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Rednecked Cane Borer Galling Affects Blackberry Growth and Yield

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Abstract. **Thorny erect blackberries *(Rubus* spp.) were evaluated for yield and cane vigor as affected by galls produced by the rednecked cane borer *Agrilus ruficollis* (F.). Galling in 'Cherokee' significantly *(P* < 0.001) decreased the count of berries and the weight of berries per centimeter of live cane. Winter injury, water stress, and nutritional stress induced by galls increased the amount of dead wood per cane. Galling did not affect the length of live laterals per 'Cherokee' cane. For 'Comanche' and 'Cheyenne', the amount of dead wood per cane increased as gall counts increased. In contrast, the length of live laterals per cane increased for 'Comanche' and decreased for 'Cheyenne' as gall counts increased. The weight of berries and the count of berries per centimeter of live cane for 'Comanche' and 'Cheyenne' were not related to the count of galls. Of the four cultivars, 'Shawnee' produced the most berries and greatest weight of berries per centimeter of live cane when canes were free of galls. Conversely, when galls exceeded two per cane, 'Shawnee' yielded least, followed by 'Comanche', 'Cheyenne', and 'Cherokee'.**

The rednecked cane borer has been reported to be a serious pest of wild and commercial blackberries and raspberries (Riley, 1870). Chittenden (1922) reported that the rednecked cane borer extended from eastern Canada and New England west to Minnesota and south to the Gulf States. However, Riley (1870) noted that this beetle is more likely to injure raspberry and blackberry plants in southern than in northern latitudes.

Bramble cultivars vary greatly in susceptibility to attack by rednecked cane borer and the extent to which canes are injured. Riley (1870) stated that the rednecked cane borer indiscriminately attacked the European red raspberry *R. idaeus* L., two American black raspberries, *R. occidentalis* L., and the high blackberry, *R. villosus* L. Hixson (1938) observed that the rednecked cane borer preferred the trailing or semi-erect type blackberry or dewberry cultivars and commonly infested 25% to 72% of canes. In comparison, infestations of 0% to 25% were observed in canes of the more upright cultivars and the trailing cultivar Advance, which has a relatively small cane diameter. Thorny raspberry cultivars appeared to be more attractive to the rednecked cane borer than those with less-thorny canes (Mundinger, 1941).

I found nothing in the literature on the effect of rednecked cane borer on cane vigor or fruit yields of the more recently released blackberry cultivars Comanche, Cheyenne, Cherokee, and Shawnee. A recent survey of blackberry production in north America showed that 58% of total production in the eastern United States consisted of 'Shawnee', 'Cheyenne', 'Cherokee', 'Comanche', 'Navaho', and 'Choctaw' (J.R. Clark, personal communication). The objective of this study was to evaluate 'Cherokee' in one planting and to compare four of the newly released Arkansas blackberry cultivars ('Shawnee', 'Cheyenne', 'Cherokee', and 'Comanche') in another planting for differences in cane growth and yield in response to increasing counts of galls per cane produced by the rednecked cane borer.

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Materials and Methods

'Cherokee' evaluation. Two hundred 'Cherokee' plants were propagated in 1985 from root cuttings and planted in 1986 at the Univ. of Arkansas Horticulture Farm in Fayetteville. The plants were planted 0.6 m apart in rows 3 m apart (0.4-ha plot). In 1989, fifty floricanes each with or without galls were tagged before harvest. Data were collected twice weekly for cane height, length of dead canes and dead laterals (indicator of winter injury that appeared to be correlated to galling), total length of live laterals, total length of live wood including vertical trunk and lateral growth, and count and weight of berries per cane.

Four-cultivar comparison. On 1 Apr. 1985, 'Comanche', 'Cheyenne', 'Cherokee', and 'Shawnee' were planted in five-plant plots at the Univ. of Arkansas Fruit Substation in Clarksville. The plants were spaced 0.6 m apart with 2 m between plots in rows 3 m apart in a randomized complete block of three treatments and three-plot replicates. In 1987 and 1988 the treatments were: 1) weekly sprays of methoxychlor (50 wp at 1.7 kg a.i./ha in 473 liters water) were applied during the period of adult beetle emergence from late April to early June; 2) insecticides were not applied and galled canes not removed the subsequent spring; and 3) insecticides were applied and galled canes removed in Mar. 1988 but not 1989.

