Table 2. Effect of mulch on nematode species and population/liter of soil in a 19-year-old planting of highbush blueberries.

Species	Population/liter of soil	
	Mulched	Nonmulched
Xiphinema americanum	173**	252
Paratrichodorus christiei	336**	2709

** Significantly different from nonmulched treatment by F test, 1% level.

presented in Table 2. *X. americanum* populations were unaffected by mulch, whereas *P. christiei* populations were greatly reduced by mulch. Suppression of *P. christiei* may have occurred due to increased competition from other organisms in the more organic soil environment, since the majority of the root system of mulched plants was in the area of the decomposing sawdust. The other species (*H. pseudorobustus* and *Pratylenchus* spp.) found in the experimental planting were not included in the analysis since they were present in only 3 of 16 and 2 of 16 samples, respectively.

Yield data (not shown) from the replicated plots did not reflect an effect of nematodes. The effect of nematodes on blueberries in northwest Arkansas is unknown, with the exception of tobacco ringspot virus transmission by *X. americanum*. Further research should reveal the other effects of nematodes on blueberries in this region.

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Training Systems for Second-year Production of Fall-planted Strawberries

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Additional index words. *Fragaria* x*ananassa,* hill row, matted row, planting date, plant spacing

Abstract. **Certified, fresh-dug plants of 'Apollo' and 'Earlibelle' strawberries (*Fragaria* x*ananassa* Duch.) were set in single plant rows on 23 Sept., 7 Oct., 21 Oct., and 5 Nov. 1982 at in-row spacings of 7.5, 15, 22.5, and 30 cm. After harvest in 1983, plants were mowed and maintained as hill rows or mowed or not mowed for conversion to matted rows. Crown number, leaves, inflorescences and flowers per crown, fruit size, and fruit number and yield were determined in Spring 1984. Mowing had no effect on yields of matted rows, which, except from the 23 Sept. set plants, were higher than hill rows. Hill rows produced larger fruit than matted rows, but the latter had higher fruit numbers and averaged 57% more crowns per unit area. The 23 Sept. hill row yields were higher than later plantings, but original planting date had no effect on matted row yields. Fruit number of the three later plantings of both training systems and hill row yields decreased as plant spacing increased. 'Apollo' had higher yields and individual yield component values than 'Earlibelle' in both training systems.**

Fall planting is an experimental but promising alternative cultural practice for strawberry production in the Piedmont region of South Carolina (1). Compared to matted rows, the relatively quick return of investment and the ease of harvesting single-plant rows make this an especially attractive option to many growers. Although numerous studies will be required before reliable recommendations can be made, growers are already establishing fall plantings.

Among the unknowns of fall planting is the best training system for the second and subsequent seasons. In Michigan, 1-year-old single plant rows were maintained a second year without runners or converted to matted rows, which produced higher yields than hill rows (5). Growers in South Carolina have a similar choice, but differences in climate, cultivar, and other cultural practices will affect results. This study compared two training systems, the single-row hill and matted row, and the effects of mowing after harvest on second-year growth and yield of fall-planted strawberries.

The experimental site was located at the Clemson Univ. Fruit Research Farm, Clemson, S.C., on a clayey, kaolinitic, thermic, Typic Hapludult soil. The field was disked and subsoiled prior to fumigation with methyl bromide/chloropicrin (98%/2%) in Aug. 1982. Raised beds were formed 4 weeks later using disk hillers, then leveled to a finished height of 20 cm and width of 30.5 cm. Each plot was 3.05 m in length.

Field-grown North Carolina-certified plants of 'Apollo' and 'Earlibelle' were harvested from a commercial nursery 2 to 3 days before planting, shipped at air temperatures, and held on site no longer than 30 hr at 15°C. Roots were pruned to 10 cm and leaves were left intact. Plants were set by hand in single-plant rows on 23 Sept., 7 Oct., 21 Oct., and 5 Nov. with in-row spacings of 7.5, 15, 22.5, and 30 cm. The experimental design was a randomized complete block with six replications.

Immediately after harvest in 1983, one of three treatments was imposed on the original treatments. Leaves were mowed 5 to 7 cm above the crown and plants were allowed to runner, leaves were mowed, and runners were removed regularly throughout the season or leaves were not mowed and the plants were allowed to runner. Commercial production practices for South Carolina were followed thereafter (5). Daughter plants were confined to a 36- to 45-cm bed width during the growing season. Runner plants formed after September and outside the designated bed were removed.

