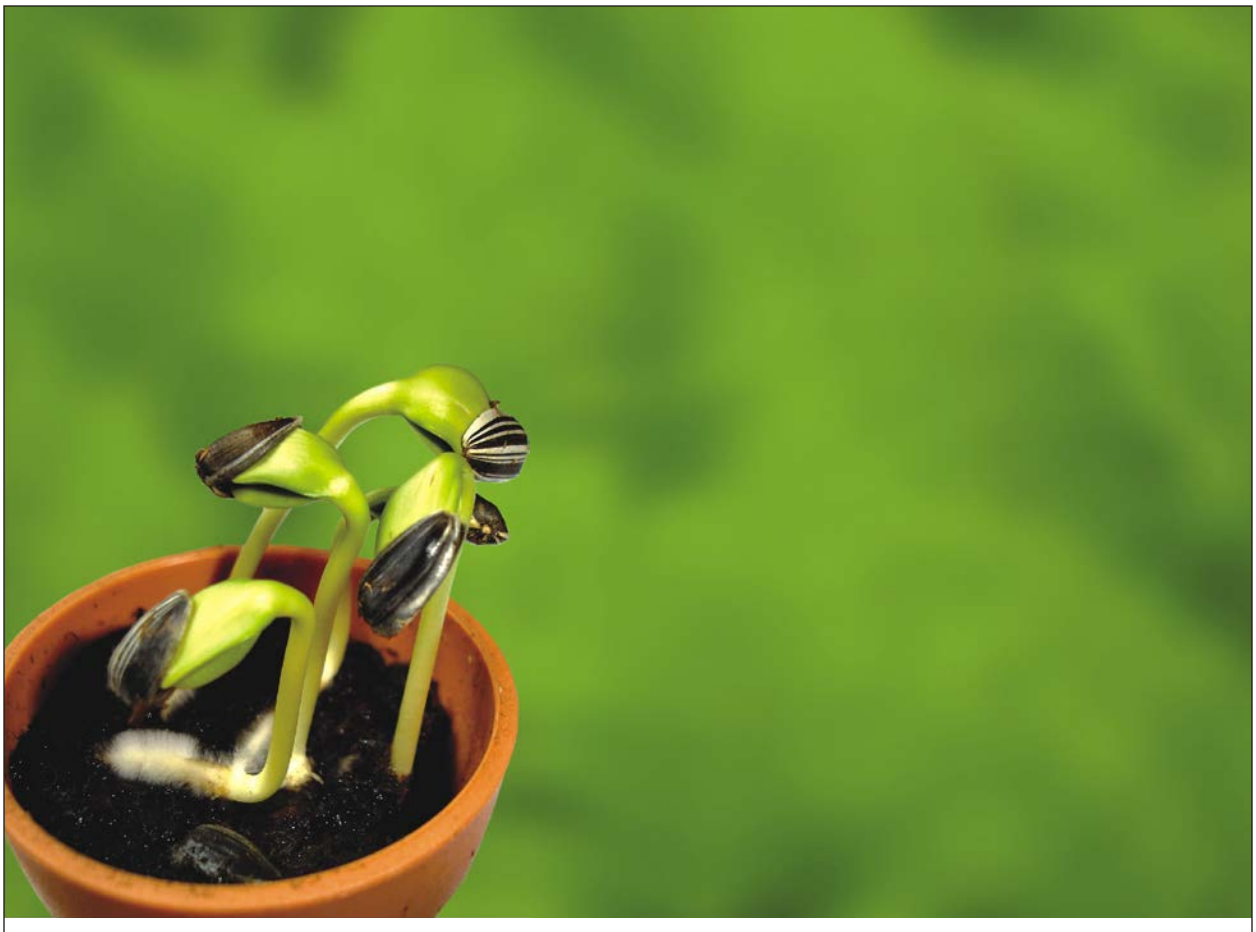

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Clonal Assessment of Sweet Potato (*Ipomoea batatas* (L.) Lam.) Lines for Flower and Seed Characteristics in Jos-Plataeu, Nigeria

