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ACHIEVING YIELD STABILITY IN SWEET POTATO BY SELECTING FOR TRANSLOCATION POTENTIAL IN ADVERSE ENVIRONMENTS

(Parvenir à la stabilité du rendement chez la patate en sélectionnant pour le potentiel de translocation des milieux adverses)

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SUMMARY

Due to large genotype by environment interactions, the sweet potato breeding programme in Burundi has been subdivided into four altitudinal regions. The corresponding test sites are viz. ; Imbo-Centre (830 m), Moso (1260 m), Mahwa (1835 m), and Kisozi (2090 m). In each test site an approximately same amount of seed from common genetic background was sown in nurseries and the seedlings were transplanted to the selection field. After two successive harvests with a selection of 10 per cent intensity each all selected clones from the four sites were grouped together and advanced into a multilocal preliminary yield trial, using the same sites, to which a swamp site, Murongwe (1470 m) was added. Unexpected results were recorded in view of the disruptive selection method used so far. Clones originally selected at Mahwa had greater yield potential and better environmental adaptability as a rule.

Two main reasons are put forward : (1) Mahwa combines low-elevation diseases (viroses) with high-elevation diseases (alternariosis) ; (2) although plant growth was vigourous and soil texture (heavy but rich in organic matter) appropriate for tuber enlargement, translocation conditions were adverse (low temperature, high humidity, and desaturated soils). Hence, stable clones are good "translocaters" combining wide disease tolerance.

RESUME

Le programme de sélection de la Patate au Burundi a été subdivisé en 4 régions altitudinales : Centre-Imbo (830 m), Moso (1260 m), Mahwa (1825 m) et Kisozi (2090 m). Dans chaque site on a mis en pépinière la même quantité de graines de même origine génétique, et les plantules ont été repiquées au champ. Une pression de sélection de 10 pour cent a été appliquée à chacune des deux cultures successives sur ces sites. Les clones alors retenus ont été regroupés et envoyés en essais multilocaux préliminaires de rendement sur la même série de localités. Les clones sélectionnés à Mahwa montrèrent dans l'ensemble la plus grande stabilité. (1) Mahwa associe des maladies de plaine (viroses) à des maladies d'altitude (alternariose) ; (2) bien que la croissance y était vigoureuse et la texture du sol (léger et riche en matière organique) adaptée au grossissement du tubercule, les conditions de translocation y étaient limitantes (faible température, forte humidité, sols désaturés). Ainsi, les clones stables se révèlent être de bons "translocateurs" combinant une large tolérance aux maladies.

INTRODUCTION

Sweet potato production has been found to be sink limited by HAHN (1977). JANSSENS (1984) however contented that sink limitation only occurrs in fertile environments, and that source limitation is inherent to marginal environments, whilst translocation limitation is governing sweet potato production wherever environmental conditions are unbalanced.

Environmental exposure of newly created sweet potato clones can be done either at an early stage of a selection cycle (JANSSENS, 1982) or at a final stage (HAHN, 1982). In the sweet potato, population breeding has been proposed as an effective way of meeting specific breeding objectives (JONES, 1965), some of them coinciding with adaptation to a particular environmental niche (JANSSENS, 1982).

The present study investigates whether environmental stability may be linked to the translocation potential of the sweet potato.

MATERIAL AND METHODS

A multilocal preliminary yield trial, comparing 59 newly selected clones to three check varieties, was established in Burundi at the end of the 1984 rainy season. The five test sites were located at elevations ranging from 830 m to 2090 m and had widely varying pedologic and climatic conditions (Table 1). Within each site three randomized blocks were used, each sweet potato clone being alloted to a $1m^2$ hill plot. Planting density was eight cuttings/m^2 i.e. three

Table 1. Agro-ecological conditions of the five experimental sites

Site	Altitude	Planting	Soil (USDA-	Annual means			
				ET_o(1)	Precipit.	t°	$t°_{min}$
	(m)	date	classification)	(mm)	(mm)	(°C)	(°C)
Imbo-Centre	830	04.28.84	Plinthaqualf	1805	810	23.9	17.7
Moso	1260	04.23.84	Haplustox	1400	1206	21.1	14.2
Murongwe	1470	05.03.84	Undetermined alluv. soils	1355	1341	19.0	11.7
Mahwa	1835	04.27.84	Sombrihumox	1275	1398	16.5	9.1
Kisozi	2090	04.27.84	Sombrihumox	1365	1492	16.2	10.8

(1) PAN evaporation

cuttings at the top of the hill plot and five at the bottom. Trials were harvested when the sum of temperatures was about 3700 which corresponded to 5½ months at 830 m up to 8 months at 2090 m of elevation.

