Growth and Fruiting of ‘Heritage’ Primocane Fruiting Red Raspberry in Response to Paclobutrazol

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Abstract. Paclobutrazol (PP333) was applied to dormant ‘Heritage’ primocane-fruiting red raspberry (Rubus idaeus L.) plants at dosages of 0, 6, 12, 24, 48, and 96 mg a.i.-0.37 m⁻²-hill⁻¹. After 29 days of fruit production, the average cumulative fruit yield of primocanes treated with 24, 48, or 96 mg of paclobutrazol was 92% greater than for control primocanes. The cumulative fruit yield of primocanes receiving the 24-mg dosage remained significantly greater through 50 days of production compared to that of control primocanes. Cumulative fruit yield was not adversely affected at any time during the production season by any of the dosages applied. The 24-mg dosage suppressed final primocane height by 19% but did not significantly decrease primocane diameter or the number of nodes formed. The vegetative responses to 48- and 96-mg dosages were similar, with an average reduction in primocane height, diameter, and total number of nodes formed of 36%, 25%, and 14%, respectively. Early onset of anthesis was positively correlated (r = 0.72) with suppression of vegetative growth. Production midpoint occurred 60 ± 3.7 days after initial anthesis and varied (r = 0.85) with the date of first anthesis. Chemical name used: β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol (paclobutrazol).

‘Heritage’, the most widely grown primocane-fruiting red raspberry cultivar, produces fruit during the fall on the upper portion of vigorous primocanes (7). In Washington State, the fall production season begins the last of August and extends through September and October. Crandall and Garth (4) found that daminozide applied in May to young ‘Heritage’ primocanes increased fruit yield during the first half of September. In a recent study (1) that reduces the vegetative growth of fruit trees (9).

Levels of daminozide required to obtain comparable growth restraint reduce fruit size. The objectives of the present study were: (1) to determine the degree to which paclobutrazol would restrain primocane growth and (2) to investigate the relationship between increasing vegetative suppression and fruiting habit and productivity.

Individual hills of ‘Heritage’ raspberry were selected in a 3-year-old field planting. The hills were spaced 1.8 m apart within the row and 2.7 m between rows. The canes formed during the 1983 growing season were mowed at the soil line prior to treatment application to limit 1984 fruit production to subsequent formation of primocanes. Selected hills were at least 5.4 m apart. Treatments were assigned according to field location in randomized complete blocks with 4 replications.

On 12 Dec. all plant debris was raked from an area 61 x 61 cm around each hill. The soil was perforated on 10-cm centers to a depth of 14 cm with a 2-cm-diameter probe. A 2-liter aqueous suspension of paclobutrazol [50% wettability powder (WP)] was then applied at dosages of 0, 6, 12, 24, 48, or 96 mg a.i.-0.37 m⁻²-hill⁻¹. Application was made as a sprinkled soil drench followed by a one-liter water rinse.

The first flowers reaching anthesis were recorded for each hill during the period of 16 July through 10 Aug. Fruit harvest began on 23 Aug. and was continued until 5 Nov. Berry loss due to fruit drop was prevented by frequent harvesting. For each hill, all fruit from 6 random primocanes were picked and weighed as a unit. Buds below the lowest fruiting lateral remained dormant. The mean individual fruit weight was determined for each hill at each harvest using a 25-fruit sample (or fewer, if less than 25 were harvested).

After the last fruit harvest, the 6 canes were removed from each hill. Cane height, cane diameter at mid-height, total number of nodes formed, and number of fruitful nodes (those with fruiting laterals) were determined for each primocane.

Cumulative fruit yield. Application of paclobutrazol at the highest dosages (24, 48, and 96 mg a.i.-0.37 m⁻²-hill⁻¹) increased cumulative yield an average 92% at the end of the first month’s production (Fig. 1). Following the 24-mg application, cumulative yield remained significantly increased through the first 50 days of production.

Primocane growth habit. Paclobutrazol applications at dosages of 24 and 48 mg suppressed final primocane height 19% and 35%, respectively (Table 1). The 24-mg dosage had no effect on primocane diameter or the number of nodes formed. However, primocane diameter and the number of nodes formed were reduced 24% and 13%, respectively, by the 48-mg dosage. Doubling the dosage of paclobutrazol to 96 mg had no significant additional effect on the 3 characteristics of vegetative growth. The number of fruitful nodes was not affected.

Date of anthesis and production curve midpoint. Both the date of initial anthesis and production curve midpoint date were similarly advanced by application of paclobutrazol (Table 1). There was an interval of 60 ± 3.7 days between initial anthesis and the production midpoint (r = 0.85, significant at P = 0.001). An average advancement of 8 days followed applications of cumulative yield an average 92% at the end of the first month’s production (Fig. 1). Following the 24-mg application, cumulative yield remained significantly increased through the first 50 days of production.

