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Dry Matter Partitioning and Carbohydrate Status of 'Kawanakajima Hakuto' Peach Trees Grafted onto Different Rootstocks or with an Interstock at Pre-bloom Period

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Summary

'Kawanakajima Hakuto' peach trees grafted onto *Prunus tomentosa* often show graft-incompatible symptoms. In relation to the tree decline, dry matter partitioning and carbohydrate status of various tree parts at pre-bloom period were investigated in 'Kawanakajima Hakuto' grafted on *P. persica* (PP), *P. tomentosa* (PT), and a compatible interstock/*P. tomentosa* (IS). Under non-bearing conditions of three-year-old trees, the total whole tree dry matter amount of PT was only half of PP, whereas IS was greater than PT. However, the ratio of scion to rootstock (S/R ratio) in dry matter levels was similar (0.57-0.59) in all combinations. The starch content, the major carbohydrate in various parts, was higher in the rootstock than in scion parts, that in the roots being highest in PP among the combinations. The total amount of non-structural carbohydrate (starch + simple sugars) per tree in IS and PT was half and one-third of PP, respectively. The greatest amount of non-structural carbohydrate was found in ϕ < 2 mm roots, regardless of combinations. The S/R ratio in non-structural carbohydrate levels was 0.18 for PP, 0.31 for IS, and 0.30 for PT. On bearing four-year-old trees, the S/R ratio in dry matter levels was reduced in PP (0.47) but increased in IS (0.63) and PT (0.66). The S/R ratio in non-structural carbohydrate levels was 0.16, 0.65, and 0.80 for PP, IS, and PT, respectively. These results suggest that the tree decline in PT is partially promoted by the depletion of non-structural carbohydrate reserve at the pre-bloom period. Furthermore, the use of compatible interstock improves dry matter and non-structural carbohydrate status especially in the rootstock.

Key Words: carbohydrate, dry matter, interstock, peach, rootstock.

Introduction

We reported previously that the root starch content of peach grafted on *Prunus tomentosa* was only half of that grafted on *P. persica* at the pre-bloom period (Yano et al., 2000). The starch and sorbitol contents in roots and shoots of 'Kawanakajima Hakuto' often indicate a smaller predisposition for it to decline than do the contents of 'Akatsuki' when grafted on *P. tomentosa*. Carbohydrate reserve in deciduous trees is very important for reproductive development in the initial growth stages (Gaudillère et al., 1992; Lockwood and Sparks, 1978; Loescher et al., 1990; Quinlan, 1969; Teng et al., 1999). Furthermore, not only carbohydrate content but also the total amount of carbohydrates in each part is important for maintaining tree vigor.

Some peach cultivars show graft-incompatibility with *P. tomentosa* (Nakano and Shimamura, 1983; Yamane and Nakano, 1999), which leads to tree decline, whereas certain cultivars such as 'Hakuho' give a good affinity with the species (Yamane and Nakano, 1999). If compatible cultivars can be used as interstocks for incompatible scion cultivars, the rate of tree decline might be reduced. However, little is known yet about effects of compatible interstock on tree growth, dry matter partitioning, and carbohydrate statuses of various parts.

In this article we report the effects of rootstocks and compatible interstock for *P. tomentosa*, on the dry matter and non-structural carbohydrate amount of 'Kawanakajima Hakuto' peach trees at the pre-bloom period.

Materials and Methods

Plant materials

Scions of 'Kawanakajima Hakuto' and 'Chikuma' were grafted on rooted *P. tomentosa* Thunb. cuttings in March, 1995, and grown in a field for one year. 'Chikuma' scions were cut 10 cm above the graft union and 'Kawanakajima Hakuto' scions were grafted onto the interstocks (IS) in March, 1996. 'Kawanakajima Hakuto' scions were cut 10 cm above the graft union in March, 1996 and allowed to grow (PT). They were dug up in December, 1996 and transplanted to 80-liter black plastic pots after trimming the roots. 'Kawanakajima