In Apr. 1984, individual plants in the runnerless treatments and mother plants in the matted rows were difficult to distinguish; therefore, the total number of crowns and the number of leaves, inflorescences, and flowers per crown within a random 30-cm length of row were counted. Fully red fruit were harvested three times a week from 8 May

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Table 1. Effect of planting date on second-year yield and yield components of fall-planted hill row 'Apollo' and 'Earlibelle' strawberries.

Hill row treatments	Crown no.[z]	Leaf no./ crown	Inflorescence no./crown	Flower no./ crown	Flowers/ inflorescence	Fruit size (g)	Fruit no.[y]	Yield[y] (kg)
Date								
23 Sept.	14.3	5.6 b	3.2	17.2	5.0 ab	8.6	726 a	621.0 a
7 Oct.	11.6	5.8 b	3.4	18.2	5.3 a	8.3	501 b	421.2 b
21 Oct.	11.5	6.7 a	3.4	15.5	4.1 bc	8.5	417 b	359.9 b
5 Nov.	11.3	5.7 b	3.3	14.7	4.0 bc	9.2	434 b	407.7 b
Cultivar								
Apollo	11.2	6.1	3.9	20.4	5.0	9.8	554	541.3
Earlibelle	13.2	5.8	2.8	12.4	4.2	7.5	486	363.7
Significance								
Date	NS	*	NS	NS	***	NS	***	***
Cultivar	NS	NS	***	***	***	***	*	***
Date × cultivar	NS	**	*	NS	NS	NS	NS	**
Spacing within date	NS	NS	NS	NS	NS	NS	**	***

[z] Crown number per 30-cm length of row.
[y] Whole plot.
NS,*,**,*** Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

Table 2. Effect of mowing and planting date on the second-year yield and yield components of fall-planted matted row 'Apollo' and 'Earlibelle' strawberries.

Matted row treatments	Crown no.[z]	Leaf no./ crown	Inflorescence no./crown	Flower no./ crown	Flowers/ inflorescence	Fruit size (g)	Fruit no.[y]	Yield[y] (kg)
Mow	26.8	4.2	2.8	13.6	4.7	7.3	775	566.4
No-mow	29.9	3.8	2.6	12.0	4.4	7.0	747	528.2
Date								
23 Sept.	30.0	4.1	2.8	14.1	4.7	7.1	833 a	593.5
7 Oct.	28.6	4.0	2.8	12.7	4.3	6.9	798 ab	556.8
21 Oct.	28.1	3.9	2.6	12.0	4.5	7.3	698 c	509.7
5 Nov.	26.8	3.9	2.6	12.5	4.6	7.3	714 bc	529.1
Cultivar								
Apollo	22.9	3.9	3.4	16.4	5.3	8.3	822	671.6
Earlibelle	33.9	4.0	2.4	9.2	3.8	6.0	700	422.9
Significance								
Mow	NS	**	NS	**	**	NS	NS	NS
Date	NS	NS	NS	NS	NS	NS	**	NS
Cultivar	***	NS	***	***	***	***	***	***
Mow × date	NS	NS	NS	NS	NS	NS	NS	NS
Mow × cultivar	NS	NS	NS	NS	NS	NS	**	NS
Date × cultivar	**	NS	NS	NS	NS	NS	NS	NS
Spacing within date	NS	NS	NS	NS	NS	NS	***	NS

[z] Crown number per 30-cm length of row.
[y] Whole plot.
NS,**,*** Nonsignificant or significant at the 1% or 0.1% levels, respectively.

through 4 June 1984. The total weight and weight of 40 fruit were determined. Fruit size was calculated as the mean of 40 fruit. Data were subjected to analysis of variance. Direct comparisons of fruit number, fruit size, and yields were made among the three treatments; otherwise, values for hill and matted rows were treated separately. Means were separated using LSD and curves for different spacings within planting dates were tested using orthogonal polynomials.

Hill rows. The number of crowns per linear 30 cm of row was not affected by planting date or cultivar (Table 1). The number of leaves per crown, however, was characterized by a significant planting date × cultivar interaction. 'Earlibelle' leaf number was not affected by planting date, but leaf number of the 21 Oct. 'Apollo' planting (7.4), although similar to the 5 Nov. planting, was significantly higher than the earlier two dates (5.3). Leaf numbers were similar between the cultivars, except on 21 Oct., when leaf number of 'Apollo' was significantly higher than 'Earlibelle'. Response of both variables to plant spacing was similar within each date.