The rednecked cane borer population in this planting was too small for analysis in 1987 and 1988. Therefore, the population was augmented in 1988 by randomly placing in the planting ≈100 rednecked cane borer-infested blackberry canes removed from an adjacent commercial blackberry planting. In 1989, thirty-nine canes with galls and 39 without galls were tagged before harvest. Data collected per cane were the same as indicated in the single cultivar trial above.

The production practices followed were according to the Univ. of Arkansas recommendations (Schaller et al., 1986). The canes in both trial locations were fertilized and trickle irrigated. Dead wood was removed each spring. Summer pruning maintained primocanes between a height of 1 to 1.2 m. Lateral growth was summer and winter pruned to a length of 0.3 m.

Data analysis. In 1987 and 1988, only plot yield data were analyzed, but within-plot growth differences between canes resulted in a large within-treatment variation of the yield data. In 1989, data were analyzed by PROC GLM procedure (SAS,

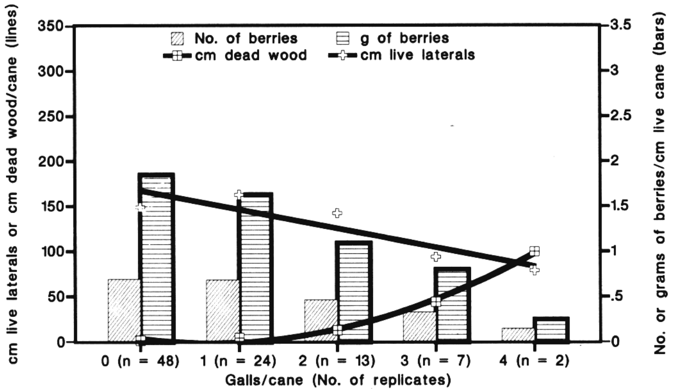

Fig. 1. Changes in ‘Cherokee’ blackberry fruiting cane berry yield, growth, and amount of dead wood per cane in response to increasing counts of galls per cane produced by feeding rednecked cane borer larvae (Fayetteville, Ark. 1989).

1985) for evidence of regression, linearity, and quadratic effects of galling on the various growth and yield variables for ‘Cherokee’ blackberry alone. In the cultivar comparison, the PROC GLM procedure was again used on individual cane growth to compare the individual and interactive effects of cultivar, i.e., ‘Comanche’ and ‘Cheyenne’, and count of galls per cane on the dependent variables of cane growth and cane yield. In the four-cultivar comparison, no statistical analysis was completed on canes of ‘Cherokee’ and ‘Shawnee’ because too few galled canes were located. Therefore, for ‘Cherokee’ and ‘Shawnee’, only the empirical trends of the effects of galling are represented in Fig. 2.

Results

‘Cherokee evaluation. ‘Cherokee’ blackberry cane vigor and yield were adversely affected by galls produced in response to rednecked cane borer larvae (Fig. 1). After bloom, vigor differences among plants became apparent as a positive quadratic trend ($P < 0.001$) between the length of dead wood per cane and the count of galls per cane (Table 1). There was significantly more dead wood on canes with more than two galls ($P < 0.001$). An increase in galls per cane was correlated with a significant linear ($P < 0.001$) reduction in count of berries and weight of berries per centimeter of live cane. Analysis of variance of ‘Cherokee’ indicated that the amount of dead wood per cane ($F = 9.58$, $df_{trtr,error} = 4,87$, $P < 0.001$) and total berry weight ($F = 8.16$, $df = 4,87$; $P < 0.001$) were significantly affected by galling, but it typically required more than two galls per cane to produce such an effect. However, the count of galls per cane alone had no significant effect on the length of live laterals per cane ($P = 0.397$).

