The Interrelationship between Photosynthetic Activity and Tuberous Root Growth in Sweet Potato Grafts

Y. Hozyo, K. Shimotsubo and S. Kato
National Institute of
Agricultural Sciences

Abstract

In this paper, we indicated that the promotion or inhibition of the apparent photosynthetic rate in leaf blade is related to tuberous root growth and the cause of change of photosynthetic rate is connected with CO_2 diffusion resistance, nitrogen and carbohydrate content of leaf blade in sweet potato grafts.

Introduction

It is suggested, that the photosynthetic capacity of the leaf blade in sweet potato is related to the thickening property of tuberous roots from the physiological study of plant production (Hozyo & Park, 1971a; Hozyo, Murata & Yoshida, 1971b; Hozyo, 1971c; Hozyo, 1973a; Hozyo & Kato, 1973b; Hozyo & Kato, 1976a; Hozyo & Kato, 1976b).

In this paper, the promotion or inhibition of the apparent photosynthetic rate of leaf blade was related to tuberous root growth and the cause of change of photosynthetic rate was connected with CO_2 diffusion resistance, nitrogen and carbohydrate content of leaf blade in sweet potato grafts. From the experimental results, we elucidated the interrelationship between scion and stock in plant production and the effect of sink to source photosynthetically in sweet potato grafts.

Materials and Methods

Materials. Experiments were conducted in Kitamoto, Saitama, Japan from June to October in 1978. During these months, sunlight conditions in Kitamoto favored maximum plant production.

Grafts were grown in unglazed containers (25 x 25 cm) of soil in natural condition.

Measuring to Photosynthetic Rate. The measuring of apparent photosynthetic rate and transpiration rate in leaf blade was conducted in a measuring room under controlled environment (inside dimension, 1.7 x 1.7 x 1.5 m).

The environmental elements of the measuring room were controlled by automatic controllers and the range of environmental conditions under control were: temperature 20-30°C, relative humidity 50-80%, CO_2 concentration 400-1000 ppm, wind velocity of duct 0-5 m/sec. The artificial light source used was "Yoko lamps" reflected type, 400W (D400) and incandescent lamps, 100W, and light intensity at 100 cm level on the floor was 0.532 cal/cm^2 min (irradiance energy), 38 klx (illuminance), 82 klx (steric illuminance).

Grafts were made as follows:

scion	stock	code	No.
Okinawa No. 100	Okinawa No. 100	0-100/0-100	1
(Ipomoea batatas,	Kanto No. 48	0-100/K-48	2
Poiret)	IB66502	0-100/IB66502	3
	IB66403	0-100/IB66403	4
	IB63005	0-100/IB63005	5
	Okinawa No. 100	IB63005/0-100	6
IB63005	Kanto No. 48	IB63005/K-48	7
(Ipomoea trifida,	IB66502	IB63005/IB66502	8
(H.B.K.) Don. *)*	IB66403	IB63005/IB66403	9
	IB63005	IB63005/IB63005	10

The environmental features during the measurement of apparent photosynthetic rate were: temperature 25°C, relative humidity 50%, irradiance energy 0.482 cal/cm.^{2} min, CO_2 concentration 300 ppm, 800 ppm.

Concurrently with the growth analysis, the age related photosynthetic CO_2 exchange potential was assayed at 15-20 day intervals for 8 replicate fully expanded leaf blades subtending nodal positions designated at the fifth to seventh nodes below the apical bud.

The assimilation chamber used to enclose single leaf blades for measurement was 25 x 22 x 4 cm with acryl resin plate.

The gas exchange measurement was carried out by passing conditioning air (8 liter/min) through a closed system containing the leaf chamber and recording the changes in CO_2 and H_2O concentrations continuously. A fraction of sample gas, 1 liter/min, was withdrawn and pumped through an infrared gas analyzer and another fraction of 1 liter/min, was withdrawn and pumped through an infrared water analyzer.

Leaf temperature was recorded continuously by copper constantan thermocouples attached to the lower surface of the leaf blade. Transpiration was calculated from the change in humidity and the rate of air flow.

Calculation of stomatal resistance (r_s) and metophyll resistance (r_m) followed the method of Lamoreaux & Chaney (1978).

Leaf Blade Analysis. The determinations of chlorophyll a and b, carbohydrate and nitrogen content and stomata number of adaximal, abaximal leaf surface were conducted with the leaf blade used for measuring apparent photosynthetic rate.

