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論　文
Articles

Plant Growth and Fruit Quality of Tomatoes Grafted on Pepino Rootstocks

By

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Summary：Prevention of soilborne diseases is an important objective for commercial tomato production. In this study, scions from tomato plants 'Momotaro Fight' (MF), were grafted on rootstocks of the pepino 'Gold No. 1'. Plant growth and fruit quality were monitored with the aim of developing a new grafting technique for avoiding soilborne diseases in tomato over 2 years (Experiment 1 ; 2016, Experiment 2 ; 2017). The test plots included an MF plot (non-grafted, self-rooted MF), an MF/P plot (MF grafted on an untreated pepino rootstock), and an MF/WRP plot (MF grafted on a pepino rootstock treated with a 4 mm inner diameter washer ring). Although growth suppression was observed immediately after grafting in the MF/P and MF/WRP plots, there were no significant differences in stem length or the position of the uppermost unfolded leaf at the end of the experiment compared to the MF plot. An increase in shoot fresh weight was observed in the grafted plots, as well as a greater shoot (leaves and stem) fresh weight to root fresh weight ratio (T-R ratio) in the MF/WRP plot resulting from a reduction in root fresh weight. Undergrowth of the rootstock was observed at the graft union, and the stem immediately above the washer ring was markedly enlarged. In the grafted plots, a reduced degree of fruit set in the lower trusses, a reduced number of marketable fruits, and a reduced yield were observed. In the MF/WRP plot, the average fruit weight was also reduced. The soluble solids content of fruit in the MF/P plot was 97 to 114% of those in the MF plot, although a significant increase was observed only in the first truss in Experiment 1, 2016. In contrast, the soluble solids content of fruit in the MF/WRP plot was 111 to 127% of that in the MF plot, indicating a marked increase. In conclusion, tomato plants grafted on pepino rootstock successfully grew and produced marketable fruits. At the same time, tomato plants grafted on washer ring-treated pepino rootstock produced fruit having an increased soluble solids content. With its resistance to bacterial wilt and fusarium wilt diseases, pepino is a promising choice of rootstock for commercial tomato cultivation. Further testing under conditions similar to those in commercial production sites is required.

Key words：fruit yield, *Solanum lycopersicum*, *Solanum muricatum* Aiton, soluble solids content, washer ring treatment

1. Introduction

In tomato cultivation, grafting with disease-resistant rootstock is practiced primarily to avoid soilborne diseases. Previous studies on tomato grafting have reported that grafting tomato scions on the rootstocks of other Solanaceous plants such as *Lycium chinense*[1)] or scarlet eggplant[2)] or on the rootstocks of certain tomato cultivars grown in saline[3)] or water stress conditions[4)] improved the soluble solids content of the tomato fruit. Pepino (*Solanum muricatum* Aiton) is a solanaceous fruit native to South America and is mostly eaten fresh as a dessert. Pepino is typically propagated from herbaceous cuttings. A technique for improving the fruit soluble solids content has been developed in which pepino stems from cuttings are inserted through the hole of a washer ring ("washer ring treatment")[5)]. The washer ring treatment has been patented as a technique to reduce plant root growth

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(JP6197257). More recently, YAMAZAKI *et al.*[6] demonstrated that pepino is resistant to bacterial wilt and fusarium wilt diseases, two significant diseases of tomato, and that this resistance is also observed in pepino-grafted tomatoes. These investigators also reported a high survival rate of pepino-grafted tomato plants and patented their technique (JP6273425) ; however, plant growth and the fruit quality of pepino-grafted tomatoes were not investigated. If pepino-grafted tomato plants are able to successfully grow and produce marketable fruits, pepino may become a valuable choice of rootstock for commercial tomato cultivation. Moreover, improvement in the fruit soluble solids content will confer added value to pepino-grafted tomato in addition to their resistance to soilborne diseases.

Thus, in this study, we examined the growth and fruit quality of pepino-grafted tomato with the aim of testing if such plants are able to grow successfully and produce marketable fruit. At the same time, we also investigated tomato plants grafted on washer ring treated pepino rootstocks.

