愛媛大学農学部農場報告
(Bull. Exp. Farm Fac. Agr., Ehime Univ.) 28：1－7 (2006)

Effect of Vertical Root Restriction with Corrugated Plastic Sheets on Growth and Flower Bud Formation in Young Peach Trees

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Summary

We studied the effect of root restriction on the growth and flower bud formation of young peach trees. Twenty two-year-old peach trees (*Prunus persica* [L.] Batsch), cv. 'Akatsuki' grafted on wild form rootstocks were randomly selected for this experiment in April 2005. The treatment planting holes were lined with different sizes of corrugated plastic sheets (65×90 cm, 45×65 cm, 32.5×45 cm) at a depth of 10 cm and replications were five. Shoot length in trees grown over full size (65×90 cm) corrugated plastic sheets declined by nearly 50%. The weight of branches pruned from trees on full size plastic sheets reduced by 60%, those on half size plastic sheets (45×65 cm) by 32% and those on quarter size sheets (32.5×45 cm) by 20%, as compared with controls. The percentage of floral buds was slightly increased by the presence of corrugated plastic sheets below the roots.

Introduction

Plant roots must sense and respond to a variety of environmental stimuli as they grow through the soil. Touch and gravity represent two of the mechanical signals that roots must integrate to elicit the appropriate root growth patterns and root system architecture. Obstacles such as rocks will impede the general downwardly directed gravitropic growth of the root system and so these soil features must be sensed and this information processed for an appropriate alteration in gravitropic growth to allow the root to avoid the obstruction[14].

A restricted root zone (RRZ) is often important in commercial horticulture. Under conventional cultivation, tillage pans or high soil bulk density restrict root penetration, hence limiting the soil volume available for roots to explore for water and nutrients[17]. Root restriction may also be important for growers who are producing plants in containers and those concerned with the establishment and maintenance of urban trees or with high density planting[1, 4]. Similarly, researchers may grow plants in confined spaces such as phytotrons or controlled environments. It

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is commonly thought that any treatment that restricts root growth may affect shoot development via a disturbance of plant water relations. For instance, root restriction led to shoot length reduction in 'Fujiminori' grapevines[21].

Touch and gravity are two of the many stimuli that plants must integrate to generate an appropriate growth response. Due to the mechanical nature of both of these signals, shared signal transduction elements could well form the basis of the cross-talk between these two sensory systems. However, touch stimulation must elicit signaling events across the plasma membrane whereas gravity sensing is thought to represent transformation of an internal force, and amyloplast sedimentation, to signal transduction events. In addition, factors such as turgor pressure and presence of the cell wall may also place unique constraints on these plant mechanosensory systems[6].

Plants adapt their growth in response to environmental cues. Gravity is a constant force that guides the direction of plant growth. Mechanical stimuli such as wind, rain, and obstacles in the soil trigger changes in growth[3, 14]. Gravitropic and mechanical stimulation in the root are interactive processes, mutually influencing differential growth[6, 14, 15].

Plants exposed to repetitive touch or wind are generally shorter and stockier than sheltered ones. These mechanostimulus-induced developmental changes are termed thigmomorphogenesis and may confer resistance to subsequent stresses. An early response of *Arabidopsis thaliana* to touch or wind is the up-regulation of *TCH* (touch) gene expression. The signal transduction pathway that leads to mechanostimulus responses is not well defined. A role for ethylene has been proposed based on the observation that mechanostimulation of plants leads to ethylene evolution and exogenous ethylene leads to thigmomorphogenetic-like changes[12].

