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USE OF POLYCROSS TECHNIQUE IN THE DEVELOPMENT OF SWEETPOTATO HYBRID LINES FOR RESOURCE-POOR FARMING SYSTEMS

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ABSTRACT

Polycross has been variously used to generate half-sib sweetpotato hybrid seeds. Nine sweetpotato genotypes were used in 2003 to establish 81 crossing blocks at the eastern farm of the National Root Crops research Institute, Umudike, Abia State, using the polycross method. Each crossing plot was $6m^2$ in size. The hybrid seeds produced were raised to seedlings in 2004 in a nursery. The seedlings that emerged were visually screened based on their resistance/tolerance to sweetpotato virus disease. 54 genotypes (51 selected clones from the seedling evaluation and three check cultivars) were evaluated in 2005 for yield traits using augmented incomplete block design. The soil was a poor acid soil typical of the eastern Nigerian soils, and fertilizer was not added to simulate the peasant farmers' condition. Data collected on hybrid seeds included number of seeds per genotype, mean seeds per capsule, and percent capsule-filling ability, while data collected on clonal evaluation trial were yield (kg/plant), number of progenies of each parent evaluated, percent progenies selected per parent, and percent parental contribution to total offspring selected. Fifteen promising clones out of the 51 evaluated were selected. The progeny, 2532.OP.1.13-03NRSP.2 recorded the highest yield (600g/plant). Tanzania contributed 40% and TIS 2532.OP.1.13 contributed 33.33% of the selected promising progenies. This study has confirmed the fact that clones that can be productive in resource-poor farming systems can effectively be developed through the polycross method.

Keywords: Polycross technique, resource-poor systems, clonal evaluation.

INTRODUCTION

Sweetpotato (*Ipomoea batatas*) is the only cultivated member of the genus *Ipomoea* and is undeniably one of the world's most important food crops due to its high yield and nutritive value (Data and Eronico, 1987). However, about 92% of the world's sweetpotato production comes from the Asian continent (Islam *et al*, 2002). The biotic and abiotic stresses in the environment tend to lower the yield and quality of agricultural produce (Adebisi *et al*., 2001). Thus, new crop varieties must constantly be developed to tolerate or overcome these constraints, and to adapt to the farming systems of the people. One way of doing this is through the development of new breeding population, followed by seedling and clone selection in a simulated resource – poor farming condition.

Plant breeding essentially consists of three phases: generation of genetic variability, selection of useful genotypes, and comparative tests to demonstrate the superiority of the selected genotypes (Brock, 1977). Genetic variability is generated through the production of botanical seeds by the crossing of two or more genotypes by hand or natural elements such as wind and insects. In sweetpotato, botanical seeds are usually developed through hand pollination or polycross technique (Tseng *et al.,* 2002). Jones (1965) proposed the polycross breeding scheme in which parental lines are planted in an isolated plot and subjected to open pollination by insects and mass selection to eliminate the pre-screening of cross-compatibility which is a must in hand pollination. Generally, hand pollination has a high rate of failure due to high degree of flower abortion and labour intensiveness of the procedure (Kanju *et. al.,*1999). Afuape *et al.* (2004) reported 100% failure of hand pollination in the development of hybrid seeds at Umudike. The polycross strategy has been the major breeding program practiced in Taiwan since 1966 to generate many elite sweetpotato cultivars with high yield potential, high beta carotene and high protein cultivars (Tseng *et al*., 2002).

