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Induction of Lateral Branching in Nursery Pear and Apple Trees with Plant Growth Regulators

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Abstract

The summer following budding the trees of 'Honey Sweet' and 'Seckel' pear on 'OHF 97' rootstock, and 'Liberty' and 'Stayman Red' apple on 'M.7A,' were sprayed once or twice with BA+GA_{4+7} or sprayed once with dikegulac. Dikegulac caused severe phytotoxicity, reduced tree height and induced narrow-angled feathers. Both pear cultivars produced branches when sprayed with BA+GA_{4+7} at 1500 ppm but only the cv. 'Honey Sweet' produced branches when treated at 750 ppm of BA+GA_{4+7}. Single and double BA+GA_{4+7} sprays significantly increased total number of feathers with both apple but double applications at 250 ppm were the most effective.

Introduction

It is well documented that the use of branched nursery trees greatly contributes to early and high orchard yields (5, 6, 12). Recently, Ferree and Rhodus (5) have shown for US conditions that feathered 'Lawspur' and 'Smoothee' apple trees outperformed unbranched trees in yields and economic returns in the initial period of orchard life. However, the lack of natural branching with nursery apple and pear trees has limited the widespread adoption of feathered trees.

Physiologically, branching is regulated by apical dominance, which is thought to be controlled by the interaction of endogenous growth hormones, with auxins and cytokinins playing major roles (10). Species and cultivars differ in their natural branching ability (3, 6, 13). Branching may be influenced by rootstocks, propagation techniques, cultural practices, and environmental factors (6, 11, 14). However, the ultimate determinant of cultivar branching ability is under genetic control (8).

Several methods of inducing lateral branching have been developed. These include: the removal of apical leaves (13, 14), pinching tree tops (14), heading cuts and the use of branching agents (3, 6, 8, 13, 14). All of these techniques are based on partial or total removal of apical dominance. Application of chemicals, however, has been shown to be one of the most efficient ways of stimulating lateral-branch formation. A combination of synthetic cytokinin benzyladenine (BA) and gibberellins (GA_{4+7}) is the most commonly used branching agent. It has been suggested that both of these components play sequential roles in overcoming apical dominance, with the initiation of buds stimulated by BA, and then subsequent elongation by GA_{4+7} (3). Another branching agent is dikegulac, a morphactin, that inhibits terminal bud growth and promotes feathering of many plants, including fruit crops, through partial or total destruction of terminal buds (1, 2).

Our objective was to evaluate the effectiveness of BA+GA_{4+7} and dikegulac in stimulating lateral-branch formation with nursery pear and apple trees.

Materials and Methods

Two experiments, using pear (Experiment I) and apple (Experiment II) trees in their first growing season following budding, were conducted at Stark Brothers Nursery and Orchards Co. in Louisiana, Missouri. Proprietary formulations of BA+GA_{4+7} (Abbott Laboratories, N. Chicago, IL.) and dikegulac (PBI/Gordon Corp., Kansas City, MO) were used. The rates of the

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chemicals and timing of applications were based on previous research (2, 3, Jacyna—unpublished).

Experiment I. Pear trees of cvs 'Honey Sweet' and 'Seckel' on 'OHF 97' rootstock were sprayed with BA+ GA_{4+7} at 750 or 1500 ppm, or dikegulac at 1440 or 2880 ppm. At the time of application the trees did not have lateral branches, and tree height was approximately 110 cm. The sprays were confined to the 35-45 cm tree terminal. The chemicals were applied on June 30, 1989 to run-off. The control trees were not treated.

Experiment II. Apple trees of cvs 'Liberty' and 'Stayman Red' on 'M.7A' rootstock were treated with BA+GA_{4+7} as a single spray at 250 or 500 ppm, or double sprays at 15 days interval at 125 or 250 ppm on every occasion. At the time of application the trees did not have lateral branches, and the tree height was approximately 85 cm. The sprays were directed to 25-35 cm of the upper part of the tree, and applied to run-off. Single sprays and the first of double sprays started on June 20, 1990. The second sprays of double application were performed on July 5, 1990. The control trees were not treated. In both experiments a Delta hand-held pressure sprayer was used, and a non ionic wetting agent Buffer X at 3000 ppm was used with each BA+GA_{4+7} application. The trees in both experiments were not pruned.

Upon harvest, tree height and the number of lateral branches $= <30$ and >30 cm were recorded for all trees in both experiments. In experiment II, feathers shorter than 15 cm were not counted. In addition, tree caliper measured at 5 cm above the bud union was determined for all trees in the experiment II. In both experiments the trees with three or more lateral shoots were considered to be feathered and their quantity was expressed as percent of total tree number per treatment.