The planting date × cultivar interaction was significant for inflorescence number per crown (Table 1). There was no difference in inflorescence number between planting dates for 'Apollo', but, with 'Earlibelle', the 7 Oct. planting averaged one more inflorescence than the 5 Nov. planting. Inflorescence numbers were similar for the two cultivars on the first two planting dates, but 'Apollo' averaged 1.8 more inflorescences than 'Earlibelle' on the last two dates. Flower number per crown was not affected by planting date, but 'Apollo' had significantly more flowers per crown than 'Earlibelle'. Plants set 23 Sept. and 7 Oct. had significantly more flowers per inflorescence than later-set plants, and 'Apollo' had more flowers per inflorescence than 'Earlibelle'. Flower and inflorescence number per crown were highly correlated ($r = 0.82$). Response to plant spacing was similar within each date for each component.

Fruit size was not affected by planting date or plant spacing (Table 1). 'Apollo' produced significantly larger fruit than 'Earlibelle', averaging 9.82 and 7.49 g, respectively.

Total yield and fruit number were highly correlated ($r = 0.96$), and yield was characterized by significant planting date × cultivar interactions (Table 1). The 23 Sept. planting produced significantly higher yields and fruit numbers than any of the later planting dates. There was no further decrease in yield of 'Apollo' after the 7 Oct. planting; however, the 7 Oct. planting of 'Earlibelle' had significantly higher yields than the 5 Nov. planting. Fruit numbers of the three later plantings were comparable. 'Apollo' produced significantly higher yields and fruit numbers than 'Earlibelle' from the 23 Sept. and 5 Nov. planting, but yields were similar between the two cultivars for the remaining two planting dates. There was a significant linear response to original plant spacing for both yield and fruit numbers on the last three planting dates. As plant spacing increased, values for both components decreased.

Matted rows. Final crown number was not affected by mowing; however, the planting date × cultivar interaction was significant (Table 2). Planting date had no effect on crown number of 'Apollo' (22.9), but 'Earlibelle' produced significantly more crowns from the 23 Sept. planting (39.5) than the 21 Oct. or 5 Nov. plantings (31.7). 'Earlibelle' produced significantly more crowns than 'Apollo', 34 and 23 per linear 30 cm of row, respectively, except on 5 Nov., when crown numbers were similar. Mowing did increase the number of leaves per crown, but leaf number was not affected by planting date or cultivar. There were no significant trends of plant spacing on crown number or leaf number per crown.

Inflorescence numbers were not affected by mowing, but flower number per crown and flowers per inflorescence were significantly higher in mowed than in non-mowed rows (Table 2). Planting date had no effect on these parameters. 'Apollo' produced significantly more inflorescences, flowers, and flowers per inflorescence than 'Earlibelle'. Flower and inflorescence number per crown were highly correlated for both 'Apollo' ($r = 0.85$) and 'Earlibelle' ($r = 0.76$). Responses of these parameters to plant spacing within each planting date were similar.

Fruit size was not affected by mowing, planting date, or plant spacing (Table 2). 'Apollo' produced significantly larger fruit than 'Earlibelle', averaging 8.3 g and 6.1 g, respectively.

Fruit number (whole plot) was characterized by a significant mowing × cultivar interaction. Mowing had no effect on 'Apollo', which averaged 822 fruit/plot, but 'Earlibelle' produced significantly fewer fruit from the non-mowed than from mowed treatments, 641 and 759, respectively. Fruit numbers of the two cultivars were similar when mowed, but, without mowing, 'Apollo' produced significantly more fruit than 'Earlibelle'. Planting date also affected fruit number. The 23 Sept. planting had comparable numbers with the 7 Oct. planting, but produced significantly more fruit than the later two dates. Original plant spacing had no effect on fruit number of the 23 Sept. planting, but a significant linear response was observed on the later three dates. As plant spacing increased, fruit number per area decreased.

Total yields, which were highly correlated with fruit number ($r = 0.90$), were not affected by mowing or planting date (Table 2). 'Apollo' produced significantly higher yields than 'Earlibelle' (671.6 and 422.9 kg, respectively). Original plant spacing had no effect on total yields.

Comparisons of whole plot fruit number, fruit size, and yield were made between the two training systems. Fruit number of the matted rows was significantly higher than the hill rows (760 and 514 fruits, respectively), but the hill rows produced significantly larger fruit (8.6 g) than matted rows (7.1 g). Yield was characterized by a significant planting date × training system interaction. Hill row yields were comparable to matted row yields on the first planting date but were significantly lower than matted rows yields in later plantings (Table 1 and 2).