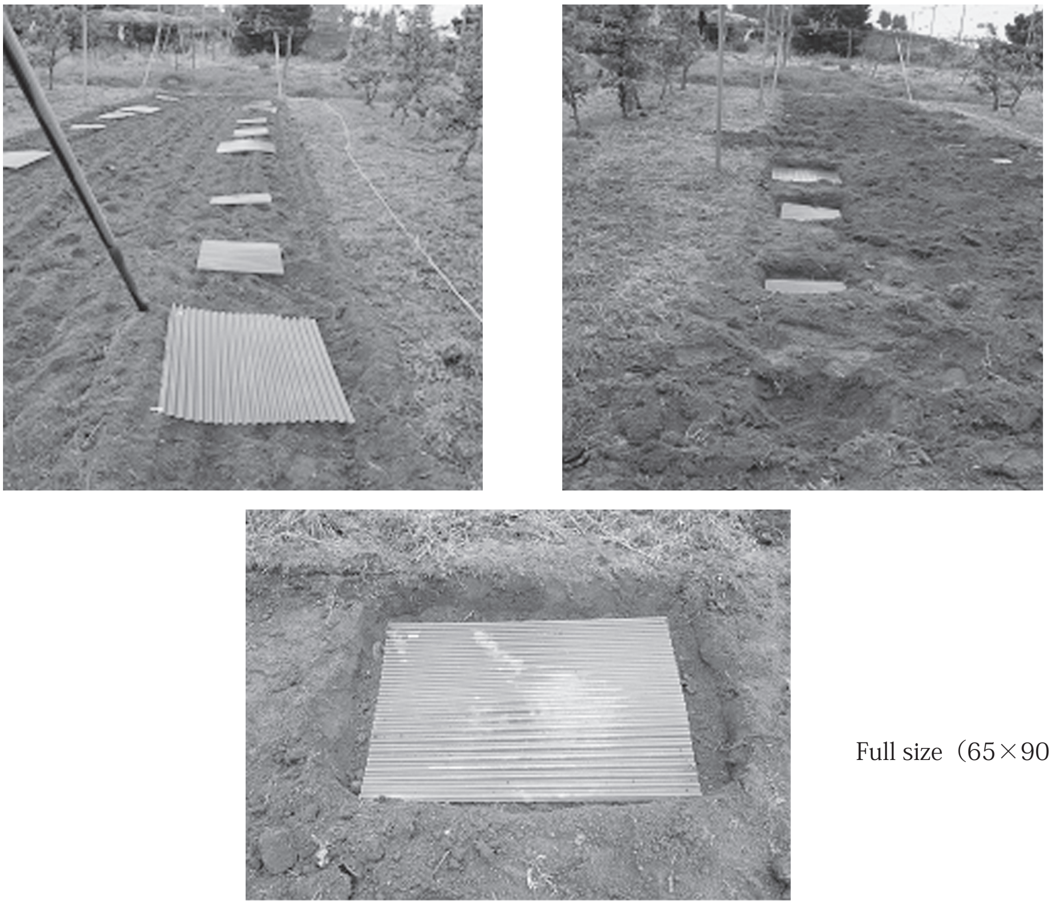
The objective of this experiment was to investigate the effect of root restriction on shoot growth in young peach trees.

Materials and Methods

Plant materials

This experiment was conducted at Ehime University Experimental Farm located in southern Japan, 33° 57' N, 132° 47' E at an elevation of about 20 m above sea level. Twenty two-year-old peach (*Prunus persica* [L.] Batsch) trees, cv. 'Akatsuki' grafted on wild form rootstocks were used for this study starting from April 2005. Ten centimeter deep holes were prepared at a spacing of 3 m x 2.5 m in a completely randomized design with five replications. The treatment holes were lined with hard corrugated plastic sheets (Fig. 1) at a depth of 10 cm designated as follows : 'Quarter size' (32.5×45 cm), 'Half size' (45×65 cm) and 'Full size' (65×90 cm). The experimental plants that were raised in pots were transplanted into the lined holes. Routine cultural practices were carried out as required. The growth of the trees was monitored weekly by measuring the lengths of ten terminal shoots.

In February 2006, lengths of all shoots were measured while in March 2006, floral and vegetative



Full size（65×90 cm）

Fig. 1　Diagrams showing how planting holes were lined with corrugated plastic sheets of different sizes at a depth of 10cm at transplanting time.