Experimental design. A complete randomized block design with three trees per plot and 3 replications (Experiment I) and a completely randomized design with three trees per plot and 4 replications (Experiment II) were used. The data from both experiments were subjected to analysis of variance. The data on percentage of feathered trees were transformed by $sx = \arcsin\sqrt{x}$ to normalize the distribution before Anova.

Results

Experiment I. Application of both BA+GA_{4+7} and dikegulac significantly increased total number of feathers in comparison with the controls of both cultivars, except at the low rate of BA+GA_{4+7} on 'Seckel' trees (Table 1).

Most of the feathers on treated 'Honey Sweet' pear trees were equal or shorter than 30 cm, whereas most feathers of treated 'Seckel' trees were longer than 30 cm. For 'Honey Sweet' trees, there were no significant differences in total number of feathers among both BA+GA_{4+7} rates and dikegulac at 1440 ppm. Each of these treatments, however, significantly differed in total number of feathers from dikegulac at 2880 ppm. With 'Seckel' trees, there was no significant difference in total number of feathers between dikegulac rates but both BA+ GA_{4+7} rates significantly differed from each other.

Both cultivars showed similar responses to applied chemicals in tree height. Dikegulac significantly reduced tree height as compared with both BA+GA_{4+7} rates and the control, among which there were no significant differences in this respect (Table 1).

Crotch angles were not measured; yet visual observation revealed that dikegulac treated trees exhibited very acute crotch angles that would have made them unacceptable as an orchard plant material (Figure 1 a-b).

Regardless of rate, dikegulac caused a severe phytotoxicity that appeared to be rate-dependent. Approximately one week after application, such symp-

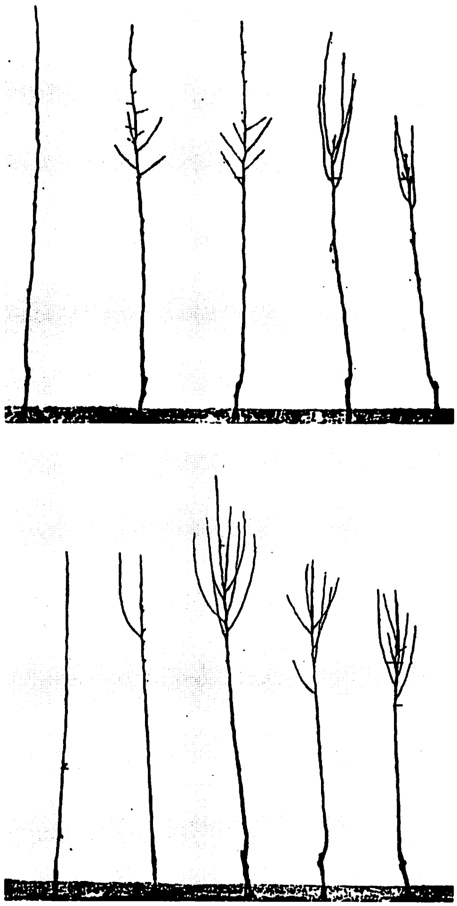

Figure 1. Branching pattern of chemically treated nursery pear trees (from left to right: control, 750 ppm BA+GA_{4+7}, 1500 ppm BA+GA_{4+7}, dikegulac 1440 ppm, dikegulac 2880 ppm): a. Honey Sweet, b. Seckel.

toms as death of the terminal bud, leaf discoloration (chlorosis and pink color) were evident. This was followed by partial leaf necrosis and partial tree leader dieback. Even after tree recovery some foliage remained deformed. No phytotoxicity symptoms were observed on BA+GA_{4+7} treated trees.

Experiment II. Both 'Liberty' and 'Stayman Red' apple cultivars responded well to single and double sprays, and applied rates of BA+GA_{4+7}. In most instances this was shown by a significant increase in the number of feathers in both length categories and total number of feathers, and by increased proportion of feathered trees, as compared with the controls (Table 2; Figure 2 a-b).

For both cultivars, the most efficient treatment in increasing the number of feathers, and consequently the quantity of feathered trees was a double application of BA+GA_{4+7} at 250 ppm. It significantly outperformed all other treatments in total number of feathers produced. No significant differences in tree height and caliper among the treatments were found, though a double spray at 250 ppm tended to produce taller and larger-caliper trees than the other treatments (Table 2).

