gested by Tukey (9) to explain the effect of some rootstocks.

Widespread reports of poor tree development on Mark rootstock have resulted in removal of Mark stoolbeds from nurseries and virtually complete cessation of its use in new commercial plantings. We had initially planned a broader survey of orchards planted on Mark but concluded that this was unwarranted because of its apparent commercial eclipse. Our data indicate that the root mass proliferations on Mark rootstock develop early in orchard life and are significantly correlated with decline in tree growth. Presence of RMP below ground influences tree growth before it becomes apparent on the soil surface. Anecdotal reports from numerous researchers and orchardists suggest that RMP growth continues through five or more years of tree development, and in most cases reaches a threshold where tree vigor and productivity declines after two to five years of promising growth and production.

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Hand and Mechanical Pruning of Thorny, Erect-Type Blackberries in Alabama

ALLISON L. BUSBY[1] AND DAVID G. HIMELRICK[2]

Abstract

Two thorny, erect blackberry cultivars were subjected to four pruning methods and evaluated for yield, berry characteristics and plant vigor in 1991 and 1992. The pruning treatments consisted of: (1) hand pruning spent floricanes immediately after harvest in the summer, summer topping primocanes to 120 cm, and pruning lateral branches to 45 cm during the dormant period (standard hand pruning); (2) hand pruning dead floricanes during the dormant period, summer topping primocanes to 120 cm, and pruning lateral branches to 45 cm during the dormant period (dormant hand pruning); (3) mechanically pruning dead floricanes and primocanes to 30 cm immediately after harvest in the summer; (4) mechanically pruning dead floricanes and primocanes to 15 cm immediately after harvest in the summer. Standard and dormant hand pruning resulted in the highest yields and simulated mowing to 15 cm resulted in the lowest yields for both cultivars tested. The amount of yield reduction from mowing due to reduced primocane vigor indicated that one year of profitable production will probably be lost. Berry characteristics were not affected by pruning method. Dormant hand pruning of dead floricanes appears to be the most economically viable alternative pruning method relative to removing the dead floricanes in the summer.

Pruning is one of the most important practices involved in blackberry culture, yet few studies have examined the effect of different pruning methods on yield, berry characteristics and plant vigor. While second-year floricanes are flower-

[1]Former Graduate Assistant and Professor, respectively, Department of Horticulture, Auburn University, Auburn, AL 36849-5408.

ing and fruiting first year vegetative primocanes are also developing, thus the type and timing of pruning practices can dramatically influence plant growth and productivity (4, 9).

Another alternative to standard hand pruning is mechanical pruning (mowing) the entire plant after harvest. For this system to be successful the primocanes must regrow before the dormant season. The amount of primocane regrowth required to maintain acceptable yields will depend on height of the mowed hedge and length of the growing season. Since there is no need to selectively cut out only one kind of cane, the operation can be totally mechanized producing a significant reduction in labor. In areas where there is a problem with the fungal disease rosette or double blossom caused by *Cercosporella rubi* (G. Wint) Plakidas, this practice may help reduce the incidence of the disease by providing the sanitation necessary to break the disease cycle (5).

In Florida, hedged blackberries are mowed to the ground after harvest every year due to the longer postharvest growing season (2). In Texas, commercial growers commonly mow the hedge to about 15 cm above the ground after harvest every four to five years rather than remove dead floricanes each year. This reduces yields 50% or more in the year after mowing (7).

Alternate-year (A-Y) or alternate-row mowing has been used in bramble production management systems to reduce spraying and pruning costs. Additional advantages of A-Y production include reduced cane damage, lower labor costs, and reduced irrigation, fertilizer and pesticide use (16). Many of the vegetative and reproductive plant responses observed in this system may also be relevant to systems using annual mowing. Experiments in Oregon and Scotland (18, 19, 20, 21) on red raspberry showed that fruiting and vegetative canes compete mainly for light, but also for water and nutrients. Waister et al. (18) showed that in the A-Y system, competition between fruiting and vegetative canes is reduced. In the absence of fruiting canes, more vegetative canes were produced and the number of nodes per cane, and thus fruiting area, was increased. In the absence of vegetative canes, yields in the fruiting year were considerably higher because of enhanced fruiting potential and because they were not shaded by vegetative canes. Wright and Waister (20, 21) showed that when the fruiting canes grew in the absence of vegetative canes, total dry weight of the fruiting canes and total leaf area and leaf numbers were higher due to increased light into the canopy. A-Y mowing studies by Nehrbas and Pritts (15), on red and purple raspberries, found that plots were only 89% as productive as the annual system (7 floricanes retained per plant) with 'Titan' red raspberry and 67% as productive with 'Royalty' purple raspberry over a 2-year period. Studies in Oregon (8) found cumulative yields with A-Y mowing to be 85% of the annual system for blackberries and about 70% for raspberries. Sullivan and Evans (17) compared annual pruning of red raspberries in Canada to A-Y pruning and found that A-Y pruning increased yield per cane 28% and increased cane diameter. The higher yield of the alternate-row canes was attributed to lack of competition of primocanes from fruiting canes during the season after mowing. Alternate-row pruning also allows pruning to be mechanized so that the row spacing can be reduced to allow higher planting density.

