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Relationship between tuber number and tuber size in reciprocal grafts of some sweet potato (*ipomoea batatas (*L.) Lam.) clones

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ABSTRACT

Six sweet potato clones, Ex-Igbariam, TIS.87/0087, TIS.2532.OP.1.13, CIP 4400168, TIS.86/0356 and TIS.2544 Rusanya 1.5, were used in a reciprocal grafting study during the wet season of 2003. The study was aimed at relating the tuber number to tuber size and the total tuber yield. Thirty-six (36) treatments were distributed to the plots using the randomized compete bock design with four replications. Results showed that tuber length and tuber girth were negatively, although non-significantly correlated with mean number of tubers/plant with coefficients of correlation of -0.234 and -0.004, respectively. Numbers of small and large tubers were positively and significantly correlated with mean number of tubers/plant with coefficients of correlation of 0.990** and 0.381*, respectively. Number of tubers/plant, tuber length, tuber girth, number of large tubers/plant and number of small tubers/plant were highly correlated with total tuber yield, with coefficients of correlation of 0.638**, 0.165, 0.545**, 0.815** and 0.449**, respectively. The study revealed that although tuber number is one of the major components of total yield in sweet potato, its relationship with tuber length and tuber girth appeared to be asymptotic. In selecting sweet potato clones for high yield, therefore, emphasis should be placed not necessarily on tuber number but on tuber size.

INTRODUCTION

The yield of a crop is dependent on the production of assimilates by a source and its accumulation in a sink. The rate of growth of a sink such as storage root and the final size it can attain is determined, partly, by the rate at which nutrients are supplied to it. Sweet potato clones vary in source potentials and sink capacities. Combining clones with high source potentials with those having large sink capacities could increase the activity of the source and the sink so that yield and/or its components are improved (Dahniya, 1979).

Storage root number, final stand count, tuberous root girth, tuber length and fresh weight per tuber have been reported as the major yield components in sweet potato (Mahungu, 1979; Chandra and Tiwari, 1987; Forbes and Watson, 1992).

The importance of the number of tubers per plant, tuber girth and mean tuberous root weight for increasing tuber yield is believed to be greater compared to the other components (Chandra and Tiwari, 1987).

In the present study, an attempt has been made to relate the number of tubers produced per plant to tuber length, tuber girth, number of large and small tubers/plant and to the total tuber yield.

MATERIALS AND METHODS

Grafting trials

Ninety-Six (96) vines of about 20cm long were planted in black polyethylene bags (15X18X24) on May 17, 2003. The bags were filled with topsoil, cowdung and riversand in a ratio of 3:2:1, respectively. Fourteen (14) days after planting (14 DAP), all possible combinations of reciprocal grafts of the six sweet potato clones (Ex-Igbariam, TIS.87/0087, TIS.2532.OP.1.13, CIP 4400168, TIS.86/0356 and TIS.2544 Rusanya 1.5) were made including six self-grafts. The whip-grafting technique was used. Scions and stocks of approximately the same diameter were carefully selected. A diagonal cut was made in a young and actively growing sweet potato used as stock. A short actively growing plant with 3-4 buds was selected and a matching diagonal cut was made with a grafting knife. The pieces were slipped together and wrapped with polyethylene grafting tape. Grafting lasted for about 21 days.

Field trial

After the graft-union has been established, the plants were regularly pruned with a pair of secateurs to remove sprouts from the stock. Hand-weeding was done to keep the pots weed-free.

Grafts were planted out in the field on June 30, 2003.

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Before field-planting, the grafts were carefully removed from the bags and the roots were pruned in order to minimize variation due to differences in dates of grafting and to induce the growth of new strong roots. The trial was conducted at the Vom Garden of the Plateau Agricultural Development Programme (P.A.D.P.), Kuru in Jos-South Local Government Area of Plateau State, Nigeria (Latitude 09°44'N, Longitude 08°47'E and at altitude 1,293.2m above mean sea level). In order to determine the relative contribution of source potential and sink capacity to the tuberous root yield, a yield trial of the six (6) experimental clones without grafting was conducted simultaneously. All the experimental conditions and the design were similar to those of the grafting experiment.

Each plot consisted of four plants, planted at a spacing of 2.0 metres on ridges 1.5 metres apart(13,333 plants/hectare). This plant density was adopted to allow for close monitoring of each graft. A randomized complete block design was used with four replications.