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Hakuto', scions which were grafted on wild peach (*P. persica* Batsch var. 'Ohatsumomo') seedling rootstock, were treated similarly (PP). All trees were trained to a slender spindle type by annual dormant pruning. Beginning in December, 1997, to the end of the experiment, trees were administered 16:10:14, NPK at a rate of 100 g and 20 g per pot annually in mid-December and late September, respectively. All flowers were removed to maintain the trees in a non-bearing state; they were sprayed with pesticides as needed. Three trees of each combination were dug up on March 20, 1999, and their roots were washed with a high-pressure hand gun to remove soil particles. Trees were partitioned into one-year-old branches, >one-year-old branches, scion trunk, rootstock trunk, $\phi \geqq 10$ mm roots, $10 > \phi \geqq 2$ mm roots, and $\phi < 2$ mm roots. After the fresh weight of each part was recorded, the samples were washed and dried at 90 ℃ for one hr, and at 60 ℃ for 24 hr in a forced-draught oven, and then reweighed. The sum of one-year-old branches, >one-year-old branches and scion trunk was represented as the scion and the sum of remaining parts as the rootstock. After April 1999, three trees of each combination were allowed to flower and set fruit (the number of leaves per fruit was 220-240 in each combination at harvest). On March 15, 2000, trees were harvested and their parts separated as above.

Carbohydrate analysis

Dried samples were ground into powder (100-mesh) with a swing mill (Kawasakijyuko, T-100). Carbohydrate was extracted and analyzed according to the method described by Taniguchi (1986) and Tanaka (1992). A 2-g sample was extracted three times with 20 ml of 80% ethanol at 80 ℃ in a water bath. The ethanolic extracts were evaporated in a vacuum at 40 ℃ to a water phase. The mixture was brought to 1.5 mM $Ba(OH)_2$ and $ZnSO_4$ to precipitate the residual proteins. After centrifugation at 6,500 × g, the supernatant was made to 30 ml with distilled water and passed through a membrane filter (pore size, 0.45 μm). The sugar concentration in the filtrate was determined by injecting a 10 μl sample into a HPLC system (Hitachi, L-7100) equipped with a refractive detector (Hitachi, L-7490) and a Shodex NH_2P-50 column (4.6 mm × 250 mm), operated at a flow rate of 1 ml · min^{-1} at 35 ℃ with 75% CH_3CN as a solvent. The concentration of sorbitol, fructose, glucose, and sucrose was calculated from known peak areas of standard sugars.

Sugar-free residues after ethanol extraction were dried at 60 ℃ for at least two days. After 5-ml of dimethyl sulfoxide was added to 100 mg aliquots of dry residues, the sample was extracted three times by an ultrasonic generator (Iuchi Co., US-2) for 60 min and then the extracted solution was diluted with distilled water. The extract was incubated with glucoamylase (Seikagaku Co.) at 37 ℃ for 3 hr, heated for 5 min in boiling water, and then cooled. After centrifugation, the supernatant was assayed colorimetrically with a glucose measurement kit (Wako, glucoseB-test wako), and then the glucose concentration was converted to the starch

Table 1. Dry matter and non-structural carbohydrate in 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica*:PP, *P. tomentosa*:PT) or interstock (IS) at pre-bloom period.

Conditions	Combinations	Dry matter (g · $tree^{-1}$)				Non-structural carbohydrate (g · $tree^{-1}$)			
		Scion[z]	Rootstock[z]	Total	S/R ratio[y]	Scion	Rootstock	Total	S/R ratio[y]
Non-bearing (three-year-old trees)	PP	647a[x] (100)[w]	1,136a (100)	1,783a (100)	0.57	51.5a (100)	285.6a (100)	336.7a (100)	0.18
	IS	485b (75.0)	723b (72.4)	1,308b (73.4)	0.59	41.7ab (81.0)	134.7b (47.2)	176.4b (52.4)	0.31
	PT	327c (50.5)	564b (49.6)	891c (50.0)	0.58	27.7b (53.8)	91.3b (32.0)	119.1b (35.4)	0.30
Bearing (four-year-old trees)	PP	857a (100)	1,824a (100)	2,681a (100)	0.47	102.2a (100)	652.4a (100)	754.6a (100)	0.16
	IS	658b (76.8)	1,041b (57.1)	1,699b (63.4)	0.63	95.4a (93.3)	146.7b (22.5)	242.1b (32.1)	0.65
	PT	617b (72.0)	935b (51.3)	1,552b (57.9)	0.66	93.4a (91.4)	116.5b (17.9)	209.9b (27.8)	0.80

[z]Scion represents the sum of one-year-old branches, >one-year-old branches and scion-trunk; Rootstock is the sum of the other parts.
[y]The ratio of scion to rootstock.
[x]Different letters in the columns show significant differences by Duncan's new multiple range test at 5% level.
[w]Values in parenthesis indicate the percentage of each combination compared with PP.

content. The sum of simple sugars and starch was designated as total non-structural carbohydrate content.

