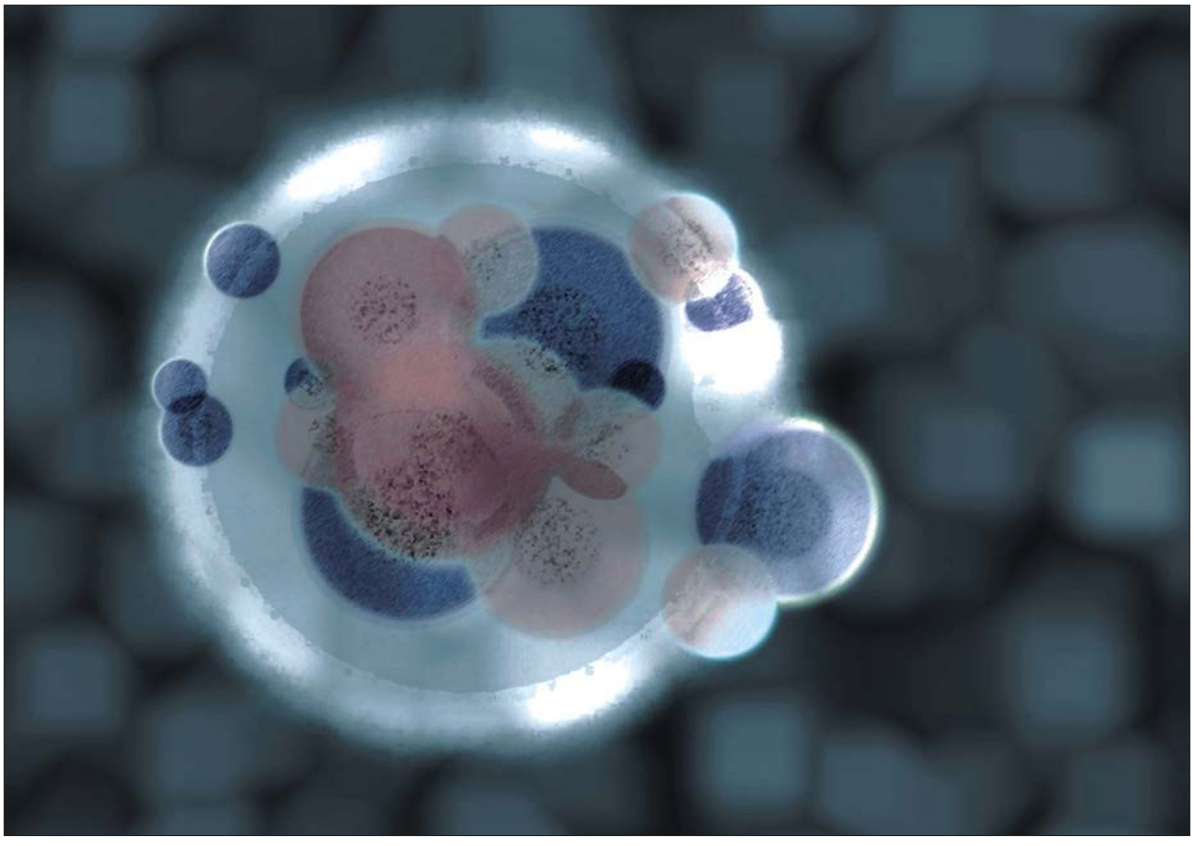

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The Influence of Net and Cheesecloth Cover on Growth, Yield and Fruit Quality of Peach (*Prunus persica* [L.] Batsch) Trees

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Abstract: Effects of net and cheesecloth cover on the growth, yield and fruit quality of peach (*Prunus persica* [L.] Batsch) trees were investigated in summer pruned trees after fruit harvest. Trees were covered with white cheesecloths (giving 30% shade) or nets. The length of regenerated shoots from the branches covered with cheesecloths and nets was one third and half as great as the control, respectively. Covering with cheesecloth reduced flower bud formation. It also led to increased Bix but decreased acidity to a slightly greater degree than nets. Both cheesecloth and net treatments increased ethylene production and ACC content in the shoot tips. Earlier flowering was noted in the following spring in the trees that had been covered with cheesecloths. Such early flower opening, which corresponded to early bud break, seems to be associated with ethylene biosynthesis caused by thigmomorphogenesis.