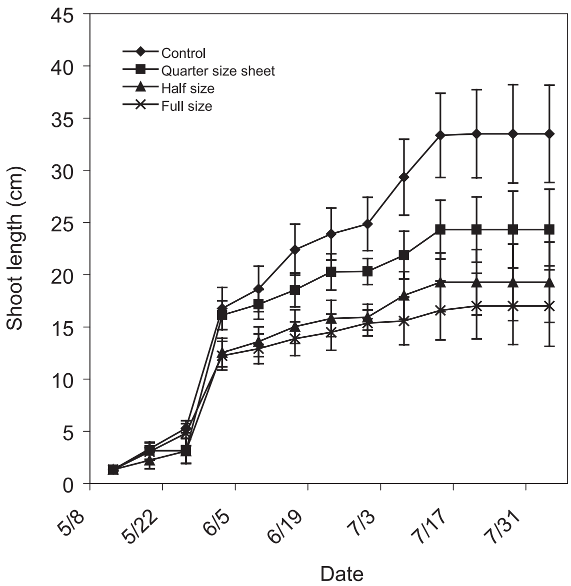


Fig. 2　Shoot length in young peach trees transplanted into planting holes lined with corrugated plastic sheets of different sizes at a depth of 10cm. Vertical bars represent SE(n = 5).

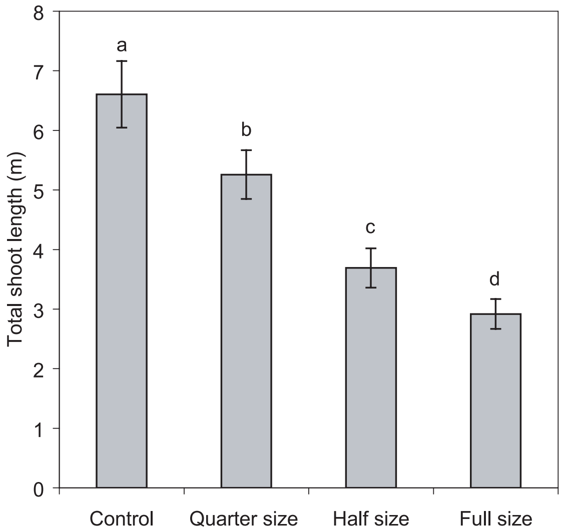


Fig. 3 Total shoot length in young peach trees transplanted into planting holes lined with corrugated plastic sheets of different sizes at a depth of 10cm. Vertical bars represent SE(n=5). Different letters indicate a significant difference at 5% by DMRT.

buds were tallied and the weight of pruned branches recorded.

Statistical analysis

Data were analyzed statistically by analysis of variance (ANOVA) and the means separated by Duncan's multiple range test (DMRT) at $P < 0.05$.

Results and Discussion

Shoot growth and total shoot length in trees on full size corrugated plastic sheets were reduced by about 50% compared with control trees (Figs. 2 and 3). Shoot growth and total shoot length increased with decreasing plastic sheet size, and total shoot length in control trees was significantly higher than other treatments.

The weight of pruned branches in the trees on full size plastic sheets was reduced by 60% compared with the controls (Fig. 4). Those on half size plastic sheets had a 32% reduction while those on quarter size were reduced by 20%. The reduction due to the presence of full and half size plastic sheets was significantly different compared with the control, while that due to quarter size sheets was not.

The percentage of floral buds was slightly increased by the presence of corrugated plastic sheets under the roots although there were no significant differences between the treatments (Fig. 5). Conversely, the percentage of vegetative buds was lowest in trees on full size plastic sheets and highest in the control.

The quarter size plastic sheets might have allowed some roots to by-pass the sheets and be in direct contact with the soil hence receiving full nutrition and water resulting in enhanced shoot

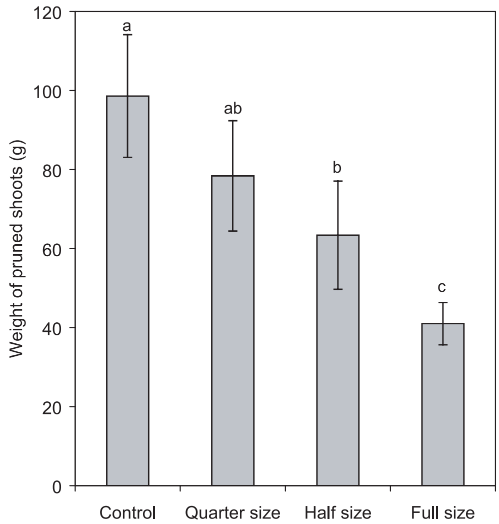


Fig. 4 Weight of pruned branches as affected by corrugated plastic sheets of different size placed at the bottom of the planting holes at transplanting. Vertical bars represent SE (n = 5). Different letters indicate a significant difference at 5% by DMRT.