Hoe-weeding was carried out at 25 and 51 DAP and at 57 DAP the plots were earthed up with a hand-hoe. This was followed by hand-weeding at 87 DAP. Grafts were continually pruned to remove sprouts from the stock or tubers from the scion, so that only the scions produced leaves (source) while the stock produced tuberous roots(sink).

The plots were harvested at 150 DAP. The total number of tubers harvested from each plot was divided by the number of plant stands at harvest to obtain the mean number of tubers/plant. Tuber length was measured from the bottom to the tip of the tubers sampled while girth of tuber was measured at the widest portion of the tubers. The number of large tubers (tubers above 50mm) in each plot was divided by the number of plant stands at harvest to obtain the mean number of large tubers/plant. The same thing was done with the number of small tubers (tubers below 50mm). The weight of the tubers harvested from each plot was extrapolated to the equivalent in tonnes per hectare before the analysis. Mean number of tubers/plant was correlated with tuber length, tuber girth, number of large and small tubers/plant; these yield components were also correlated with total tuber yield.

RESULTS

Number of tubers/plant

The self-graft of clone Ex-Igbariam produced the highest average number of tubers/plant; the combination of clones TIS.2532.OP.1.13 (stock) and TIS.86/0356 (scion) resulted in the lowest number of tubers/plant (Table 1). Clone TIS.2544 Rusanya 1.5 had the highest mean stock effect of 4.8 tubers/plant, which differed significantly (P=0.05) from the other clones. Clone Ex-Igbariam had the highest mean scion effect on mean number of tubers/plant.

Tuber length

The longest tubers were produced when clone Ex-Igbariam as stock was combined with TIS.2532.OP.1.13 as scion. The combination of clones TIS.87/0087 (stock) and TIS.86/0356 (scion) resulted in the production of the shortest tubers (Table 2). Clone 87/0087 had a significantly lower mean stock effect than the other clones except TIS.2544 Rusanya 1.5 (Table 2).

Tuber girth

The largest tubers, with a mean tuber girth of 24.1cm, were produced in the graft-combination of clone TIS.2544 Rusanya 1.5 as stock and clone CIP 4400168 as scion; the combination of clones Ex-Igbariam (stock) and TIS.86/0356 (scion) yielded the smallest tubers with a mean tuber girth of 11.0cm (Table 3).

Number of large tubers/plant

Table 4 shows mean number of large tubers produced per plant. The highest number of large tubers was observed in the self-graft of clone Ex-Igbariam, the graft-combinations of clones TIS.2544 Rusanya 1.5(stock) and TIS.2532.OP.1.13 (scion) as well as clones TIS.2532.OP.1.13 (stock) and TIS.2544 Rusanya 1.5 (scion). The lowest number of large tubers/plant was produced in the graft-combination of clones Ex-Igbariam as stock and TIS.86/0356 as scion.

Number of small tubers/plant

The self-graft of clone Ex-Igbariam produced the highest number of small tubers/plant while the lowest was observed in the cross involving clones CIP 4400168 (stock) and TIS.2532.OP.1.13 (scion). Clones Ex-Igbariam and TIS.2544 Rusanya 1.5 had a significantly higher mean stock effect on number of small tubers than the other clones (Table 5).

Interaction of stock and scion on mean number of small tubers/plant was significant at 5% level of probability. The highest mean stock effect was observed in clones TIS.2544 Rusanya 1.5 and Ex-Igbariam, followed by TIS.87/0087. On the other hand, Ex-Igbariam had the highest mean scion effect, followed by clones TIS.87/0087 and TIS.86.0356 (Table 5).

Total tuber yield

Clone TIS.2544 Rusanya 1.5 had a very large sink capacity with a mean stock effect of 28.5t/ha. CIP 4400168 showed a very high source potential with a mean scion effect of 24.6t/ha. Differences in the mean stock and mean scion effects were significant (Table 6).