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ABSTRACT

A study was carried out during the wet season of 2013 at the Potato Research Farm of the National Root Crops Research Institute (NRCRI), Kuru, Plateau State, to assess five sweet potato clones procured from the NRCRI, Umudike, Nigeria, for flowering and seed characteristics. The clones TIS.2532.OP.1.13, TIS.87/0087, CIPM 3, CIPM 31 and Ex-Igbariam were laid out in a randomized complete block design with three replications. The results showed that the mean number of days to onset of flowering was highest in the clone CIPM 31 (102 days after planting) and lowest in the clone TIS.2532.OP.1.13 (56.67 days after planting). The highest mean number of flowers per plant was observed in the clone CIPM 31 and lowest in the clone TIS.2532.OP.1.13. The mean seed weight per plant was highest in clone TIS.2532.OP.1.13 and lowest in the clone CIPM.31. The study showed that the pattern of flowering and the potential of seed production in the sweet potato varied with clone. There is, therefore, high prospect for improving the sweet potato through hybridization and controlled pollination in the Jos-Plateau environment.

Key words: *Ipomoea batatas* (L.) Lam., improvement, hybridization, photoperiod

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam.) is an important root crop which is extensively cultivated in tropical and sub-tropical zones (Islam *et al*., 2002). It is one of the world's most important food crops due to its high yield and nutritive value. Its importance in starch, alcohol, livestock, pharmaceutical and textile industries cannot be over emphasized (Tewe *et al*., 2003). The orange-fleshed varieties with high β-carotene content have become very important in combating vitamin A deficiency especially in children. The cultivation and production of sweet potato is on the increase in Nigeria. The crop has moved up from a minor crop status to an enviable position of being the fourth most important root and tuber crop after cassava, yam and cocoyam (Tewe *et al*., 2003).

Survey reports placed Nigeria, as the number two producer of sweet potato in Africa with an annual production output of 2.5 million Mt in 2004 from 149,000 Mt in 1961 (FAO., 2004). The ravaging effect of diseases and pests have also been noted, even as emphasis is also shifting to include such important traits like dry matter and starch content (Tewe *et al*., 2003).

Propagation by seed or hybridization and controlled pollination is limited by photoperiodically controlled flowering (Rieger and Sedgley, 1996), low pollen viability (Onwueme, 1978), short flower life, slow rate of pollen tube growth, incompatibility complexes as well as poor seed-set and dormancy (Hossain and Islam, 1988).

Clones adapted to tropical environments have been reported to flower more readily than those adapted to temperate environments, where flowering is mostly artificially induced (Onwueme, 1978).

Even amongst clones that flower readily in the tropics, low pollen viability, short flower life, slow rate of pollen tube growth and poor seed-set or dormancy may limit the use of sexual reproduction as a method of crop improvement.

Dumpe and Ortiz (1996) reported a positive correlation between pollen number produced and pollen viability. Weaver and Timm (1989) observed that pollen viability played a major role in determining fruit-set and that it could serve as a basis for selecting clones with potentials of high fruit and/or seed production.

Understanding the nature of fertility problems in the sweet potato could assist the breeder to develop procedures to overcome the barrier. This could be achieved by investigating the pattern of flowering and potential for seed production in some commonly cultivated sweet potato clones. This study was, therefore, designed to explore the prospects for improving sweet potato using the method of hybridization in the Jos-Plateau environment in North-Central Nigeria.

MATERIALS AND METHODS

The experiment was carried out at the Potato Research Farm of the National Root Crops Research Institute (NRCRI) located at Kuru in Plateau State, North-Central Nigeria (09°44'N, 08°47'E; altitude 1,293.2 m above sea level).

The five clones of sweet potato used TIS.2532.OP.1.13, TIS.87/0087, CIPM 3, CIPM 31 and Ex-Igbariam were laid out in a randomized complete block design with 3 replications. The agronomic characteristics of the clones are shown in Table 1.

Land preparation was done manually. The net plot, which measured 3×3 m, consisted of 3 rows, each measuring 3×1 m. Vine cuttings of about 20 cm long were planted on each row at 30 cm (within row) and 100 cm (between row) to give a population of 33,333 plants ha^{-1}. Planting was done on July 11, 2013.