2. Materials and Methods

Plant culture

The tomato 'Momotaro Fight' (Takii & Co., Ltd) and pepino 'Gold No. 1' were used as the scion and the rootstock in all experiments, respectively. Two sets of experiments were carried out in which plants were cultivated from September 1, 2016 to April 21, 2017 (234 days) in Experiment 1 or from December 23, 2016 to June 9, 2017 (168 days) in Experiment 2. In both experiments, plants were cultivated in a glasshouse that was ventilated when the temperature inside the glasshouse rose above 25℃ and heated when the temperature fell below 14℃. The test plots were a MF plot with non-grafted, self-rooted 'Momotaro Fight' (MF), a MF/P plot with MF grafted on an untreated pepino rootstock, and a MF/WRP plot with MF grafted on a pepino rootstock treated with a washer ring (4 mm inner diameter, 25 mm outer diameter, and 1 mm thick). One tomato seed was sown in each 7.5 cm diameter pot filled with Nippi-Engei-Baido-1 go (N : P_2O_5 : K_2O : MgO = 200 : 2500 : 200 : 200 mg L^{-1}, Nihon Hiryo Co., Ltd. ; this soil mixture was also used for repotting and final transplanting). On the same day, a pepino cutting (lateral shoot) that had five to six leaves was planted vertically approximately 2 cm deep into the soil mixture in a similar pot, after removing the lower two leaves. Pepino cuttings in the MF/WRP plot were planted with the stem passing through the hole of a washer ring. The day of seeding and cutting planting was defined as the first day of the experiment. Grafting was carried out when each tomato plant had four to five leaves (September 22, 2016 in Experiment 1 and February 4, 2017 in Experiment 2). The cleft grafting technique was used, where a scion whose stem had been trimmed into a wedge shape immediately above the cotyledons was inserted into a 1 cm deep vertical cleft made on a rootstock whose stem had been pinched immediately below the fifth leaf. After forming a successful union, the grafted plants were repotted in 10.5 cm pots. On the first day of flowering of the first inflorescence in the MF plot (October 24, 2016 in Experiment 1 and March 5, 2017), each of the plants was transplanted (final repotting) to a larger pot with a diameter of 40 cm containing 27 L of the soil mixture. Eight plants were prepared per plot, with a total 24 plants arranged in two rows (the distance between adjacent pots was 60 cm and the distance between the rows was 80 cm). Plants were arranged such that the effects of positional variation among plots were minimized. The plants were supported by strings hanging from the ceiling for single-stem training and pinched immediately below the eleventh inflorescence. A solution of 4-chlorophenoxyacetic acid (4-CPA, 15 ppm) was sprayed on the inflorescences to induce fruit setting with each truss thinned to a maximum of four fruits. Once the mean diameter of the largest fruits on the first trusses reached approximately 2 cm, each pot received 500 to 1,000 mL of liquid fertilizer (Hyponex, Hyponex Japan Corp. Ltd., N : P_2O_5 : K_2O = 6 : 10 : 5%) diluted 500 to 1,000-fold every ten days or otherwise irrigated as necessary every day.

Adjustment of soil moisture

As plants were transplanted (final repotting), a soil moisture sensor (EC-5, Decagon Devices) was inserted in the soil mixture in each pot to a depth of 15 to 20 cm and approximately 6 cm away from the plant stem. The soil moisture values (nominal volumetric water content percentage) displayed on a handheld reader (ProCheck, Decagon Devices) were recorded three times (10:00, 12:00, 15:00) daily. After measuring the soil moisture content, the amount of water that corresponded to the difference between the mean moisture content (%) and a moisture content of 19% (the target moisture content after irrigation) was supplied manually to the entire soil surface of the pots in each plot. A soil moisture content of 19% in the Nippi-Engei-Baido-1 go soil mixture corresponds to a soil moisture retention (pF) value of 1.8[7].

