定植方法がM.26中間台ふじの生育,収量と果実品質に及ぼす影響

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Influence of Planting Depth on Growth, Yield and Fruit Quality of M. 26 Interstem 'Fuji' Apple Trees

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Summary

The effect of planting method on the tree vigour of M. 26 interstem 'Fuji' apple trees was examined in shallow sandy soil from 1978 to 1986. Trees on M. 26 interstem exposed exhibited a retardation of tree vigour from the 5th to 6th year after planting ; particularly, tree growth and yield were significantly decreased. Tne calculated orchard LAI including alley ways showed 2.5 (interstempiece half-buried) and 1.1 (interstempiece exposed). Fruit from trees with interstem half-buried were larger and the eatin gquality was better than from trees with interstem exposed. Burrknots were formed at the node of the exposed interstem. It was thought that tree vigour was affected by the degree and number of those burrknots. Original roots of trees with interstem half-buried were replaced by new roots arising from the M. 26 interstempiece near the soil surface at the 4th year after planting. Root growth of the interstem exposed trees were drastically suppressed. These findings suggest that M. 26 interstem trees, which have been widely used in Japan, must be planted deeply in order to avoid burrknot formation on the interstempiece above ground.

Introduction

In 1985, apple trees with dwarfing rootstocks were growing in about 25 percent of apple orchards in Nagano Prefecture. The main dwarfing rootstock was M. 26 (83% in 1983) and trees were planted in hedgerows at a spacing of 1.5×4 m or 2×4 m using trellis or metal pole supports. Most dwarfing apple trees grown in Japanese nurseries were M. 26 interstem trees using the weeping Marubakaido (*M. prunifolia* var. *ringo*) rootstock. Except for virusfree sources, M. 9 has not been used as an interstempiece on the weeping Marubakaido rootstock because of an incompatibility caused by a latent chlorotic leaf spot virus carried in M. 9.

Many researchers demonstrated different effects of interstocks and interstem lengths(2, 5, 7). Especially, Parry and Rogers (7) showed that long interstocks of M. 26 caused extreme dwarfing. Shallow planted interstem trees tended to develop burrknots on the above ground parts of the interstem(3, 6, 9, 12). Burrknots were formed at the node of stem and tended to cause reduced vigour (10, 11).

We report the effects of two planting methods on the field performance of M. 26 interstem 'Fuji' apple trees over 9 years at the Nagano Prefectural Fruit Tree Experiment Station.

Materials and methods

One-year-old 'Fuji' trees with 30 cm M. 26 interstems over 20 cm of Marubakaido N-1 (*M. purnifolia* var. *ringo*) were planted in sandy loam soil in March 1978. Two different planting methods, at 1.5×4 m spacing, were used.

Planting method treatments were : 1) stempiece exposed (the soil line 5 cm below the stempiece/rootstock union) ; 2) stempiece half-buried (the soil line at the mid-section of stempiece by mounding the soil in fall of the same year).

All trees were trained similar to the Slender Spindle Training system. A randomized block design was used with 5-tree plots replicated 8 times.

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Trunk girth at 15 cm above scion/stempiece union, tree height and spread were annually measured, and annual yields were recorded including fall fruits. Burrknots on the M. 26 stempiece were counted at the 8 th year after planting.

At harvest, a 50-fruit composite sample (10 fruit from each of 5 trees) was used to measure soluble solids.

The root system of a characteristically grown tree from each treatment was dug up by hoseing with pressurised water, to measure growth at the 4th year after planting. For the anatomical study of root nodules, material from 1-year-old and 2-year-old M. 26 shoots were used. Stems were cut at node and internode to find the original position of root germs or root nodules.

Results and Discussion

Growth

Tree size of M. 26 interstem 'Fuji' apple trees was influenced by the planting methods. Exposing the stempiece tended to reduce tree vigour from the 4th to 5th year after planting.

Interstem exposed trees were, at the 9th year, only 55% the size (height and spread), and half the trunk growth (cross sectional area) of interstem half-buried trees (Table 1).

Nine-year-old interstempiece exposed trees did not fill the given empty space. Heavy intertwining of the shoots from trees with half-buried interstems, planted in 1.5×4 m, were recognized the 9 th year after planting. The distance between trees within the rows should be about 2.0 or 2.5 m for half-buried interstem trees in fertile soils.

Jackson(4) reported the highest LAI to be 2.6 in a typical hedgerow orchard including alley ways, at the East Malling Research Station. The calculated orchard LAI including alley ways in this study was 2.5 (interstempiece half-buried) and 1.1 (interstempiece exposed)at the 8th year after planting(Table 2). The optimum LAI for hedgerow orchards of the 'Fuji' variety is anticipated to be lower than 2.5, based on growth characteristics and fruit production.