Dry Matter Production. Dry matter production and carbohydrate production were measured in grafts on August, September and October, respectively.

Results and Discussion

Dry Matter Production. The results of dry matter production are indicated in Fig. 1. The dry weight of the whole plant was found to be greater in the cultivar scion grafts than in the wild type scion grafts.

In the same scion grafts, the dry weights of whole plants in cultivar stock grafts and IB 66502 stock grafts were superior to the IB 66403 and IB 63005 stock grafts.

The dry weights of tuberous roots in the cultivar scion grafts were greater than that of the wild type scion grafts. In the same scion grafts, the dry weights of tuberous roots in cultivar stock grafts and IB 66502 stock grafts were superior to the IB 66403 and IB 63005 stock grafts.

Photosynthetic Rate. The average photosynthetic rates of leaf blades in grafts are shown in Fig. 3. The apparent photosynthetic rates (P_0) of Okinawa No. 100 and Kanto No. 48 stock grafts indicated similar values from Jun. 29-Sept. 26.

In the case of Okinawa No. 100 scion grafts, the decrease of Po value in IB 66502, IB 66403, IB 63005 stock grafts were found to be compared with the Po values of 0-100/0-100 grafts (control graft). In the case of IB 63005 scion grafts, the increase of Po value of cultivar, IB 66502 stock grafts were regarded to be compared with the Po values of IB 63005/IB 63005 grafts (control graft). It was indicated that the large difference of Po value among grafts were found in changing the kind of stock from cultivars to wild types.

Therefore, it is suggested that a close relationship between the growth of tuberous root and the apparent photosynthetic rate of leaf blade existed in grafts.

Co_2 Diffusion Resistance. It was clear that the metophyll resistance and its tendency was regarded in 300 ppm and 800 ppm CO_2 concentrations, respectively.

The stomatal resistances slightly increased in wild type stock grafts compared with that of the cultivar stock grafts. And also, the metophyll resistances were greater in wild type stock grafts than that of cultivar stock grafts.

From the results, it was considered that the increase of stomatal and metophyll resistance due to the change in kind of stock from cultivars to wild types and the thickening property of tuberous roots affected by CO_2 diffusion resistances in leaf blade.

Leaf Blade Features. The results in Fig.5 show that a positive correlation between apparent photosynthetic rate and nitrogen content in leaf blade, the negative correlation between apparent photosynthetic rate and carbohydrate content exist in grafts.

Conclusion

The facts allowed several conclusions regarding the interrelationship between photosynthetic activity and tuberous root growth.

1. The photosynthetic activity of leaf blade is closely related to the growth of tuberous roots in sweet potato plant. The promotion or inhibition of photosynthetic activity in leaf blade results to vigorous tuberous root growth or inferior tuberous root growth.
2. The change of CO_2 diffusion resistance is affected by the photosynthetic activity in graft. The observed changes in the apparent photosynthetic rate were due to the changes in physical resistance to CO_2 diffusion and the changes of internal photochemical capacity.
3. The change of photosynthates partitioning occurred in grafts due to the effect of stock on the plant production process and photosynthates partitioning affected the carbohydrate and nitrogen contents in leaf blade. These facts were connected with the promotion or inhibition of photosynthetic activity in leaf blade.