Evaluation of plant growth

Plant growth was evaluated only in Experiment 1. At the completion of the experiment, stem lengths from the graft union (or where the cotyledons emerged in the MF plot) to the position of pinching, the position of the uppermost unfolded leaf, and fresh weights of shoots and roots were measured. The top fresh weight to root fresh weight ratio (T-R ratio) was also calculated. Shoot weight (the combined weight of stems and leaves) was measured in shoots cut at the soil surface after removing all the trusses. Prior to measuring root weight, the soil mixture was rinsed off from the roots in a tray using water with care taken to not cut the roots. The rinsed roots and collected cut roots were wrapped in a cloth to remove water before measuring their combined weights. For each of the first to fifth inflorescences, the position of the leaf immediately below the inflorescence, the number of flowers, and the percentage of fruit set (the percentage of fruits set on the first to fifth flowers at the time of fruit thinning) were determined.

Evaluation of harvested fruit

Fruits on the first to third trusses were harvested when their color was almost fully red. Only marketable fruits were used in the analysis, excluding disordered fruit with blossom-end rot, cracks, etc. After removing the calyx, the weight, height (longitudinal diameter), and maximum diameter of each fruit was measured, and the height to diameter ratio was calculated. The value observed when the plunger (a 5 mm diameter cylinder) of a hardness tester (KM-5, Fujiwara Scientific Company Co., Ltd.) broke through the skin of the fruit's equatorial plane was recorded as the fruit firmness. The soluble solids content of fruit juice was measured using a digital refractometer (PR-101α, Atago Co., Ltd.) ; the fruit was divided longitudinally into four sections, of which two opposite fruit sections were wrapped in a double layer of gauze and squeezed to release the juice.

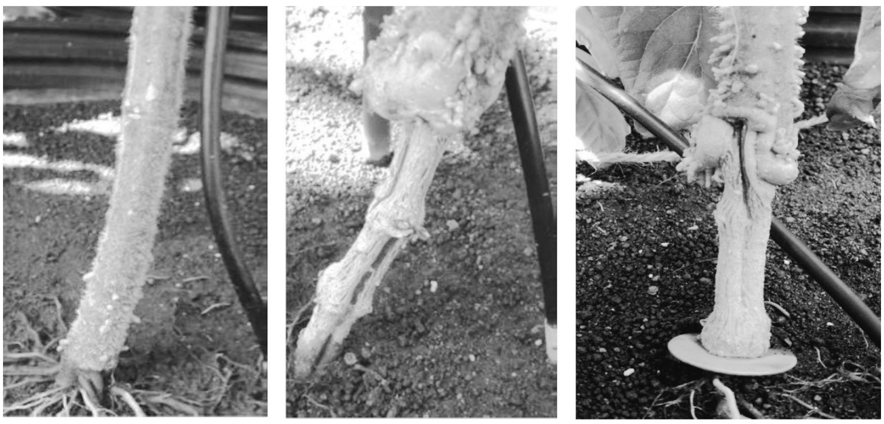
Statistical analysis

The 5% Tukey's test was used to examine differences in the means of plant growth and fruit quality parameters among the plots. Two plants, one from the MF plot and another from the MF/P plot in Experiment 1 whose growth became determinate during the experiment, were thus excluded from the analysis.

Table 1 The effects of grafting tomato scions on pepino rootstock on plant growth (Experiment 1)

Plot	Stem length (cm)	Number of nodes to uppermost unfolded leaf	Shoot fresh weight^z (g)	Root fresh weight (g)	T-R ratio^y
MF	297	39.9	1476 b^x	445 a	3.4 a
MF／P	295	37.0	1730 a	415 a	4.2 a
MF／WRP	288	36.9	1791 a	271 b	6.8 b

^{z} Stems and leaves (all trusses removed).
^{y} Shoot fresh weight / Root fresh weight.
^{x} Different letters for each plot indicate significant differences by Tukey's test (5%).
There is no significant difference where there is no letter.



