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Effect of Intergeneric Grafting on Growth and Photosynthesis in *Momordica dioica* Roxb.

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Plants of ***Momordica dioica*** grafted onto rootstocks of five different Cucurbita species were evaluated with respect to growth and photosynthetic activities. Growth rate of ***M. dioica*** plants grafted on rootstocks of C. *ficifolia*, ***C. moschata* 'No.** 8', 'Tetsukabuto' (F_1 hybrid of C. ***maxima*** x ***C.*** *moschata*) and 'Shintosa 1 gou' (F_1 hybrid of C. ***maxima*** x *C.* ***moschata)*** was greater than that of non-grafted ones. Differential influence of rootstocks upon growth characteristics was also observed. The plants using the rootstocks except the Bangladesh local produced 2-3 times higher leaf area and dry matter than those of non-grafted plants at both early vegetative and flowering stages. The rootstocks played an important role in the suppressing tuberization of roots and in the enhancement of the scions. The results suggest that there is ample scope for modifying dry matter partitioning to increase of economic yield of this crop through grafting on other Cucurbita species.

INTRODUCTION

Momordica dioica Roxb., a Cucurbitaceous crop, has edible fruits and is grown in Bangladesh and the north eastern part of India as a summer vegetable (Singh, 1990). It is generally propagated by root tuber although seed propagation is also possible (Ali et *al.*, 1991). The plants propagated either by sexual or asexual means produce inedible roots for future propagation. Normally, the plants complete their life cycle within one year but the tuberous roots remain viable until the next summer when high temperatures and the high moisture content of the soil stimulate sprouting of new plants (Ali et al., 1991). Since the tuberous roots are a storage organ, the plants partition a large amount of photosynthates to the roots which limits the availability of the metabolic products for economic yield of fruits. It is assumed that, if the formation of root tubers is suppressed there would be an increase in the total above-ground biomass and an improvement in economic yield. It is not possible to achieve this goal through conventional breeding as there is a lack of non-tuber forming genotypes within *Momordica dioica* and there is incompatibility between this species and other closely related Momordica genotypes (Trivedi and Roy, 1972). One possible solution is to suppress tuberization by grafting *M. dioica* plants onto other non-root tuber forming plants. There are reports of successful intergenetic grafts in many cucurbits

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(Imatsu,1949; Lee, 1989; Uffelen, 1983) but there are no reports of grafting of *Momordica dioica* with any other crop species. In the present investigation, the effect on growth and photosynthetic activities of grafting *Momordica dioica* on other Cucurbita species was studied.

MATERIALS AND METHODS

Development of grafted plants

A cultivar of *M. dioica* from Bangladesh was grafted on five different rootstocks, namely 'Tetsukabuto' (an F_1 hybrid of C. *maxima* Duch x C. *moschata* Duch), 'Shintosa 1 gou' (another F_1 hybrid of C. *maxima* x *C. moschata*), *C. moschata* ('Bangladesh local'), C. moschata 'No. 8' and C. *ficifolia* Boucha. The stock plants were grown in vermiculite in mid-August, 1990 under glasshouse conditions at the laboratory's field of Horticulture, Kyushu University, Cleft grafting was made when the stock plants were at the cotyledonary leaf stage. Young shoot tips having three unopened leaves were collected from opposite sides of the lower end with a sharp blade. A straight cut, about 1 cm deep, was made between the two leaves of the rootstocks plant and the cut end of the scion was inserted. A plastic clip was attached at the joint to achieve a proper graft union. Fifty grafts were made with each of the rootstocks. The grafted plants were transplanted to small plastic pots (9 cm diameter) containing vermiculite, covered with polyethylene sheet and kept under shade for one week and sprayed with a mist water 3-4 times per day. The clips were removed after two weeks. When the graft union was established, shades were also removed so as to harden the plants. After one month the plants were transferred to larger pots (15 cm diameter) filled with a mixture of sand and volcanic gravels. For comparison, 20 non-grafted *M. dioica* plants were propagated as stem cuttings. All plants were grown in a plastic house at a temperature of 25-30°C. Growth characteristics and photosynthetic activities were measured at two stages, (41 days after grafting) and at flower bud initiation (81 days after grafting).