Polycross technique has been described as an effective method for generating sweetpotato hybrid seeds because it requires only one generation per cycle, no hand pollination, easy handling of large number of lines per cycle and better seed-set (Kanju *et. al.,* 1999). From the hybrid seeds developed through the polycross technique, clones are produced upon which various selection processes are carried out. The first root selection stage is at the clonal evaluation level where selected seedlings are evaluated for good agronomic traits. At this stage, yield and disease/pest resistance are the most critical criteria upon which selection is based. To select for resource-poor systems, evaluation must be done in an environment that simulates farmers' production systems which are characterized by low level inputs (fertilizer and herbicide) use and nutrient depleted soils. Therefore, the objectives of this work were to demonstrate the effectiveness of the use of the polycross technique in the development of sweetpotato hybrid seeds in the rain forest ecology of Umudike, Abia state (longitude $07^0033'E$, latitude $05^0029'N$, altitude 122m above sea level), Nigeria, and to evaluate and select developed clones from the polycross hybrid seedlings for adaptability to resource-poor farmers' conditions.

MATERIALS AND METHODS

Nine sweetpotato genotypes (TIS 87/0087, TIS 8164, TIS 8441, TIS 2532.OP 1.13, TIS 86/0356, Ex-Igbariam, Wagabolige, TIS 440168 and Tanzania) from the National Root Crops Research Institute, Umudike sweetpotato germplasm were used to establish crossing blocks in 2003 in an isolated field. The nine genotypes were established in nine blocks repeated nine times with each block measuring $6m^2$. In the whole, there were 81 blocks. The genotypes were randomized across the 81 blocks for effective natural cross-pollination. Planting was delayed till the end of July for the reproductive phase to coincide with short day length period noted for initiating and enhancing flowering in sweetpotato (Major, 1980) After four months, dry capsules of same genotype were collected in calico bags and bulked together. Data from well-filled seeds were taken on number of seeds, mean seeds per capsule and percent capsule filling. Seedling nursery was established in 2004 to raise the seeds to seedlings for evaluation Seedlings were selected based on

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virus resistance, vigour and root yield potential. Fifty-one breeding lines were selected for clonal evaluation.

The selected fifty-one lines were evaluated in 2005 with three popular cultivars (TIS 87/0087, TIS 8164 and Ex-Igbariam) as checks on an ultisol with low organic matter in five blocks using augmented incomplete block design according to Federer (1991). Each block comprised thirteen plots (ten breeding lines and three checks except the last block, which had eleven lines). Thus, only the checks were replicated across the blocks, other breeding lines were not. However, all the genotypes in each block were randomized. The plot size was $6m^2$ with inter-and intra-row spacing of 1m x 30cm, respectively, and with an inter-plot spacing of 1m. Weeding was manually done at 4 weeks after planting (WAP) followed by rouging at 8WAP. Fertilizer was not applied to simulate resource-poor farmers' condition in order to select genotypes that could do well under resource-poor farmers' condition. Standard error (S.E.) according to IITA SAS training Manual (2004) was calculated on the checks to compare means within the blocks.

RESULTS

The agro-meteorological data showed that there was adequate rainfall for the growth and development of the sweetpotato crop during the cropping season of 2005. Collins (1995) stated that at least rainfall of 18-20mm/week in the early season, 40-45mm/week at mid-season when roots are rapidly tuberising, and about 20mm/week rainfall late in the season were needed by sweetpotato for good performance. The rainfall and temperature range during the evaluation of the clones from the polycross method for fresh root yield were adequate for good growth development (Table 1). Also, the result of the soil analysis (Table 2) showed that the soil of the experimental field was acidic and very poor in nutrient status.

The evaluation of the nine genotypes showed that only six genotypes flowered at Umudike in 2003. Wagabolige, TIS 8441 and TIS 86/0356 did not flower at all. The hand pollination that was carried out was 100% failure as all the flowers aborted (data not included). However, through the polycross technique, TIS 2532.OP.1.13 produced the highest number of seeds (3592), followed by TIS 8164 (444), Tanzania (392), TIS 440168 (195), TIS 87/0087 (71) and Ex-Igbariam (62). The total number of seeds collected was 4666 (Table 3). TIS 87/0087 recorded the highest number of seeds per capsule and % capsule filling ability at 1.87 and 46.74 respectively, followed by TIS 2532.OP.1.13, Ex-Igbariam, Tanzania, TIS 8164 and TIS 440168 in that order (Table 3).

