Table 1. Weight loss (percent of initial wt) of 'Shamouti' oranges precooled at different air temp.

Air Temp (°C) during precooling	Wt loss (%) After precooling and simulated shipment	Wt loss (%) After 2 additional weeks at 17°C
0	2.0 a[z]	2.8 a
3	2.4 b	2.8 b
6	2.3 b	3.1 b
9	2.3 b	3.2 b
17	2.8 b	3.3 b

[z]Means not followed by the same letter differ significantly at the 5% level. (Duncan's multiple range test).

Table 2. Weight loss (percent of initial wt) after forced-air precooling and simulated ventilated shipment of 'Valencia' oranges.

Treatment	Wt loss (%) Length of treatment (days) 1	5	14	Wt loss (%) After 2 additional weeks at 17°C
Forced-air precooling at 0°C, followed by simulated ventilated shipment	0.1	0.4	1.0	2.2
Non-precooled control (gradually decreasing temp during simulated ventilated shipment)	0.6	1.1	1.7	2.8

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Cane Characteristics Associated with Berry Number of Red Raspberry[1]

P. C. Crandall, J. D. Chamberlain, and K. A. Biderbost[2,3]

Washington State University, Pullman

Abstract. In a 3-year study of 'Willamette' red raspberry canes the number of berries per lateral and the number of berries per cane were positively correlated with cane diameter. The number of fruitful nodes per cane was negatively correlated with cane diameter. Increased cane height caused more berries per lateral but the effect on number of berries per cane was minimal because of fewer fruiting laterals. The yield of 'Puyallup' was more adversely affected by reduced numbers of fruiting laterals than that of 'Willamette'.

Higher topping increased the number of berries per cane by leaving more fruiting laterals. Berries per lateral was affected more by the amount removed in topping than by height of topping.

Cane diameter and height accounted for less than 25% of the variation in total berry production. Cane quality and other factors must also be considered in developing production practices for maximum yield.

The yield of raspberry canes is related to cane diam (1, 2, 3). Darrow and Waldo (1) concluded that more productive fields had taller canes with fewer buds, greater basal diam, and less taper from base to 5½ ft (1.3 m). More vigorous canes had fewer buds per unit of length and more berries per lateral. Wood (4) found much increased yield from higher topping of dormant canes.

Most research thus indicates a direct relation between cane vigor and yield. However, some growers in the Pacific Northwest produce canes over 3.6 m tall yet yields are often disappointing.

We undertook to determine the reliability of cane vigor as a measure of potential productivity.

Materials and Methods

About 200 dormant, randomly selected 'Willamette' red raspberry canes were tagged in 1967 and 1968 and tied individually to support wires. The height of each cane was measured and the diam determined at a height of .9 m above soil level. Equal numbers of the canes were topped at 1.1, 1.4, 1.7, and 2.0 m. Just prior to first picking the canes were cut at

Table 1. Number of canes examined, mean diameter, and height of 'Willamette' and 'Puyallup' red raspberries.

Parameter	Willamette 1967	Willamette 1968	Willamette 1970[z]	Puyallup 1969
Number of canes	193	172	183	361
Mean diameter (mm)	9.7	10.1	10.6	9.6
Mean height (m)	2.4	2.5	2.6	2.4

[z]Data for 1970 from Abbotsford, British Columbia. All other data from Vancouver, WA.

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[2]Horticulturist, Sr. Exp. Aide, and Exp. Aide respectively, Southwestern Washington Research Unit, Vancouver.

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ground level and the following data recorded starting with the basal bud: presence or absence of laterals at each node, length of lateral, and berries per lateral. The count recorded as berries included those blossoms and blossom buds which were considered advanced enough to develop into fruit. In 1969 the same procedure was followed on 400 'Puyallup' canes. In 1970 'Williamette' plants at the C.D.A. Horticultural Substation near Abbotsford, B.C., Canada were used. All of these canes were topped at 1.7 m and the same data recorded. Data were analyzed by computer for linear, quadratic, cubic, and multiple regression and correlation. Only the more significant comparisons are presented.