Yields in 1984 were below average for this area, probably as a result of cold damage in December. Air temperatures averaged 6.4°C through the month until 25 Dec., when temperatures fell suddenly to −15°. The planting had not been mulched, which is a standard practice in this area (6). Young, poorly established runner plants in the matted rows were killed and some crown damage was observed in both training systems. No direct comparisons of crown and/or flower bud injury were made, but it is possible that the extent of damage could differ between training systems and cultivars. Temperatures of −7.8° to −4.4° have been reported to damage flowers of nonacclimated strawberries, especially primaries and secondaries, and high plant and flower mortality was observed at −11.7° to −4° (2). Given the vigorous growth of all plants in Spring 1984 and the generally small fruit size, higher-order flowers were probably the most-affected plant parts in this study.

Matted rows contained 57% more crowns per unit area than hill rows and subsequently produced more total flowers and fruit. Matted row yields were also higher than hill rows, 14.7 and 12 $t \cdot ha^{-1}$, respectively, except from the 23 Sept. plantings. When planted early, the large fruit size of the hill rows could compensate for the relatively small differences in fruit number on the first planting date, resulting in comparable yields for the two training systems (16.3 $t \cdot ha^{-1}$).

The decrease in hill row yields between the 23 Sept. and later plantings may have been related to plant size as expressed by leaf number in the previous season. In Spring 1983, leaf numbers in plants set 23 Sept. were significantly higher than those set 7 Oct. (1). Although the later-set, smaller plants produced comparable numbers of crowns, as well as leaves, inflorescences, and flowers per crown by Spring 1984, these plants did not develop and/or support fruit numbers equal to plants set 23 Sept.

The later-set plants also did not support comparable yields across plant spacings. Although crowns per unit area were similar across spacings and planting dates, crowns per plant increased from 3, 6, 9, to 12 as plant spacing increased from 7.5, 15, 22.5, to 30 cm, respectively. Fruit number and yield of plants set after 23 Sept. decreased as plant spacing increased, suggesting some degree of intraplant competition at the wider spacings. Again, the different response to spacing between planting dates may be related to leaf number in Spring 1983, since the most dramatic drop in leaf number was between 23 Sept. and 7 Oct. at the wider spacings (1). The high leaf numbers of plants set 23 Sept. may have reflected improved root systems and/or the presence of already formed, though not visible, branch crowns (4), either of which could have affected subsequent growth, development, and productivity.

In contrast, original planting date and plant spacing had no effect on matted row yields. Like hill rows, fruit number tended to decrease across planting dates and plant spacings of the later three plantings, but the magnitude was not sufficient to affect yield. This response perhaps reflected mother plant productivity, since final crown numbers generally were not affected by either variable. Final crown numbers were also similar to those of spring-planted matted rows of 'Apollo' and 'Earlibelle' (3), which should have been sufficient for full production. Reducing crown numbers would not be expected to increase fruit size (3).

Although mowing plants after harvest has been promoted commonly as a means of increasing runner plant production, mowing had no effect on final matted row crown numbers of the fall plantings. Mowing did increase leaf and flower number per crown and flowers per inflorescence of both cultivars, as well as fruit number of 'Earlibelle' in matted rows; however, these differences were not sufficient to influence 1984 yields. Mowing fall-planted 'Apollo' and 'Earlibelle' that will be trained in matted rows after the first harvest then could be considered an optional practice based on herbicide and sanitation requirements rather than the need to ensure adequate crown numbers. The effect of mowing on plants maintained in hill rows could not be compared due to limited plot numbers.

'Apollo' produced more inflorescences and flowers per crown, higher fruit numbers, larger fruit, and, subsequently, higher yields (16.9 $t \cdot ha^{-1}$) than 'Earlibelle' (10.7 $t \cdot ha^{-1}$). The difference in yield between the two cultivars was similar to that within first-year spring-planted hill or matted rows (3). Although first-year yields of fall-planted 'Earlibelle' were comparable to 'Apollo (1), the substantially lower second-year yields and small fruit size of 'Earlibelle' do not justify the use of this cultivar for commercial perennial production. Cultivars other than those studied may vary in their responses to plant spacing and/or training system (3, 5).

Selecting the best training system for second-year production of fall-planted strawberries may be a grower decision based both on first-year growth of fall plantings and management capabilities. Given the importance of fruit size and ease of harvesting to the consumer, hill rows may be the best option, but only when plants have been set early enough in the fall or growing conditions have otherwise produced plants of sufficient size the spring after planting. Determining adequate plant size will be difficult. Leaf number may prove to be a reliable indication of adequate growth for hill row culture, but the threshold leaf number will need to be established and will vary with cultivar and spacing (1). Plants originally spaced 7.5 to 22.5 cm in the row may also be better-suited to hill rows than widely spaced plants. However, the feasibility and economics of timely runner removal are limiting factors in maintaining hill row production.