The yield of evaluated sweetpotato clones is presented in Table 4. Out of the fifty-one lines evaluated, fifteen lines with yields up to 0.2kg/plant were selected as promising lines. The yields of the 51 breeding lines ranged between 0.001 and 0.6 kg/plant. Clone 2532.OP.1.13-03NRSP.2 had the highest yield (0.6kg/plant), followed by 440166-03NRSP.1 and 440166-03NRSP.9 each with 0.51kg/plant. Ex-Igbariam – 03NRSP.12 recorded the lowest yield of 0.001kg plant. Of the fifteen genotypes selected, 40% were progenies from Tanzania, 33.33% from 2532.OP.1.13, 13.33% from Ex-Igbariam, 6.67% from TIS 8164 and 440168, while TIS 87/0087 had no progeny selected from it (Table 5). However, the progenies of 2532.OP.1.13 showed the highest level (65%) of segregation for desirable traits, followed by Tanzania (54%). TIS 87/0087 had no segregation for desirable traits.

Table 1: Agro-meteorological data of the experimental site at Umudike in 2005.

Months	Rainfall Amount (mm)	Temperature	
		Max.	Min.
January	17.3	32.6	19.2
February	126.7	35.0	23.0
March	64.0	34.0	23.0
April	141.3	34.0	24.0
May	222.4	32.0	23.0
June	264.4	31.0	23.0
July	277.0	29.0	23.0
August	225.0	30.0	22.0
September	339.0	31.0	23.0
October	333.0	31.0	22.0
November	45.4	33.0	23.0

Source: Agro-meteorological Unit, National Root Crops Research Institute, Umudike, Abia State.

Table 2: Nutrient status of the site used for the evaluation of the 51 clones at Umudike in 2005.

	Organic matter	Organic carbon	Total nitrogen	Exchangeable potassium	Exchangeable magnesium	Exchangeable sodium	Exchangeable calcium
Soil analysis	0.27	0.16	0.07	0.15	1.73	0.27	3.46
Nutrient	Very	Low	Low	Very Low	Moderate	Low	Low
Status	Low						

Nutrient status classification was done according to Onwueme and Sinha (1991) and USDA (1986) soil survey manual.

Table 3: Total number of seeds, mean number of seeds per capsule and % capsule-filling ability of six sweetpotato parent lines.

Genotype	Total number of seeds collected	Mean Seed per capsule	% Capsule-filling ability
TIS 2532. OP. 1.13	3592	1.85	46.25
TIS 8164	444	1.40	35.06
Tanzania	392	1.54	38.50
Ex-Igbariam	62	1.63	40.83
TIS 87/0087	71	1.87	46.74
TIS 440168	105	1.06	26.43
Total	4666		

Table 4: Yield (kg/plant) performance of clones of progenies developed from six sweetpotato cultivars at Umudike in 2005.