Results

Non-bearing trees

The dry matter amount of PT was only half of the PP in the scion and rootstock fractions; IS had intermediate amounts between the two. The S/R ratio in dry matter amount was 0.57-0.59, regardless of combinations (Table 1). In the scion, PP had the greatest amount of dry matter, except for one-year-old branches, which did not differ among the combinations. Dry matter of the trunk was greater in IS than in PT. In the rootstock parts,

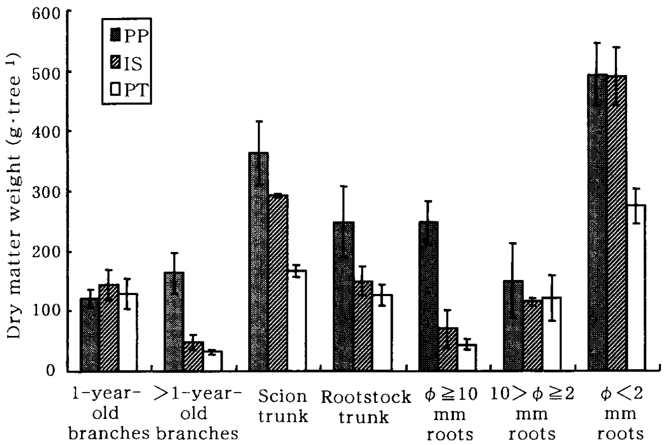

Fig. 1. Dry matter partitioning of 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica* : PP, *P. tomentosa* : PT) or interstock (IS) at pre-bloom period (non-bearing trees). Vertical bars indicate SE (n=3).

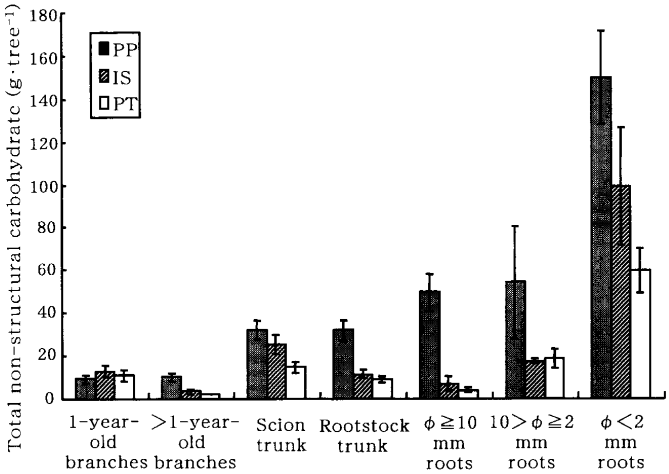

Fig. 2. Total non-structural carbohydrate status of 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica* : PP, *P. tomentosa* : PT) or interstock (IS) at pre-bloom period (non-bearing trees). Vertical bars indicate SE (n=3).

Table2. Non-structural carbohydrate contents in non-bearing 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica*:PP, *P. tomentosa*:PT) or interstock (IS) at pre-bloom period.

