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Influence of Paclobutrazol Plant Growth Regulator on Strawberry Plant Growth, Fruiting, and Runner Suppression

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Abstract. **Paclobutrazol (ICI PP333), an inhibitor of gibberellin biosynthesis, suppressed early season number of berries but did not affect seasonal yield of field grown strawberry plants. Plant growth was greatly suppressed at all application rates. Petioles, peduncles, and pedicels were shortened with leaves and fruit tightly appressed to the crown. Green leaf color was intensified in all paclobutrazol treatments, but fruit color was not appreciably influenced. Runner suppression was obtained in mid-July field applications, but runners were not inhibited by August application. In the greenhouse, PP333 applied directly to the soil of potted plants was more effective than foliar applications in suppressing crown, leaf, and root growth. The degree of suppression generally was related to increasing the concentration of the chemical.**

PP333 [1-(4-chlorophenyl)-4, 4-dimethyl-2(1,2,4-triazol-l-yl) pentan-3-ol], a triazole with the common name paclobutrazol, is an experimental growth regulator showing great promise for controlling excess shoot growth in a number of plant species (1). The product is under development worldwide by the Plant Protection Division of ICI Ltd. (United Kingdom) and in the USA by ICI Americas, Inc., Goldsboro, NC 27530.

Paclobutrazol is a potent inhibitor of gibberellin biosynthesis, resulting in internode shortening and longterm growth suppression on many monocot and dicot plants. Activity occurs after stem penetration or root uptake following irrigation or rainfall. Flowering can be enhanced in some crops. A characteristic response is intensified leaf greening with little or no phytotoxicity.

Preliminary reports of the effects of paclobutrazol on fruit crops, primarily apples, indicate exciting potential for growth suppression, potentially reducing pruning requirements (2, 4, 5).

The current interest in high density, ribbon row, or spaced plant systems for strawberry (*Fragaria xananassa* Duch.) culture as an alternative to conventional matted rows focuses on the need for plant runner control (3). Paclobutrazol offers potential for effective runner control, reducing the need for hand labor or repeated mechanical removal with associated high costs and possible plant injury.

The objectives of this research were to examine the effects of paclobutrazol on strawberry plant growth, fruiting, runnering, and to evaluate dosage response for subsequent field testing.

1981. Paclobutrazol was applied as a foliar spray to 'Badgerbelle' strawberries grown in a matted row system at the Peninsular Experiment Station, Sturgeon Bay, Wis. on 27 May, at about the full-bloom stage. Rates equivalent to 4.60, 2.30, 1.16 and 0.58 kg a.i./ha were applied to each of 3 random 3.0 m plots. Fruit harvest was initiated 3 July and continued at 2–3 day intervals for 19 days. At each harvest, fruit were counted and weighed. Plants were observed for runner growth and development until mid-August.

The same treatment rates of paclobutrazol were spray applied on 22 May to 3 random replicated 2.0 m plots of 'Midway' strawberry plants set 15 cm apart in the row in a close spaced, single row commercial strawberry planting near Mukwonago, Wis. All fruit were counted and weighed on 6 July. No unripe fruit remained on plants at this time.

1982. Dramatic and sustained growth suppression at even the lowest 1981 treatment rate of 0.58 kg a.i./ha paclobutrazol indicated a need to test substantially reduced field application rates in 1982. On this basis, paclobutrazol was applied to 6 replicated 2.5 m plots, each in a 1-year-old 'Raritan' strawberry planting at the Hancock Experiment Station, Hancock, Wis. Rates of 0.14, 0.28, and 0.56 kg a.i./ha were applied on 15 July and to 6 additional replicated plots on 12 Aug. Prior to this treatment, plant rows had

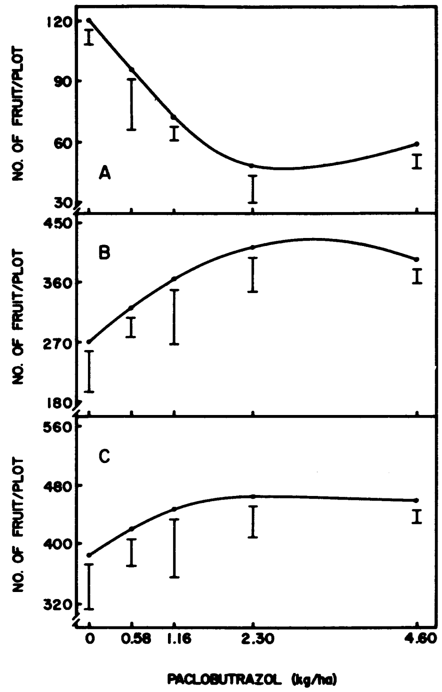

Fig. 1. The effects of paclobutrazol on the total number of fruit per plot in 'Badgerbelle' strawberry. **A.** Cumulative fruit number for 1st 4 harvests (early season). **B.** Cumulative fruit number for final 4 harvests (late season). **C.** Total fruit number for the season. Vertical bars indicate SE.