Genotype	Yield (kg/plant)	Genotype	Yield (kg/plant)
TIS 8164-03NRSP.1	0.16667	EX-IGBARIAM–03NRSP.4	0.1100
TIS 8164-03NRSP.2	0.0900	EX-IGBARIAM–03NRSP.5	0.1231
TIS 8164-03NRSP.3	0.008	EX-IGBARIAM–03NRSP.6	0.0158
TIS 8164-03NRSP.4	0.132	EX-IGBARIAM–03NRSP.7	0.1895
TIS 8164-03NRSP.5	0.2110	EX-IGBARIAM–03NRSP.8	0.4000
440166 – 03NRSP.1	0.5100	EX-IGBARIAM–03NRSP.9	0.1530
440166 – 03NRSP.2	0.0450	EX-IGBARIAM–03NRSP.10	0.2430
440166 – 03NRSP.3	0.2909	EX-IGBARIAM–03NRSP.11	0.0060
440166 – 03NRSP.4	0.1158	EX-IGBARIAM–03NRSP.12	0.0010
440166 – 03NRSP.5	0.2630	EX-IGBARIAM–03NRSP.13	0.1350
440166 – 03NRSP.6	0.2000	EX-IGBARIAM–03NRSP.14	0.0400
440166 – 03NRSP.7	0.1250	EX-IGBARIAM–03NRSP.15	0.1000
440166 – 03NRSP.8	0.1380	TIS 87/0087 – 03NRSP.1	0.0050
440166 – 03NRSP.9	0.5100	TIS 87/0087 – 03NRSP.2	0.1200
440166 – 03NRSP.10	0.2470	TIS 87/0087 – 03NRSP.3	0.0500
440166 – 03NRSP.11	0.1000	TIS 87/0087 – 03NRSP.4	0.0940
2532.OP.1.13–03NRSP 1	0.0090	440168 – 03NRSP.1	0.0105
2532.OP.1.13–03NRSP 2	0.600	440168 – 03NRSP.2	0.0842
2532.OP.1.13–03NRSP 3	0.1350	440168 – 03NRSP.3	0.1600
2532.OP.1.13–03NRSP 4	0.0690	440168 – 03NRSP.4	0.0360
2532.OP.1.13–03NRSP 5	0.2400	440168 – 03NRSP.5	0.1350
2532.OP.1.13–03NRSP 6	0.3500	440168 – 03NRSP.6	0.0150
2532.OP.1.13–03NRSP 7	0.3200	440168 – 03NRSP.7	0.1300
2532.OP.1.13–03NRSP 8	0.2077	TIS 8164	0.2500
EX-IGBARIAM–03NRSP.1	0.0737	TIS 2532.OP.1.13	0.2000
EX-IGBARIAM–03NRSP.2	0.0895	TIS 87/0087	0.1650
EX-IGBARIAM–03NRSP.3	0.1263		
		SED	0.2000

Table 5: Number of progenies of each parent evaluated, % progenies selected, and % parental contribution to the selected progenies at Umudike in 2005.

PARENT	No. of progenies evaluated	No. of progenies selected	Percent selected	Percent parental contribution
TIS 8164	5	1	20.00	6.67
Tanzania	11	6	54.00	40.00
TIS 2532.OP.1.13	8	5	62.00	33.33
Ex-Igbariam	15	2	13.33	13.33
TIS 87/0087	4	0	0.00	0.00
TIS 440168	8	1	12.50	6.67
TOTAL	51	15	29.4	100.00

DISCUSSION

Very low success rate of hand pollinated flowers in sweetpotato genotypes have been noted by several workers (Kanju *et. al.*,1999; Reynoso *et al.*,1999). Afuape (2007) and Reynoso *et al.*(1997) also noted that sweetpotato cultivars differ in their flowering and seed set ability, and under normal growing conditions, most cultivars do not flower or flower scarcely, and only a few flower profusely. This explains the variation observed in the total number of seeds collected per genotype.

Kanju *et al.* (1999) reported mean seeds per capsule of between 1.1 to 1.8, and an overall mean of 1.5 seeds per capsule. This corroborated the result of this study which recorded a range of 1.06 to 1.87, and an overall mean of 1.6. Wang (1952) reported a mean of 1.54, while Hernandez and Miller (1964) reported a mean of 1.2. The result of this study did not deviate from the finding of Jones (1980), who reported that mean seeds per capsule seldom exceed 1.70 in sweetpotato.