Parts	Combinations	Starch (%DW)	Sorbitol (%DW)	Other soluble sugars[z] (%DW)	Total non-structural carbohydrate (%DW)
One-year-old branches	PP	3.8 ± 0.7[y]	2.2 ± 0.1	1.8 ± 0.1	7.8 ± 0.6
	IS	5.2 ± 1.3	2.1 ± 0.2	1.8 ± 0.3	9.1 ± 1.2
	PT	5.2 ± 0.6	1.7 ± 0.2	1.4 ± 0.1	8.3 ± 0.5
>One-year-old branches	PP	2.4 ± 0.1	1.8 ± 0.2	2.1 ± 0.1	6.2 ± 0.1
	IS	3.7 ± 0.7	1.6 ± 0.1	2.0 ± 0.2	7.2 ± 0.8
	PT	5.1 ± 0.6	1.2 ± 0.2	1.5 ± 0.1	7.8 ± 0.9
Scion trunk	PP	5.6 ± 0.6	0.9 ± 0.1	2.6 ± 0.1	9.1 ± 0.7
	IS	6.1 ± 1.5	0.7 ± 0.1	2.1 ± 0.3	8.9 ± 1.8
	PT	6.5 ± 1.5	0.7 ± 0.1	1.5 ± 0.4	8.7 ± 1.8
Rootstock trunk	PP	9.9 ± 1.1	1.0 ± 0.2	2.4 ± 0.6	13.3 ± 1.6
	IS	4.7 ± 0.2	0.8 ± 0.1	2.2 ± 0.2	8.8 ± 0.3
	PT	5.3 ± 1.1	0.6 ± 0.1	1.4 ± 0.1	7.4 ± 1.1
$\phi \geqq 10$ mm roots	PP	15.3 ± 1.5	1.5 ± 0.2	3.3 ± 1.0	20.2 ± 1.8
	IS	6.1 ± 1.0	1.0 ± 0.1	1.9 ± 0.7	9.0 ± 1.6
	PT	6.6 ± 1.0	0.8 ± 0.1	1.3 ± 0.3	8.7 ± 1.2
$10 > \phi \geqq 2$ mm roots	PP	28.2 ± 2.1	1.7 ± 0.2	4.4 ± 0.7	34.2 ± 2.5
	IS	11.1 ± 0.7	1.4 ± 0.1	2.6 ± 0.2	15.1 ± 0.8
	PT	13.8 ± 1.3	0.9 ± 0.1	1.7 ± 0.2	16.4 ± 1.3
$\phi < 2$ mm roots	PP	25.9 ± 1.6	1.5 ± 0.2	2.8 ± 0.2	30.2 ± 1.8
	IS	15.8 ± 3.3	1.2 ± 0.1	2.7 ± 0.1	19.6 ± 3.4
	PT	18.6 ± 1.7	0.8 ± 0.1	2.1 ± 0.1	21.4 ± 1.8

[z]Other soluble sugars represent the sum of fructose, glucose and sucrose.
[y]Data represent mean ± SE (n=3).

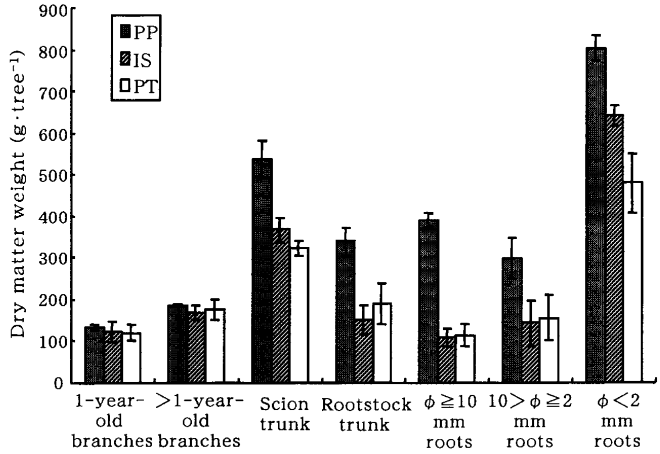

Fig. 3. Dry matter partitioning of 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica* : PP, *P. tomentosa* : PT) or interstock (IS) at pre-bloom period (bearing trees). Vertical bars indicate SE (n=3).

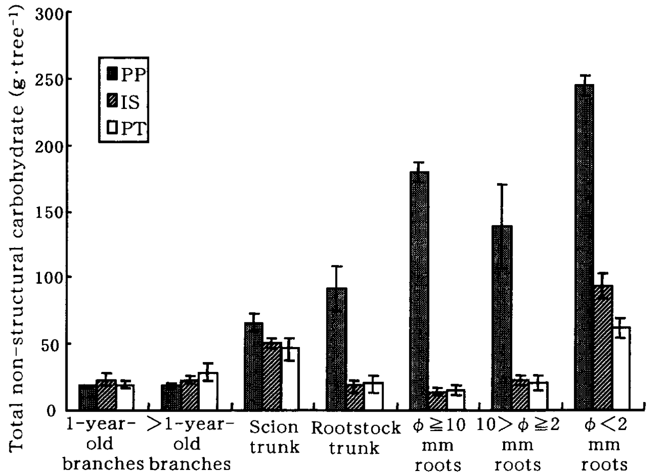

Fig. 4. Total non-structural carbohydrate status of 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica* : PP, *P. tomentosa* : PT) or interstock (IS) at pre-bloom period (bearing trees). Vertical bars indicate SE (n=3).

the amount of dry matter in the rootstock trunk and $\phi \geqq$ 10 mm roots was greatest in PP. In $\phi < 2$ mm roots, there were no significant differences between PP and IS, whereas PT had a significantly lower amount (Fig. 1).