Table 1. Mean number of tubers per plant of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	7.4[a]	4.2[bc]	2.8[bc]	2.9[bc]	4.6[abc]	3.0[bc]	4.2
TIS.87/0087	3.9[bc]	5.4[ab]	3.3[bc]	2.9[bc]	4.8[abc]	3.0[bc]	3.9
TIS.2532.OP.1.13	2.7[bc]	2.7[bc]	3.0[bc]	2.4[bc]	1.7[c]	3.7[bc]	2.7
CIP 4400168	4.4[bc]	2.7[bc]	3.0[bc]	4.6[abc]	2.3[bc]	3.3[bc]	3.4
TIS.86/0356	2.3[bc]	3.0[bc]	3.5[bc]	3.0[bc]	2.8[bc]	2.9[bc]	2.9
TIS.2544 Rusanya 1.5	4.0[bc]	5.3[ab]	5.1[ab]	4.7[abc]	4.4[bc]	5.4[ab]	4.8
Mean scion (source) effect	4.1	3.9	3.5	3.4	3.4	3.6	

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

Figures underlined are for self-grafts.

Table 2. Mean tuber length (cm) of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	14.8^{abc}	13.4^{abc}	18.7^{a}	10.5^{abc}	9.5^{bc}	13.5^{abc}	13.4
TIS.87/0087	9.6^{bc}	10.9^{bc}	11.5^{bc}	9.4^{bc}	8.3^{c}	10.4^{bc}	10.0
TIS.2532.OP.1.13	13.8^{abc}	10.8^{bc}	14.9^{abc}	14.7^{abc}	12.1^{abc}	12.3^{abc}	13.1
CIP 4400168	14.3^{abc}	12.2^{abc}	14.1^{abc}	13.8^{abc}	14.6^{abc}	12.1^{abc}	13.5
TIS.86/0356	14.1^{abc}	10.7^{bc}	11.9^{abc}	16.0^{ab}	11.3^{bc}	16.1^{ab}	13.4
TIS.2544 RUSANYA 1.5	12.3^{abc}	10.5^{bc}	11.7^{bc}	11.7^{bc}	10.4^{bc}	10.6^{bc}	11.2
Mean scion (source) effect	13.2	11.4	13.8	12.7	11.0	12.5	

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

Figures underlined are for self-grafts.

Table 3. Mean tuber girth (cm) of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	15.5^{bcdef}	15.1^{bcdef}	18.9^{abcd}	17.4^{abcdef}	11.0^{f}	16.6^{bcdef}	15.8
TIS.87/0087	15.1^{bcdef}	17.4^{abcdef}	17.6^{abcdef}	19.2^{abcd}	13.3^{cdef}	15.9^{bcdef}	16.4
TIS.2532.OP.1.13	15.4^{bcdef}	11.6^{ef}	18.3^{abcd}	21.7^{ab}	14.0^{cdef}	18.4^{abcde}	16.6
CIP 4400168	15.5^{bcdef}	12.8^{def}	18.7^{abcd}	15.0^{bcdef}	14.8^{bcdef}	15.4^{bcdef}	15.4
TIS.86/0356	19.9^{abc}	14.8^{bcdef}	19.3^{abcde}	18.8^{abcd}	15.7^{bcdef}	17.1^{bcdef}	17.6
TIS.2544 RUSANYA 1.5	19.8^{abcd}	17.9^{abcde}	17.7^{abcdef}	24.1^{a}	18.4^{abcde}	17.3^{abcdef}	19.2
Mean scion(source) effect	16.9	14.9	18.4	19.4	14.5	16.8	

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

Figures underlined are for self-grafts.

Table 4. Mean number of large tubers(>50mm) per plant of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	0.6[a]	0.5[ab]	0.3[abc]	0.3[abc]	0.0[d]	0.2[bcd]	0.3
TIS.87/0087	0.3[abc]	0.5[ab]	0.2[bcd]	0.3[abc]	0.1[cd]	0.2[bcd]	0.2
TIS.2532.OP.1.13	0.2[bcd]	0.2[bcd]	0.5[ab]	0.5[ab]	0.1[cd]	0.6[a]	0.3
CIP 4400168	0.4[abc]	0.1[cd]	0.4[abc]	0.4[abc]	0.3[abc]	0.3[abc]	0.3
TIS.86/0356	0.5[ab]	0.3[abc]	0.5[ab]	0.5[ab]	0.4[abc]	0.3[abc]	0.4
TIS.2544 RUSANYA 1.5	0.5[ab]	0.4[abc]	0.6[a]	0.5[ab]	0.3[abc]	0.5[ab]	0.5
Mean scion(source) effect	0.4	0.3	0.4	0.4	0.2	0.3	

Values are detransformed weighted means.

