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INVESTIGATION OF SOURCE-SINK RELATIONSHIP IN SWEET POTATO BY RECIPROCAL GRAFTS

LIANG LI and CHING-HUEI KAO[1]

Chiayi Agricultural Experiment Station
Taiwan Agricultural Research Institute
Chiayi, Taiwan, Republic of China

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Abstract

The source-sink relationship of four sweet potato lines with different agronomic characteristics was investigated by means of reciprocal grafts. There were marked differences in the sink capacity and source potential of the lines. Both source potential and sink capacity are important in determining the yield of sweet potato. Howeveve, the contribution of source potential and sink capacity seems to be dependent upon the growth period of sweet potato.

Key words: Reciprocal graft; sink capacity; source potential; sweet potato.

Introduction

The yield of a crop is dependent on the production of assimilates by a "source" and the degree of accumulation in a "sink". In sweet potato (*Ipomoea batatas* L.), the tuberous roots which accumulate assimilates are the predominant sink and the shoots, mainly leaves, which produce assimilates are the source. Attemps have been made to study source-sink relations by changing the sizes of both source and sink. Source size has been varied by removing leaves, while sink size has been varied either by exposing the tuberous roots to light (Tsnno and Fujise, 1965) or to different temperatures (Spence and Humphries, 1972) or by removing the tuberous roots and by treating with growth regulators (Spence and Humphries, 1972). Treatments as such described above may have an adverse effect on physiological processes. In order to minimize interference with these processes, reciprocal grafts have been used.

Using reciprocal grafts, it has been inferred that the yield of sweet potato was determined primarily by the sink capacity rather than the source potential (Hozyo,

[1] Department of Agronomy, National Taiwan University, Taipei, Taiwan, Republic of China.

1970; Wilson, 1967). However, Hahn (1977) reported that both photosynthetic source potential and storage root sink capacity were important in determining final yield of sweet potato.

In the present investigation, four sweet potato lines were grafted in all combinations to study source-sink relationships.

Materials and Methods

Four sweet potato lines were used in this investigation. From each line, slips with 30 cm long were planted in a greenhouse. One week later, when slips were rooted, all possible combinations of reciprocal grafts for the four lines were made including four self-grafts. They were grown for about one week. Successful grafts were then planted in the field on August 11, 1983. Randomized complete-block design with four replications was used. Each plot consisted of two rows 1 m aparts and 15 plants on each row. Plants were spaced 30 cm apart in rows. Each plot received fertilizers in the amounts equivalent to 40-30-100 kg/ha of N-P_2O_5-K_2O. The plants were harvested 2, 4 and 6 months after planting and dried in the oven at 90°C for 2 days. Dry tuberous root yield and dry top weight were obtained. In this study only dry root yield data were analyzed.

Another experiment with the same grafting procedure described above was conducted. Successful grafts were planted on September 10, 1983. For this experiment, plants were harvested 5 months after planting.

The source potentials (mean scion effect) and the sink capacities (mean stock effects) for each of the four lines were computed according to Hahn (1977).

Results

Table 1 shows the yield of dry tuberous roots and top/root ratio of four sweet

Table 1. *Yield of dry tuberous root and top/root ratio of four sweet potato lines used for reciprocal grafts*

Sweet potato was planted in 1982 and 1983, respectively. Top/root ratio was calculated on fresh weight basis.

Line	Five-month-yield (kg/ha)		Top/root ratio	
	1982	1983	1982	1983
C70-245	8.9	9.9	0.55	0.64
C70-200	7.6	8.1	1.08	1.57
C70-311	8.1	8.0	0.52	0.81
C70-105	4.5	6.7	1.35	1.02

potato lines from the experiments conducted in 1982 and 1983, respectively. Among four lines tested, line C70-245 had the highest yield of dry tuberous roots. As for leaf size, lines C70-245 and C70-311 were larger than lines C70-105 (Fig. 1).