Measurement of growth characteristics

Plant growth parameters including the number of fully expanded leaves (EL), length of vines (VL), number of internodes per vine (NI), and number of branches per vine (NB) , were recorded on 10 plants selected randomly. Shoot dry weight (SDW) and root dry weight (RDW) were recorded on three plants from each treatment, with the exception of plants grafted on C. *moschata* ('Bangladesh local') as insufficient plants were available at the flowering stage. The shoots and roots of the sample plants were separated and oven dried at 80 °C for 48 hours. Total leaf area per plant (TLA), and mean leaf area (MLA) on a single plant per treatment were measured using an automatic leaf area meter (model AAM-8).

Measurement of photosynthetic activities

Net photosynthetic rate (Pn), transpiration rate (E), stomata1 conductance (Gs) and intercellular CO_2 concentration (Ci) were determined by a portable infrared gas analyzer and data logger (ADC, model-SPS-H_z UK). Measurements were made on at least three fully expanded mature leaves between the 5th and the 9th nodes from the top of five different plants, under a solar photon flux of about 1500 $\mu E\, m^{-2} s^{-1}$, and the parameters were calculated using the method of Von Caemmerer and Farquhar (1981). Root respiration was also measured by infrared gas analyzer at a temparature of 30 “C.

RESULTS

All the growth parameters of *M. dioica* at both the early vegetative and flower initiation stages were strongly influenced by grafting (Table 1 and 2). At the early stage, the shoot dry weight of the grafted plants was significantly greater than on the non-grafted plants. The difference between non-grafted and grafted plants was even greater at the flower bud initiation stage except for those using C. *moschata* (‘Bangladesh local’) as a rootstock. The plants grafted on Bangladesh rootstock grew very poorly and at flowering, all the plants became yellow and ultimately died through rotting of the roots. The grafted plants produced significantly more biomass than the non-grafted ones. At the early growth stage, the difference in above-ground dry matter production between grafted and non-grafted plants was marked, although the root dry matter weights were similar at that stage.

At flower initiation, the grafted plants had the highest shoot dry weight but the non-grafted plants had the highest root dry weight (Table 2). Some root tubers were observed in non-grafted plants, while tuber formation was completely suppressed in plants grafted onto rootstocks having a normal root forming habit.

Both total leaf area per plant and mean leaf area per one leaf were greatly influenced by the rootstocks at the early flowering stages but the effect was more pronounced at the later stage (Table 2).

Grafting did not have a consistent effect on net photosynthetic rate (Table 3). The rootstock, ‘Tetsukabuto’ produced the highest rate of net phtosynthesis at both the early vegetative and flowering stages. In general, irrespective of treatment, the rate of photosynthesis was higher at the early stage. At the flowering stage, the plants using rootstock C. *moschata* (‘Bangladesh local’) gave aberrant results because of the abnormal growth of these plants. The effect of rootstocks on transpiration rate and stomata1 conductance were similar to those for photosynthesis. The relative effect of rootstock on net photosynthetic rate, respiration rate and stomata1 conductance were similar at both the stages. The intercellular CO_2 concentration was not influenced by rootstock at the developmental stage. However, at the flowering stage, the CO_2 concentration in grafted plants was comparatively higher than that in non-grafted ones in spite of the concentration was lower. The rate of root respiration, particularly in non-grafted plants, was the lowest during tuber forming stage though it was the highest at the early vegetative stage (Table 3).

DISCUSSION

The results obtained in this experiment revealed that *M. dioica* was graft compatible. Those rootstocks that are used extensively for grafting Cucumis in Japan and other countries (Lee, 1989) also performed well with *M. dioica*. The poor

Table 1. Effect of grafting on growth characteristics in *Momordica* **dioica** at early vegetative stage (41 days after grafting).

