treatment. The increased fruit size may have resulted from greater photosynthate production provided by the increased vegetative growth.

The WS plants averaged greater total berry weight per plant than did CS plants. The increased production by WS plants can be explained by the increased number of flower buds and total flower number that were associated with WS plants. The increase in flower buds and total number of flowers resulted in more total fruit being produced from WS plants than CS plants.

Increases in fruit size and number of flowers per bud, factors associated with CS plants, probably minimized the difference in production between WS and CS plants. The large fruit could be attributed to increased vegetative growth associated with the CS. The greater vegetative growth also may have contributed to the greater number of flowers produced per bud, although light relationships also may have been involved, since HN plants increased in vegetative growth, not in number of flowers per bud.

The greater growth made by CS plants compared to WS plants may have been the result of microclimate. The CS plants may have experienced less evaporation and transpiration of moisture than WS plants because of a humid microclimate. The branches of CS plants were intertwined by the end of the study, which was not the case in the WS plants.

These findings indicate that researchers wishing to use potted highbush blueberry plants for studies where flower and fruit production are important need to provide adequate space between plants for light penetration and increase the N nutrition above commonly used rates. The study also points to potential problems in commercial fields where reduced pruning and close spacings are used to facilitate mechanical picking. Restricted light penetration into the plant canopy could cut production through reduced flower bud development.

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Vegetative and Fruiting Responses of Grapes to Chlorsulfuron and Oryzalin

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Abstract. **Chlorsulfuron was applied alone at 0.018 kg·ha^{-1} and in combination with 3.4 kg·ha^{-1} of oryzalin at rates of 0.018, 0.035, 0.070, and 0.140 kg·ha^{-1} to a mature 'Chancellor' grape (*Vitis* x sp.) vineyard. Oryzalin was also applied alone at 3.4 kg·ha^{-1}. Oryzalin plus chlorsulfuron treatments provided excellent weed control. The vegetative growth of vines was reduced in the oryzalin plus chlorsulfuron treatments at rates of 0.07 and 0.14 kg·ha^{-1} as compared to the control. Oryzalin used alone and oryzalin plus chlorsulfuron used at the lowest rate were the only treatments that did not adversely affect vine growth or fruit quality. Chemical names used: 2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide (chlorsulfuron); 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide (oryzalin).**

Chlorsulfuron is a relatively new herbicide that controls most annual broadleaf weeds in cereal crops. Both preemergence and postemergence activity have been demonstrated at very low rates of application with good residual control (1, 3, 5, 7, 8, 9). Persistence in the soil has been prolonged by low rainfall, cool soil temperatures, and high soil pH (2, 4). Brewster and Appleby (3) reported that chlorsulfuron applied at 35 g·ha^{-1} reduced vegetative growth of sugarbeets (*Beta vulgaris* L.) planted 26 months after the herbicide treatment.

Chlorsulfuron is absorbed by roots and is translocated throughout plants (10). Susceptible plants exhibit chlorosis, necrosis, and terminal bud death (11). Ray (12) reported that chlorsulfuron inhibited cell division and growth, whereas photosynthesis, respiration, and RNA and protein synthesis were not initially affected by the herbicide. Rost (14) demonstrated that chlorsulfuron inhibited the progression of cells from G_2 to mitosis and from G_1 to DNA synthesis. More recently, acetolactate synthesis has been identified as the site of action of chlorsulfuron (13).

Sweester et al. (15) reported that tolerant grasses rapidly metabolized chlorsulfuron to a polar, inactive product. This metabolite was characterized as the O-glucoside of chlorsulfuron. Hutchison et al. (6) also demonstrated that some broadleaf plants, such as black nightshade (*Solanum nigrum* L.) and flax (*Linum usitatissimum* L.), detoxified chlorsulfuron by conjugation with a carbohydrate.

Chlorsulfuron has not been evaluated for broadleaf weed control in grapes. The long residual activity of chlorsulfuron could reduce the number of herbicide applications required during the growing season. However, a mixture with another herbicide that controls grass weeds would be necessary to provide broad spectrum weed control. Oryzalin has controlled annual grasses effectively and currently is labeled for use in vineyards (16, 17). Thus, a tank-mixture of chlorsulfuron plus oryzalin could be an effective herbicide combination for use in vineyards. The objectives of this study were to evaluate chlorsulfuron plus oryzalin for weed control in grapes and to determine if fruit quality or vegetative growth of grape vines was affected by the herbicide combination.