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

Figures underlined are for self-grafts.

Table 5. Mean number of small tubers (<50mm) per plant of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	4.3[a]	2.0[abcdefg]	1.0[efgh]	1.4[bcdefgh]	2.9[abc]	1.5[bcdefgh]	2.2
TIS.87/0087	2.0[abcdefg]	2.9[abc]	1.7[bcdefgh]	1.4[bcdefgh]	3.1[ab]	1.6[bcdefgh]	2.1
TIS.2532.OP.1.13	1.4[bcdefgh]	1.3[bcdefgh]	1.1[defgh]	\0.7[gh]	0.8[fgh]	1.4[bcdefgh]	1.1
CIP 4400168	2.3[abcdef]	0.9[fgh]	0.5[h]	1.5[bcdefgh]	1.2[cdefgh]	1.5[bcdefgh]	1.3
TIS.86/0356	0.9[fgh]	1.8[bcdefgh]	1.8[bcdefgh]	1.1[cdefgh]	1.3[bcdefgh]	1.4[bcdefgh]	1.4
TIS.2544 RUSANYA 1.5	1.5[bcdefgh]	2.8[abcd]	2.7[abcde]	2.2[abcdefg]	1.3[abcde]	2.9[abc]	2.2
Mean scion(source) effect	2.1	2.0	1.5	1.4	1.8	1.7	

Values are detransformed weighted means

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

Figures underlined are for self-grafts.

Table 6. Total tuber yield (t/ha) of reciprocal grafts of six sweet potato clones

	SCION						
STOCK	EX-IGBARIAM	TIS.87/0087	TIS.2532.OP.1.13	CIP 4400168	TIS.86/0356	TIS.2544 RUSANYA 1.5	MEAN STOCK (SINK)EFFECT
EX-IGBARIAM	42.2[a]	25.4[abcde]	8.7[cdef]	18.0[bcdef]	7.3[def]	14.8[bcdef]	19.4
TIS.87/0087	14.8[bcdef]	29.2[ab]	15.8[bcdef]	12.1[bcdef]	8.5[cdef]	7.7[cdef]	14.7
TIS.2532.OP.1.13	7.0[ef]	6.3[f]	29.3[ab]	28.2[ab]	9.1[cdef]	26.3[abc]	17.7
CIP 4400168	21.7[bcdef]	8.8[cdef]	12.5[bcdef]	22.0[bcdef]	12.1[bcdef]	16.7[bcdef]	15.6
TIS.86/0356	13.7[bcdef]	14.3[bcdef]	19.6[bcdef]	26.1[abcd]	15.3[bcdef]	18.8[bcdef]	18.0
TIS.2544 RUSANYA 1.5	22.8[bcdef]	26.1[abcd]	30.8[ab]	41.2[a]	21.2[bcdef]	28.7[ab]	28.5
Mean scion(source) effect	20.4	18.4	19.5	24.6	12.3	18.8	

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

Figures underlined are for self-grafts

A significant stock and scion interaction on total tuber yield was observed. Whereas clone TIS.2544 Rusanya 1.5 had the highest mean stock effect, clone CIP 4400168 had the highest mean scion effect on total tuber yield (Table 6). Combining clones TIS.2544 Rusanya 1.5 as stock with CIP 4400168 as scion resulted in a very high tuber yield of 41.2 t/ha. Results of the yield trial of the six clones without grafting are presented in Table 7. Clone TIS.2544 Rusanya 1.5 with a total tuber yield of 36..3t/ha differed significantly (P=0.05) from the rest of the clones in its sink capacity.

Table 7. Mean tuber yields of twelve plants for six sweet potato clones without grafting.

Clone	Yield (t/ha)
TIS.2544 Rusanya 1.5	36.3[a]
TIS.87/0087	26.7[b]
Ex-Igbariam	26.3[b]
TIS.86/0356	25.3[b]
TIS.2532.OP.1.13	21.8[b]
CIP 4400168	20.5[b]

Correlation of tuber number/plant with some yield components

Tuber length and tuber girth were negatively correlated with mean number of tubers/plant with coefficients of correlation of -0.234 ($\hat{Y}$ = 14.055 – 0.446X) and -0.004 ($\hat{Y}$ = 16.759 – 0.009X), respectively. Number of large and small tubers/plant were positively correlated with mean number of tubers/plant with coefficients of correlation of 0.381* ($\hat{Y}$ = 0.170 + 0.051X) and 0.900**($\hat{Y}$ = -0.539 + 0.622X), respectively.