Results

Data were recorded for 548 'Willamette' canes and 361 'Puyallup' canes (Table 1). Differences between years were of about the same magnitude as differences between the cultivars and locations.

Correlations for the number of berries per cane with cane size and height of topping ranged from .36 to .52 (Tables 2, 3). These r values are highly significant yet they mean that only 25% of the total variation in berry number per cane can be attributed to cane size or topping height.

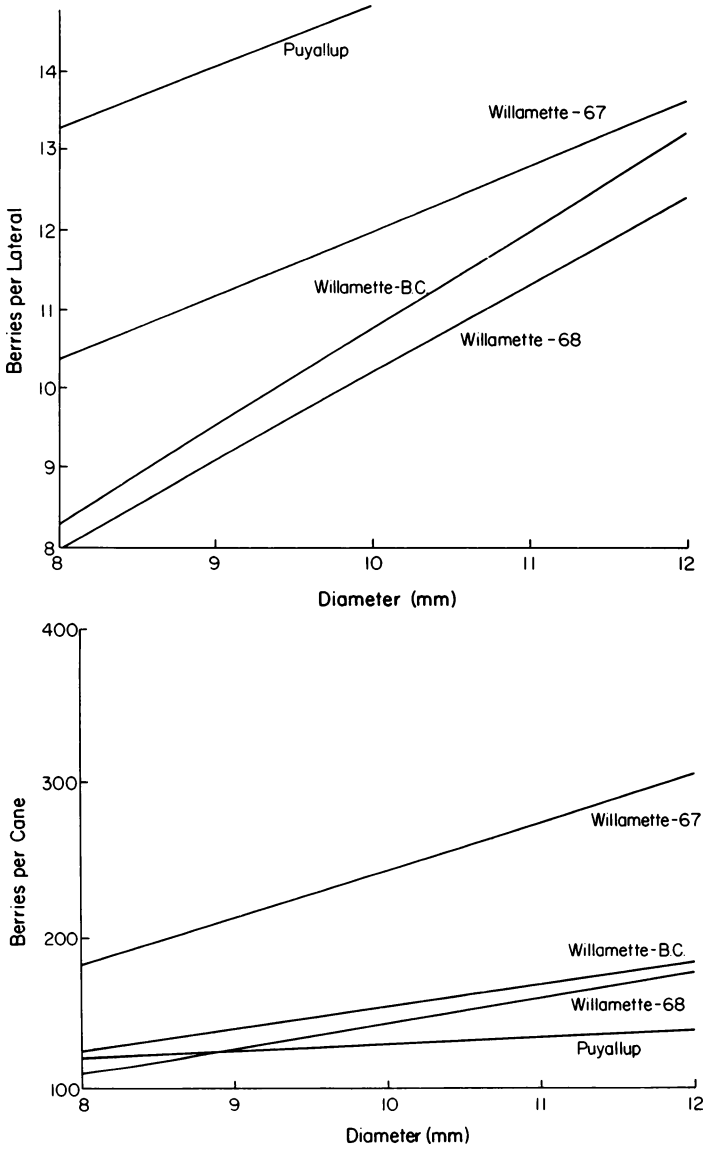

Fig. 1. Regression of berries per lateral and berries per cane on cane diameter of red raspberries.