MF plot MF/P plot MF/WRP plot

Fig. 1 The appearance of graft unions (MF/P and MF/WRP) at the end of the experiment compared to the ungrafted control (MF).
MF : Self-rooted MF ('Momotaro Fight')
MF/P : MF grafted on an untreated pepino rootstock
MF/WRP : MF grafted on a pepino rootstock treated with a 4 mm (inner diameter) washer ring

3. Results

Moisture content of the mixed soil after transplanting

Each pot was irrigated at 10:00, 12:00, and 15:00 when the soil moisture content was below 19%, such that the moisture content returned to this level. From transplanting to the end of the experiment, the mean soil moisture content before irrigation was 17.7, 17.9, and 18.3% in the MF, MF/P, and MF/WRP plots, respectively, in Experiment 1, and 17.4, 17.7, and 18.2% in the MF, MF/P, and MF/WRP plots, respectively, in Experiment 2. HARADA *et al.*[7] observed that there was a significant negative correlation between the soil moisture content and the pF of the soil mixture used in this experiment, and expressed the equation $y = -0.2981x + 7.4733$ ($R^2 = 0.9282^{***}$). Using this regression equation, the pF values corresponding to soil moisture contents of 19, 18.3, 18.2, 17.9, 17.7, and 17.4% were calculated to be 1.81, 2.03, 2.04, 2.15, 2.19, and 2.28, respectively.

Plant growth in Experiment 1 (Table 1, Fig. 1)

There were no significant differences in the stem length or the position of the uppermost unfolded leaf among the test plots. The shoot fresh weights were greater in the MF/P and MF/WRP plots, reaching 117% and 121%, respectively, of the corresponding weight in the MF plot. The root fresh weight was markedly smaller in the MF/WRP plot, reaching 61% and 65% of the corresponding weights in the MF and MR/P plots, respectively. In contrast, the T-R ratio was markedly greater in the MF/WRP plot, reaching 203% and 163% of the T-R ratios in the MF and MF/P plots, respectively (Table 1). Regardless of the rootstock source, undergrowth of the rootstocks occurred at the graft union. The stem diameters immediately above the washer ring in the MF/WRP were significantly larger than the corresponding stem parts in the MF/P plot (Fig. 1).

The leaf number immediately below the inflorescence, the number of flowers, and the percentage of fruit set in Experiment 1 (Table 2)

There were no significant differences among the test plots in the number of leaves immediately below each inflorescence or the number of flowers for each of the first to fifth inflorescences. The percentage of fruit set was significantly lower in the second inflorescence in the MF/P plot.

Days to harvest, the numbers of fruit per plant, the percentage of disordered fruit, fruit weight and the total weight of fruit (Table 3)

It took 10 to 30 days longer to harvest fruit from the first to third trusses in Experiment 1 and from the first truss in Experiment 2 in the MF/P and MF/WRP plots compared to the MF plot. A difference in the total number of harvested fruits was observed only in the first truss in Experiment 2, where the number in the MF/P plot was smaller than that in the MF plot. The number of harvested marketable fruits was reduced in the first truss in Experiment 2 in the MF/P plot, in the first truss in Experiment 1 and the second truss in Experiment 2 in the MF/WRP plot compared to the MF plot. A reduced

Table 2 The effects of grafting tomato scions on pepino rootstocks on tomato inflorescences (Experiment 1)

Plot	Leaf number[z]	Number of flowers	Fruit set[y] (%)
	First inflorescence		
MF	9.1	4.6	91
MF／P	9.6	5.0	76
MF／WRP	9.1	5.3	65
	Second inflorescence		
MF	12.3	4.3	100 a[x]
MF／P	12.6	5.7	70 b
MF／WRP	12.9	4.4	84 ab
	Third inflorescence		
MF	15.3	5.9	89
MF／P	16.3	5.9	94
MF／WRP	15.8	4.6	84
	Fourth inflorescence		
MF	18.3	6.9	90
MF／P	18.6	6.3	89
MF／WRP	18.5	5.3	93
	Fifth inflorescence		
MF	21.3	5.6	80
MF／P	21.7	7.9	89
MF／WRP	21.4	6.3	80

[z] Leaf number just below the inflorescence indicate.
[y] Calculated with the first to fifth flowers of each inflorescence: percentage of fruit set (%) = number of fruit / 5 × 100.
[x] Different letters for each plot indicate significant differences by Tukey's test (5%).
For the fruit set ratio, an angular transformation was conducted.
There is no significant difference where there is no letter.