The three check varieties were viz., TIS2498DB well adapted to the lower range of altitude, RUSENYA well adapted to the higher elevations, and NSASAGATEBO with good overall environmental adaptability. The other 59 clones came from a disruptive phase of a selection cycle conducted under four different environments, respectively Imbo-Centre (830 m), Moso (1260 m), Mahwa (1835 m) and Kisozi (2090 m). Seed coming from common seed gardens was divided in four approximately even lots and sown in seedling nurseries within each of the above mentioned environments. At the 6-8 leaf stage the surviving seedlings were transplanted to the selection field (Phase I) and at harvest the 10 per cent best clones were immediately cloned up in a randomized block experiment (Phase II), always within each respective site. At harvest, again a selection intensity of 10 per cent was applied, leaving about 1 per cent from the initial population (Table 2). These 59 clones were grouped together into a multilocal preliminary yield trial using the same four selection environments to which a swampy environment, Murongwe (1470 m) was added. The material comprised four groups of clones belonging to the second selection cycle (1982-83) and one group from a first selection cycle conducted in the Moso in 1981-82.

From the different observations made, only fresh tuber yield will be reported here. Because of unequal number of clones within each selection group (Table 2), ordinary one-way analysis of variance was used. Moreover, the genotype by environment effects i.e. selection groups x test sites, were plotted against elevation.

RESULTS AND DISCUSSION

According to the F-tests, differences between groups with regard to fresh tuber yield were significant ($p=.05$) in the Moso and highly significant ($p=.01$) in the four other sites. Similarly, a highly significant F-test for site means was recorded. Group performances within each site are given in Table 3.

The Mahwa 83 group (0.98 kg/m^2) was superior to all other groups, and its superiority was consistant across all environments except in the Moso and in Kisozi where it was equal to the check group and the Kisozi group. The Mahwa 83 group yielded particularly well in the Murongwe swamp (1.66 kg/m^2). Unexpectedly, some selection groups yielded poorly in their respective sites of origin as e.g. Imbo 83, Moso 82 and Moso 83 suggesting that specific environmental adaptability does not necessarely include yield potential as well.

Table 2. Composition of the multilocal preliminary yield trial (PYT)

Selection environment	Selection year	Selection cycle	Population size		Number of clones advanced to PYT	Selection intensity (%)
			Phase I	Phase II		
Moso	1982	1st	859	122	15	1.7
Imbo-Centre	1983	2nd	1678	117	13	0.8
Moso	1983	2nd	1739	152	16	0.9
Mahwa	1983	2nd	1325	104	12	0.9
Kisozi	1983	2nd	961	54	3	0.3
Totals			6562	549	59	0.9

Table 3. Fresh tuber yield (kg/m^2) of five selection groups in five sites

Site / Selection group (a)	Imbo-Centre	Moso	Murongwe	Mahwa	Kisozi	Group means	$LSD_{.05}$ (sites)
Check (3)	0.30	0.37	1.22	0.60	0.76	0.66	0.50
Moso 82 (15)	0.63	0.24	0.71	0.40	0.41	0.49	0.22
Imbo 83 (13)	0.39	0.29	0.41	0.55	0.35	0.41	0.24
Moso 83 (16)	0.67	0.25	0.88	0.60	0.43	0.58	0.22
Mahwa 83 (12)	0.99	0.44	1.66	0.95	0.70	0.98	0.25
Kisozi 83 (3)	0.61	0.37	1.04	0.89	0.69	0.74	0.50
Site means (62)	0.65	0.30	0.92	0.63	0.49	0.62	0.11
$LSD_{.05}$ (groups)	0.16-0.36	0.11-0.24	0.21-0.49	0.14-0.31	0.11-0.25	0.10-0.22	