Discussion

The cultivars chosen for this study were characterized by pronounced

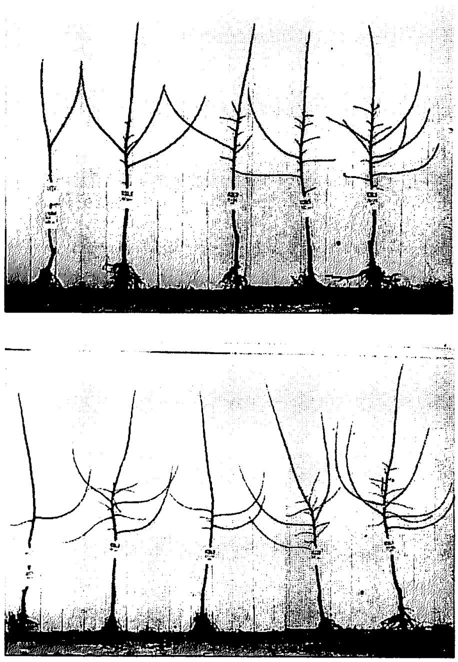

Figure 2. Branching pattern of BA+GA_{4+7} treated nursery apple trees (from left to right: control, 250 ppm, 125 ppm x 2, 500 ppm, 250 ppm x 2): a. 'Stayman Red,' b. 'Liberty.'

Table 1. Vegetative growth characteristics of nursery pear trees as influenced by growth regulators.

Treatment Rate (ppm)	Final tree height (cm)	No. of feathers per tree in length (cm) = < 30	> 30	Total	% feathered trees
'Honey Sweet'					
Control	152.7	0.3	0.0	0.34	11.8
$BA+GA_{4+7}$ - 750	160.6	4.4	0.2	4.64	78.2
$BA+GA_{4+7}$ - 1500	157.3	4.7	0.3	5.00	78.2
Dikegulac - 1440	142.5	1.6	2.5	4.14	82.8
Dikegulac - 2880	115.8	1.5	0.9	2.40	53.5
LSD p = .05	12.9	1.60	0.90	1.53	35.5
'Seckel'					
Control	174.8	0.0	0.0	0.0	0.0
$BA+GA_{4+7}$ - 750	170.2	0.0	0.0	0.0	0.0
$BA+GA_{4+7}$ - 1500	177.1	0.3	3.6	3.9	60.0
Dikegulac - 1440	142.3	0.8	4.1	4.9	90.0
Dikegulac - 2880	131.8	1.8	3.3	5.1	90.0
LSD p = .05	12.2	0.75	1.35	1.15	23.4

apical dominance and poor or no branching of untreated trees (Figure 1 a-b; 2 a-b).

Although the trees were grown on vigorous rootstocks and in a hot humid climate [both of which have been shown to improve branching in fruit trees (6, 9, 11)] the untreated pear trees produced no feathers, and the untreated apples produced very few feathers (Figure 1 a-b).

Applications of $BA+GA_{4+7}$ caused a significant increase in quantity of induced feathers with both the pear and apple cultivars. The apple trees responded better, both quantitatively and

Table 2. Vegetative growth characteristics of nursery apple trees as influenced by $BA+GA_{4+7}$.

$BA+GA_{4=7}$ Rate (ppm)	Final tree height (cm)	Final tree caliper (cm)	No. of feathers per tree in length (cm) 15-30	> 30	Total	% feathered trees
'Liberty'						
Control	178.4	1.40	0.3	1.3	1.6	17.0
250	174.8	1.51	2.3	4.0	6.3	100.0
125 x 2	174.7	1.44	2.3	3.8	6.1	100.0
500	171.5	1.38	4.6	3.3	7.9	100.0
250 x 2	182.9	1.56	5.0	5.5	10.5	100.0
LSD p = .05	n.s.	n.s.	1.24	1.6	2.14	14.0
'Stayman Red'						
Control	134.8	1.43	0.0	1.1	1.1	9.0
250	141.6	1.43	1.1	1.9	3.0	67.0
125 x 2	142.7	1.48	0.8	1.6	2.4	42.0
500	130.3	1.42	0.5	2.0	2.5	45.0
250 x 2	147.3	1.59	2.6	3.9	6.5	92.0
LSD p = .05	n.s.	n.s.	0.8	1.05	1.65	20.0

qualitatively to BA+GA_{4+7} in producing feathering than the pear cultivars. Pear trees usually require higher doses of BA+GA_{4+7} than apple trees (3). The two pear cultivars showed diverse branching responses with regard to applied chemicals. It appears that the cv. 'Honey Sweet' could also be responsive to lower rates of BA+GA_{4+7} than applied here. 'Seckel' trees, which exhibit strong apical dominance (Jacyna—unpublished data) require a different approach to stimulate an adequate lateral-branch formation. In this experiment the quantity of feathers induced did not match the quality of branching pattern represented by length of feathers and magnitude of crotch angle (Table 1, Figure 1 b).