Increases in hand pruning labor costs have compelled growers to consider mechanization of this operation and more information is needed on yield components resulting from pruning techniques that differ from standard hand pruning. The objective of this study was to evaluate the effects of different types of hand and mechanical pruning techniques on two cultivars of thorny, erect blackberries.

Materials and Methods

Root cuttings of the thorny, erect blackberry cultivars Cheyenne (11) and Shawnee (10) were planted at the Chilton Area Horticulture Substation in Clanton,

Ala. in March 1989. Plots were 6.1 m long with 1.5 m alleys between plots and 3.6 m between rows. The cuttings were planted 45.7 cm apart in the row. All plots were drip-irrigated uniformly throughout the entire growing season, and standard cultural practices such as fertilization and preemergent herbicide application were followed.

'Cheyenne' and 'Shawnee' were evaluated as two separate experiments. Plots of both cultivars were arranged in a randomized block design with four pruning treatments replicated four times. The treatments were as follows: (1) hand pruning spent floricanes immediately after harvest, summer topping primocanes to 120 cm as they reached the desired height, and pruning lateral branches to 45 cm during the dormant period (standard hand pruned); (2) hand pruning dead floricanes during the dormant period, summer topping primocanes to 120, and pruning lateral branches to 45 cm during the dormant period (dormant hand pruned); (3) mechanically pruning dead floricanes and primocanes to 30 cm immediately after harvest (mowing to 30 cm); and (4) mechanically pruning dead floricanes and primocanes to 15 cm immediately after harvest (mowing to 15 cm). Ammonium nitrate was surface-applied after harvest at a rate of 0.74 kg/m of row to encourage primocane regrowth.

Ripe fruit were hand-harvested and weighed twice a week. Nine harvests, starting on 4 June, were required in 1991 to harvest the entire crop, and seven harvests, starting on 2 June, were needed in 1992. All plots were harvested on the same day, and cumulative yield and average weight of 25 randomly sampled berries from each plot were recorded at each picking date in both 1991 and 1992. Percent soluble solids concentration was determined with a Bausch and Lomb refractometer and titratable acidity was measured and reported as percentage citric acid (6). Total lateral branch length prior to pruning was measured, and the number of laterals per cane in each plot was counted within the center 3.05 m of the plot. Ten random canes were selected from each plot to determine cane diameter at 45 cm from the base of the plant. Total inflorescence number and number of flowers/inflorescence were determined in a 40 cm region from the lateral tip on six random fruiting laterals per plot.

Results and Discussion

There was a treatment by year interaction. There were no yield differences among pruning methods in 1991 for 'Cheyenne' (Table 1). In 1992, yields were similar for plots of 'Cheyenne' standard hand pruned, dormant hand pruned, and mowed to 30 cm. Both hand pruned treatments produced greater yields than

Table 1. Effect of pruning on vegetative and fruiting characteristics of 'Cheyenne' blackberry.

	Pruning method							
	Standard hand pruned		Dormant hand pruned		Mowed to 30 cm		Mowed to 15 cm	
Variable	1991	1992	1991	1992	1991	1992	1991	1992
Yield (kg/ha)	10,578.0 a[z]	3,710.0 a	10,108.0 a	3,403.0 a	9,109.0 a	2,077.0 ab	7,242.0 a	1,470.0 b
Berry wt (g)	3.5 a	2.8 a	3.7 a	2.7 a	3.3 a	2.9 a	3.3 a	2.9 a
Laterals/cane	3.9 ab	1.4 b	5.1 a	1.2 b	3.3 ab	2.6 a	2.4 b	2.7 a
Lateral Length (cm)	113.5 a	58.6 ab	101.3 a	65.2 a	116.5 a	43.3 bc	107.7 a	37.9 c
Inflorescences/Lateral	10.5 ab	17.2 a	10.8 a	14.8 ab	9.2 b	11.0 bc	9.8 ab	8.3 c
Flowers/Lateral	52.8 a	12.5 a	61.6 a	10.9 a	52.7 a	9.0 a	52.9 a	5.9 a
Flowers/inflorescence	5.0 b	0.8 a	5.7 a	0.7 a	5.7 a	0.8 a	5.4 ab	0.7 a
Cane diameter (mm)	13.3 a	12.4 a	14.5 a	12.1 a	7.0 b	4.3 b	6.4 b	4.0 b
Soluble solids (%)	6.8 a	7.7 ab	6.8 a	7.6 b	6.1 a	8.0 ab	6.3 a	8.4 a
Titratable acidity (% malic)	1.0 a	1.2 a	0.9 a	1.2 a	0.9 a	1.2 a	0.9 a	1.3 a