The amount of non-structural carbohydrates in the scion parts was proportional to the dry matter. However, in the rootstock, non-structural carbohydrates in IS and PT was 47.2% and 32.0% of PP, respectively. The S/R ratio in non-structural carbohydrate of IS and PT were higher than those of PP (Table 1), whereas the total non-structural carbohydrates of IS and PT in each part were lower than those of PP, except for one-year-old branches. IS showed higher a amount non-structural carbohydrates than PT in scion trunk and $\phi < 2$ mm roots (Fig. 2).

There was no significant difference in the starch content in the scion parts among combinations, but that in the rootstock of PT and IS was lower than PP. Sorbitol and other soluble sugars contents, the sum of fructose, glucose, and sucrose, were lowest in all parts of PT. The total non-structural carbohydrate contents showed a tendency similar to the starch content (Table 2).

Bearing trees

The dry matter amount of the scion and rootstock in PT and IS was lower than that in PP. There were no significant differences between IS and PT. The S/R ratio in dry matter amount of PT and IS were higher than PP (Table 1). PP had the maximum amount of dry matter in the scion trunk, rootstock trunk and roots. There were no significant differences in dry matter in one-year-old or >one-year-old branches among combinations; that in $\phi < 2$ mm roots, IS was intermediate between PP and PT (Fig. 3).

There was no significant difference in the amounts of the non-structural carbohydrates of the scion parts among combinations. However, in the rootstock parts, the non-structural carbohydrates of IS and PT were 22.5% and 17.9% of PP, respectively. Total non-structural carbohydrate amounts of the whole tree in IS and PT were significantly less than that in PP. The S/R ratio in non-structural carbohydrate levels of PT was higher than IS; it was lowest in PP (Table 1). PP had the most total non-structural carbohydrates in each part of the rootstock; that of IS was higher than PT in only $\phi < 2$ mm roots (Fig. 4).

The starch content in the scion of PT was greater than those in IS; it was lowest in PP. As for the rootstock, the starch content was highest in PP. The content of sorbitol, other soluble sugars and total non-structural carbohydrates of IS were higher than PP and PT in one-year-old branches. There was no significant difference of sorbitol content in the other parts; IS contained more sugar than did PT in $10 > \phi \geqq 2$ mm roots and $\phi < 2$ mm roots. Total non-structural carbohydrate content parallels that of the starch content except one-year-old branches (Table 3).

Discussion

Carbohydrate reserves in deciduous trees play essential roles in the initial growth of spring so that any occurrences e.g. adverse weathers or pest infestation in the previous season affects the initial growth of trees (Hirata et al., 1974; Toyama and Hayashi, 1957). Root reserves play an especially important role as the major source of substrates (Keller and Loescher, 1989; Loeschr et al., 1990; Teng et al., 1999). We previously reported that the starch content of root in PT was highest before the leaf absission period and decreased to pre-bloom period, but that of PP showed little changes during the dormant period (Yano et al., 2000). These results suggest that the cause of dwarfing in PT is attributed partly to the smaller amount of the non-structural carbohydrates that in the rootstock at the pre-bloom period. Brown et al. (1985) also found that in apple trees grafted

Table 3. Non-structral carbohydrate contents in bearing 'Kawanakajima Hakuto' peach trees grafted onto different rootstocks (*P. persica*:PP, *P. tomentosa*:PT) or interstock (IS) at pre-bloom period.