The development of cultural practices that enhance first-year growth may make hill rows more practical for second-year production. Also, cultivars that produce relatively few runners, such as 'Apollo', may be best-adapted to the hill system. In general, however, matted rows ≈35-45 cm wide may be the most reliable training system. When plants have been set 7.5 to 30 cm apart sufficient crown numbers can be produced for potential full production, even with relatively poor-running cultivars such as 'Apollo'. This system will still require some control of late-formed runners once desired populations have been established.

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Effect of Early Season Foliar Sprays of GA_{4+7} on Russeting and Return Bloom of 'Golden Delicious' Apple

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Abstract. **Early season multiple spray applications of 5, 10, or 20 ppm of gibberellins A_{4+7} (GA_{4+7}) reduced the severity and frequency of russet on four strains of 'Golden Delicious' apple (*Malus domestica* Borkh) fruit at three locations over 1, 2, or 3 years. The distribution of fruit in the U.S. extra fancy and fancy categories (graded for russet only) increased with increasing concentration of GA_{4+7} sprays. Regression analysis of data pooled from seven trials predicted for the 5-, 10-, and 20-ppm GA_{4+7} sprays, respectively, 68%, 74%, and 76% of the fruit falling in the combined extra fancy and fancy grades as compared to 40% on the untreated control trees. Additional experiments revealed tank-mixing GA_{4+7} with pesticides reduced the degree of russet suppression in one trial, but not in another. Return bloom was diminished on trees sprayed with GA_{4+7} in the previous year and the flower cluster density was inversely related to GA_{4+7} concentration. Chemical names used: (1α,2β,4aα,4bβ,10β)-2,4a,7-trihydroxy-1-methyl-8-methylenegibb-3-ene-1,10-dicarboxylic acid 1,4a-lactone (GA_{4+7}); polyoxyethylene-polypropoxypropanol dihydroxypropane (Regulaid).**

Russet detracts from the appearance of 'Golden Delicious' apples and causes economic loss by reducing their grade. Many environmental conditions, such as frost, certain pesticides, and, especially, exposure of the fruit to prolonged periods of high relative humidity or wetness, are associated with the occurrence of russet (4, 14). Initially, russet development is closely associated with epidermal cracking and cell death, which results in formation of an epidermal phellogen and leads to the development of periderm (cork cells) 2 to 3 weeks later (9). Generally, the most crucial period for initiation of russet occurs within 2 to 3 weeks after petal fall (9).

Experimentally, apple fruits have been protected from environmental conditions conducive to russet with rain and particulate matter shields (6, 7), bags, or early season silicon dioxide sprays (3, 8). Unfortunately, none of these treatments was commercially acceptable.

Gibberellin sprays applied from petal fall to 30 days after petal fall reduced apple russet (1, 2, 10, 15). GA_4, GA_7, and GA_{4+7} applied in concentrations of 5 to 200 ppm were effective in reducing russet, but GA_3 was less effective (10, 15). However, higher concentrations of gibberellin sometimes have reduced flower bud formation (11, 15).

Since russet is frequently a problem on 'Golden Delicious', this study was initiated to determine the effectiveness of GA_{4+7} foliar sprays in reducing russet under midwest climatic conditions.

Four strains of 'Golden Delicious' in three locations (southern, central, and northern Illinois) were used in the experimental trial designs detailed in Table 1. Four applications of GA_{4+7} (ABG-3035, Abbott Laboratories, North Chicago, Ill.) at 0, 5, 10, and/or 20 ppm plus 0.125% (v/v) spreader-activator (Regulaid) were applied to 'Golden Delicious' trees at 10-day intervals starting at late bloom in nine different trials. In trials 1–8, all treatments were applied as a dilute spray with a high-pressure handgun to wet the foliage to the point of runoff. In trial 9, the sprays were applied with an airblast sprayer at 935 liters·ha^{-1} (100 gal/acre). In trials 8 and 9, the first spray treatments were delayed until petal fall and applied as tank mixes with commercially recommended pesticides as listed in Table 1.

At harvest, random limb samples of 50 or 100 fruit per plot (Table 1) were graded into four USDA apple grade categories (13): extra fancy, fancy, number 1, and utility, corresponding to percent coverage of fruit with russet. The fruit samples were graded for russet only and other characteristics and defects affecting grade were ignored.

Data on the percentage distribution of fruit in USDA grade categories for russet for trials 1 through 7 were analyzed together, with the effects of location, strain, year, and blocking subtracted out. U.S. extra fancy and U.S. fancy grades were combined as a U.S. extra fancy and fancy grade, a grade frequently used by midwest growers. The linear, quadratic, and cubic effects on the grade distribution percentages were all tested and found to be significant at the 5% level; however,

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