[z]Mean separation within variables and year by Duncan's multiple range test, 5% Level.

mowing to 15 cm in 1992. Although no statistical differences were found in 1991, yields from the standard hand pruned plots were numerically higher for 'Cheyenne' and plots mowed to 15 cm were the least productive. In 1992, there was an obvious loss of productivity resulting from disease (crown gall), glyphosate herbicide drift and frost damage, however, the same relative yield relationships exist among treatments as in 1991 with the standard hand pruned canes being the most productive and the 15-cm mowed canes the least productive.

Plots hand pruned when dormant and mowed to 30 and 15 cm had a similar number of laterals/cane compared to standard hand pruned plots of 'Cheyenne' in 1991. Hand pruning of dormant canes produced a greater number of laterals/cane than mowing the canes to 15 cm. In 1992, however, mowing the canes to 30 and 15 cm produced a greater number of laterals/cane than standard or dormant hand pruning for 'Cheyenne'. Morris and Sims (14), reported that pruning erect blackberries to 90 cm, summer topping the primocanes, and leaving old dead canes in place increased lateral branching, which contributed to a yield increase.

There were no differences in lateral length (prior to pruning back the laterals of the hand pruned treatments to 45 cm during the dormant period) among pruning methods for 'Cheyenne' in 1991. Cane diameter for 'Cheyenne' was greatly reduced in both years by mowing the canes to 30 and 15 cm. Since cane diameter has been used as an indicator of vigor and productivity, much of the yield reduction may be due to the loss of vigor from the severity of the mowing treatments. Mowing produced thinner, less vigorous laterals which resulted in a less erect hedge. In 1992, prior to cutting back laterals of hand pruned plots to 45 cm in the winter, lateral lengths were similar for standard and dormant hand pruned canes. However, mowing the entire canes again in the summer with no hand pruning of laterals during the winter weakened cane and lateral growth to such an extent that a short and less erect hedge resulted, making hand harvesting difficult without stooping. Even though there were no differences in lateral length between canes mowed to 30 cm and the standard hand pruned canes, the lateral growth was thin and weak in the mowed plots. Mowing the canes to 15 cm produced shorter laterals than either hand pruning method.

The number of inflorescences/lateral from canes dormant hand pruned and mowed to 30 and 15 cm were similar to those from canes standard hand pruned for 'Cheyenne' in 1991. In 1992, mowing the canes to 30 and 15 cm produced fewer inflorescences/lateral than standard hand pruning, but dormant hand pruning did not affect inflorescences/lateral when compared to standard hand pruning. There were no differences in the number of flowers/lateral among the different pruning methods in either year for 'Cheyenne'.

Dormant hand pruning and mowing to 30 cm produced a greater number of flowers/inflorescence than standard hand pruning for 'Cheyenne' in 1991. In 1992, there was only about one flower/inflorescence as compared to over five per inflorescence the previous year for each of the pruning treatments, which explains much of the yield reduction.

Berry characteristics, including berry weight, soluble solids and titratable acidity, were unaffected by pruning method in 1991 for 'Cheyenne'. In 1992, dormant hand pruning reduced the soluble solids concentration compared to mowing the canes to 15 cm. Pruning method did not affect berry quality in the pruning study by Morris et al. (13).

For 'Shawnee', there were no differences in yield from plots standard and dormant hand pruned in either year, (Table 2). In 1992, mowing the plots to 15 or 30 cm reduced yields when compared to the two hand pruned treatments.

For 'Shawnee' in 1991, there were nearly twice as many laterals/cane for the two hand pruned treatments than the two mowed treatments. In 1992, however, the two mowed treatments produced slightly

Table 2. Effect of pruning on vegetative and fruiting characteristics of 'Shawnee' blackberry.