(a) Number of clones between brackets

In Figure 1 the G X E effects are plotted against altitude. For the Kisozi 83 group, G X E effects are increasing with increasing elevation as would be expected. The Mahwa 83 group on the contrary has G X E effects which are proportional to the environmental index with a high positive effect in the Murongwe swamp. The Moso 83 group can be characterized as a very stable group having only negligible G X E effects (Figure 1). It is deceiving to note that none of the selection groups had highly positive G X E effects in their respective sites of origin. Apparently, a disruptive selection stage in the selection cycle has not been very effective in identifying clones which would be specifically adapted to their respective environment of selection in terms of yield potential. And yet the information gathered on the performances of selection groups in test sites outside their respective environments of selection can be very informative. The three selection groups Imbo 83, Moso 82, and Moso 83 which were selected in environments with frequent drought stresses, showed no negative G X E effects in Kisozi. Hence, drought resistance mechanisms appear to coincide at least partly with cold resistance. The superior behavior of the Mahwa 83 group in the Murongwe swamp points to the fact that these clones possess a strong translocation potential, as swampy conditions favor vegetative growth (CONSTANTIN et al., 1974 ; HAHN, 1977 ; JANSSENS, 1984 and MARTIN, 1983). Moreover, the G X E effects in Murongwe reflect the overall performances of the selection groups, the most productive group, Mahwa 83 (0.98 kg/m^2), having the highest positive G X E effect, and the least yielding group, Imbo 83 (0.41 kg/m^2) having the most negative G X E effect (Figure 1). Hence, the Murongwe swamp conditions during the 1984 dry season were appropriate to identify not only the translocation but also the production potential of the five different selection groups. Finally, the Murongwe environment indicated that the Mahwa 83 selections had good translocation potential, and hence, that the latter clones originated from an environment where translocation conditions were adverse. Mahwa has the climatic conditions of a high plateau. Average yearly minimum temperature is only 9.1°C (Table 1). SPENCE & HUMPHRIES (1972) have demonstrated that tuberisation process is stopped below 10°C. The low yearly PAN evaporation (1275 mm) is not conducive of a high metabolic activity. Moreover, the highly desaturated Sombrihumox soils with strong Phosphorus deficiency (Table 1) are all inhibiting the normal translocation process in the sweet potato. Finally, the Mahwa environment combines high elevation diseases as Alternariosis, with low elevation diseases as viroses.

From Figure 1 it appears that the Mahwa 83 group was highly unstable and yet in a practical way it can be considered as an environmentally stable group as in each test site it produced either better than or least as well as the other groups.

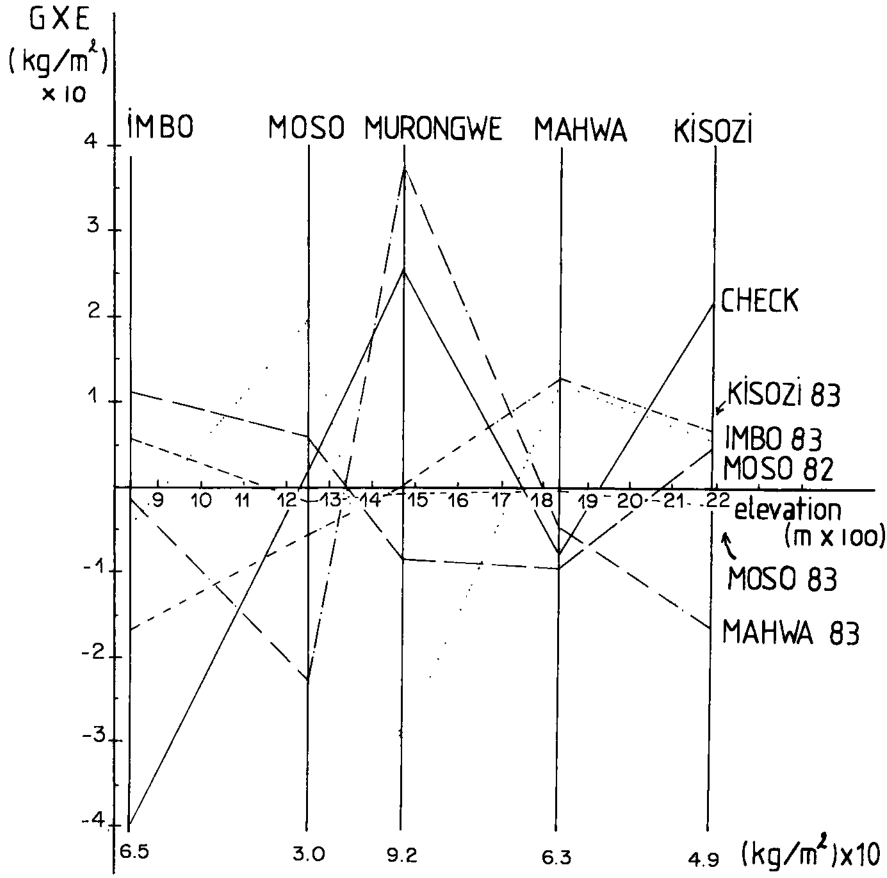

Fig.1 : The GXE effects (selection group x test site)
for fresh tuber yield plotted against elevation

CONCLUSIONS

Selecting in an environment where translocation conditions are adverse is a good way of identifying sweet potato clones which combine translocation potential with environmental adaptability.

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