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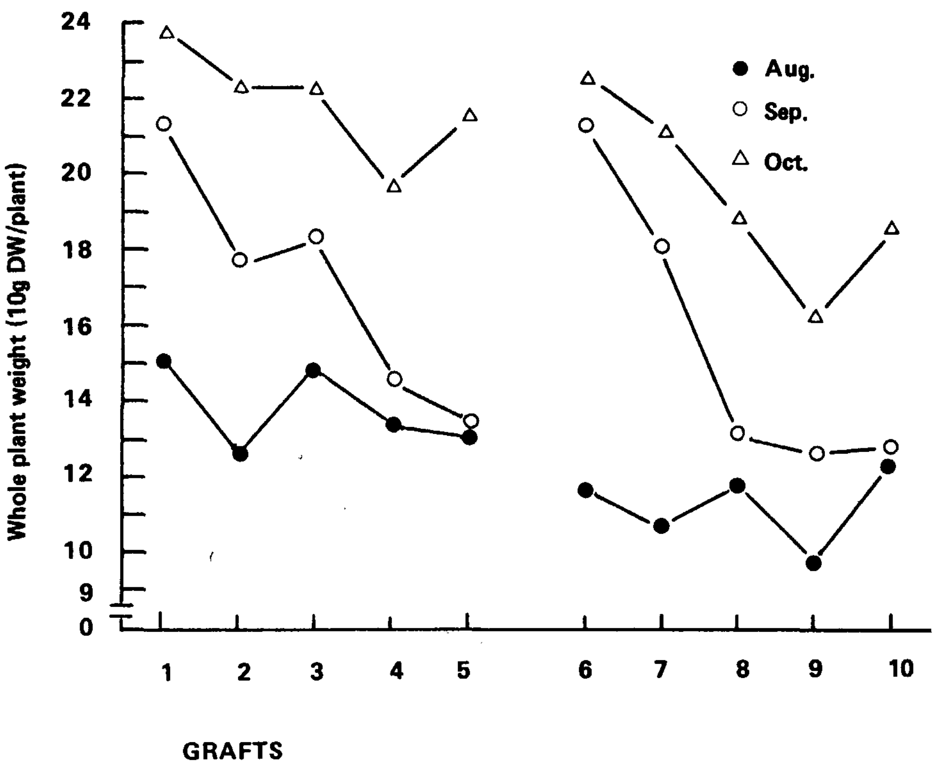

Fig. 1. Dry matter production in grafts.

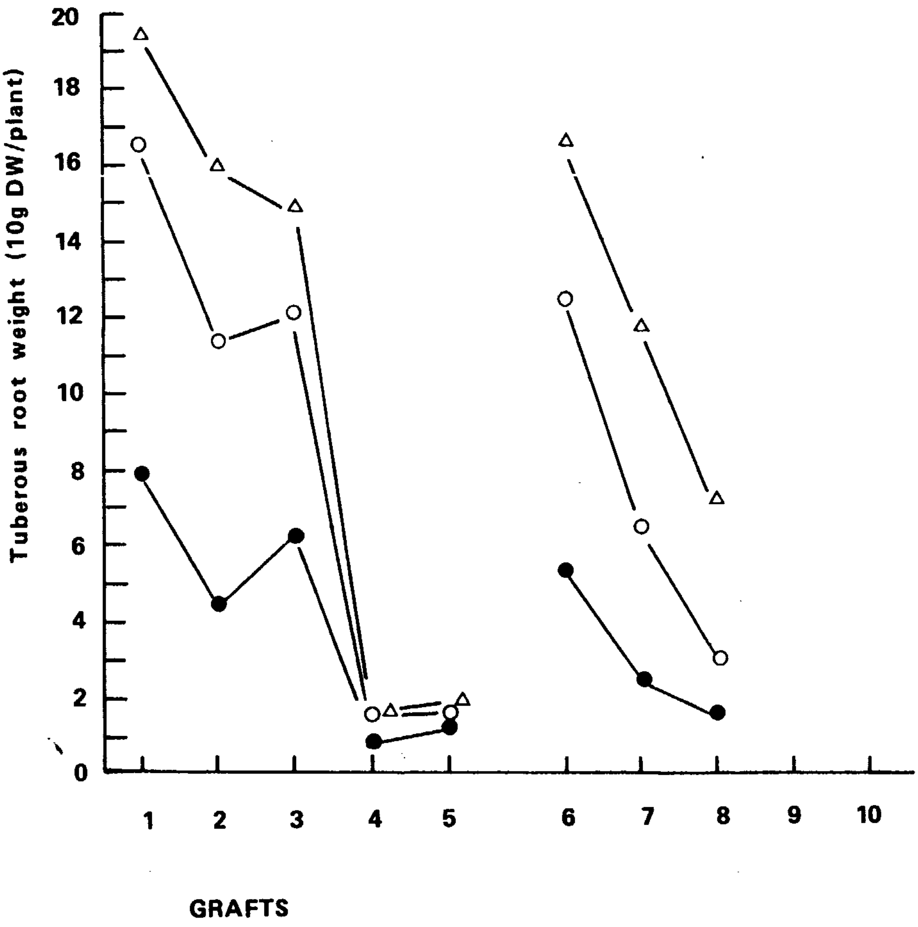

Fig. 2. Tuberous root weight in grafts

Abbreviations used are the same as described in Fig. 1.