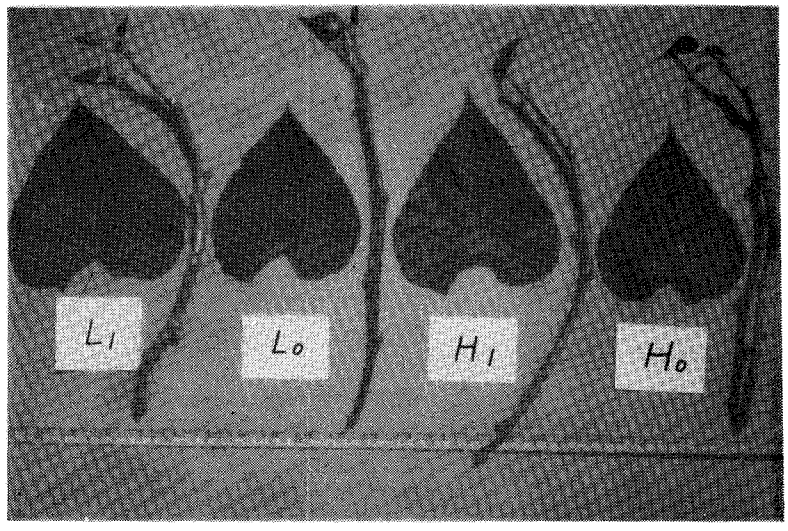

Fig. 1. Typical size of fully expanded leaf of four sweet potato lines used for reciprocal grafts. H_1, H_0, L_1, and L_0 refer to line C70-245, C70-200, C70-311, and C70-105, respectively.

The dry tuberous root yield of different growth periods was analyzed statistically and is summarized in Tables 2 to 4. According to Hahn (1977), the source potential (X_1) of a variety is defined as its mean stock effect and the sink capacity (X_2) is mean scion effect. By this definition, it can been seen from Tables 2 to 4 that no matter how long the growth period was, lines C70-200 and C70-105 demonstrated poor source potentials and sink capacities. Line C70-311, on the other hand, had a poor source potential but good sink capacity irrespective of growth period. As for line C70-245, good source potential and low sink capacity was observed at 2-month-growth period. When growth period was extended, line C70-245 showed both good source potential and sink capacity.

When line C70-245 and line C70-311 were used as scion and stock, respectively, on each of the other lines, dry tuberous root yield was in every case higher than the self-graft of each line irrespective of growth period (Tables 2-4).

To determine the relative contribution of source potential (X_1) and sink capacity (X_2) to the tuberous root yield (Y), the standard partial regression coefficients of X_1 on $Y(Pyx_1)$ and X_2 on $Y(Pyx_2)$ were calculated. Fig. 2 shows that when growth period was two or four months, source potential seemed to be more important

Table 2. *Two-month-yield (g/plant) of dry tuberous roots of reciprocal grafts of four lines*

Scion	Stock				Mean scion (source) effect
	C 70-245	C 70-200	C 70-311	C 70-105	
C 70-245	6.5*	3.4	28.8	2.0	10.2^{c}**
C 70-200	0.8	1.6	5.0	1.1	2.1^{a}
C 70-311	1.0	1.9	2.9	0.8	1.7^{a}
C 70-105	2.6	2.3	15.6	1.0	5.4^{b}
Mean stock (sink) effect	2.7^{a}**	2.3^{a}	13.1^{b}	1.2^{a}	4.8

* The figures underlined are for self grafts.

** Means with the same letter are not significantly different by Duncan's New Multiple Range Test (P=0.01).

Table 3. *Four-month-yield (g/plant) of dry tuberous roots of reciprocal grafts of four lines*

Scion	Stock				Mean scion (source) effect
	C 70-245	C 70-200	C 70-311	C 70-150	
C 70-245	100.9*	76.8	129.2	35.8	85.7^{b}**
C 70-200	59.4	27.6	110.8	7.1	51.2^{a}
C 70-311	60.3	38.8	59.0	21.3	44.9^{a}
C 70-105	39.6	13.5	102.5	8.3	41.0^{a}
Mean stock (sink) effect	65.1^{c}**	39.9^{b}	100.4^{d}	18.1^{a}	55.7

* The figures underlined are for self grafts.