Earlier work (Onyenweaku and Nwaru, 2005) had described resource-poor production system as one often characterized by small and uneconomic production units with predominance of primitive techniques of agricultural production. Their soils are often poor in fertility as a result of overuse of farm lands and poor soil management techniques, and low farm input (pesticides, irrigation, fertilizer, etc) use. Thus, the soils under cultivation are often low in essential nutrients with the consequence of low crop productivity. The soil nutrient analysis (Table 2) of the field under which the breeding lines were evaluated for fresh root yield showed that the soil fits into a resource-poor production system as described by Onyenweaku and Nwaru (2005). Using Onwueme and Sinha (1991) and the USDA (1986) soil nutrient status classification manual, the soil under the trial could best be described as very low in organic matter and exchangeable potassium, low in organic carbon, total nitrogen, exchangeable sodium and exchangeable calcium. The selected hybrid lines in this environment will possess the ability to adapt to such resource-poor environments.

The selection of fifty-one progenies from the 4666 seeds sown, approximating 1.1% of the total seeds sown in this trial, followed the findings of Yencho and Pecota (2000) who reported the selection of < 1% of the total seedlings from the seeds planted for replicated trials. Yencho and Pecota (2000) also used the polycross method to develop 61,000 sweetpotato sexual seeds from three polycross nurseries

(average of 20,300 seeds per nursery). This was far above the 4666 seeds developed under the Umudike condition.

High yield is the most important trait farmers look for in agricultural production (Laurie *et al.*, 1999). The development of high yielding varieties is usually achieved by the selection of progenies that perform above the best available and adapted varieties in the production system. Fifteen progenies developed through the polycross technique performed better than the mean (0.20g/plant) of the three best cultivars available at the National Root Crops Research Institute, Umudike. The progenies varied in their performance in fresh root yield. The variability observed in the performance of the clones of the progenies could be as a result of the high heterozygosity found in sweetpotato, a hexaploid (Nwinyi, 1991). Muntzing (1961) noted that cross-fertilizing crops (like sweetpotato), have every genotype heterozygous for a large number of genes. A cross between two genotypes is thus expected to produce segregants with respect to many traits.

CONCLUSION

The polycross technique has been shown to be effective in the development of sexual seeds in sweetpotato. The selection of fifteen genotypes will enhance the development of varieties that yield higher than the existing ones. The establishment of the trial on a poor soil, and the non-use of fertilizer and herbicide on the soil will help in the selection and subsequent development of varieties that could fit into the resource-poor farming systems of the local farmers in the zone.

REFERENCES

Adebisi, M. A., Ariyo, O. J. and Kehinde, O. B., 2001. Variation and correlation studies in quantitative characteristics in soybean. Proc. of the 35th Ann. Conf. of the Agric. Soc. of Nigeria, Abeokuta, Sept. 16-20, 2001, Pp. 121-125.

Afuape, S. O., 2007. Evaluation and characterization of genetic diversity in sweetpotato (*Ipomoea batatas* (L.) Lam) genotypes. M.Sc. Thesis, Michael Okpara University of Agriculture, Umudike. 99pp.

Afuape, S.O., Amadi, C.O. and Nwauzor, E.C. (2004). Flowering and seed-setting of nine sweetpotato genotypes at high altitude. National Root Crops Research Institute, Umudike, Nigeria, 2004 Annual Report, pp 45-47.

Brock, R. D., 1977. When to use mutations in plant breeding. In: Manual on Mutation Breeding (2nd Edition). Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, International Atomic Energy Agency, Vienna 1977. Technical reports Series No. 119. 28pp.

Collins, W. W., 1995). Sweetpotato. NewCROPFactSHEET. http:/www.hortpurdue.edu/newcrop/cropfactsheets/sweetpotato.html., March, 2006

Data, E. S. and Eronico, P. S., 1987. Storage performance of newly developed Sweetpotato hybrids. Radix 9 (1), 3-5.

Federer, W. T., 1991. Statistics and Society (2nd Ed.). Mercel Dekker, New York.

Hernandez, T.P. and Miller, J.C. (1964). Further studies on incompatibility in sweetpotato. Proc. Amer. Soc. Hort. Sci. 85: 426-429.

International Institute for Tropical Agriculture. SAS Training Manual, 2004.