Rootstocks	Scion	EL	NI	NB	VL	TLA	MLA	SDW	RDW	%of RDW
		(No./plant)			(cm)	(cm²)	(cm²)	(g)	(g)	to TDW
Non-grafted	*M.* **dioica**	9.5* ± 1.9	9.7 ± 1.6	0	38.7 ± 8.3	332	25.5 ± 9.6	1.23 io.22	0.15 f0.06	10.37
'Tetsukabuto'[1]	〃	20.3 ± 6.0	16.7 ± 4.0	0.8 ± 1.0	70.1 ±20.3	916	38.1 ±15.9	2.42 ±0.56	0.22 ±0.02	8.33
'Shintosa 1 gou'[2]	〃	18.6 ± 4.8	16.9 ± 3.1	0.6 ± 0.7	75.5 ±20.8	700	30.7 ± 14.3	1.98 ±0.55	0.17 ±0.04	7.91
C. moschata [3]	〃	19.0 ± 4.6	18.1 ± 2.0	0.8 ± 1.0	77.2 f18.5	445	21.1 ± 10.8	1.68 ±0.60	0.13 ±0.01	7.18
C. moschata 'No. 8'	JJ	20.3 ± 4.4	16.4 ± 2.6	1.4 ± 0.9	60.6 f17.2	799	39.3 ±15.5	1.98 ±0.37	0.22 f0.04	10.00
C. *ficifolia*	〃	20.3 ± 4.0	17.5 ± 2.4	0.7 ± 0.8	73.9 ±21.1	585	27.9 ±11.8	2.39 ±0.47	0.25 ±0.04	7.86

1 and 2: F_1 hybrids of C. **maxima** x C. moschata 3: 'Bangladesh local' EL: Number of expanded leaves, NI: Number of internode, NB: Number of branches, VL: Vine length, TLA: Total leaf area, MLA: Mean leaf area, SDW: Shoot dry weight, RDW: Root dry weight, TDW: Total dry weight, *: mean ±S.E.

Table 2. Effect of grafting on growth characteristics in *Momordica* **dioica** at flower initiation stage (81 days after grafting).

Rootstocks	Scion	EL	NI	NB	VL	TLA	MLA	SDW	RDW	%of RDW
		(No./plant)			(cm)	(cm²)	(cm²)	(g)	(g)	to TDW
Non-grafted	*M.* **dioica**	28.3* ± 5.6	25.7 ± 1.3	0.3 ± 0.5	148.0 ± 4.3	909	43.3 f15.1	5.25 ±0.47	2.10 f0.54	28.67
'Tetsukabuto"	JJ	63.0 ±13.6	35.0 ± 2.9	3.0 ± 0.8	192.3 ±11.5	2542	.72.7 f20.1	16.73 ±2.60	0.65 10.12	3.74
'Shintosa 1 gou'[2]	JJ	80.7 f19.4	34.3 ± 5.5	3.3 ± 2.1	221.0 t21.2	1896	75.9 f19.5	14.57 ±2.50	0.74 f0.24	4.83
C. **moschata** [3]	〃	20.0	18.0	1.0	74.0	318	21.2 ± 7.0	2.50	0.13	4.94
C. moschata 'No. 8'	JJ	67.7 F14.4	30.7 ± 6.2	2.7 ± 1.0	151.3 ± 16.7	1812	47.7 ±16.0	11.53 ±3.56	0.91 ±0.08	7.32
C. *ficifolia*	JJ	54.7 ± 2.6	31.3 ± 8.9	3.0 ± 2.5	153.3 ±24.2	2012	49.1 t17.2	11.90 ±0.65	0.89 ±0.34	6.96

1 and 2: F_1 hybrids of C. **maxima** x C. moschata **3:** 'Bangladesh local' EL: Number of expanded leaves, NI: Number of internode, NB: Number of branches, VL: Vine length, TLA: Total leaf area, MLA: Mean leaf area, SDW: Shoot dry weight, RDW: Root dry weight, TDW: Total dry weight, *: mean ±S.E.