Table 3 The effects of grafting tomato scions on pepino rootstock on the days to harvest, numbers of fruit per plant, percentage of disordered fruit, fruit weight, and total weight of tomato fruit per plant

Plot	Days to harvest	Numbers of fruit per plant: Total (no. / plant)	Numbers of fruit per plant: Marketable (no. / plant)	Disorder fruit[z] (%)	Fruit fresh weight[x]: Individual (g / fruit)	Fruit fresh weight[x]: Total (g / plant)
Experiment 1 (2016)						
			First truss			
MF	130 b[y]	3.29	3.29 a	0	144 ab	472 a
MF／P	159 a	2.71	2.57 ab	4.8	157 a	404 a
MF／WRP	160 a	2.25	2.13 b	7.1	126 b	267 b
			Second truss			
MF	157 b	3.86	3.00	22.6	167	503 a
MF／P	179 a	2.86	2.71	4.2	149	403 a
MF／WRP	177 a	2.25	2.00	8.3	130	258 b
			Third truss			
MF	171 b	3.57	3.00	14.3	149	445
MF／P	180 a	3.86	3.71	3.6	145	539
MF／WRP	181 a	3.50	3.38	3.1	155	527
Experiment 2 (2017)						
			First truss			
MF	134 b	4.00 a	4.00 a	0	144	576 a
MF／P	144 a	3.13 b	3.13 b	0	116	360 b
MF／WRP	145 a	3.63 ab	3.50 ab	3.1	126	443 b
			Second truss			
MF	151	4.00	4.00 a	0	194	776 a
MF／P	154	3.88	3.38 ab	12.9	192	648 ab
MF／WRP	154	3.75	3.25 b	13.3	163	528 b
			Third truss			
MF	162	3.88	2.75 ab	29.0	228 a	627 a
MF／P	163	4.00	3.50 a	12.5	226 a	791 a
MF／WRP	165	3.50	2.13 b	39.3	130 b	275 b

[z] Days from seeding to harvest.
[y] Percentage of disordered fruit (%) = disordered fruit number / total fruit number × 100.
[x] Marketable fruit.
[w] Different letters for each truss indicate significant differences by Tukey's test (5%).
For the disordered fruit, an angular transformation was conducted.
There is no significant difference where there is no letter.

number of harvested marketable fruits in the third truss in Experiment 2 in the MF/WRP was observed not in comparison with the MF plot but with the MF/P plot. In terms of the percentage of disordered fruits, there were no significant differences or any trends among the test plots in any of the trusses. The average fruit weight was lighter in the MF/WRP plot compared to the MF/P plot in the first truss in Experiment 1 and to the MF and MF/P plots in the third truss in Experiment 2. The total weight of fruit in the MF/P plot was reduced only in the first truss in Experiment 2 compared to the MF plot (62% of MF). The total weight of fruit in the MF/WRP plot was reduced in all trusses except the third truss in Experiment 1 compared to the MF plot (44 to 77% of MF).