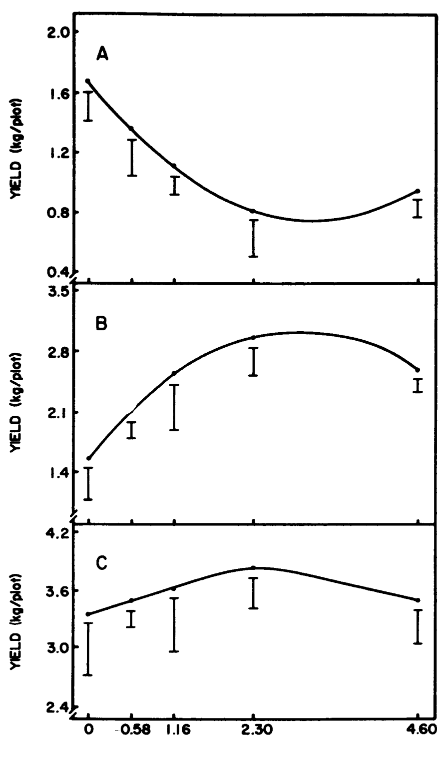

Fig. 2. The effects of paclobutrazol on yield per plot in 'Badgerbelle' strawberry. **A.** Cumulative yield for 1st 4 harvests (early season). **B.** Cumulative yield for final 4 harvests (late season). **C.** Total yield for the season. Vertical bars indicate SE.

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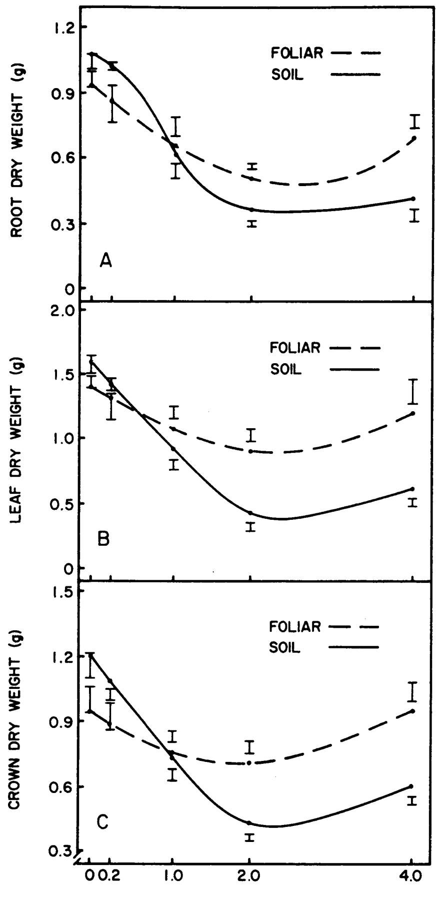

Fig. 3. Effect of soil and foliar applications of paclobutrazol on 'Raritan' strawberry plant root, leaf, and crown dry weight. Vertical bars indicate SE.

been narrowed to 15 cm width at postharvest renovation on 25 June 1982. A count of the number of established plants on all plots was made at the time of initial application of PP333 on 15 July.

On 26 Oct., all rooted or unrooted runner plants were counted to calculate the number of runner plants per mother plant for each date of application.

To determine the influence of foliar vs. soil applied PP333 on the effectiveness of plant growth control, uniformly rooted 1st runner 'Guardian' and 'Raritan' strawberry plants grown in a Plano silt loam at the Arlington Experiment Station, Arlington, Wis. were transferred with roots and soil intact to 15 cm clay pots in early November, 1981. Plants were placed in a greenhouse at 22° day/15°C night temperature and were permitted to reestablish root and top growth before application of PP333 in mid-December.

Paclobutrazol at rates of 4.0, 2.0, 1.0, and 0.2 mg/plant in distilled water was applied to 5 plants each of the 2 cultivars as a foliar spray or soil application. For uniformity, 4 ml of solution was applied to each plant. Cardboard collars were placed over the soil surface and around the base of plants receiving foliar sprays to prevent contact with the soil. For soil applications, 4 ml of solution was poured onto soil followed by 100 ml distilled water to disperse the chemical through the soil without loss by drainage. Pots then were placed in aluminum trays and watered only from below to prevent the chemical from being washed from the leaves in foliar treatments. To eliminate the effects of variable flowering and fruiting, all flowers were removed at emergence.

In April, plants were removed from pots and the soil was washed from the roots. All leaves and roots were separated from individual crowns and air dried for 5 days at 60°C for determination of dry weight.