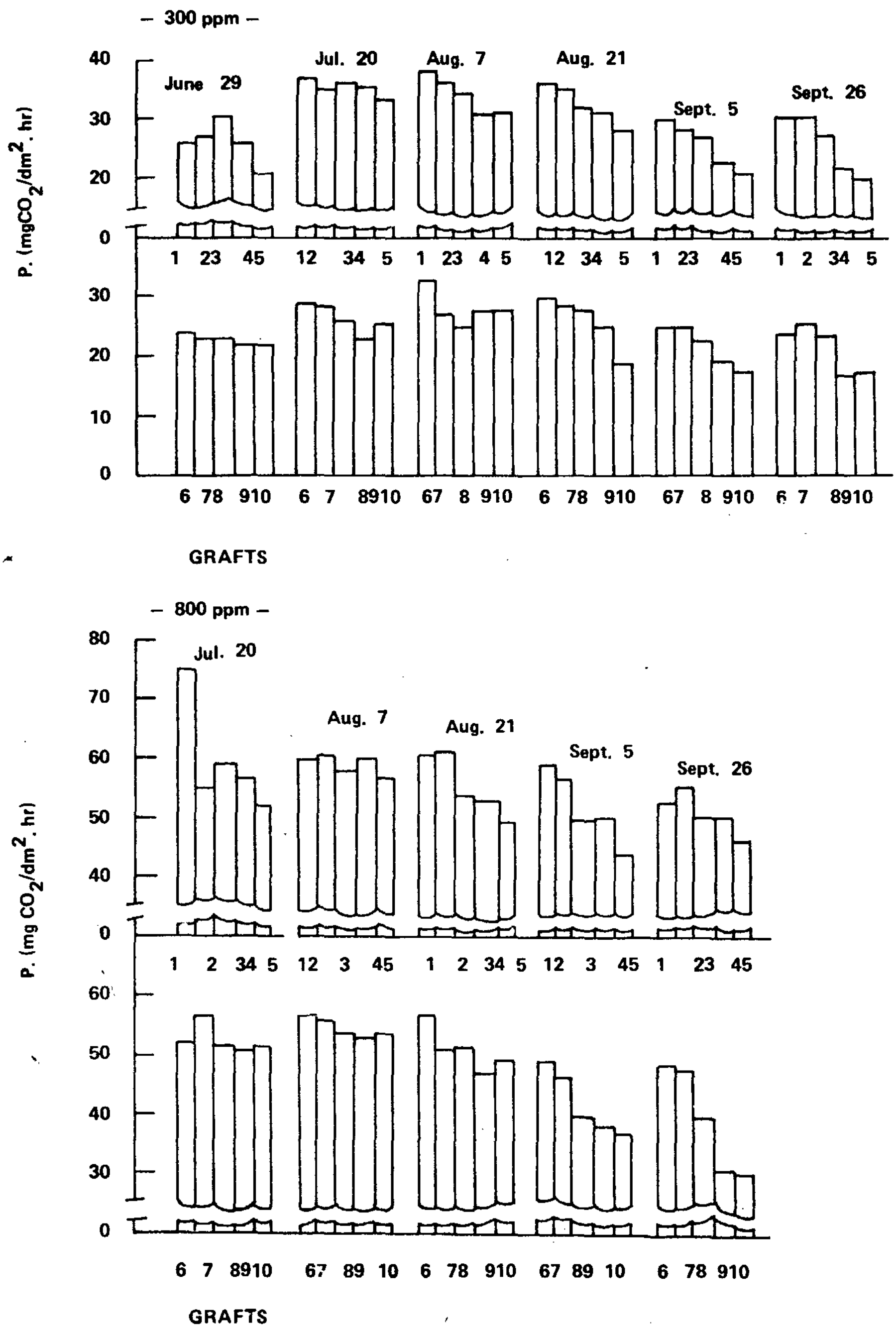

Fig. 3. Apparent photosynthetic rates in grafts

Abbreviations used are the same as described in Fig. 1.