Correlation of Some Yield Components with Total Tuber Yield

Number of tubers/plant, tuber length, tuber girth, number of large tubers/plant and number of small tubers/plant were positively correlated with total tuber yield with coefficients of correlation, respectively, of 0.638** ($\hat{Y}$ = 0.602 + 5.045X), 0.165 ($\hat{Y}$ = 10.455 + 0.685X), 0.545**($\hat{Y}$ = -12.702 + 1.884X), 0.815**($\hat{Y}$ = 1.866 + 48.119X) and 0.449**($\hat{Y}$ = 10.115 + 5.136X).

DISCUSSION AND CONCLUSION

The self-graft of Ex-Igbariam produced the highest number of tubers/plant. Clone Ex-Igbariam as stock when combined with clone TIS.2532.OP.1.13 as scion produced tubers which were significantly longer than those produced in the other graft-combinations. The largest tubers were produced in the graft involving clones TIS.2544 Rusanya 1.5(stock) and CIP 4400168(scion). The highest mean stock effects on tuber length and tuber girth were observed in clones CIP 4400168 and TIS.2544 Rusanya 1.5, respectively. Clone CIP 4400168 showed the highest mean scion effect on tuber girth.

Tuber length, tuber girth and mean number of tubers/plant have been reported as the major components of total tuber yield in sweet potato(Mahungu, 1979; Chandra and Tiwari, 1987; Forbes and Watson,1979). These components appeared to have been influenced by the size and activity of the source and the sink. Clone TIS.2544 Rusanya 1.5 with a large sink capacity showed the highest mean stock effect on number of tubers/plant and tuber girth. Similarly, clone CIP 4400168, which showed a very high source potential, had the highest mean scion effect on tuber length and tuber girth. The significant interaction of stock and scion on mean number of tubers/plant indicates that source and sink sizes can easily be exchanged through reciprocal grafting in order to increase the number and size of tubers.

Results of this study also indicate differences in the source potentials and sink capacities of the six clones. Clone TIS.2544 Rusanya 1.5 had a very large sink capacity but a poor source; clone CIP 4400168 with a very high source potential was apparently limited by a poor sink capacity. This implies that a clone with a large sink capacity may be limited by a poor source potential. The self-graft of TIS.2532.OP.1.13, for example, ranked amongst the highest yielders, but when it was grafted with clone TIS.87/0087 (with a poor source) as scion, the lowest tuber yield of 6..3t/ha was observed. On the other hand, the combination of clone TIS.2544 Rusanya 1.5 (with a large sink capacity) with clone CIP 4400168 (with a high source potential) resulted in a high tuberous root yield of 41.2t/ha.

The high correlation observed between tuber number, tuber girth, large tubers, small tubers and the total tuber yield indicates that any factor that enhances these yield components is likely also to increase total tuber yield in the sweet potato. The study revealed that although number of tubers/plant is a major yield component, its relationship with tuber length and tuber girth appeared to be asymptotic. In selecting sweet potato clones for high yield, therefore, emphasis should be placed not necessarily on tuber number but on tuber size

REFERENCES

Chandra, A. and Tiwari, J.P.(1987). Productivity potential of sweet potato (*Ipomoea batatas* Poir) *J.Root Crops. 13*(2): 95-101.

Dahniya, M.T. (1979). Defoliation and Grafting Studies of Cassava (*Manihot esculenta* Crantz) and Sweet potatoes (*Ipomoea batatas* L.) *Ph.D. Thesis. University of Ibadan, Ibadan, Nigeria*.

Forbes, J.C. and Watson, R.D. (1992). *Plants in Agriculture.*

Cambridge University Press, The Pitt. Building, Trumpington Street, Cambridge. 355pp.

Mahungu, N.M. (1979). Relationship between fresh tuberous root yield and its components in sweet potato (*Ipomoea batatas* (L.) Lam). *M.Sc. Thesis*. University of Ibadan, Ibadan, Nigeria.