Key words: ACC content, brix, ethylene evolution, fruit set, shoot growth reduction, titratable acidity

INTRODUCTION

The control of tree size in deciduous fruit species has been a major concern to reduce production costs (Blancho, 1986). In peach and nectarine (*Prunus persica* [L.] Batsch), the need for reduction in tree height has been given prominence by growers (Ferree, 1988). Dwarfing rootstocks have not been developed for peaches at this time and cultural techniques to control tree growth are either too expensive or inconsistent in their response. Thus, mechanical stress has been proposed as an alternative treatment for height control in some species (Vernieri *et al*., 2003).

Excessive shoot growth in peach trees limits fruit yield by shading the interior of the tree which reduces flower bud initiation, directly competes with growing fruit, and increases the cost of production through high labor costs for pruning. It has been reported that shading to 9% full sun during the first half of the final swell reduced the number of flowers per shoot in peach trees the following spring (Marini, 2002). Shading, even to 9% full sun after harvest did not affect flowering the following spring. Thigmomorphogenesis refers to the widespread ability of sessile organisms to modify their morphology in response to a variety of mechanical stimulations, from direct contact with the stem by insects or other plants to flexure caused by wind, water, or snow (Murren and Rigliucci, 2005). They include the resistance to root growth by soil particles, rubbing by animals and plants and or rubbing of one plant or plant part against another. These thigmomorphogenetic stimuli can lead to decrease in elongation (Telewski and Jaffe, 1986), increase in lateral enlargement (Jaffe, 1976) and decreased susceptibility to various stresses (Jaffe and Telewski, 1984). Most of these aspects have been widely investigated and documented but little data are available about the rubbing of growing shoot tips of fruit trees against physical barriers like nets or cheesecloths.

The objectives of this study were to describe how thigmomorphogenesis responds to cheesecloths and nets in terms of growth, flowering, fruit set, fruit quality, ethylene and ACC as well as to test if cheesecloths or nets are better alternative ways to limit vegetative growth in peach trees.

MATERIALS AND METHODS

Study site: This experiment was conducted at the Ehime University Experimental Farm located in southern Japan, 33°57' N, 132°47' E at an elevation of about 20 m above sea level. The region has a mild temperate climate characterized by hot humid summers and cold dry winters. The soil at the experimental site was

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sandy loam (eutric fluvisol) with a pH (H_2O) of 5.7, a bulk density of a 1.08 g cm^{-3} and horizon A thickness of 0.15 m.

Plant materials: Sixteen four-year-old peach (*Prunus persica* [L.] Batsch, cv. 'Hikawa Hakuho') trees grafted on wild type rootstocks were selected for this experiment in July 2003 in a completely randomized design. They were summer pruned by cutting their branches back to 20 cm after fruit harvest. Four of them were covered with nets (4.5 × 4.5 cm giving less than 1% shade), another four were covered with white cheesecloths that provided 30% shade while the rest were controls including 4 winter pruned trees. Observations were made daily for the emergence of new shoots. Once new shoots appeared, their growth was monitored by measuring the lengths of 10 terminal shoots from each tree every fortnight. The total shoot length and flower bud number were recorded in winter and the flowering frequency and fruit set in early spring 2004. In July 2004, the fruit number per tree, fruit weight and yield per tree were recorded. Titratable acidity was determined by acid-base titration using 0.1 N NaOH and total soluble solids (Brix) content by means of a refractometer (Atago PR-1).

Ethylene determination: On September 26, 2003, five shoot tips per tree were collected and put in 5 cc gas-tight vials. The vials were incubated at 25°C for one hour. One milliliter of the gas was injected for ethylene analysis by using a Shimadzu GC 9A gas chromatograph equipped with a Flame Ionization Detector (FID) and an activated alumina column. All assays were replicated 5 times. The shoot tips were weighed and transferred into vials containing 80% ethanol. They were then kept in a deep freezer for 1-aminocyclopropane-1- carboxylic acid (ACC) determination.

ACC determination: The samples were homogenized using a mortar and pestle. The homogenized sample was washed three times with 80% ethanol and filtered into a conical flask. The extracts were evaporated *in vacuo* to dryness and the residues taken up in 4 mL distilled water. An aliquot of the solution was used to determine the levels of ACC according to the method of Lizada and Yang (1979).