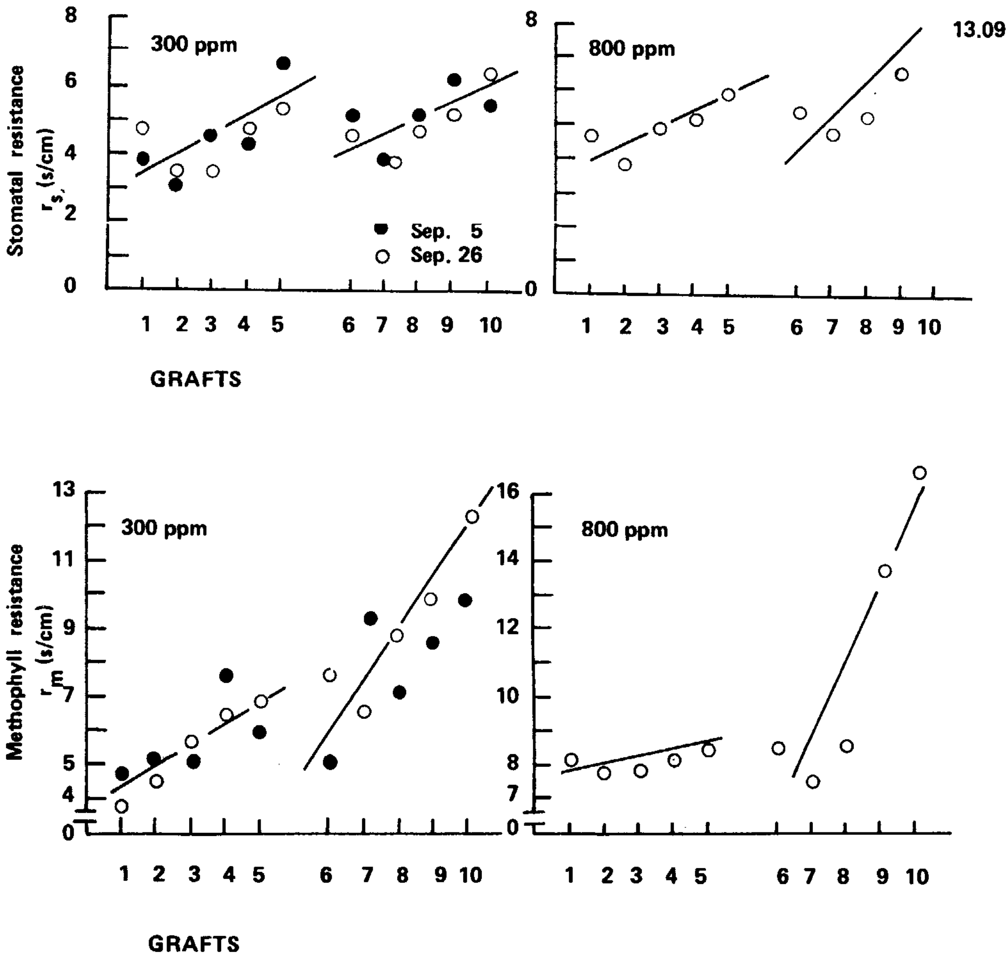

Fig. 4. CO_2 diffusion resistances in grafts.

Abbreviations used are the same as described in Fig. 1.

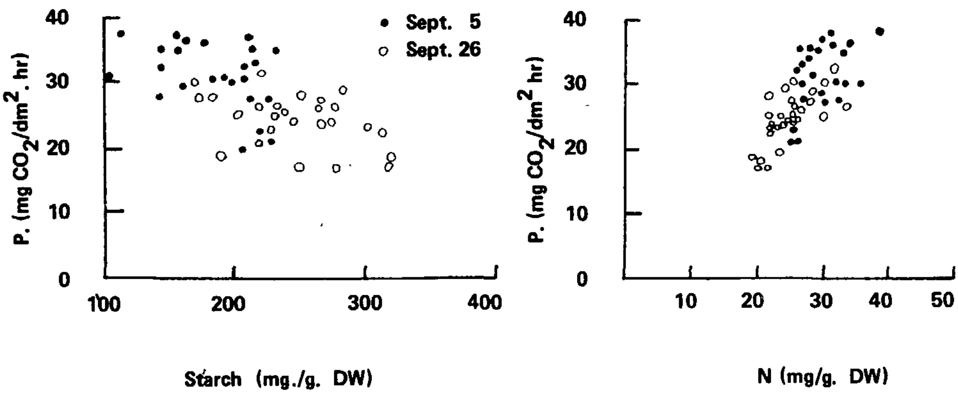

Fig. 5. Interrelationship between apparent photosynthetic rate and starch and nitrogen content.