Fruit quality (Table 4)

In terms of the quality of the harvested marketable fruits from the first to third trusses, a difference in fruit firmness was observed only in the third truss in Experiment 2, in which the firmness of fruit from the MF/P

Table 4 The effects of grafting tomato scions on pepino rootstock on the firmness, height-diameter ratio, and soluble solids content of marketable tomato fruits

Plot	Firmness (kg)	Shape (height / diameter)	Soluble solids content (°Brix)
Experiment 1 (2016)			
		First truss	
MF	2.09	0.82	6.1 b
MF／P	1.97	0.79	7.0 a
MF／WRP	1.84	0.84	7.0 a
		Second truss	
MF	2.16	0.81	7.0 b
MF／P	2.18	0.84	7.1 ab
MF／WRP	2.28	0.87	7.8 a
		Third truss	
MF	2.21	0.89 a	6.7 b
MF／P	2.14	0.80 ab	7.3 ab
MF／WRP	2.13	0.79 b	7.8 a
Experiment 2 (2017)			
		First truss	
MF	1.57	0.82	5.9 b
MF／P	1.55	0.81	6.5 b
MF／WRP	1.75	0.83	7.5 a
		Second truss	
MF	1.50	0.85 b	6.6 b
MF／P	1.45	0.85 b	6.6 b
MF／WRP	1.50	0.91 a	7.9 a
		Third truss	
MF	1.75 a[z]	0.84 b	7.2 b
MF／P	1.43 b	0.81 b	7.0 b
MF／WRP	1.69 a	0.91 a	8.3 a

[z] Different letters for each truss indicate significant differences by Tukey's test (5%).
There is no significant difference where there is no letter.

plot was reduced compared to those growing in the other two plots. Fruit shape in the MF/WRP plot was smaller in the third truss in Experiment 1 compared to the MF plot, and larger in the second and third trusses in Experiment 2 compared to the other two plots. In terms of the soluble solids content, there were no significant differences between the MF/P and MF plots in Experiment 2, whereas in Experiment 1, the soluble solids content in the MF/P plot was significantly greater in the first truss (114%) and tended to be greater in the second and third trusses compared to the MF plot. The soluble solids content in the MF/WRP plot was greater (111 to 127%) in all trusses in both experiments compared to the MF plot, and greater (115 to 120%) in all trusses in Experiment 2 compared to the MF/P plot.

4. Discussion

Our experiments were completed when the seventh truss in Experiment 1 and the third truss in Experiment 2 were harvested. In Experiment 1, fruits harvested from the first to third trusses but not from subsequent trusses were evaluated. This decision was made because fruits successfully set and grew on the fourth and subsequent trusses, suggesting that the results would not be significantly different from those obtained from the first to third trusses in terms of differences between the MF plot and the grafted plots. Experiment 1 was ended before fruits from the tenth truss were harvested since the plants were growing well in all plots prior to harvesting the seventh truss. Experiment 2 was ended when fruits could be harvested from the third truss since the purpose of this experiment was to obtain fruit quality measurements only from up to the third truss. Plant growth was therefore not evaluated in Experiment 2.

The water content of the soil mixture before irrigation varied depending on the plot. This means that the water level in the soil mixture after irrigation was the same in all the plots, but the amount of water absorbed from it was different in each plot.

At the end of Experiment 1, there were no significant differences among the plots for stem length or the position of the uppermost unfolded leaf, whereas the shoot fresh weight was greater in the grafted plots (Table 1). A number of studies have reported increased shoot fresh weights or dry weights as a result of grafting[8-10], consistent with our results. The stem of the tomato scion was markedly enlarged at the graft union, exhibiting an undergrowth of the rootstock (Fig. 1) that is a symptom of graft incompatibility. Other symptoms of graft incompatibility include wilting and dying[11], were not observed in the grafted tomato plants in our study. ODA *et al.*[2] reported that undergrowth of the rootstock in scarlet eggplant-grafted tomato, similar to that observed in our study, did not affect cultivation. It is therefore likely that the incompatibility observed in the pepino-grafted tomato will not interfere with cultivation.

