS countries and the F.W,I. They combine the following advantages over the control "Grosse Caille-Grande Savane" of Guadeloupe:

- Fair aptitude to single harvest with smooth regular skin all over. The control shows a longitudinal heterogeneity of its rhyzome with thick or decomposed skin on the head when the bottom is mature; irregular germination of sets follows.

- Good yields without stake: 25-30 t/ha can be expected from a 3t-5t plantation rate (80-100g/plant x 30,000-40,000 pl/ha).

- Good ability for post-harvest storage over 4 months. Traditional cultivars are more susceptible to decay by that time, which bears on their propagation. However, the comparison needs to be conducted at identical level of nematode infestation.

- Convenient shape for mechanical harvesting. They are generally more stout than traditional cultivars, for a mean weight of 1-2.5 kg/rhyzome.

Unfortunately they still have some defects, namely a general higher susceptibility to virosis than local cultivars of Guadeloupe, and a diversity of foliar diseases, mainly Sclerotium rolfsii and Rhizoctonia solani.

As genetical resources the material selected comprises two kinds of clones: dioecious and monoecious. Dioecious clones must reach a good level of agronomic performance, but the first quality wanted for the use of this material is its sexual efficiency, either as pollinator or as sexual seed producer.

As verified in 1987-88, a potential of at least ten thousand sexual seeds is at hand each normal year now. However, several commercially promising clones are poor breeding partners.

We are less exacting for agronomic performance regarding the monoecious clones, considering their use as material for breeding method studies. Their frequency is less than five percent in the total polycross progenies, eleven clones being considered as more or less monoecious predominating, either male or female. In several cases the proportion and the localization of each sex in the plant varied over the years of observation.

Knowledge acquired for improving the selection methods

Two interesting hypotheses are now being tested: nematode resistance can be found and tested at the seminal growing cycle, and productivity of classes of clones can be predicted at the very first cycles.

1. The resistance to Pratylenchus coffeae has been investigated recently (Kermarrec et al., 1989) among progenies obtained from crossings of clones N.83 parentage. Determination of the optimal discriminating doses of nematode eggs for soil infestation of seminal plantlets was done in 1987. The dose was applied in 1988 to a progeny after taking a cutting of each plantlet for maintenance and repeated infection at the next clonal cycle. Unfortunately this cloned material was lost under hurricane Hugo. But since a number of clones were found not infested in 1988, it seems likely that resistance to Pratylenchus coffeae exists in these polycrosses. The experiment must be repeated.

2. If the sample of clones coming from four clonal selection growing cycles of these polycrosses is confronted with classes of rhyzome weight obtained at the first clonal cycle, a statistical probability of dependence between first and fourth clonal yield is established by the chi-square test of Pearson (Table 2).

DISCUSSION AND CONCLUSIONS

The interest in the introduction of new germplasm from the area of speciation of the D. cayenensis-rotundata is now obvious. But this germplasm could have been better defined, and it is really a pity that the genetic parentage of the polycrosses could not be known. The variation exhibited has many bearings on the conception of the complex cayenensis-rotundata. For instance, the question of the panmictic origin of the complex appears to be an academic problem from the associations of the traits of cayenensis with the rotundata ones observed in a number of clones: yellowish flesh with elongated leaf, white flesh with "round" leaf, purplish flesh... But the reality of genetic complex of characters featuring cayenensis and rotundata biotypes can be seen in the statistical association between male sex and wide-sized leaf, female and elongated leaf. This situation is rather consistent with the result obtained by Onyilagha and Lowe (1985) when they found that the cultivar "Abi" of Nigeria must be considered a hybrid between the cayenensis and rotundata. However, though the polycrosses N83-42 and N83-43 were less affected by the selection pressure than N83-32 from the seminal to the first clonal growing cycle, the significance of the distribution of all traits at this last cycle remains questionable.

Table 2. Homogeneity test in the progenies of the polycross of D. cayenensis-rotundata for classes of rhyzome weight in the first and fourth clonal cycle.

Weight classes	Number		Theoretical	Difference	$\frac{(N-n)^2}{N}$
	in 1st cycle	in 4th cycle			
< 1000	180	5	12,3	+ 7,3	4,33
1000 - 2000	104	10	7,1	- 2,9	1,18
> 2000	140	14	9,6	- 4,4	2,01
	424	29	29	. 0	χ^2 = 7,52

χ^2 = 5,99 P 0,05

The method of screening permits obtaining valuable new clones. But we think that the use of regular controlled pressure by artificial infection must be worked for anthracnose, Rhizoctonia and Sclerotium rolfsii. In addition, the use of Elisa test could offer a more complete approach to virus susceptibility.

As has been advocated, future selection could be improved for nematode resistance. It is noteworthy that different levels of hosting nematodes have been ascertained in the African yam by Adesiyan (1977) and by Bridge (1978) for five Nigerian cultivars, though in rather inverse rank, a result due perhaps to different methods utilized by these authors.

We found again here a relation between sex and yield in this specific complex which has been seen by Degras (1957, in Degras, 1976) and confirmed by Akoroda et al. (1984), who discuss thoroughly this point.

As for the possibility of an early estimate of productivity in selections that was set forth by Degras (1976) and by Wilson and Victor (1980), it should be worked through an effort to standardize the environmental conditions of growth at the highest growing level during the first cycles, including the seminal cycle.

The constitution of the Network for studying the behavior of yam varieties did not involve a design permitting a common statistical approach. This was allowed as a necessary initial flexibility in consideration of many constraints, but it reasults in an obvious weakness in the accuracy of the selection. In the future this should be standardized for more efficiency.

As indicated in the introduction, selection of the progenies obtained by hybridization of African elite clones is the first step for the introgression of this germplasm in the Caribbean material. The next steps follow three approaches:

1. Improvement of the new germplasm through hybridization of the fertile clones including the ones most adapted to the Caribbean.

2. Hybridization of these adapted clones with the Caribbean clone "Grosse Caille Epineuse" (Guadeloupe) and "Entoine" (St Lucia).

3. Increase low efficiency flowering of other Caribbean clones in view of hybridization with the progenies of the precedent series.

Last but not least, observations and experiments are in progress to investigate the use of monoecious clones in new methods of breeding.

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