Parts	Combinations	Starch (%DW)	Sorbitol (%DW)	Other soluble sugars[z] (%DW)	Total non-structural carbohydrate (%DW)
One-year-old branches	PP	9.3 ± 0.6[y]	1.5 ± 0.1	2.6 ± 0.1	13.4 ± 0.4
	IS	11.0 ± 0.8	2.5 ± 0.1	4.7 ± 0.5	18.1 ± 0.8
	PT	12.0 ± 0.3	1.3 ± 0.1	3.0 ± 0.7	15.9 ± 0.1
>One-year-old branches	PP	6.5 ± 0.7	1.2 ± 0.2	2.4 ± 0.3	10.0 ± 0.9
	IS	9.9 ± 1.0	1.1 ± 0.2	2.3 ± 0.4	13.6 ± 1.3
	PT	12.0 ± 1.0	1.2 ± 0.3	2.7 ± 0.6	15.9 ± 1.5
Scion trunk	PP	9.2 ± 1.2	0.7 ± 0.1	2.3 ± 0.4	12.2 ± 0.8
	IS	9.8 ± 1.1	0.9 ± 0.1	3.1 ± 0.3	13.8 ± 0.7
	PT	11.1 ± 1.6	0.7 ± 0.2	2.2 ± 0.6	14.0 ± 1.7
Rootstock trunk	PP	24.5 ± 3.3	0.6 ± 0.1	1.5 ± 0.2	26.6 ± 2.5
	IS	9.8 ± 2.0	0.6 ± 0.1	1.7 ± 0.3	12.1 ± 1.8
	PT	8.3 ± 1.4	0.6 ± 0.1	1.5 ± 0.1	10.4 ± 1.0
$\phi \geqq 10$ mm roots	PP	42.5 ± 0.5	1.1 ± 0.2	2.5 ± 0.6	46.1 ± 0.5
	IS	10.7 ± 1.2	0.7 ± 0.2	1.5 ± 0.4	12.9 ± 1.5
	PT	10.5 ± 1.9	0.6 ± 0.2	1.8 ± 0.5	13.0 ± 1.9
$10 > \phi \geqq 2$ mm roots	PP	41.7 ± 3.9	1.3 ± 0.2	2.9 ± 0.5	45.9 ± 3.7
	IS	14.0 ± 4.1	1.1 ± 0.1	2.7 ± 0.2	17.8 ± 3.6
	PT	12.1 ± 2.1	0.7 ± 0.2	1.5 ± 0.3	14.3 ± 1.6
$\phi < 2$ mm roots	PP	28.1 ± 2.7	1.1 ± 0.2	1.4 ± 0.1	30.6 ± 2.0
	IS	11.2 ± 2.4	0.9 ± 0.1	2.5 ± 0.1	14.6 ± 2.0
	PT	10.4 ± 1.9	0.8 ± 0.1	1.9 ± 0.2	13.1 ± 1.7

[z] Other soluble sugars represent the sum of fructose, glucose and sucrose.
[y] Data represent mean ± SE (n=3).

on dwarfing rootstocks, the reserve food in roots at the pre-bloom period was less than that of the tree grafted on vigorous rootstocks.

The horticultural significances of interstock in the fruit tree cultivation are: (1) It allows dwarfing, such as M9 interstock in apple; (2) It overcomes incompatibility between scion and rootstock (Soejima, 1995). Gur et al. (1968) reported that toxic cyanide was produced at the graft union by hydrolyzation of prunasin in the 'Quince' rootstock with β-glycosidase of scion, when certain pear cultivars were grafted on 'Quince' rootstocks. Cyanide accumulation interrupts translocation by destroying phloem and xylem at the graft union and results in an incompatibility symptom (Andrews and Serrano, 1993). However, certain pear cultivars possess enzymes for degrading prunasin and detoxifying the cyanic compound (Gur and Blum, 1973). Therefore, there were no incompatible symptoms when a compatible variety was used as interstock, even in the incompatible combination such as 'La France' grafted on 'Quince' (Andrews and Serrano, 1993; Ito et al., 1994). Similarly in peach trees, several researchers mentioned that the hydrolysis of cyanogenic glycoside caused graft incompatibility (Andrews and Serrano, 1993; Moing and Salesses, 1988). Whether cyanide toxicity is involved in the incompatibility between peach and *P. tomentosa* has not been determined. Yamane and Nakano (1999) reported that lignification, accumulation of polyphenol, and activity of L-phenylalanine ammonia-lyase at the graft union in an incompatible combination between peach scion and *P. tomentosa* rootstock were greater than in a compatible combination. Furthermore, irregular morphogenesis at the graft union may inhibit normal transport of sap. Hence, improvement of graft-compatibility by using the interstock may enhance the transport of sap and photosynthates through the vascular system at the graft union.