To kill existing weeds, a 1.8-m band of glyphosate [*N*-(phosphonomethyl)glycine] was applied at 0.8 kg·ha^{-1} underneath 9-year-old 'Chancellor' grape vines on 9 May

Table 1. Effect of herbicide treatments on weed control in 'Chancellor' grapes 9 weeks after treatment.[z]

Treatment	Rate (kg·ha^{-1})	Weed control (%) Broadleaf weeds	Grass weeds
Control	---	0 b[y]	0 d
Chlorsulfuron	0.018	100 a	24 c
Oryzalin	3.4	20 b	90 a
Oryzalin + Chlorsulfuron	3.4 + 0.018	97 a	47 bc
Oryzalin + Chlorsulfuron	3.4 + 0.035	100 a	70 ab
Oryzalin + Chlorsulfuron	3.4 + 0.070	100 a	94 a
Oryzalin + Chlorsulfuron	3.4 + 0.140	100 a	94 a

[z]Means represent 3 replications of each treatment

[y]Mean separation by Duncan's multiple range test, 5% level, analysis performed on arcsin $\sqrt{x}$ transformed data.

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Table 2. Effect of herbicide treatments on vegetative growth of 'Chancellor' grape vines[z].

Treatment	Rate (kg·ha^{-1})	Pruning wt/plot (g)
Control	---	1506 ab[y]
Chlorsulfuron	0.018	1306 ab
Oryzalin	3.4	1591 a
Oryzalin + Chlorsulfuron	3.4 + 0.018	1418 ab
Oryzalin + Chlorsulfuron	3.4 + 0.035	1240 abc
Oryzalin + Chlorsulfuron	3.4 + 0.070	1058 bc
Oryzalin + Chlorsulfuron	3.4 + 0.140	773 c
Significance[x]		
Linear		**
Quadratic		NS

[z]Means represent 3 replications with 2 vines/plot.
[y]Mean separation by Duncan's multiple range test, 5% level.
[x]Linear and quadratic orthogonal contrasts were performed to test the trend of different rates of chlorsulfuron.
NS,*,**Nonsignificant or significant at the 5% and le1 % levels, respectively.

Table 3. Effects of herbicide treatments on berry weight and quality of 'Chancellor' grapes[z].

Treatment	Rate (kg·ha^{-1})	Wt/ 100 berries (g)	Soluble solids (brix)	pH	Titratable acidity (g·liter^{-1})
Control	---	163 a[y]	16.6 a	3.10 bc	13.4 a
Chlorsulfuron	0.018	119 ab	15.9 a	3.23 ab	9.2 bc
Oryzalin	3.4	164 a	15.6 ab	3.07 bc	13.1 a
Oryzalin + Chlorsulfuron	3.4 + 0.018	118 ab	15.8 ab	3.13 abc	11.7 ab
Oryzalin + Chlorsulfuron	3.4 + 0.035	111 b	16.0 a	3.17 abc	10.6 ab
Oryzalin + Chlorsulfuron	3.4 + 0.070	72 bc	14.3 b	3.03 c	10.4 ab
Oryzalin + Chlorsulfuron	3.4 + 0.140	31 c	10.8 c	3.30 a	6.6 c
Significance[x]					
Linear	**	**	*	**	
Quadratic	NS	*	NS	NS	

[z]Means represent 3 replications of each treatment.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.
[x]Linear and quadratic orthogonal contrasts were performed to test the trend of different rates of chlorsulfuron.
NS,*,**Nonsignificant at the 5% and 1% levels, respectively.

1984. Chlorsulfuron was applied alone at 0.018 kg·ha^{-1} and in combination with 3.4 kg·ha^{-1} of oryzalin at 0.018, 0.035, 0.070, and 0.140 kg·ha^{-1} to the Menfro silt loam on 23 May 1984. Oryzalin was also applied alone at 3.4 kg·ha^{-1}. Weedy control plots were included to evaluate the weed population. All herbicide treatments were made with a CO_2-pressurized plot sprayer delivering 243 liter·ha^{-1} at 207 kPa. Each plot was 1.8 m × 4.9 m with 2 vines/treatment. Plots were arranged in a randomized complete block design with 3 replications/treatment. Linear and quadratic orthogonal contrasts were performed to test the trend of different rates of chlorsulfuron.