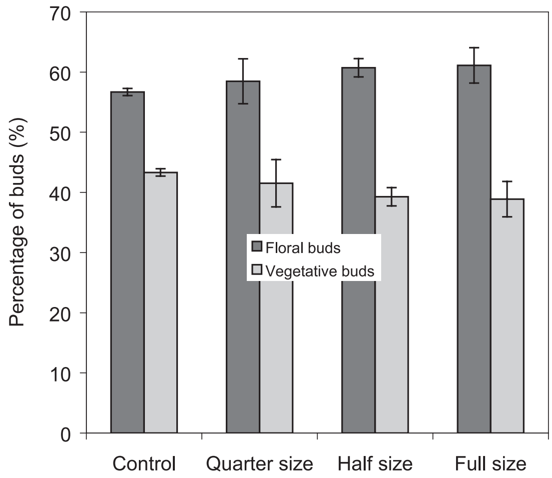


Fig. 5 Flower bud formation as affected by corrugated plastic sheets of different sizes placed at the bottom of planting holes at transplanting. Vertical bars represent SE (n = 5).

length. The blockage of the roots causes stress on the roots triggering ethylene evolution leading to a higher number of floral buds. The blockage results in low root biomass that corresponds to a low shoot biomass as observed from the reduced shoot length[19)].

Smaller rooting volume tended to result in a more rapid reduction of soil moisture and led to a smaller trunk, shorter shoot, smaller leaf area, and lower photosynthetic rate[19)]. Root restriction inhibited the growth of starfruit plants as indicated by the reduction in leaf and root growth, and to a greater extent under water stress conditions[11)].

The main consequence of the reduced root growth is a subsequent decrease in shoot growth[9, 10, 13, 20)], because a restricted root system will supply insufficient water[7, 16)] and nutrients[5, 8)] to the shoot. As a result of root restriction, shoot growth may also be limited by insufficient carbon supply, because more carbon may be required by roots for increased osmotic pressure. Also, a reduction in the root "sink" as a result of root restriction can cause carbohydrates to accumulate in the leaves, resulting in a feedback inhibition of photosynthesis[2, 18)].

Conclusion

The lining of planting holes with plastic sheets may result in higher plant densities due to reduced tree size. However, such an experiment needs to be carried out until the trees are in production to find out if such root impediment practices are also favorable for yield and fruit quality. The impediment of vertical extension of roots that results in their horizontal extension also needs to be examined in relation to tree stability especially during times of strong wind or typhoons.

Acknowledgement

The authors are most grateful to the Ministry of Education, Culture, Sports, Science and Technology of Japan for supporting this work. They also thank Mr. J. Nakamura, Mr. Y. Ishida, Mr. T. Kutsuna, Mr. W. Kibet and Ms. H. Toyota for their useful discussions and technical assistance.

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プラスチック波板による根の垂直方向への伸長抑制が モモの幼樹の生長と花芽分化に及ぼす影響

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摘要

プラスチック波板を利用してモモの根の垂直方向への伸長を抑制した場合に、モモ幼樹の樹体生長と花芽分化にどのような影響を与えるかを調査した。実験には２年生の野生モモ台‘あかつき’を20本利用し、2005年４月に実験を開始した。植穴の深さは約10㎝として、波板の大きさは、65×90㎝、45×65㎝、32.5×45㎝とし、これに波板を使用しない対照区を設けた。１区５反復とした。一番面積の大きい65×90㎝の区で、枝の伸長が対照区比べて約50％抑制された。冬季の剪定による枝の重さは、対照区に比べて、65×90㎝区で60％、45×65㎝区で32％、32.5×45㎝区で20％の減量が見られた。花芽形成は波板を処理することによって、やや促進される傾向が見られた。