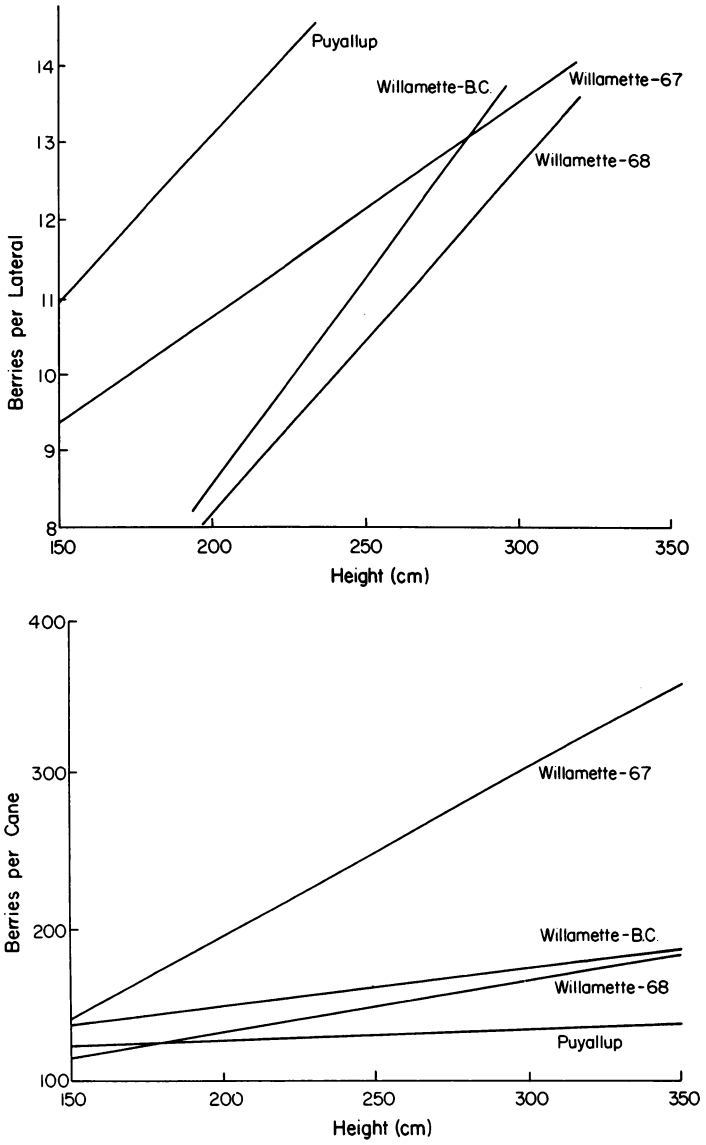

Fig. 2. Regression of berries per lateral and berries per cane on height of red raspberries.

Diameter. As 'Willamette' cane diam increased the total number of berries per cane and per lateral increased (Fig. 1). The number of fruitful nodes in the harvested portion of the canes decreased slightly. 'Puyallup' behaved somewhat differently in that the number of berries per cane was not significantly affected by cane diameter.

Height. An increase in total cane height caused more berries per lateral but the increase in berries per cane was not significant except for 'Willamette' in 1967 (Fig. 2). The number of fruitful nodes below the topping height of 1.7 m decreased (Table 3).

Topped height. The height at which the dormant canes were topped influenced the number of berries per cane but had little effect on berries per lateral. Increasing the height of topping increased the berries per cane for both cultivars but reduced the number of berries per lateral only for 'Puyallup'.

Amount removed in topping. Taller canes required that more top be removed in pruning. This increased the number of berries per lateral but had either no effect or a negative effect on the total number of berries per cane (Table 2).

Discussion

Raspberry yield components include: 1) size of berries, 2) berries per lateral, 3) number of fruiting laterals per cane and 4)

Table 2. Correlation of cane characteristics and berry number for 'Willamette' and 'Puyallup' red raspberries.[z]

	Diam	Ht.	Topped ht.	Total berries	Berries per lat.	Amount topped
Diam	---	.71**	.25**	.45**	.47**	.59**[y]
	---	*.78***	*.04*	*.08*	*.29***	*.51***
Height	.71**	---	.40**	.36**	.46**	.81**
	*.78***	---	*.03*	*.03*	*.28***	*.67***
Topped ht.	.25**	.40**	---	.40**	.05	-.23**
	.04	*.03*	---	*.52***	*-.14*	*-.72***
Total berries	.45**	.36**	.40**	---	.60**	.12
	.08	*.03*	*.52***	---	*.41***	*-.37***
Berries per lat.	.47**	.46**	.05	.60**	---	.45**
	*.29***	*.28***	*-.14*	*.41***	---	*.30***
Amount topped	.59**	.81**	-.23**	.12	.45**	---
	*.51***	*.67***	*-.72***	*-.37***	*.30***	---

[z]Values in bold face type for 'Willamette', italicized values for 'Puyallup'.
[y]Double asterisks indicate correlation was significant at the 1% level.

number of canes per hectare. Our study did not include data on berry size or canes per hectare.