The plots were first weeded manually at 40 Days After Planting (40 DAP). At 41 DAP, the plots received a blanket application of fertilizer NPK (15:15:15) at the rate of 60 kg ha^{-1} each of nitrogen, phosphorus and potassium, which was equivalent to 360 g per plot.

Field sampling: Field observations began at 40 DAP and continued until 140 DAP. Mean number of days to onset of flowering was recorded as the number of days after planting to when the first flower emerged.

Table 1: Agronomic characteristics of sweet potato clones used in the experiment

Clone	No. of plants ha^{-1}	No. of days to maturity (WAP)	Average yield (t ha^{-1})	No. of days to 50% flowering (WAP)
TIS.2532.OP.1.13	33.333	16	10.45	5
TIS.87/0087	33.333	16	11.65	6
CIPM 3	33.333	16	9.79	6
CIPM 31	33.333	16	1.30	8
Ex-igbariam	33.333	16	18.73	7

Source: National root crops research institute (NRCRI), Umudike, Nigeria

The total number of flowers produced by ten randomly sampled plants was divided by ten to obtain the mean number of flowers produced per plant. Ten plants were sampled from each plot to calculate the rate of flowering computed as the rate of increase in the number of flowers per unit time. Readings were taken at 7 day intervals:

$$\text{Rate of flowering} = \frac{b - a}{t_2 - t_1}$$

Where:
a = No. of flowers produced at t_1
b = No. of flowers produced at t_2

Pollen viability tests were carried out at 56 DAP using the method of glycerol-acetocarmine stainability (Kobayashi *et al*., 1994; Dumpe and Ortiz, 1996). Five percent glycerol-acetocarmine stain was prepared by adding 1 g of carmine powder to 95 mL of acetic acid in 250 mL conical flask. The acetocarmine solution was boiled for five minutes on a hot plate and allowed to cool. Thereafter, the solution was poured into a 100 mL cylinder. Five milliliter of glycerol was added to 95 mL of acetocarmine solution to make up the 100 mL of 5% glycerol-acetocarmine stain.

Anthers from open flower buds were squashed in a drop of 5% glycerol-acetocarmine on a slide. After removing the debris, the slides were covered with cover-slips and left for about 18 h before examination.

The pollen grains were observed under 25 different microscopic fields of view. Those which were filled with stained cytoplasm were considered to be fertile, while the small, shriveled and unstained ones were considered to be sterile. Pollen viability was calculated as the ratio of stained pollen to the total number of pollen observed multiplied by 100:

$$\text{Pollen viability} = \frac{\text{No. of stained pollen}}{\text{Total no. of pollen observed}} \times 100$$

Mean seed weight was calculated thus, all the seeds harvested from the ten sampled plants in each plot were weighed. The weight was divided by ten to obtain the mean seed weight.

Mean seed size was calculated thus, a seed from each capsule of the ten sampled plants in each plot was held tightly with a screw knob of the micrometer screw gauge to determine the diameter of the seed. The Least Count (LC) of the micrometer screw gauge used (which is a constant) was 0.01 mm. The Main Scale Reading (MSR) and the Circular Scale Reading (CSR) were also taken. The seed diameter (seed size) was calculated using the equation:

$$D = MSR + (CSR \times LC)$$

Where:
MSR = Main Scale Reading
CSR = Circular Scale Reading
LC = Least Count

The total diameter of seeds was divided by the number of seeds to obtain the mean seed size.

Data analysis: Data collected was subjected to analysis of variance (ANOVA) test and the means were compared using the Duncan's new Multiple-Range Test.

RESULTS

Mean number of days to onset of flowering: The highest mean number of days to onset of flowering (102.00) was observed in clone CIPM 31, while the lowest (56.67) was observed in clone TIS.2532.OP.1.13 and difference ($p<0.05$) was significant. The mean number of days to onset of flowering was similar in clones TIS.87/0087 and CIPM 3 (Table 2).

Mean number of flowers per plant: The mean number of flowers per plant increased with crop age and the peak period varied with clone. In all but clones TIS.2532.OP.1.13 and TIS.87/0087, the mean number of flowers per plant increased with time up to 17 Weeks After Planting (17 WAP) and thereafter decreased. Clone TIS.2532.OP.1.13 was observed to have the highest number of flowers per plant at all stages of growth except at 9 and 20 WAP (Table 3).