Statistical analysis: Data were analyzed statistically by analysis of variance (ANOVA) and the means separated by Duncan's Multiple Range Test (DMRT) at 5% level.

RESULTS

The length of regenerated shoots from the control branches increased gradually in the first two weeks and exponentially in the next two weeks (Fig. 1). The increase in the subsequent weeks was gradual but steady. Those from the branches that were covered with nets showed a similar trend but at a lower level than the control ones for the first four weeks. Subsequently, they maintained a more or less equal level. Those covered with cheesecloths had a similar trend with those that were net covered but at the lowest level.

The total shoot length in the control trees was nearly twice as long as that in the ones covered with cheesecloths while that in those covered with nets was slightly shorter than in the control ones (Table 1). This trend was similar to the one observed in the respective individual shoot lengths. The total shoot length in the trees covered with nets was closer to those of the control trees because the net used was wide enough to allow some shoots to grow out without being touched.

The percentage of flower buds was generally greater than that of vegetative ones (Table 1). It was lowest in the trees covered with cheesecloths. On the other hand, the percentage of vegetative buds was highest in the trees covered with cheesecloths while that in the net covered, winter pruned and the control were essentially similar. This implies that touch stress plays a role in breaking or controlling the dormancy of buds.

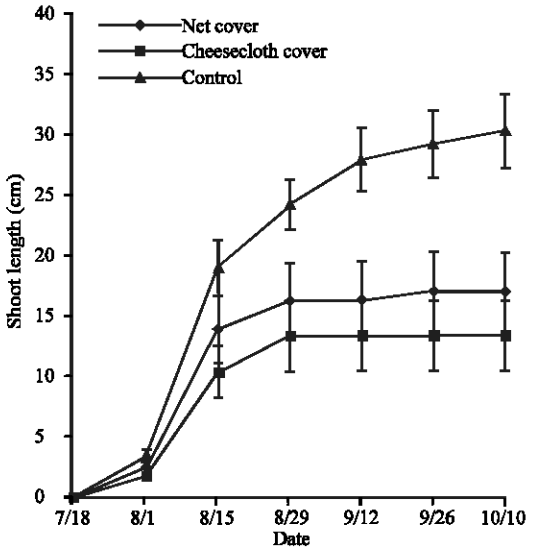

Fig. 1: Length of regenerated shoots of peach trees covered with nets and cheesecloths after summer pruning in which branches were cut back to 20 cm. Vertical bars indicate SE (n = 4)

Table 1: Total shoot length, percentage of buds, fruit set, ethylene production and ACC content in peach trees as affected by net or cheesecloth covering

Treatment	Total shoot length (m)	Flower buds (%)	Vegetative buds (%)	Fruit set (%)	Ethylene production (nL g FW/h)	ACC content (nmoL g FW)
Control	40.06a	64a	36a	55a	15.48a	0.69a
Net cover	36.54a	65a	35a	59b	26.62b	0.94b
Cheesecloth cover	22.56b	57b	43b	52c	26.46b	0.85b

Different letter(s) in the same column represent significant differences by Duncan's Multiple Range Test, 5% level

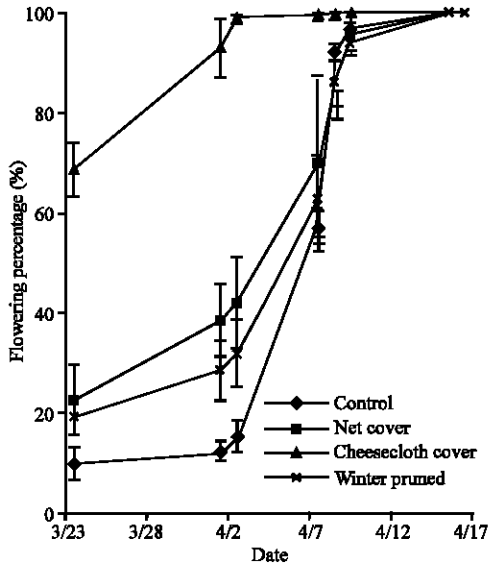

Fig. 2: The flowering percentage in peach trees the following year as influenced by net or cheesecloth covering. Vertical bars represent standard error (SE) (n = 4)

Initially, the flowering percentage in the trees covered with cheesecloths was four times higher than in the control ones (Fig. 2). In the following 5 days, the flowering percentage in the trees covered by cheesecloths exponentially increased almost reaching a maximum while that in the others similarly increased but at a very low level. The flowering percentage in the trees covered with nets, control trees and the winter pruned ones increased exponentially and achieved the same level at 80%, seventeen days from the start of counting date.