** Means with the same letter are noe significantly different by Duncan's New Multiple Range Test (P=0.01).

Table 4. *Six-month-yield (g/plant) of dry tuberous root of reciprocal grafts of four lines*

Scion	Stock				Mean scion (source) effect
	C 70-245	C 70-200	C 70-311	C 70-105	
C 70-245	206.3*	132.4	206.3	113.0	164.5^{c}**
C 70-200	150.3	61.5	164.6	95.8	118.0^{b}
C 70-311	127.7	114.8	156.5	76.5	118.9^{b}
C 70-105	81.3	41.5	153.4	66.8	85.7^{a}
Mean stock (sink) effect	141.4^{b}**	87.5^{a}	170.2^{c}	88.0^{a}	121.8

* The figures underlined are for self grafts.

** Means with the same letter are not significantly different by Duncan's New Multiple Range Test (P=0.01).

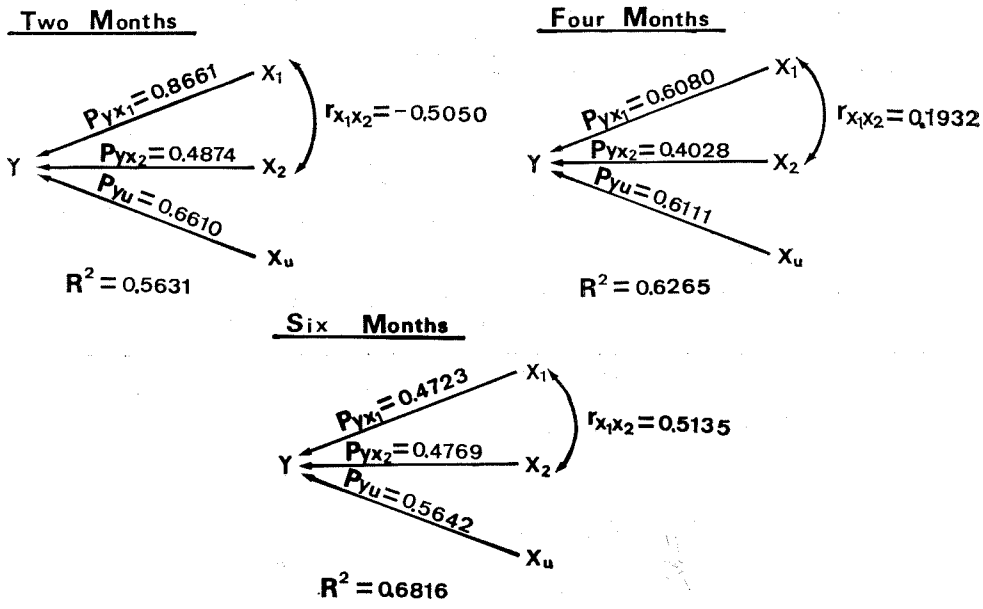

Fig. 2. Effect of source potential (X_1), sink capacity (X_2) and unknown factors (X_u) on dry tuberous root yield (Y) at different growth period. Pyx_1 refers to standard partial regression coefficient of X_1 on Y, Pyx_2 to that of X_2 on Y and Pyu to that of X_u on Y. $r_{x_1x_2}$ refers to simple correlation coefficient between X_1 and X_2.

than sink capacity in determining sweet potato tuberous root yield. However, source potential and sink capacity were equally important in determining yield, when growth period was extended to six months. The data of coefficient of determination clearly showed that the contribution of the combined effect of source and sink was increased as growth period was extended. Fig. 2 also shows that other unknown factors contributed to the determination of tuberous root yield, contribution of unknown factors decreased when growth period extended.