Four-cultivar comparison. In the case of data for ‘Cheyenne’ and ‘Comanche’ only, the significant sources of variation in the overall model predicting the linear increase in the amount of dead wood per cane as gall counts increased per cane were galls; cultivar; and their interaction (Table 2; Fig. 2A). Significant slopes and intercepts for number of live laterals per cane and

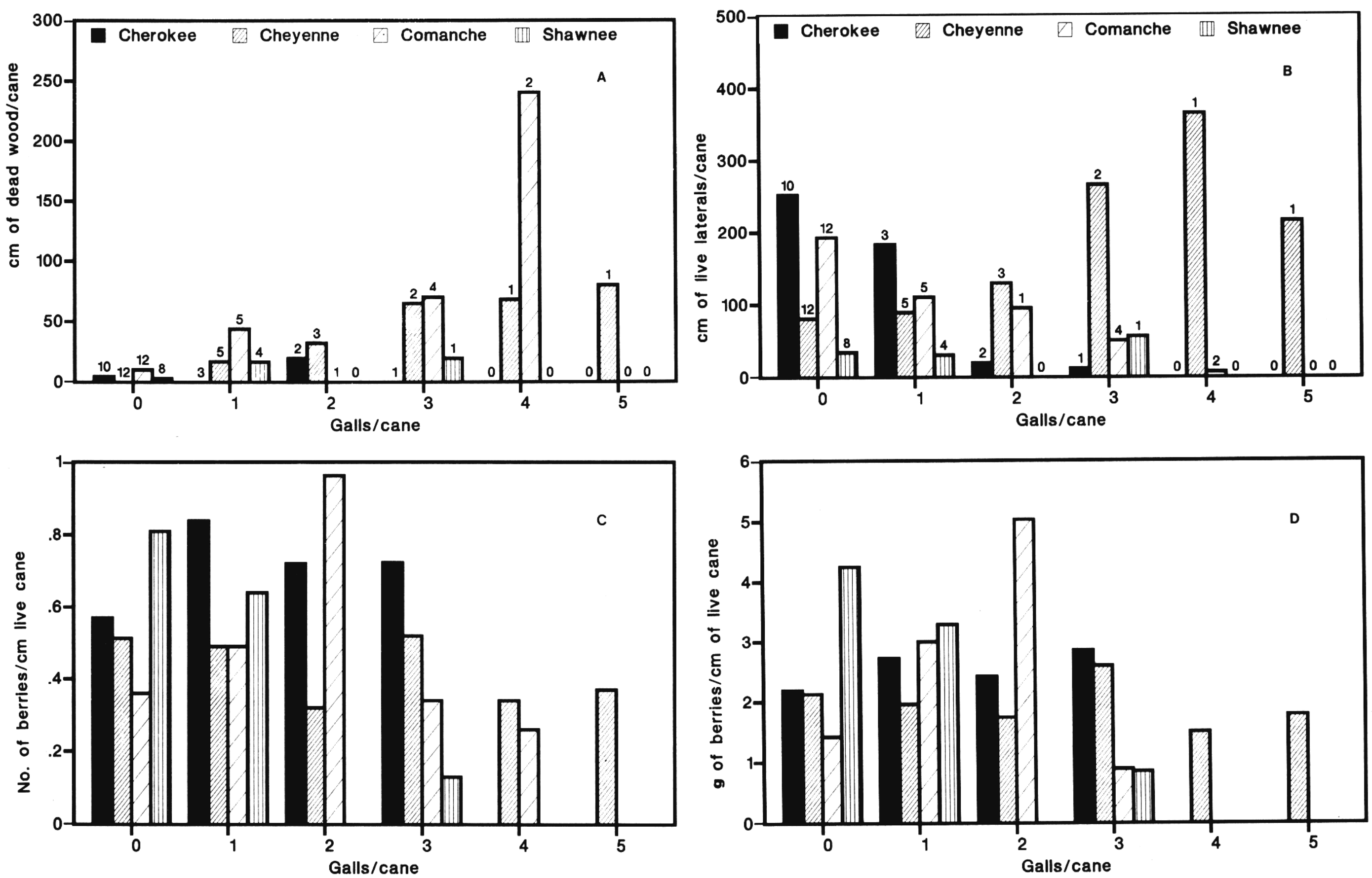

Fig. 2. Blackberry cultivar responses to increasing count of galls per cane that were produced by feeding rednecked cane borer larvae: **(A)** amount of dead wood per cane; **(B)** live lateral growth per cane; **(C)** count of berries per centimeter of live cane; and **(D)** berry weight per centimeter of live cane (numbers above the bars indicate the number of replicates per mean value; Clarksville, Ark. 1989).