Visual evaluations of weed control were recorded on 15 June, 15 July, and 15 Aug. 1984. Weed control was rated on a scale of 0% (no control) to 100% (complete control). One hundred random berries per plot were taken from the middle portion of the clusters on 15 Aug. 1984, and fresh berry weights were determined. Total yield was not obtained due to a high incidence of disease caused by high humidity and rainfall during the growing season. Grape samples were crushed and soluble solids, pH, and titratable acidity were measured according to the procedure described by Zoecklein et al. (18). A 5-ml juice sample from each treatment was titrated to pH 8.2 with 0.67 N NaOH. Titratable acidity is a measurement of tartaric, malic, and citric acids, which affect the flavor, color, and stability of wine.

The primary weed species in the vineyard were horseweed [*Conyza canadensis* (L.) Cronq.], dandelion (*Taraxacum officinale* Weber), yellow foxtail [*Setaria glauca* (L.) Beauv.], and large crabgrass [*Digitaria sanguinalis* (L.) Scop.]. No weeds were present in plots that had been treated with chlorsulfuron and oryzalin on 15 June. Broadleaf weeds had infested plots treated with oryzalin alone and grass weeds were present in plots treated with chlorsulfuron alone. On 15 July, broadleaf weeds were controlled at all rates of chlorsulfuron (Table 1). Oryzalin provided control of grass weeds except when combined with chlorsulfuron at the lowest rate. This lack of grass weed control in the plots treated with oryzalin plus chlorsulfuron at 0.018 kg·ha^{-1} cannot be explained. Weed control ratings recorded on 15 Aug. did not differ from those taken on 15 July. Grape vines were examined for herbicide injury at weekly intervals throughout the growing season. Growth appeared to be normal until mid-July. Reduced internodal growth on the terminal portions of primary and lateral shoots was observed on vines treated with the higher rates of chlorsulfuron. Vines produced about 8 nodes of normal growth before injury was observed. The length of internodes in the area of injury on vines was measured after defoliation. Internodal length on lateral shoots of untreated and oryzalin treated vines averaged 50 mm, whereas oryzalin plus chlorsulfuron at 0.018, 0.035, 0.070, and 0.140 kg·ha^{-1} measured only 35, 30, 15, and 4 mm, respectively. Grape vines eventually recovered and normal internodal growth resumed after 8 Aug. 1984. Pruning weights also were recorded as a measurement of vegetative growth in 1984. Vines treated with oryzalin plus chlorsulfuron at the 0.14 kg·ha^{-1} rate had a lower pruning weight than the control, oryzalin, and chlorsulfuron treatments at 0.018 kg·ha^{-1} (Table 2). Pruning weights exhibited a linear decrease with increased rates of chlorsulfuron.

Berry weight, soluble solids, pH, and titratable acidity were measured to determine if the enological properties of grapes were affected by the herbicide treatments. Berry weight, pH, and titratable acidity showed a linear trend related to chlorsulfuron rate and soluble solids exhibited a linear and quadratic response to the herbicide rate (Table 3). Oryzalin plus chlorsulfuron at 0.035, 0.070, and 0.140 kg·ha^{-1} reduced berry weight as compared to the control. Soluble solids were lower in the oryzalin plus chlorsulfuron treatments at 0.07 and 0.14 kg·ha^{-1} than in the untreated grapes. Grapes receiving the highest rate of chlorsulfuron had a higher pH and lower titratable acidity than the control. Chlorsulfuron alone also reduced titratable acidity. Oryzalin alone did not affect fruit quality. Thus, the only herbicide treatment combination that provided weed control without an adverse affect on growth or berry quality was oryzalin at 3.4 kg·ha^{-1} plus chlorsulfuron at 0.018 kg·ha^{-1}. However, the margin of safety of chlorsulfuron in grapes would be very narrow. An overdose of chlorsulfuron could cause reduced vine growth and fruit size.