Yield

The trees quickly came into production and the first crop was harvested in 1980, the third year after planting. Yield of trees with stempiece half-buried increased to 30-40 kg at the 6th to 8th year. Trees with interstem exposed recorded maximun yield at the 4th to 5th

Table 1. Growth and yield of interstem exposed and half-buried M. 26 interstem 'Fuji' apple trees at the 9th year.

Planting method	Height (cm)	Spread (cm)	TCA[z] (cm^2)	Yield /tree (kg)	Cumulative yield/tree (kg)	Cumulative yield/TCA (kg)
Interstem :						
half-buried	427	277	68.4	32.3	166.8	2.43
exposed	282	208	33.4	17.1	91.3	2.73
Significance	**	**	**	**	**	NS

z : Trunk cross sectional area was measured at 15 cm above graft union.
** Significantly different at the 1% level.
* Significantly different at the 5% level.

Table 2. Effect of planting methods on shoot growth, leaf weight and leaf area of 8-year 'Fuji' apple trees on M. 26 interstem.

Planting method	Shoot length[y] (cm)	Avg. shoot length (cm)	No. of leaves	Leaf weight (g)	Avg. leaf weight (g)	Leaf area (cm^2)	LAI /Area[z]
Interstem :							
half-buried	10,214	26.8	8,391	3,611	0.43	151,285	2.5
exposed	3,787	17.3	4,706	1,557	0.33	67,874	1.1

y : Total current shoot growth.
z : Data were calculated from a leaf area to leaf weight relationship and 167 trees per 10 are. ($y=36.06x+2.52$, y : leaf area, x : leaf weight, $r=0.973$ ** $n=200$)

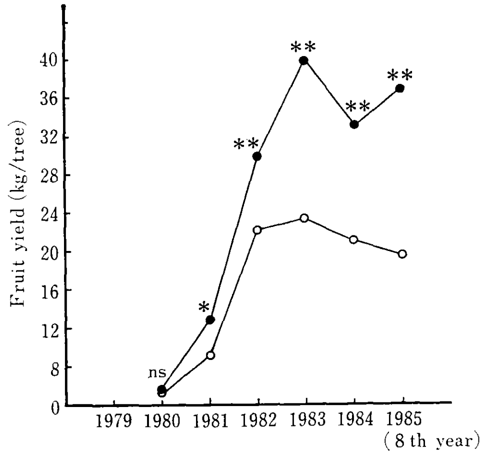

Fig. 1. Annual yield per tree of M. 26 interstem 'Fuji' apple trees. ○—○ : Interstem exposed. ●—● : Interstem half-buried. Each point is the mean of eight plots (5 replications per plot). ns=nonsignificant; *, $p \leqq 0.05$; **, $p \leqq 0.01$.

Fig. 2. Intermediate stem sections and burrknots.
A : Exposed M. 26 interstems and burrknots at the 8th year. Note that burrknots encircled the interstem surface near the upper graft union.
B : Twisting and disfiguration of half-buried M. 26 interstems caused by the burrknots.

year, then tended to decrease their yield gradually. Yield of trees with interstem exposed was about half that of interstem half-buried trees after the 6th year (Fig. 1). A significant difference of cumulative yield per trunk cross sectional area was not recognized (Table 1).

From these results, it is clear that M. 26 interstem trees are precocious and productive, but interstem exposed planting causes tree vigour retardation and gradual decrease in yield.

Burrknot formation on the interstempiece

The clonal rootstocks MM. 111, MM. 106, M. 7 and M. 26 have a strong tendency to produce burrknots when exposed above ground(9). Root nodules began to occur on the above ground portion of M. 26 interstempieces during the first or second year after planting. These root nodules extended annually and developed into burrknots. Interstempiece exposed trees formed more burrknots on the interstems than interstem half-buried trees (Table 3). Most burrknots, formed on the exposed interstems, developed annually and finally encircled the surface within five to six years after planting. Burrknots formed on the above ground portion of the interstempiece tended to cause interstem fluting, interstem twisting and disfiguration (Fig. 2).

Root germ and root nodule formation on young M. 26 shoots

Root nodules were recognized on nodes of well grown one-year-old shoots near the soil surface in the nursery. Swingle(11) showed that root germs in apple shoots may be initiated at several points in the cambium ring: 1) at the branch gaps, 2) at the leaf gaps, 3) at the primary medullary rays, 4) at the secondary medullary rays. In this study, most root nodules were thought to be initiated from

Table 3. Burrknot development on M. 26 interstem at the 8th year.