Table 3. Effect of grafting on net photosynthetic rate (Pn), transpiration rate (E), stomata1 conductance (Gs), intercellular CO_2 concentration (Ci) and root respiration (RR) at early vegetative and flower initiation stages of ***Momordica dioica.***

Rootstocks	Scion	Pn ($\mu molm^{-2}s^{-1}$)	E ($mmolm^{-2}s^{-1}$)	Gs ($molm^{-2}s^{-1}$)	Ci (ppm)	RR ($CO_2mgDWg^{-1}h^{-1}$)
		Early vegetative stage (41 days after grafting)				
Non-grafted	M. ***dioica***	11.20* ± 0.55	6.99 ±0.75	0.59 ±0.16	296.7 ± 5.9	19.42
'Tetsukabuto"	〃	12.09 ± 1.38	6.55 f0.80	0.72 ±0.27	296.5 ± 8.6	10.78
'Shintosa 1 gou'[2]	〃	8.66 ± 0.80	4.08 ±0.52	0.31 ±0.07	292.2 ±11.2	17.25
C. moschata [3]	〃	8.82 ± 2.27	4.40 ± 1.39	0.36 ±0.19	288.1 ±21.6	4.98
C. moschata 'No. 8'	〃	9.42 ± 2.73	4.36 ± 1.01	0.36 to.15	291.0 ± 9.8	7.47
C. ficifolia	〃	10.20 ± 0.88	5.20 ±0.43	0.51 ±0.41	299.3 ± 4.3	8.82
		Flower initiation stage (81 days after grafting)				
Non-grafted	***M. dioica***	8.05* ±2.70	***2.00*** ±0.60	0.10 ±0.04	194.5 ± 6.7	4.41
'Tetsukabuto"	〃	9.11 ± 1.50	2.98 ±0.76	0.18 ±0.06	239.7 ± 12.3	7.50
'Shintosa 1 gou'[2]	〃	6.84 ±1.67	1.99 f0.37	0.09 ±0.02	213.3 ± 1.8	7.50
C. moschata [3]	〃	− 0.09	0.24	0.01	362.2	2.56
C. moschata 'No. 8'	〃	6.75 ±2.50	2.20 f0.90	0.11 ±0.07	223.2 ± 14.3	6.66
C. ficifolia	JJ	4.44 ±2.99	1.66 ±1.10	0.07 ±0.06	223.9 ± 10.5	11.42

1 and 2: F_1 hybrids of C. ***maxima*** × ***C.*** *moschata*, 3:'Bangladesh local' *: mean ±S.E.

performance of *C. moschata,* a 'Bangladesh local' rootstock might be due to post-graft incompatibility. Such differential graft compatibility was also reported by Marukawa and Onuma (1967) and Marukawa and Yamamuro (1967) who grafted melon and water melon on different Cucurbita species. The plants with Japanese rootstocks produced 2 - 3 times more total leaf area and dry matter production per plant than non-grafted ones at both the early and flowering stages.

The most interesting results was that root dry matter accumulation increased dramatically at the flowering stage in non-grafted plants (Table 2). At that stage, the non-grafted plants diverted about 29% of the total photosynthates to the roots for tuber formation, while the grafted plants diverted only 3-7%. Root respiration in non-grafted plants also declined markedly in spite of increasing of root dry weight. Such partitioning of photosynthates and the low root respiration at the flowering stage of the non-grafted plants helped to accumulate greater dry weight in the roots. Tuber formation was completely suppressed in grafted plants, while there was the opportunity to transport more than 90% of the photosynthates to the shoot. It is also possible that the rootstocks are inherently more efficient in absorbing and supplying nutrients to the scions.

The suppression of the tuber forming habit, might be the cause of the higher growth performance as well as more dry matter production in grafted plants.

This is the first report of grafting *M. dioica* grafted on other Cucurbita species. It is clearly important to know whether grafting improves yield of *M. dioica*. So the effect of grafting on economic yield will be dealt with in the next paper. Lee (1989) has observed that Cucumis and Cucurbita species performed better when grafted on Cucurbita rootstocks and Uffelen (1983) reported superior perfomances when Cucurbita species were used as rootstocks. There is other evidence that Thorne and Evans (1964) obtained higher net assimilation rate in spinach beet plants grafted on sugar beet rootstocks.

In conclusion, the findings of the present investigation suggest that there is the potential for improving the productivity of *M. dioica* through grafting with other Cucurbita species.

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