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Influence of Summer Pruning on the Growth Pattern of Vigorous 'Delicious' Apple Limbs

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Abstract. **'Delicious'/M9 planted in 1974 were unpruned or pruned on 3 July, 3 Aug., or 3 Sept. 1979, and at a comparable time in 1980. In the distal section, total length and dry weight of lateral shoots were greater on vertical than on horizontal limbs. Lateral shoot length and dry weight were decreased in the distal but not affected in the middle and proximal sections by pruning. Pruning and limb orientation had no effect on the distribution of dry weight in the limb sections. Time of pruning had no influence on the distribution of growth in the limb sections.**

In the absence of pruning, apple trees eventually exceed their allotted growing space, and changes occur in fruiting patterns and fruit quality. For example, fruit production of unpruned 'Delicious' trees moved away from the center of the tree, and 40% of the spurs on 2-year-old limbs died the year after fruiting (6). However, July pruning increased spur numbers and leaf area, decreased total bloom but not fruit number on 2-year-old limbs, and increased the number of fruit borne in the canopy interior compared to the unpruned trees. Elfving and Forshey (2) found that severe dormant heading increased shoot growth on 2-year-old limb sections and was associated with a decrease in spurs and fruit production.

The influence of limb orientation and spreading on patterns of growth is well-documented (1, 3, 4, 7). Orientation of trees away from vertical did not affect total shoot growth but did result in different patterns of growth (4, 7). As trees were oriented further from vertical, shoot growth was distributed more toward the base of the tree (4).

Orientation also has been shown to influence the response to pruning (1, 3, 4, 6). Regrowth, which generally occurs in close proximity to the pruning cut in vertical potted trees, was distributed toward the base of the trees oriented at 45° to 90° from vertical (4). Dormant heading on limbs of mature 'Delicious' trees increased shoot growth on 2-year-old sections in vertical limbs but decreased growth on horizontal limbs (1). Vertical limbs had more shoot growth than horizontal limbs in both unpruned and summer-pruned limbs (6). However, the distribution of shoot growth along apple limbs following summer pruning was not reported.

This study examines the distribution of growth along 2-year-old sections of vertical and horizontal limbs following 2 years of pruning in July, August, or September.

Trees of 'Red Prince Delicious'/M9, planted in 1974 at a 1.52 × 3.05 m spacing, were trained to the slender spindle system. In 1979, the following treatments were applied to trees: a) control (unpruned); b) pruned 3 July; c) pruned 3 Aug.; and d) pruned 3 Sept. In 1979, terminal shoots were removed at a point 5 cm below the 1978 bud scale scar, and current season's lateral shoots greater than 10 cm in length were removed at their point of origin. In 1980, current season's growth as well as previous season's regrowth greater than 10 cm in length were removed at their point of origin on about the same dates. Limb sections originating in 1978 (1978 limb) on the outside of the tree canopy were selected from each of 2 orientation groups: a) vertical to 40° from vertical (vertical) and b) 45° from vertical to horizontal (horizontal). Treatments were included in a split-plot design, with pruning as the main plot and orientation as the subplot with 8 single tree replications.

Following the 1981 growing season, three 1978 limbs from each orientation group were selected from each tree. The limb samples included all lateral and terminal shoot growth (lateral shoots) that had developed on the 1978 limbs subsequent to the 1980 pruning. Each 1978 limb was divided equally into proximal, middle, and distal sections. On each limb section, the following were measured: length and dry weight of lateral shoots, and the dry weight of the 1978 limb, excluding lateral shoots. Data were analyzed by square-root transformation.

There were no pruning × orientation interactions and only main effects of pruning or orientation are presented. The length of the 1978 limb was reduced by pruning and was greater in vertical than horizontal limbs as previously reported (6).

Following the 1981 season, pruning of previous years had no effect on dry-weight distribution in the proximal, middle, and distal sections of the 1978 limb (Table 1). Dry weight was distributed somewhat uniformly between the sections, and orientation had little effect on the percentage of total dry weight in the various sections of the 1978 limb.

Both pruning and horizontal orientation decreased total dry weight of lateral shoots produced on the distal section of the 1978 limb (Table 1). On unpruned limbs, 98% of the total shoot dry weight was distributed in the distal section of the 1978 limb, a pattern consistent with characteristic growth habit of 'Delicious'. Pruning did little to alter this pattern of dry-weight accumulation. August pruning, but not that of July or September, slightly increased the percentage of total shoot dry weight in the middle section, apparently at the expense of dry weight in the distal section. Orientation did not affect the rela-

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