Planting methods	Average no. of burrknots						Total
	<10[z]	10—20	20—30	30—40	40—50	50<mm	
Interstem :							
half-buried	0.1	0.2	0.7	1.8	1.5	1.9	6.2
exposed	0.3	1.5	2.7	3.2	2.7	1.3	11.7
Significance	NS	*	**	**	**	NS	**

[z] : Diameter of burrknots.
** Significantly difference at the 1% level.
* Significantly difference at the 5% level.

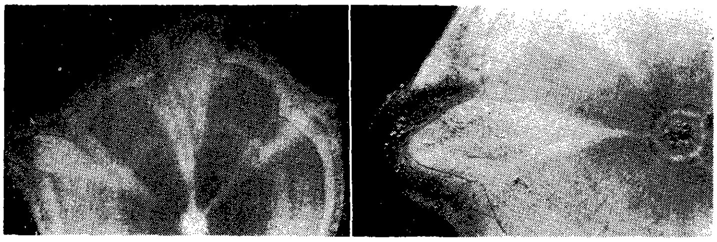

Fig. 3. Root nodules which have arisen on a leaf trace or internode of a 1-year-old M. 26 shoot.
A : A cross section of root nodules formed on the node.
B : A cross section of root nodules formed on the internode. Note that nodules are connecting with the central pith.

leaf traces or bud gaps at the node. Root nodules or root germs which had arisen on internodal parts were not related to leaf traces or bud traces but were connected to the central pith(Fig. 3).Thus the burrknots are thought to interfer with movement of water or nutrients, because of their connection to the central pith.

Root development

Rogers and Parry (8) showed that deep planted dwarfing apple trees develop a new root system near the soil surface replacing the original roots. When the root system of a 4-year-old interstem half-buried tree was examined after grubbing, it was found that the original roots of Marubakaido N-1 (*M. prunifolia* var. *ringo*) had been almost replaced by new roots arising from the M. 26 interstempiece near the soil surface (Fig. 4). But even though the original basal roots of Marubakaido N-1 (*M. prunifolia* var. *ringo*) showed little growth, they survived and seemed to help keep the tree stable.

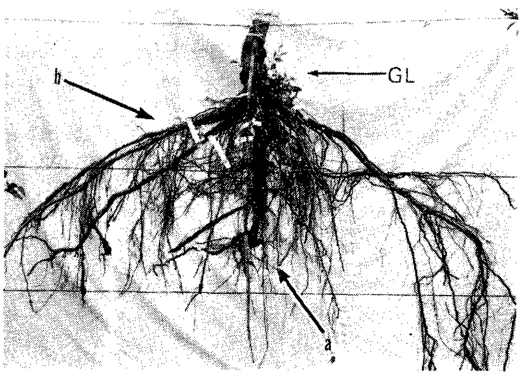

Fig. 4. A root system of interstem half-buried 'Fuji' apple trees at the 4th year.
a : Original roots (Marubakaido N-1).
b : New roots (M. 26).
GL : Ground level.

The root growth of the interstem exposed tree was drastically suppressed.

Fruit quality

Fruit from trees with interstem exposed became smaller than those of trees with interstem half-buried from the third year after fruiting. The average fruit weight of trees with interstem exposed was 18% less than that of trees with interstem half-buried, at the 8th to 9th year after planting (Fig. 5).

Fruit of trees with interstem exposed had a little higher soluble solids and were somewhat less juicy than those of trees with interstem half-buried. Brix changes usually depend on pre-harvest rainfall. In spite of the heavy rainfall that occurred in the pre-harvest season in 1981, fruit from trees with interstem exposed had higher soluble solids than that of

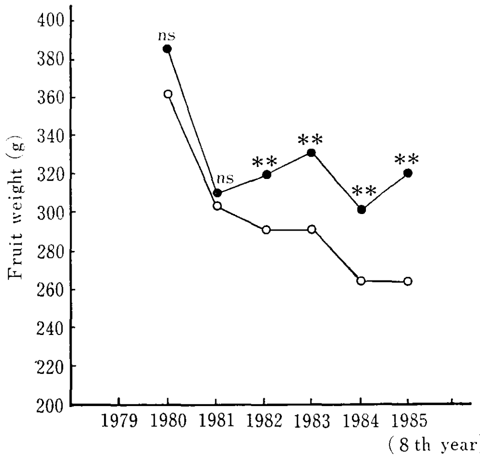

Fig. 5. Changes in fruit weight of M. 26 interstem 'Fuji' apple trees. ○—○ : Interstem exposed. ●—● : Interstem half-buried. Each point is the mean of eight plots (5 replications per plot). ns=nonsignificant; *, p≦0.05; **, p≦0.01.