Fruit size. Individual fruit weights at the production midpoint tended to be larger following paclobutrazol application (Table 1). The application of 2 growth inhibitors, paclobutrazol in the present investigation and daminozide in a previous study (1), now have been shown to result in substantial yield increases throughout the first month of fruit production by ‘Heritage’ primocanes. The effect of paclobutrazol on the first month’s cumulative yield was nearly twice the effect previously observed for daminozide.

The advanced yield response to paclobutrazol appears to be related to the suppression of vegetative growth which, in turn, promotes earlier anthesis. Advancement of the date of first anthesis correlates with suppression of primocane diameter, primocane height, and total number of nodes formed (r = 0.72, significant at P = 0.001). This response is similar to that of ‘Heritage’ to daminozide (1), and agrees with the results of Crandall and Chamberlain (2). They concluded that factors associated with restrained primocane growth during late summer hastened the appearance of floral primordia in June-bearing cultivars.

The extended period of increased yield accumulation following the 24-mg dosage may...
Table 1. Effects of paclobutrazol on growth and fruiting habit of 'Heritage' raspberry primocanes.

<table>
<thead>
<tr>
<th>Paclobutrazol dosage (mg·0.37 m⁻²·hill⁻¹)</th>
<th>Julian date of first anthesis</th>
<th>Julian date of production curve midpoint</th>
<th>Berry size² (g/berry)</th>
<th>Total No. nodes/primocane</th>
<th>No. fruitful nodes/primocane</th>
<th>Final primocane ht (cm)</th>
<th>Final primocane diam (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>212 a²</td>
<td>271 ab</td>
<td>2.2 b</td>
<td>46.8 a</td>
<td>19.6 a</td>
<td>172 a</td>
<td>10.8 a</td>
</tr>
<tr>
<td>6</td>
<td>214 a</td>
<td>275 a</td>
<td>2.5 ab</td>
<td>47.8 a</td>
<td>20.2 a</td>
<td>171 a</td>
<td>10.8 a</td>
</tr>
<tr>
<td>12</td>
<td>215 a</td>
<td>275 a</td>
<td>2.7 a</td>
<td>47.4 a</td>
<td>20.2 a</td>
<td>174 a</td>
<td>11.1 a</td>
</tr>
<tr>
<td>24</td>
<td>205 b</td>
<td>264 b</td>
<td>2.5 ab</td>
<td>42.7 ab</td>
<td>19.9 a</td>
<td>139 b</td>
<td>9.8 a</td>
</tr>
<tr>
<td>48</td>
<td>203 b</td>
<td>263 b</td>
<td>2.7 a</td>
<td>40.7 b</td>
<td>19.1 a</td>
<td>111 c</td>
<td>8.1 b</td>
</tr>
<tr>
<td>96</td>
<td>204 b</td>
<td>263 b</td>
<td>2.8 a</td>
<td>39.8 b</td>
<td>19.0 a</td>
<td>108 c</td>
<td>8.2 b</td>
</tr>
</tbody>
</table>

F test significances
- paclobutrazol dosage
  - linear: **, ** NS
  - quadratic: NS NS NS NS NS NS NS NS

- Berry size at production curve midpoint.
- ** Nonsignificant or significant at 1% level.
- * Nonsignificant or significant at 5% level.

Fig. 1. Cumulative fruit yield of 'Heritage' primocanes grown from hills treated with 0, 6, 12, 24, 48, or 96 mg a.i.·0.37 m⁻²·hill⁻¹ of paclobutrazol as a soil drench the previous December. Mean separation (a, b, c) within each date by Duncan's multiple range test, 5% level. F test significances are given below each harvest date—nonsignificant (NS), or significant at 5% (*) or 1% (**) levels.

The use of higher soil fertility levels. Nitrogen applications often are adjusted to constrain cane vigor (8). Such vigor control may be at the expense of reduced yield potential in terms of number of flowers formed and fruit set. Further studies are needed to determine the effects of paclobutrazol on long-term raspberry growth and yield, as well as on management practices.

The Effect of Woven Plastic Mulch, Herbicides, Grass Sod, and Nitrogen on 'Foch' Grapes Under Irrigation

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Abstract. Three soil surface treatments were compared for grape production under irrigation. Plastic mulch was superior to glyphosate and to grass sod in producing yields during the first 2 years of production. By the 3rd year, the glyphosate treatment was equal to the plastic and both were superior to grass sod. Cluster weights and pruning weights were suppressed by grass sod, compared with plastic or herbicide, but were unaffected by nitrogen. Nitrogen fertilizer treatments had no measurable effects on the grapevines and showed no interaction with the soil surface treatments. None of the treatments (soil surface or fertilizer) had any effect on berry soluble solids. The use of plastic mulch is an effective cultural technique, the usefulness of which will depend mostly on cost and environmental comparisons with herbicides.