Some researchers reported that certain peach varieties do not show incompatibility with *P. tomentosa* rootstocks (Nakano and Shimamura, 1983; Tsuruta et al., 1985; Yamane and Nakano, 1999). We used 'Chikuma' as an interstock in this experiment because it seems to be compatible with *P. tomentosa* (unpublished). Thus, whether bearing or non-bearing, this stock:interstock:rootstock combination allowed greater dry matter and non-structural carbohydrate and soluble sugar accumulation than in PT, especially, in the roots. That vigorous vegetative growth tends to retard reproductive processes, such as fruit set and fruit growth was demonstrated when *P. tomentosa* was used as a dwarfing rootstock. It led to overcropping and faster decline in tree vigor than PP (Nakano and Shimamura, 1983). In this case, it seems likely that the unbalance of photosynthate partitioning easily occurs in incompatible combinations. Moing and Gaudillère (1992) found that sorbitol concentration was lower in the roots of the incompatible graft than in the roots of compatible graft, whereas an abundance of soluble sugars and starch accumulated in the peach scion of the incompatible graft. They concluded, therefore, that carbon transfer to the roots is slowed down as a result of graft incompatibility as we did with starch accumulation in the scion of bearing trees of PT. That there were no significant differences in the sorbitol content of the rootstock and other soluble sugar content of the scion among the combinations indicate that the difference depended on the degree of incompatibility. Starch accumulation in the above-ground part is often observed under incompatible conditions (Andrews and Serrano, 1993; Moing et al., 1990; Moing and Gaudillère, 1992). But an accurate comparison is difficult between our bearing and non-bearing trees, because their ages and climatic conditions were not identical.

That starch content in scions of IS was intermediate between PP and PT indicates the improvement of graft-compatibility by using the interstock. Likewise, under bearing conditions, the S/R ratio in dry matter accumulated was similar but the ratio in non-structural carbohydrate was greater in PT than in IS which shows that IS trees can translocate more photosynthetic products to the rootstock. As this experiment was carried out in the plastic pots, it is possible that the growth of underground parts was restricted even in relatively graft-compatible situations, such as in PP and IS. Therefore, further studies are necessary under field conditions.

In conclusion, we recommend the use of compatible interstock to enhance the translocation of photosynthates to roots to be stored as reserve food. That should improve initial growth in the spring and extend the longevity of the tree.

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モモ'川中島白桃'樹の開花前の乾物分配および炭水化物量に及ぼす台木と中間台木の影響

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摘　要

ユスラウメを台木とした'川中島白桃'の栽培においては不親和症状が発生しやすい．そこで，樹勢衰弱との関連において，台木の種類(普通台木:PP樹，ユスラウメ台木:PT樹)，およびユスラウメ台と親和性の良い中間台木の挿入(IS樹)が，'川中島白桃'の開花前の樹体各部位の乾物量と，炭水化物量に及ぼす影響を検討した．

無着果の3年生樹における1樹当たりの全乾物重は，PT樹がPP樹の約半分で，IS樹はPT樹より多かった．しかしながら，乾物重の地下部に対する地上部の割合(S/R比)は全ての区で同程度であった(0.57-0.59)．また，主要な炭水化物であるデンプンは，地上部よりも地下部に多く含まれ，特にPP樹の根で高かった．1樹当たりの全炭水化物量(デンプン+可溶性糖)はIS樹がPP樹の約半分，PT樹はPP樹の1/3程度であった．部位別にみると，直径2 mm未満の根で，どの区においても全炭水化物量が多かった．全炭水化物量のS/R比はPP樹が0.18，IS樹が0.31，PT樹が0.30であった．着果させた4年生樹では，全乾物重のS/R比がPP樹では0.47と，無着果樹のものに比べて低くなったのに対して，IS樹(0.63)とPT樹(0.66)では高くなった．一方，全炭水化物量のS/R比はPP樹が0.16，IS樹が0.65，PT樹が0.80であった．以上のことから，ユスラウメ台木との親和性が低い品種では，開花前の炭水化物量が少ないことが衰弱症状の発生を助長していると考えられるが，親和性品種を中間台として用いることにより，地下部における乾物分配，炭水化物量が増加し，衰弱症状の発生を軽減できる可能性が示唆された．