The original cane height, diam, and height of topping affected these components differently. Number of berries per cane for 'Willamette' was more closely correlated with diam than with height. Taller canes had more berries per lateral but fewer fruitful nodes and hence had a limited effect on total berries per cane. Since diam and height are closely related, the same interaction occurred with diam but to a lesser degree. We assume that cane vigor reduced the number of fruitful laterals for 'Puyallup' also, but this cultivar had more berries per lateral resulting in no significant correlation of either height or diam with total berries per cane.

Height of topping during the dormant season also affected yield. Higher topping of moderate to vigorous canes increased the number of fruiting laterals with only slight reduction of berries per lateral. The actual amount of top removed when pruning had a more positive effect on the number of berries per lateral than did the topping height. These relationships were referred to by Locklin (2) who found large diam (14 mm) canes tended to yield less than smaller diam (12 mm) canes. When the canes were woven to allow longer canes to be trained, yields kept increasing with diameter.

Table 3. Correlation of cane characteristics and berry number for 'Willamette' red raspberry in British Columbia.

	Berries per cane	Berries per lateral	No. fruit nodes
Diam	.44**	.56**	-.18*
Height	.13	.38**	-.42**

*significant at 5%, ** significant at 1%.

Although there was a definite relationship between cane vigor and berry number, this accounted for less than 25% of the variation in fruitfulness of the canes. Size of the canes, therefore, is only a partial measure of potential raspberry yield. Cane quality and other factors must also be considered in development of cultural practices for maximum production.

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Evaporative Cooling of 'Delicious' Apples – The Economic Feasibility of Reducing Environmental Heat Stress[1]

C. R. Unrath and R. E. Sneed[2,3]

North Carolina State University at Raleigh

Abstract. The response of 'Red Delicious' apples to low volume overtree evaporative cooling (EC) irrigation was studied over a 4-year period from 1969-72. While the amount of thermal load and irrigation system run-time varied from year to year, EC consistently resulted in fruit temperature reductions averaging 5.6°C (10.1°F) for the entire 509 hr the system operated over the 4-year period. In each of the 4 years, EC improved fruit quality; on the average increasing total reddish color 8%, solid red color 13%, soluble solids 1%, and fruit weight 22-g while reducing corking 8% and bitter pit 7%. The additional fruit coloration stimulated by EC concentrated harvest in the earlier portion of the harvest season. During the 4 years of the experiment, an additional 1/3 of the cooled crop was harvested, with sufficient solid red color to meet "extra fancy" U.S. grade, during the 1st 2 weeks of the seasons. Because of higher early-season prices, the concentrated earlier harvest of EC fruit is of considerable economic benefit. In locations where heat stresses are common, the use of EC and soil irrigation should be economically feasible.

As apple production increases in areas where unfavorable environmental conditions are common and growers move to higher density plantings, the need to alleviate heat and soil moisture stresses becomes more critical for commercial production of max yields of high quality fruit.

Van DenBrink and Carolus (7) tested the theory of evaporative cooling (EC) to modify plant temp. Soon after their work on low growing vegetable crops, Lombard et al. (3) reported that EC irrigation over the top of pear trees could alter micro-climate of a larger plant as well. They found that while air temp could be reduced and humidity increased, it was fruit temp that was reduced most. Gilbert and co-workers (2) showed that EC could reduce stress temp on larger canopied crops with

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[2]Associate Professor, Dept. of Horticultural Science, and Extension Assistant Professor, Dept. of Biological & Agricultural Engineering, respectively.

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