Islam, M. J., Haque, M. Z., Majunder, U. K., Haque, M.M. and Hossain, M. F. (2002). Growth and yield potential of nine genotypes of sweetpotato. Pakistan, J. of Biological Science. 5(5): 537-538.

Jones, A., 1965. A proposed breeding procedure for sweet potato. Crop. Sci. 5: 191-192.

Jones, A., 1980. Sweet Potato. In: Fehr, W.R. and H.H. Hadley (eds.). Hybridization of Crop Plants. Amer. Soc. Agrom. and Crop Science. Pp 645-655.

Kanju, E.E, Laurie, S., Carey, T. and Deventer, C. van., 1999. Flowering and fertility of some South African Sweetpotato cultivars. In: M.O.Akoroda and J.M. Teri (eds). Food Security and Crop Diversification in ADC Countries: The Role of Cassava and sweetpotato. Proc. of the Scientific Workshop of the Southern Africa Root Crops Research Network (SARRNET), Lusaka, Zambia, 17-19 August, 1998.

Laurie, S. M., van den Berg, A.A. and Stork, P.O., 1999. Progress by the South African sweetpotato breeding and multiplication program in support of resource–poor farmers. In: Akoroda, M.O. and Terry, J.M. (eds). Food Security and Crop Diversification in SADC Countries. The Role of Cassava and Sweetpotato. Proc. of the Scientific Workshop of the Southern African Root Crops Research Network (SARRNET), Lusaka, Zambia, 17-19 Aug, 1998.

Major, D J., 1980. Environmental effects of flowering. In: Fehr, W.R. and Hadley, H H. (eds). Hybridization of Crop Plants. American society of Agrononmy and Crop Science Society of America, Madison, Wisconson, USA, pp1-15.

Muntzing, A., 1961. Genetic Research. Meijels Bokindustris Halmstad. P 480.

Nwinyi, S C O., 1991. Pre-planting method and duration of storing sweetpotato (*Ipomoea batatas* (L) Lam) shoot cutting planting materials for increased tuber yield. Tropical Science 31: 1-7.

Onwueme, I.C. and Sinha, T. D., 1991. Field Crop Production in Tropical Africa. CTA, pp 157.

Onyenweaku, C. E. and Nwaru, J. C., 2005. Application of stochastic frontier production function to the measurement of technical efficiency of food crop production in Imo state. Niger Agric. Journal 36: 1-12.

Reynoso, D., Huaman, Z. and Aguilar, C., 1997. Methods for flowering induction in sweetpotato. International Potato Centre (CIP) Sweetpotato Germplasm Management Training Manual, Section 2.7, pp 1-7.

Reynoso, D., Huaman, Z. and Aguilar, C., 1999. Methods to determine the fertility and compatibility of sweetpotato. International Potato Centre (CIP) Sweetpotato Germplasm Management Training Manual, Section 2.7, pp 1-8.

Tseng, U.T., Lo, H.F. and Hwang, S.Y., 2001. Genotyping and assessment of genetic relationships in elite polycross breedingcultivars of sweetpotato in Taiwan based on SAMPL polymorphisms. Bot. Bull. Acad. Sin., 43: 99-105.

Tysdal, H. M., 1948. History and development of the polycross technique in alfalfa breeding. Alfalfa Improvement Conference Report, 11: 36-39.

USDA., 1986). United States Department 0f Agriculture. Soil Survey Staff In Soil Fertility Investigations (5 Volumes), pp 330.

Wang, H., 1982. The breeding of sweetpotato for human consumption. In: Villareal and Griggs (eds.). Sweetpotato. Proc. of the first International Symposium, Asian Vegetable Research and Development Centre, Shanhua, Tainan, Taiwan, china. Pp 297-311.

Yencho, C.G. and Pecota, K., 2000. North Carolina State University Sweetpotato Breeding Program: Summary of Cultivar Development Work. North Carolina State University Report.