Table 1. Multiple linear regression analysis of ‘Cherokee’ blackberry yield and growth parameters as a function of the count of galls per cane (N) produced by rednecked cane borer larvae (Fayetteville, Ark. 1989).

Variable	Regression Source	Coefficient[z]	P value	ANOVA (df = 4, 89) Source	MS	P
Dead wood (cm)/cane	Intercept	2.46 (3.71)	0.508	Regression	6998.0	<0.001
	N	−8.64 (7.02)	0.222	Error	692.0	
	N × N[y]	7.74 (2.27)	0.001			
Berry wt/ cm live cane	Intercept	1.88 (0.08)	<0.001	Regression	3.622	<0.001
	N	−0.37 (0.06)	<0.001	Error	0.340	
	N × N	0.04 (0.05)	0.463			
Berry count/ cm live cane	Intercept	0.72 (0.03)	<0.001	Regression	0.426	<0.001
	N	−0.12 (0.02)	<0.001	Error	0.054	
	N × N	−0.03 (0.02)	0.109			
Live laterals (cm)/cane	Intercept	156.53 (12.20)	<0.001	Regression	8892.0	0.397
	N	−12.77 (9.05)	0.162	Error	8642.0	
	N × N	−10.60 (8.02)	0.189			

[z]Value in parentheses is the estimated SE of coefficient.
[y]N × N = quadratic effect of the count of galls per cane (N).

Table 2. General linear multiple regression of the count of rednecked cane borer galls, cultivar, and interaction effects on cane growth and yield of ‘Cheyenne’ and ‘Comanche’ blackberries (Clarksville, Ark. 1989).

Variable	ANOVA (df = 3, 44) Source	MS	P
Live laterals (cm)/cane	Regression	60,610.0	0.005
	Error	12,180.0	
	Galls	875.0	0.790
	Cultivar	2,491.0	0.6534
	Interaction	178,465.0	<0.001
Dead wood (cm)/cane	Regression	29,529.0	<0.001
	Error	2,067.0	
	Galls	71,384.0	<0.001
	Cultivar	7,951.0	0.056
	Interaction	9,253.0	0.04
Berry count/ cm live cane	Regression	0.037	0.626
	Error	0.063	
	Galls	0.035	0.462
	Cultivar	0.064	0.319
	Interaction	0.013	0.659
Berry wt/ cm live cane	Regression	0.796	0.679
	Error	1.566	
	Galls	1.067	0.414
	Cultivar	1.161	0.394
	Interaction	0.161	0.750

significant slopes for dead wood per cane, each vs. counts of galls per cane for ‘Cheyenne’ and ‘Comanche’, are noted in Table 3.

Only the gall x cultivar interaction indicated significant differences (Table 2) between the slopes of the length of live laterals for each cultivar (Fig. 2B). Galls alone had an inconsistent effect on the length of live laterals across cultivars (Table 2). In the absence of galls, live lateral growth per cane of ‘Cherokee’, ‘Comanche’, ‘Cheyenne’, and ‘Shawnee’ was 252, 193, 80.9, and 33.9 cm, respectively.

Table 3. Estimated regression coefficients, intercepts, and SE for variables in Table 2 that had significant regressions.