In 1981, paclobutrazol applied to 'Badgerbelle' at full-bloom at rates above 0.58 kg/ha resulted in a reduction in the number of berries per plot harvested early in the picking season (Fig. 1). An increase in the number of fruit obtained in later harvests, however, compensated for this reduction; total fruit number for the season was not influenced significantly.

Yield reduction in early harvests corresponded to reduced fruit number. Both related to increasing concentrations of paclobutrazol with maximum response at the intermediate treatment rate of 2.30 kg/ha (Fig. 2). Alternately, increased yield in late season harvests offset early yield reductions so that the total yield for the season was not influenced by paclobutrazol.

As might be expected, mean berry weight increased in early harvested fruit from paclobutrazol treated plots, with a significant difference occurring near mid-season (data not shown).

In the close spaced, single row commercial 'Midway' planting, plant growth also was greatly suppressed at all treatment rates, resulting in tightly rosetted plants with short, closely appressed leaves and fruit. Maximum yield (data not shown) in the single late season harvest occurred at intermediate treatment rates of 1.16 and 2.30 kg/ha paclobutrazol. Increased numbers of fruit were observed at the 2.30 kg/ha rate and increased berry size at the 1.16 kg/ha rate.

In addition to the suppression of plant growth, fruiting responses at both test locations in 1981 suggest that a principal effect of paclobutrazol applied during bloom is to delay fruit development and ripening, concentrating fruit maturity in a short period late in the harvest season. Total yield and mean fruit size for the season are not adversely affected. Even at the lowest treatment rate of 0.58 kg/ha, at both locations, paclobutrazol severely restricted plant growth and prevented runner development for the entire season. Check plant runners were not counted, but developed normally. Observations on plant

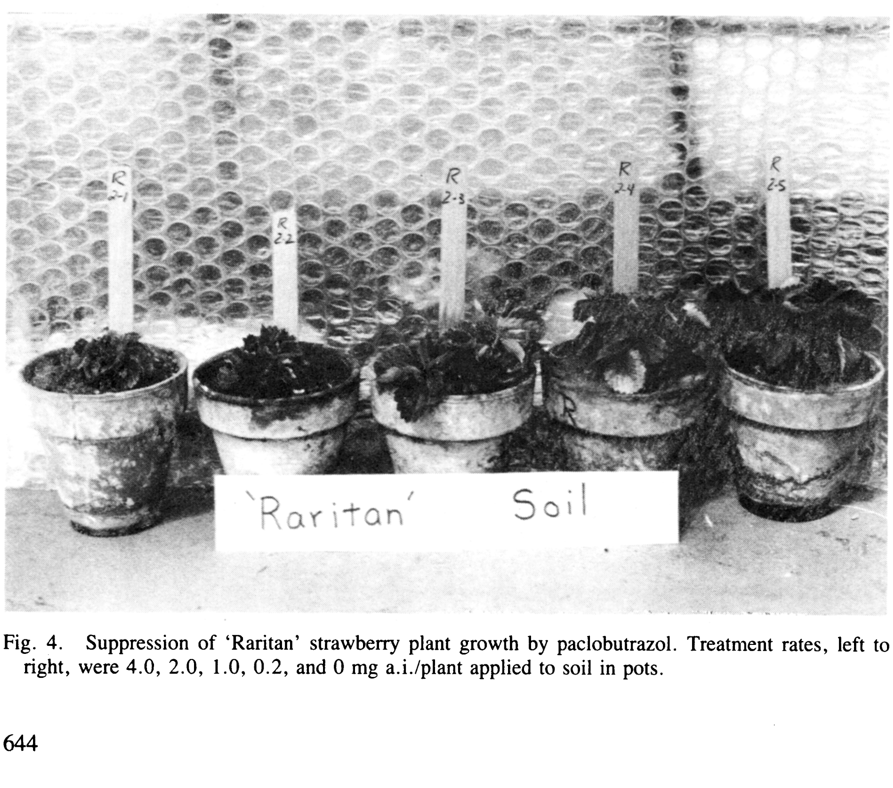

Fig. 4. Suppression of 'Raritan' strawberry plant growth by paclobutrazol. Treatment rates, left to right, were 4.0, 2.0, 1.0, 0.2, and 0 mg a.i./plant applied to soil in pots.

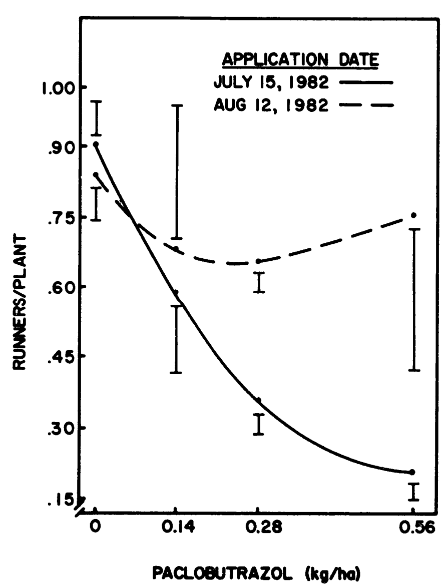

Fig. 5. Effects of paclobutrazol rates and timing of application on number of runners per plant in 'Raritan' strawberry. Vertical bars indicate SE.

root growth in the field indicated slight reductions in total root growth in paclobutrazol treatments, but roots were otherwise normal. Fruit color was normal in comparison to checks. Leaf petioles and fruit pedicels and peduncles were greatly shortened. Green leaf color was intensified in treated plants with no apparent phytotoxicity.