Double sprays of BA+GA_{4+7} (3) or the application of BA+GA_{4+7} combined with tree leader tipping (7) might have been other options in increasing branching with the difficult-to-feather pear trees. Volz et al. (13) reported that simultaneous application of BA and GA_{4+7} to nursery apple trees might in some situations suppress feather's production. This seems to be rather cultivar specific since in this experiment BA+GA_{4+7} increased feathering in all instances except at the low rate (750 ppm) on 'Seckel' pear trees (Table 1). The results of this research parallel earlier findings by Cody et al. (3) and Elfving (4).

Application of dikegulac failed to produce quality trees. Despite increasing feathering, dikegulac caused severe phytotoxicity that negatively influenced tree quality. Its mode of action favors formation of narrow-angled branches near the point of chemical decapitation (Figure 1 a-b). Similar adverse effects were reported on peach trees (1) but no detrimental effects were observed on some ornamental plants (2).

With the apple cultivars the improved branching of the double application compared with the single application using the same cumulative quantity of BA+GA_{4+7} indicates that the method of application (single or double) was of a greater importance in stimulating feathering than the total quantity of BA+GA_{4+7} used. The reason for this is not clear. However, one of the possibilities might be that double applications at 250 ppm may provide better hormone supply to the plant over a relatively longer period of time than single application at 500 ppm. It is also possible that smaller and gradual exogenous hormone supplies are more efficiently adsorbed, released and then used by the plant, resulting in better lateral-branch formation.

Considerable improvement of branching pattern of treated apple trees (Figure 2 a-b) contributed to their better commercial acceptance than untreated trees. Pear trees of both cultivars produced by BA+GA_{4+7} were commercially acceptable while those produced by dikegulac were not (Figure 1 a-b).

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Sources of Bacterial Spot Resistance in Plum Cultivars

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Abstract

Bacterial spot (*Xanthomonas campestris* pv. *pruni*) resistance in Japanese and European-type plum cultivars was evaluated under greenhouse conditions by means of a pressure infiltration inoculation procedure. Cultivars 'Pluma 7' (susceptible) and 'The First' (resistant) were used as standards for comparison to the genotypes inoculated with an inoculum concentration of 1 x 10^8 cfu/ml. Resistance levels were rated using a scale based on percentage of affected leaf area. Cultivars 'Harry Pickstone,' 'Carmesin,' 'Wickson,' 'Frontier,' 'Rosa Mineira,' 'Reubennel,' 'Amarelinha' and 'Santa Rosa' were highly susceptible while 'Wade,' 'Ozark Premier' and 'Methley' were moderately resistant. 'Bruce,' 'Stanley,' 'Burbank,' 'D'Agen' and 'America' were selected as major sources of resistance to the pathogen.

Introduction

Most high quality commercial plum cultivars (*Prunus salicina* Lindl. and *P. domestica* L.) are susceptible to *Xanthomonas campestris* pv. *pruni* (Smith) Dye in warm, humid, temperate conditions in Southern Brazil. It is estimated that there is less than 5000 ha of plums in the country. The number of plum orchards has decreased in recent years due to this disease and leaf scald. Most of the cultivated plums are Japanese-type because generally, they have a lower chilling requirement. The European-type are acceptable in colder regions for its desirable blooming time and higher degree of resistance to bacterial spot. Bacterial leaf and fruit spot, tree defoliation and stem canker vary from year to year, sometimes occurring in epidemic proportions due to the frequency of rains and favorable temperature. Chemical control is costly and often ineffective, and the use of disease resistant cultivars is the recommended approach to disease control (8, 9, 11). Selection for germplasm resistant to bacterial spot has been considered an important part of management programs in several countries, for reducing the risk of loss from this disease (3, 4, 7, 10, 11). The purpose of this paper is to report the resistance levels of commercial plum cultivars in Brazil as determined by an artificial inoculation procedure in the greenhouse.

Materials and Methods

Eighteen plum cultivars budded on peach rootstock cv. 'Capdeboscq' (Table 1) were grown in 30 x 30 x 20 cm plastic bags containing 3:1 (V/V) mixture of sterilized soil and vermiculite. The soil was poured weekly with

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