The fruit set percentage was highest in the trees covered with nets followed by the control and those that were winter pruned (Table 1). The trees covered with cheesecloths recorded the lowest percentage. The present results imply that cheesecloth cover (30% shading) leads to premature flower drop in the following spring.

The ethylene production from the plants that were covered with cheesecloths and those covered by nets was essentially similar (Table 1). The ethylene production of the control plants was significantly lower implying that the net and cheesecloths have a similar effect in stimulating ethylene evolution. The

Table 2: Fmit weight, yield per tree and fruit qualities of peach at harvest. Treatment trees were subjected to net or cheesecloth covering in the previous year

Treatment	Fmit weight(g)	Yield (g/tree)	Brix (%)	Titratable acidity (%)
Control	129b	616.2b	11.93a	0.23a
Net cover	148a	715.2a	12.15a	0.17a
Cheesecloth cover	143a	680.2a	12.46a	0.15a

Different letter(s) in the same column represent significant differences by Duncan's Multiple Range Test, 5% level

ACC content from the plants that were covered with nets was slightly higher than that from those that were covered with cheesecloths though there was no significant difference between them (Table 1). The control plants recorded considerably low levels.

Net covering recorded higher values than cheesecloth while the control recorded the lowest values in terms of fruit weight and the yield per tree (Table 2). The difference between the control and the treatments was significant implying that covering with nets or cheesecloths can be of commercial importance in peach orchards. Covering with cheesecloths led to increased Bix but decreased acidity to a slightly greater degree than nets though there was no significant difference between them (Table 2). Both treatments showed better effects than the control demonstrating the potential of thigmomorphogenesis in improving fruit quality.

DISCUSSION

In nature, the most common forms of mechanical perturbation are the resistance to root growth by soil particles and the flexing and rubbing of aerial plant parts to wind, animals or other plant organs (Jaffe, 1973). When shoots came in contact with the nets or cheesecloths, the touch stress stimulated ethylene evolution leading to the reduction in shoot length. This was confirmed from the high levels of ACC and ethylene recorded in treated plants. The reduction of shoot length was more pronounced in the plants covered with cheesecloths than those covered with nets. This was because the cheesecloths provided total contact to all the shoots while the nets gave room for some shoots to go through untouched. Accumulation of ethylene in soybean seedlings enclosed in BRIC (Biological Research in Canister) canisters caused a 33% decrease shoot length (Hilaire *et al*., 1986).

Ethylene was reported to be involved in the transition from vegetative to reproductive growth in *Arabidopsis thaliana* (Ogawara *et al*., 2003). The number of flowers of ethylene sensitive plants exposed to atmospheric ethylene was higher than that of control ones (Tonneijck *et al*., 2003). Flowering in some plant species might be promoted by presence of ethylene (Abeles *et al*., 1992). In our experiment, however, the flower bud formation was least in the trees covered with cheesecloths although ethylene biosynthesis in the shoot tip was promoted in those trees. This reduction might have been caused by a reduction in photosynthesis due to shading with cheesecloths. A delicate balance, therefore, needs to be maintained for the cheesecloths used to ensure that they do not cause excessive shading.

It has been reported that ethylene itself has little or no effect on breaking bud dormancy and that HCN, which is produced during ethylene biosynthesis, may break bud dormancy in grapevines (Tohbe *et al*., 1998b). The application of ethephon to grape buds in a profound dormant condition delayed termination of bud rest (Iwasaki, 1980). Bud scale removal in grapevines increased ethylene production and ACC content and induced the bud break (Mizutani *et al*., 1995). In the same study, exogenous ACC application promoted bud break. Dormancy of grapevine buds is also broken when GSSG converts to GSH, and that cyanide produced during ethylene biosynthesis may stimulate the conversion (Tohbe *et al*., 1998a).

The results suggest that the earlier flowering found in the trees that were covered with cheesecloth seems to be associated with ethylene biosynthesis due to thigmomorphogenesis. Since covering with cheesecloths led to better results in reducing shoot length and improving fruit quality than nets, it is recommended for use in commercial peach orchards.

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