Rate of flowering: In the clones, rate of flowering (Table 4) increased by crop age and the peak period varied with clone. In all but clones CIPM 31, the rate of flowering peaked at 14 WAP. At 11 and 14 WAP, the highest rate of flowering was observed in clone TIS.87/0087 whereas, at 17 and 20 WAP, the highest rate of flowering was observed on clone CIPM 31.

Pollen viability: Pollen viability ranged from 71.19% in clone TIS.2532.OP.1.13 to 85.03% in clone CIPM 31 and the difference ($p<0.05$) was significant. Pollen viability was similar in clones

Table 2: Mean number of days to onset of flowering in some sweet potato clones in Jos-Plateau

Clone	Days to onset of flowering
TIS.2532.OP.1.13	56.70[c]
TIS.87/0087	58.67[c]
CIPM 3	58.67[c]
CIPM 31	102.00[a]
Ex-igbariam	78.67[b]
CV (%)	4.46

Means followed by the same letter(s) are not significantly different at 5% level of probability (Duncan's new multiple-range test)

Table 3: Mean number of flowers per plant in some sweet potato clones at different stages of growth in Jos-Plateau

	Growth stage (weeks after planting)				
Clone	9	11	14	17	20
TIS.2532.OP.13	1.37	5.10	24.90	21.23	1.18
TIS.87/0087	1.30	4.10	18.10	17.00	0.76
CIPM 3	1.47	3.94	16.80	18.53	1.20
CIPM 31	0.71	0.71	0.71	3.83	0.71
Ex-igbariam	0.71	0.71	6.03	10.80	0.85
SE±	0.28	0.45	1.21	1.13	0.07

Table 4: Rate of flowering in some sweet potato clones at different stages of growth in Jos-Plateau

	Growth stage (weeks after planting)			
Clone	11	14	17	20
TIS.2532.OP.1.13	1.47	1.48	0.30	0.22
TIS.87/0087	1.48	1.72	0.58	0.50
CIPM 3	1.38	1.64	0.57	0.26
CIPM 31	0.71	0.71	2.06	0.71
Ex-igbariam	0.71	1.08	0.57	0.41
SE±	0.10	0.15	0.20	0.15

Table 5: Pollen viability in some sweet potato clones in Jos-Plateau

Clone	Pollen viability
TIS.2532.OP.1.13	71.19[d]
TIS.87/0087	72.72[c]
CIPM 3	77.76[b]
CIPM 31	85.03[a]
Ex-igbariam	83.84[a]
CV (%)	2.47

Means followed by the same letter(s) are not significantly different at 5% level of probability (Duncan's new multiple-range test)

Table 6: Mean seed weight and seed size in some sweet potato clones in Jos-Plateau

Clone	Seed weight (g)/plant	Seed size (mm)/plant
TIS.2532.OP.1.13	3.90[a]	2.33[c]
TIS.87/0087	3.54[b]	2.26[c]
CIPM 3	3.85[a]	2.36[c]
CIPM 31	1.66[d]	3.92[a]
Ex-igbariam	2.28[c]	3.70[b]
CV (%)	12.54	3.67

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's new multiple-range test)

Table 7: Meteorological data for 2013

	Climatic factors						
				Temp. (°C)		Solar	
Months	Rainfall (mm)	Rainy days	Relative humidity (%)	Maximum	Minimum	radiation (Jm^{-2} day^{-1})	Sunshine (h)
Jan.	0.00	0.00	23.03	26.44	11.17	14.20	7.44
Feb.	0.00	0.00	14.13	24.58	12.68	16.70	7.37
Mar.	1.30	1.00	23.87	28.90	18.58	17.80	7.93
Apr.	34.80	5.00	39.66	26.90	18.60	17.10	5.83
May	155.30	16.00	60.69	24.90	18.74	15.50	5.89
Jun.	138.20	18.00	65.36	22.50	16.85	14.12	5.20
Jul.	290.20	22.00	81.51	23.66	18.19	8.30	3.20
Aug.	322.50	24.00	80.06	23.79	17.80	8.70	1.96
Sep.	264.00	14.00	69.86	26.10	16.95	10.30	2.12
Oct.	73.70	6.00	48.29	27.12	15.17	16.10	7.10
Nov.	0.00	0.00	18.40	29.05	12.23	15.80	8.10
Dec.	13.40	1.00	23.12	28.91	11.95	16.70	7.90
Total	1293.40	107.00	547.98	312.85	176.23	171.32	70.04
Mean	107.78	8.92	45.67	26.07	14.69	14.28	5.84