	Pruning method							
	Standard hand pruned		Dormant hand pruned		Mowed to 30 cm		Mowed to 15 cm	
Variable	1991	1992	1991	1992	1991	1992	1991	1992
Yield (kg/ha)	15,217.0 a[z]	9,901.0 a	13,960.0 ab	8,953.0 a	8,691.0 b	3,201.0 b	9,037.0 b	2,066.0 b
Berry wt (g)	5.0 ab	3.7 a	5.3 a	4.1 a	4.6 b	4.0 a	4.6 b	3.9 a
Laterals/cane	4.6 a	1.8 b	4.8 a	1.5 b	2.5 b	2.4 a	2.4 b	2.7 a
Lateral Length (cm)	84.4 b	64.0 a	82.2 b	70.2 a	111.0 a	49.6 b	106.2 a	47.2 b
Inflorescences/Lateral	9.0 a	12.9 a	8.2 ab	13.6 a	8.1 ab	12.2 a	7.8 b	11.8 a
Flowers/Lateral	43.3 a	9.9 a	35.7 ab	8.6 a	36.8 ab	8.0 a	31.2 b	7.2 a
Flowers/inflorescence	4.8 a	0.8 a	4.3 ab	0.6 a	4.5 ab	0.6 a	4.0 b	0.6 a
Cane diameter (mm)	15.5 a	14.4 a	14.2 a	14.4 a	6.6 b	5.2 b	6.6 b	4.9 b
Soluble solids (%)	7.6 a	7.7 a	7.7 a	7.9 a	6.4 b	8.1 a	6.6 b	8.2 a
Titratable acidity (% malic)	1.4 a	1.4 a	1.3 a	1.5 a	1.2 a	1.5 a	1.4 a	1.5 a

[z]Mean separation within year and variables by Duncan's multiple range test, 5% Level.

more laterals/cane than the two hand pruned treatments.

Mowing the canes to 15 and 30 cm produced longer laterals than either hand pruning treatment for 'Shawnee' in 1991. Similar weak, thin growth was observed for the mowed treatments as was noted for 'Cheyenne.' In 1992, the two hand pruned treatments produced longer laterals than the two mowed treatments as vigor of the entire plant was reduced from mowing.

For 'Shawnee' in 1991, there were no differences in the number of inflorescences/lateral or flowers/lateral among canes standard hand pruned, dormant hand pruned or mowed to 30 cm. Mowing the canes to 15 cm resulted in fewer inflorescences/lateral and flowers/lateral than standard hand pruning. In 1992, the number of inflorescences/lateral were increased, regardless of pruning method, and the number of flowers/lateral and flowers/inflorescence were greatly reduced.

For 'Shawnee', there were no differences in berry weights for any of the treatments when compared to the standard hand pruned treatment in either year. In 1991, mowing the canes produced fruit with lower soluble solids than fruit from hand pruned canes. Percent soluble solids was not affected by pruning method in 1992, and titratable acidity was unaffected by pruning method for either year.

Due to the severe loss of vigor of all the plants in the experiment the third year after planting, it is difficult to precisely evaluate the pruning methods. It appears that one year of profitable production will probably be sacrificed from mowing. The severity of the mowing greatly reduced primocane vigor. Growers in Texas (7) similarly noted heavy yield reductions in the year after mowing blackberry hedges to 15 cm. However, this was done only every 4 or 5 years instead of removing dead floricanes every year. Dormant hand pruning of dead floricanes seems to be the most viable alternative pruning method of those evaluated relative to removing the dead floricanes in the summer after the harvest. Yields were not reduced in either year and there were no disease or insect problems. In the pruning study by Morris et al. (12), yields were similar whether the old canes were left in the row or removed. Morris et al. (13) similarly reported increased yields and more erect hedges by leaving floricanes in after harvesting.

The objectives of pruning are to maximize fruit production and harvest efficiency. Labor requirements, however, are also increased when standard cane pruning management is used. From an economic viewpoint, labor requirements and costs may play an important role in selecting a pruning method for erect blackberries, especially for large commercial operations. It has been estimated that 47-49 man-

hours of labor per hectare were required to hand-prune red raspberries (1). Hewitt (3), estimated 62 man-hours per hectare to hand-prune blackberries. We estimate that about 1.2 hours are required to mow a hectare of blackberries using a 1.8 meter mower at 4.8 kph. Obviously, the problem is whether the time saved with mowing more than offsets the decrease in production and associated harvesting difficulties. Mowing the hedge may only be a productive alternative pruning method if hedge heights are above 30 cm or by mowing to the ground in alternate years (16, 17). Yield per cane and cane diameter increased without competition from floricanes after mowing.

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