Root fresh weight was reduced and the stem immediately above the washer ring was enlarged in plants growing in the MF/WRP plot. TAKAHATA and MIURA[12] successfully improved the soluble solids content of tomato fruit by treating plants with a wire coiled around the stem base, while at the same time they reported stem enlargement immediately above the wire coil and suppressed root growth. These investigators hypothesized that the wire coil treatment prevented the translocation of phloem sap to underground plant parts, causing the accumulation of photosynthates and phytohormones. Subsequently, callus growth and cambium cell division were induced, resulting in stem enlargement and root growth suppression. Similar patterns of stem enlargement and root growth suppression were observed by TAKAHATA[5] in pepino plants treated with a washer ring to improve the fruit soluble solids content. These plant responses likely involve mechanisms similar to those suggested for wire coil-treated tomato plants. The larger T-R ratio observed in the MF/WRP plot compared to the MF and MF/P plots was due to suppressed root growth, a result consistent with those reported by TAKAHATA[5].

The number of leaves immediately below each inflorescence did not differ significantly among the plots, suggesting that grafting did not affect the position for truss formation. Grafting did not affect the number of flowers in our study, although previous studies have reported contradicting results including an increased flower number in tobacco-grafted tomato plants[13] and no change in flower number in eggplant-grafted and tomato-grafted tomato plants[14, 15]. The number of fruits set in the first inflorescence tended to be lower in the grafted plots compared to the non-grafted plot, although the difference was not significant. The number of fruits set in the second inflorescence was lower in the MF/P plot compared to the MF plot. However, we did not know about these factors.

The increased number of days to harvest fruits in the lower trusses of the grafted plots was likely a result of grafting causing retardation of initial growth. The initial growth of the grafted plots was slower than that of the MF plot, and it seemed to be a succulent growth overall. However, the growth of the grafted ward suddenly became vigorous after a while. Therefore, no significant difference was found in the number of days to harvest in the upper trusses, suggesting that grafting would not cause delays in later harvests.

A number of studies have reported improved fruit yield as a result of grafting[15–18], possible factors for which include disease resistance, vigorous growth maintained until later stages of cultivation[17], increased fruit weight, size, and number of flowers or fruits[13, 19, 20] as a result of grafting. However, no increases in the number of flowers or yield were observed in the MF/P plot, and instead, the number of harvested fruits and the yield were reduced in the first truss in Experiment 2 compared to the MF plot. On the other hand, the occurrence of disordered fruit and the weight of individual fruits in the MF/P plot were comparable to those in the MF plot. Thus, pepino-grafted tomato plants may ultimately be able to produce fruit yields equivalent to or higher than those in self-rooted tomato plants due to enhanced disease resistance or longer durations of vigorous growth as reported by LEE *et al.*[17]. Since our study used pinching and fruit thinning, future investigations with plants cultivated without pinching or fruit thinning are required in order to test this hypothesis.

In the MF/WRP plot, a reduced number of marketable fruits, lower fruit weights, and smaller yields were observed. The lower yields are likely the result of smaller numbers of marketable fruits and the lower individual fruit weights. Reduced fruit weights have also been observed in washer ring-treated pepino plants[5] and wire coil-treated tomato plants[12] and is suggested to be the result of reduced water absorption from the roots due to suppression of root growth. Similar mechanisms are likely involved in the reduced fruit weight observed in the MF/WRP plot in our study. Similar reductions in fruit weight have also been observed in tomato plants grown by other techniques for improving the fruit soluble solids content[1, 21–23].

In terms of fruit quality, the soluble solids content of fruit grown in the MF/P plot was higher than that grown in the MF plot only in the first truss in Experiment 1. Previous studies have reported both improved fruit quality[2, 3, 18] and reduced or equivalent fruit quality[8, 24, 25] in grafted tomato plants. One possible factor leading to these conflicting results may be that the effects of grafting on tomato fruit quality varies depending on the rootstock-scion combination[26]. The results of our study suggest that tomato grafting on pepino rootstock does not reduce fruit quality, although it is not likely to improve the fruit soluble solids content either.