Source: Irish Potato Programme, Kuru, Plateau State, Nigeria. (latitude 09°44'N, longitude 08°47'E, altitude 1,293.2 m amsl)

CIPM 31 and Ex-Igbariam. The clone with the highest pollen viability percentage was observed in CIPM 31 (85.03%) whereas, the lowest was observed in clone TIS.2532.OP.1.13 (71.19%) (Table 5).

Mean seed weight: The mean seed weight ranged from 1.66 g in clone CIPM 31 to 3.91g in clone TIS.2531.OP.1.13. Seed weights were similar in clones CIPM 3 and TIS.2531.OP.1.13 (Table 6).

Mean seed size: The mean seed size was highest in clone CIPM 31 (3.92 mm) followed by clones Ex-Igbariam (3.70 mm) and CIPM 3 (2.36 mm). Seed size in clones TIS.2532.OP.1.13, TIS.87/0087 and CIPM 31 did not differ significantly at 5% level of probability (Table 7).

DISCUSSION

Variations in the number of days to the onset of flowering amongst the clones could be attributed to both genotypic and environmental influences. On the basis of photoperiodic response, crops are categorized into long-day, short-day or day-neutral. Roberts *et al*. (1996) noted that when

the critical photoperiod is exceeded, flowering is delayed. The delay increases with photoperiod, until a ceiling period (Pce) is reached. In photoperiods longer than the ceiling, there is no response to either the number of days to onset of flowering or the rate of flowering. In this study, the clone CIPM 31, which took the longest time to flower, might be described as having poor sensitivity to photoperiod. Chung and Myeong (1996) demonstrated the effect of photoperiod on flowering using four sweet potato clones, which flowered following treatment with 9-11 h day length of more than three weeks of consecutive short-day. Two of the clones required seven weeks of consecutive short-day treatment to flower, while one required three weeks. The fourth clone showed no flowering response regardless of the duration of day-length treatment. Clones that flowered late took a longer time to transit from the vegetative to reproductive phase.

Variations in the mean number of flowers and rate of flowering depend on the length of time in which new flowers are produced as well as the length of life of individual flowers (Rieger and Sedgley, 1996).

The high pollen viability (ranging from 85.03% in clone CIPM 31-71.19% in clone TIS.2532.OP.1.13) in this study indicates that the Jos-Plateau environment is suitable for both flower production and pollen viability in sweet potato. Weaver and Timm (1989) reported that pollen viability played a major role in determining fruit-set and that it could serve as a basis for selecting clones with potentials of high production and seed-setting. The clone which took the longest time to flower (CIPM 31) had the highest pollen viability while, the clone that took the shortest time to flower (TIS.2532.OP.1.13) had the lowest pollen viability (Compare Table 2 and 5). This could be attributable to negative correlation between onset of flowering and pollen viability. The low temperatures in Jos-Plateau environment (Table 7) might have contributed to the high pollen viability as has been reported by Mes and Menge (1954).

The mean number of seeds, seed weight and seed size varied with clone, suggesting that these traits were genotypic. A similar observation was reported by Lardizabal and Thompson (1990).

CONCLUSION

Results of this study showed that all the clones used, flowered and produced seeds to varying degrees. The clone CIPM 31 flowered late and produced low numbers of flowers and seeds. The clone TIS.2532.OP.1.13 recorded the highest mean number of flowers and seed weight. The study showed that the pattern of flowering and the potential for seed production in the sweet potato varied with clone. Therefore, there are prospects for improving the sweet potato through hybridization n Jos-Plateau environment.

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