In order to determine whether the planting date would affect the source-sink relationships, another experiment was conducted. The planting date of this experiment was about one month later than that of the previous experiment. Results were shown in Table 5 and Fig. 3 and in general similar to those data of four-month yield shown in Table 4 and Fig. 2.

Discussion

Using reciprocal grafts, Hozyo (1970) and Wilson (1967) suggested that yield was determined primarily by the sink capacity rather than source potential of the sweet potato plant. Hahn (1977), on the other hand, has inferred that both source potential and sink capacity can be rate limiting of yield with the later more

Table 5. *Five-month-yield (g/plant) of dry tuberous root of reciprocal grafts of four lines*

Scion	Stock				Mean scion (source) effect
	C70-245	C70-200	C70-311	C70-105	
C70-245	237.1*	169.1	176.6	145.5	182.3^{b**}
C70-200	144.0	116.3	203.8	90.9	138.7^{a}
C70-311	179.4	112.8	176.1	129.6	149.5^{ab}
C70-105	172.8	117.3	159.1	84.6	133.4^{a}
Mean stock (sink) effect	183.5^{b**}	128.9^{a}	178.9^{b}	112.6^{a}	151.0

* The figures underlined are for self grafts.

** Means with the same letter are not significantly different by Duncan's New Multiple Range Test (P=0.01).

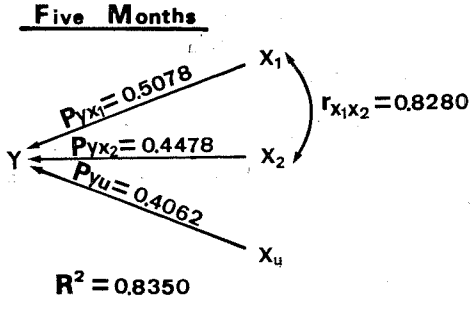

Fig. 3. Effect of source potential (X_1), sink capacity (X_2) and unknown factor (X_u) on dry tuberous root yield (Y). The planting date of this experiment was one month later than that of the experiment shown in Fig. 1. Other legends are similar to those in Flg. 2.

important than the former. Results of our investigation also showed that both source potential and sink capacity are important in determining the yield of sweet potato. However, the contribution of source potential and sink capacity seems to be dependent upon growth period. Source potential seems more limiting than sink capacity when the growth period of sweet potato was 2 and 4 months, but source potential and sink capacity were equally important in determining dry tuberous root yield with a growth period of 6 months.

Results of this experiment indicate that line C70-311 had a poor source potential but good sink capacity, whereas line C70-245 showed both good source potential and sink capacity when growth period was 6 months. This would explain why line C70-245 had the highest yield of dry tuberous roots among four lines tested (Table 1).

Although leaf size of line C70-311 seems to be slightly larger than that of

C70-245 (Fig. 1), line C70-311 always shows poor source potential irrespective of growth period, whereas C70-245 shows good source potential. It, therefore, seems unlikely that leaf size would determine the capacity of source potential.

Judging from the results reported here, those genotypes with larger source potential, sink capacity or both should, therefore, be selected primarily in breeding program with subsequently improvement by incorporating other desirable characteristics.

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甘藷供源 (Source) 與積儲 (Sink) 間關係之研究

李 良[1] 高 景 輝[2]

[1]嘉義農業試驗分所
[2]臺灣大學農藝學系

本研究係利用四個不同特性之甘藷品系，行完全組合相互嫁接，以探討甘藷塊根乾物重係受地下部塊根生長或受地上部莖葉光合作用能力之影響。不同品系間具有不同之供源能力與積儲能力。供源與積儲能力係決定塊根產量之主要因子。不過供源與積儲對塊根產量之貢獻隨着生長期之延長而改變。