An increase in the soluble solids content was observed in fruits harvested from the MF/WRP plot. An improved soluble solids content has also been reported in washer ring-treated pepino plants by TAKAHATA[5] and tomato plants by HARADA *et al.*[7]. These outcomes are suggested to result from the washer ring treatment affecting the shoot to root (T-R) ratio leading to reductions in water absorption due to suppressed root growth and thereby causing a reduced moisture content in the plant and a restricted water supply to the fruits. Similar mechanisms are likely to be involved in the increased fruit soluble solids content observed in the tomato plants grafted on washer ring-treated pepino rootstocks in this study. The soluble solids content of fruit from the MF/WRP plot were 111 to 127% of those from the MF plot in our study, whereas the soluble solids content of washer ring-treated, non-grafted tomato plants was 109 to 114% of those in the control plot in the study by HARADA *et al.*[7]. These results suggest that grafting tomato plants onto washer ring-treated pepino rootstocks causes greater improvements in the fruit soluble solids content compared to treating the tomato plants directly with a washer ring. Increased fruit firmness has been reported to increase due to water or saline stress[27], although we observed no increase in fruit firmness in fruits with an increased soluble solids content as a result of washer ring treatment.

In conclusion, in the grafted plots, the stems grew normally, and the leaves also developed normally (Table 1). In addition, the pepino rootstock had no disadvantageous effects on fruit production, such as an increase in the leaf number immediately below each inflorescence, a decrease in the number of flowers, or a decrease in the fruit set ratio of tomato (Table 2). Furthermore, when comparing the fruit quality of the MF plot and the MF/P plot, there was no significant difference in the percentage of disordered fruit, fruit weight, shape, soluble solids content, etc. (Table 3, 4). Therefore, we believe that the pepino-grafted tomato plants successfully grew and produced marketable fruits. Pepino is therefore a promising choice of rootstock for commercial tomato cultivation, offering a rootstock that is resistant to bacterial wilt and fusarium wilt diseases. At the same time, tomato grafting onto a washer ring-treated pepino rootstock may be a promising technique for improving the soluble solids content of tomato fruit, based on the increased soluble solids content observed even in fruits from the lower trusses. Further testing under conditions similar to those in commercial production sites is required. In addition, tomato plants grafted on washer ring-treated pepino rootstocks need to be tested for their resistance to bacterial wilt and fusarium wilt diseases.

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ペピーノを台木とした接ぎ木トマトの生育および果実品質

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要約：トマトの土壌病害を回避するための新しい接ぎ木栽培を開発することを目指して，ペピーノ‘Gold No. 1’を台木にした接ぎ木トマトの生育および果実品質を2年間（実験1；2016，実験2；2017）調査した。トマトの品種は‘桃太郎ファイト’として，自根トマトのMF区，無処理のペピーノを台木としたMF/P区，内径4mmのワッシャーでリング処理したペピーノを台木に用いたMF/WRP区を設けた。MF/P台区およびMF/WRP区について，接ぎ木直後の生長は抑制されたものの，栽培終了時の茎長および最上部の展開葉位におけるMF区との差は認められなかった。また，接ぎ木区においては茎葉新鮮重の増大が認められ，MF/WRP区では根新鮮重の減少によってT/R比が大きくなった。なお接ぎ木部は台負け現象を呈し，リング処理直上部の茎径は顕著に肥大した。接ぎ木区では低段果房の着果率，正常果実数および収量の減少が認められた。MF/WRP区においては，1果重も減少した。糖度について，MF/P区では無処理区の97～114%となったが，有意な上昇は実験1の第1果房のみであった。その一方で，MF/WRP区での糖度は無処理区の111～127%と著しく上昇した。本研究の結論として，ペピーノを台木とした接ぎ木トマトは順調に生育し，問題なく正常果を収穫することが可能であった。さらに，リング処理を施したペピーノを台木にすれば，糖度が高い果実を収穫出来ることが明らかとなった。そのため，ペピーノはトマト栽培において青枯病および萎凋病を回避できる新しい台木としての実用化が期待できる。今後は，ペピーノを台木とした接ぎ木トマトを実際の生産現場において栽培検証する必要がある。

キーワード：果実収量，*Solanum lycopersicum*，*Solanum muricatum* Aiton，糖度，リング処理

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