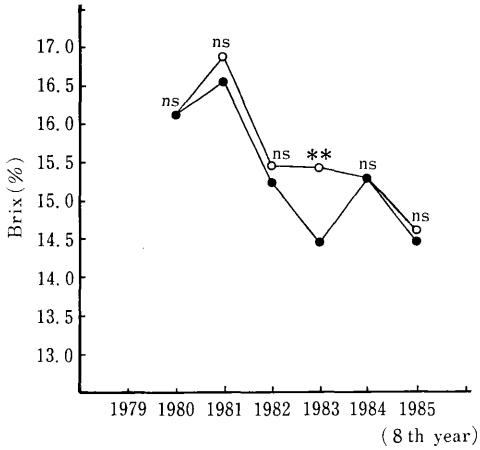

Fig. 6. Soluble solid content in fruit. ○—○: Interstem exposed. ●—●: Interstem half-buried. Each point is the mean of eight plots (5 replications per plot). ns=nonsignificant *, $p \leqq 0.05$; **, $p \leqq 0.01$. Pre-harvest month, September in 1983 had above average rainfall. It was the highest rainfall between 1979 to 1985 and totalled 253 mm, more than double the average of 115 mm.

trees with interstem half-buried (Fig. 6).

It is thought that the burrknots interfered with movement of water or nutrients and reduced fruit quality.

Based on this study, we would recommend that dwarfing apple trees propagated by double grafting long M. 26 interstocks on Marubakaido N-1 (*M. prunifolia* var. *ringo*) be planted deeply with the interstempiece at least 5 to 7 cm exposed. We also recommend that growers choose short interstem dwarfing apple nursery trees.

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Literature Cited

1. ATKINSON, D. 1973. The root sysem of Fortune/M 9. Rpt. East malling Res. Sta. for 1972. p. 72-78.
2. CARLSON, R. F. and S. D. OH. 1975. Influence of Interstem Lengths of M. 8 Clone *Malus sylvestris* Mill. on Growth, Precocity, Yield and Spacing of 2 Apple Cultivars. J. Amer. Soc. Hort. Sci. 100: 450-452.
3. COSTANTE, J. F., W. J. LORD, D. HOWARD and L. CONNINGTON. 1983. Influences of planting depth on growth, root suckering and yield on interstem apple trees. HortScience 18: 913-915.
4. JACKSON, J. E. 1980. Light interception and utilization by orchard systems [mainly apple]. Hort. Rev. Vol. 2: 208-267.
5. LOCKARD, R. G. 1974. Effects of rootstocks and length and type of interstock on growth of apple trees in sand culture. J. Amer. Soc. Hort. Sci. 99: 321-325.
6. LYONS, C. G. Jr., R. E. BYERS and K. S. YODER. 1983. Influence of planting depth on growth and anchorage of young 'Delicious' apple trees. HortScience 18: 923-924.
7. PARRY, M. S. and W. S. ROGERS. 1972. Effects of interstock length and vigour on the field performance of Cox's Orange Pippin apples. J. Hort. Sci. 47: 97-105.
8. ROGERS, W. S. and M. S. PARRY. 1968. Effects of deep planting on anchorage and performance of apple trees. J. Hort. Sci. 43: 103-106.
9. ROM, R. C. and S. A. BROWN. 1979. Factors affecting burrknot formation on clonal Malus rootstocks. HortScience. 14: 231-232.
10. SIEGLER, E. A. and R. B. PIPER. 1929. Aerial crown gall of the apple. J. Agr. Res. 39: 249-262.
11. SWINGLE, C. F. 1927. Burrknot formations in relation to the vascular system of the apple stem. J. Agr. Res. 34: 533-544.
12. YOUNG, E. and R. H. TYLER. 1983. Burrknot control on apple. HortScience 18: 921-922.

定植方法がM. 26中間台ふじの生育，収量と果実品質に及ぼす影響

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摘 要

M. 26中間台ふじの定植方法と生育特性について，1978年から1986年の9年間，耕土の浅い砂壌土の条件で検討を行った．中間台を地上に露出させた浅植え区では，定植後5～6年目より樹勢が衰弱し，中間台の半分程度まで盛土した深植え区とは著しい生育差と収量差を示した．深植え区の果実は大粒果であり，浅植え区より果汁が多く，食味が優れた．

地上部に露出したM. 26中間台の節部には，根源基の発達したバーノット（気根束）が多数形成された．樹勢はバーノットの数と発達程度によって影響された．

台木から発生するヒコバエは，深植え区で少ない傾向であった．

定植後4年目の根群調査の結果から，深植え区では地表近くに中間台部から新根が発生し，地下深く位置する苗床起源の根に代って肥大することが明らかとなった．

これらの結果から，M. 26の中間台利用樹は地上部に形成されるバーノットを避けるため，出来るかぎり深植えにするべきと思われる．