Variable	Parameter	Cultivar: Cheyenne (n = 24)	Cultivar: Comanche (n = 24)
Live laterals (cm)/cane	Slope (SE)	45.88 (15.96)	−41.06 (16.16)
	Slope *P* value	0.006	0.015
	Intercept (SE)	71.7 (28.4)	182.2 (29.0)
	Intercept *P* value	0.015	<0.001
Dead wood (cm)/cane	Slope (SE)	17.58 (6.57)	37.38 (6.66)
	Slope *P* value	0.011	<0.001
	Intercept (SE)	0.018 (11.7)	3.898 (11.9)
	Intercept *P* value	>0.05	>0.05

Live laterals per cane and dead wood per cane significantly differed between only two cultivars (Table 3). Gall counts increased 2- to 3-fold from zero to three galls per cane for ‘Cheyenne’, whereas for ‘Comanche’ live laterals per cane were reduced by 74% (Table 3). ‘Comanche’ had a greater positive slope than did ‘Cheyenne’ for the amount of dead wood per cane, as both responded to increasing gall counts (Table 3).

Data for ‘Cherokee’ and ‘Shawnee’ appear in Fig. 2 A-D, but due to the few observations at the higher galling levels, a statistical analysis was not warranted on the counts of galls vs. the amount of dead wood, lateral growth, count of berries, and berry weight.

There was no significant effect on the count of berries or the weight of berries per centimeter of live cane (Table 2; Fig. 2 C and D). Similarly, ‘Shawnee’ outproduced ‘Cherokee’, ‘Cheyenne’, and ‘Comanche’. The counts of berries per centimeter of live cane with no galling were 0.8, 0.6, 0.5, and 0.4, respectively (Fig. 2C). In terms of berry weight per centimeter of live cane with no galling, ‘Shawnee’ produced 4.3 g, ‘Cherokee’ 2.2 g, ‘Cheyenne’ 2.1 g, and ‘Comanche’ 1.4 g (Fig. 2D). Conversely, when there were more than two galls per cane, ‘Shawnee’ produced the least, followed by ‘Comanche’, ‘Cheyenne’, and ‘Cherokee’.

Discussion

The galling of 'Cherokee', 'Cheyenne', and 'Comanche' blackberry canes by larvae of the rednecked cane borer significantly increased the amount of dead wood per cane and decreased fruit yield as the count of galls exceeded two per cane. However, data were inconclusive for 'Shawnee' and 'Cherokee' in the cultivar comparison trial. The fact that fewer than three galls per cane had little effect on yield is in agreement with Mundinger (1941), who noted that many blackberry and some raspberry cultivars produced strong, thick, vigorous canes and good yield of berries, even when infested with rednecked cane borer larvae. This situation was also observed at the Univ. of Arkansas Fruit Substation in Clarksville, where 100% of the canes in planting of 'Shawnee' were galled by rednecked cane borer, yet produced yields similar to those of plantings with healthy canes (J.B. Buckley, personal communication). The average count of galls per cane was not reported by either Mundinger (1941) or Buckley.

Cane death was attributed to a significant interaction between galling and unrecorded factors such as extreme changes in winter temperatures, water stress, and/or nutrition. In Oklahoma, Walton (1951) determined the effects on yield and rednecked cane borer control of irrigation and of pruning fruiting canes and primocanes to the ground at various times. Rednecked cane borer control of 99% was achieved in primocanes of 'Youngberry' postharvest-pruned plants (20-25 June) compared with preharvest pruning (5-25 May), which gave 83% rednecked cane borer control. Other factors may be interacting with galling, such as irrigation and fertilization. Walton (1951) reported a 46% reduction in blackberry yield in nonirrigated plots, compared with those in subirrigated plots. The use of postharvest pruning for rednecked cane borer control and irrigation for optimal plant growth may be applicable for early maturing cultivars. However, postharvest pruning would reduce yield the next spring in late cultivars because regrowth would be prostrate primocanes, which are less productive (J.N. Moore, personal communication).

Knowing the count of galls per cane that constitute an economic threshold would allow a grower to scout a planting, calculate the potential percentage yield loss attributable to cane galling by the rednecked cane borer, and decide on the appropriate control practice: no control; prune out and burn infested canes; and/or implement an insecticide control program against the rednecked cane borer (Johnson and Mayes, 1989).

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