Soil application of paclobutrazol to greenhouse grown plants substantially suppressed growth in 'Raritan' with reduced crown, leaf and root dry weights (Figs. 3, 4), compared to foliar application in 1982. The degree of plant growth suppression increased with increasing paclobutrazol, up to 2.0 mg/plant. Similar results were obtained with 'Guardian' (data not shown) except that crown weight was not affected by either foliar or soil application of paclobutrazol. Roots in soil-treated pots generally were normal in color but were reduced in diameter, more numerous with substantially increased numbers of fine roots and root hairs.

In field tests, runner development was inhibited at all application rates in 'Raritan' when applied in July, about 3 weeks after renovation of the planting (Fig. 5). Extent of runner control was directly related to concentration. Runnering was not suppressed by application in mid-August after the initial runners were established and rooted.

Paclobutrazol offers exciting possibilities for strawberry plant growth control, particularly runner control in either matted row or close spaced systems. Field application rates below 0.5 kg/a.i./ha are likely to provide adequate runner suppression and minimize adverse effects on leaf and fruit stem elongation.

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Rating Scales to Assess Cold Injury and Bacterial Canker Development in Peach Trees in the Field

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Abstract. **Visual rating scales were developed for evaluating tissue injury in peach trees [*Prunus persica* (L.) Batsch] in the orchard due to cold/winter temperatures and bacterial canker (*Pseudomonas syringae* van Hall) development. The numerical ratings on a scale of 1 to 9 separately describe key stages of damage and its severity due to cold and bacterial canker and are portrayed pictorially for clarity. Accurate estimation of tree status at very early stages of injury and good correlation with ultimate tree survival have been possible through the use of these rating scales. This information has been incoporated in the data collection for a regional research project dealing with the development and evaluation of rootstocks for peach in the southern United States and also is under consideration for use in another regional project involving peach in addition to apple, pear, and cherry.**

Under growing conditions in the southeastern United States, winter/cold injury and bacterial canker development pose the greatest threats to peach tree survival and, in association with certain other factors, comprise the syndrome known as peach tree short life or PTSL (1, 7). Although a number of attempts have been made to reproduce and quantify these 2 problems in the laboratory, results do not correlate reliably with field observations. Therefore, it has been necessary to obtain quantitative information on tree status in the field, with the goal of evaluating the extent of tissue injury from the earliest possible date following its occurrence.

Information on the extent and intensity of discoloration of peach trunk cambial areas due to cold has been reported (6), where the ratings ranged from 1 = dead or nearly dead tissue to 5 = no discoloration, indicating healthy tissue. The authors did not present information distinguishing between injury from cold and that from bacterial canker. A scale from 0 to 5 for natural tissue browning of apple bark due to cold injury also has been described (4). This scale was based on death of portions of the tissue area, with 1 = death of 10% to 20% area, and 5 = death of 80% to 100% area. A recent report (5) on sweet cherry (*Prunus avium* L.) and its resistance to bacterial canker caused by *Pseudomonas mors-prunorum* Wormald, established 4 distinct classes of seedling resistance to the pathogen, where class I indicated no canker damage on tissue and class IV signified severe tissue damage.

These rating scales lack precision, since the categories or classes used are broad, subjective and greatly influenced by the evaluator's judgement. A rating system based on a scale from 1 to 9 (0 = no data) reported by Fogle (3) for evaluating fruit tree performance, seems to be precise, adequately detailed, and logical for use with modern data handling systems. In practice, accurate estimation of tree damage status at a very early stage of injury and good correlation with ultimate tree survival have been possible through the trunk cambial browning (TCB) and bacterial canker (BCR) ratings on a 1 to 9 scale (2, 7, 8). This article provides descriptive details of key stages of damage severity and portrays these stages pictorially for further clarity (Table 1, Fig. 1 and 2).

Experience has shown that peach trees should be examined for cold injury and bacterial canker damages in late winter following completion of the rest period (physiodormancy), when temperature fluctuation typically promotes tree dehardening. A 2nd examination, usually for confirmation, should be made after new shoots have begun to elongate, at which time most bacterial canker damage will have appeared to eliminate confusion between cold and/or canker damage. The procedure for tissue ex-

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