Mulching for water conservation, for retention of or insulation against heat, and for weed control is a very old cultural technique. Among the first to report effects of synthetic materials was Emmert (5) who, in 1957, tried black polyethylene with vegetables. Since then, plastics have been investigated on such diverse fruit crops as strawberries (1, 9), pears (7), apples (10), and mulberry (11). Researchers have tested plastic mulches on grapes (2, 3, 6, 8, 12, 14) and reported improved yields as well as increased vigor of vines. Volosky (14) found increased shoot growth and weights of cane prunings of 'To­rontel' vines, which he attributed to complete weed control by plastic. He did not report yields, because the vines were young and nonbearing.

Most of these trials on grapes were conducted under rainfall alone or with only occasional supplemental irrigation. Of interest in the Okanagan Region of the Pacific Northwest is the effect of mulches and ground covers where irrigation is regular and comprises almost the entire source of water. Stevenson (13) reported a competitive effect of cover crop on grape yields under full season-long irrigation.

Solid plastics keep rain and sprinkler water away from roots and prevent evaporation of water that is in the soil at the time the plastic is laid. As long as ground vegetation or weeds are suppressed by plastic or herbicide, water is not lost through their transpiration. Under rain-fed noncontrolled soil water conditions, control of ground vegetation can be vital to grape production. Under irrigation, where soil water is controllable, it may be of lesser importance.

Godden and Hardie (8) reported that, in Australia, weights of prunings and fresh berry clusters of 'Cabernet Sauvignon' vines under trickle irrigation were doubled by the use of plastic sheeting compared to the use of a number of herbicides for weed control. The nonselective herbicide glyphosate is commonly used for removing ground vegetation in tree and vine rows in orchards and vineyards in the United States and Canada, but must be applied carefully to avoid drift to the vines. Daniell and Lane (4) reported that muscadine grapes (Vitis rotundifolia) were undamaged as long as basal leaves were not hit by glyphosate spray. Wallinder et al., however, reported severe damage to 'Con­cord' grapes (Vitis labrusca) when glyphosate spray struck low hanging foliage or basal shoots (15).

The objectives of this experiment were to test, under season-long irrigation, the field usefulness of plastic mulching and to compare plastic mulch, herbicide, and grass sod effects on yields, cluster weights, pruning weights, and soluble solids of grapes. The mulch could be an alternative to glyphosate, which can damage grapes and which may be environmentally less desirable than the mulch. Since N fertilization is a normal practice in vineyards in the region, a secondary objective was to establish appropriate levels of N fertilization under mulch, herbicide, and grass sod.

A vineyard of the French hybrid, cv. Foch, was planted in 1979 in a sandy loam soil on a south-southeast facing slope. The vines were row- and trained onto a T-bar system. They were planted 2 m apart in rows 4 m apart.

Trickle irrigation with emitters 1.5 m apart applied water for about 5 hr, 5 days out of every 7, at a rate equivalent to 35 mm-wk⁻¹, or about 750 mm-season⁻¹. This irrigation was more than 80% of the water supply for the grapes during the 150- to 160-day growing season. Light, infrequent rains, totaling only 140 to 200 mm per growing season, occasionally halted evapotranspiration but seldom would contribute significantly to soil water. The spacing of the emitters allowed for about a 20% overlap of the spreading circles, in the particular soil type, of water moving laterally from the emitters. The result was a band of irrigated soil about 1.5 m wide along the rows.

Comparative treatments were initiated in 1981. However, solid black plastic mulch was put in place in 1980, where it remained until Spring 1982. During the 1980 season, the vines were trained and a complete grass cover crop was established, primarily of crested wheat grass (Agropyron cristatum) and Kentucky bluegrass (Poa pratensis). Treatments were (on each side of a row): a) a strip of grass sod mowed when 10 to 15 cm high, b) a strip kept clean with glyphosate, and c) a strip of plastic cover. All 3 strips were 1 m wide on each side of each row making each plot 2 m wide. The glyphosate was applied in time to prevent ground vegetation from becoming large and competitive with the grapevines. The remaining 2 m between rows were mowed 2 or 3 times per season as needed. In combinations with soil surface treatments (SST) were 3 levels of N, specifically 25, 50, and 75 kg·ha⁻¹ applied in the form of NH₄NO₃. Because of zero responses to N in 1982 and 1983, these rates were doubled in 1984. Together, these made 3 distinct SST x 3 levels of N in a randomized block design. There were 4 vines per plot replicated 4 times. For all treatments, the trickle irrigation system was placed on the ground. The plastic covered the trickle lines in the mulch treatments.