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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Table 1. Experimental designs for GA_{4+7} applications to 'Golden Delicious' trees.

Trial	GA_{4+7} sprays: ppm	GA_{4+7} sprays: Mixture[z]	Strain	Growth habit	Illinois location	Design[y]	Replications	Trees/ replication	Years of treatment	No. fruit sampled/ plot
1, 2	0, 5, 10, 20	Water + surfactant	Frazier	Spur	Cobden	RCB	7	1	1982, 1983	100
3, 4	0, 5, 10, 20	Water + surfactant	Sundale	Spur	Cobden	RCB	8	1	1982, 1983	100
5, 6	0, 5, 10, 20	Water + surfactant	Starkspur	Spur	Urbana	CR	4	2	1982, 1983	50
7	0, 5, 10, 20	Water + surfactant	Mullins	Nonspur	Kell	CR	4	3	1982	50
8	0, 5, 10, 20	Water + surfactant + pesticides	Frazier	Spur	Cobden	RCB	8	1	1983	100
9	0, 5, 10	Water + surfactants + pesticides	Starkspur	Spur	Urbana	CR	4	2	1984	50

[z] Tank-mixed pesticides used at recommended rates are listed by application time: for trial 8—benomyl, zineb, and phosmet added to sprays applied 10, 20, and 30 days after petal fall (PF); for trial 9—benomyl, glyodin, polyram (Zn), and phosmet at PF + 2 days; benomyl, polyram, phosmet at PF + 9 days; polyram and phosmet at PF + 21 days; polyram, phosmet, and propargite at PF + 29 days.
[y] RCB = randomized complete block design; CR = completely randomized design.

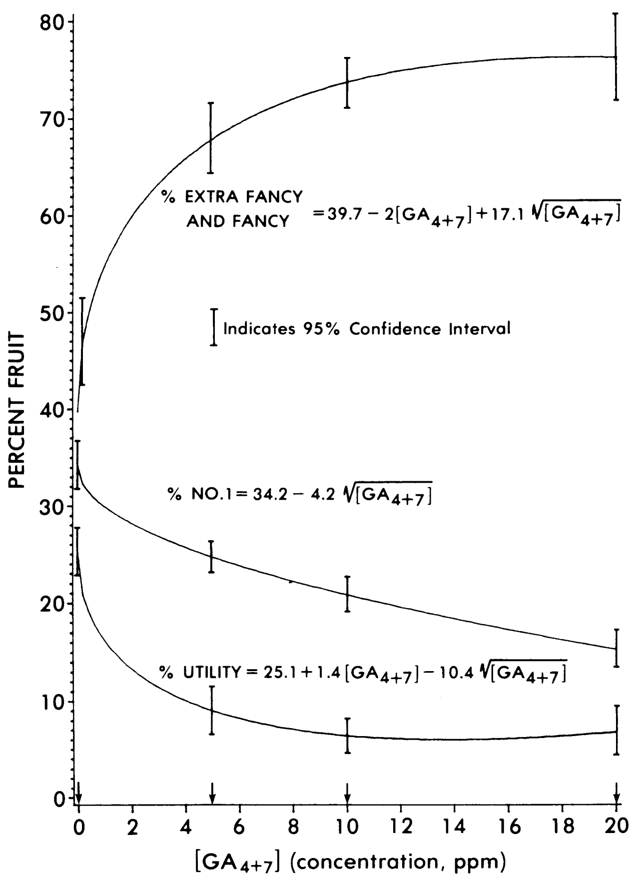

Fig. 1. Response of fruit grade distribution (for russet only) to the $[GA_{4+7}]$ of four consecutive sprays applied to 'Golden Delicious' trees at 10-day intervals starting at late bloom in trials 1 through 7. Vertical bars represent 95% confidence intervals.

due to the unusual response curve and because there were only 3 df for GA, the cubic model was judged to be overparameterized. Therefore, alternate models were tested. The regression model based on the square root of GA_{4+7} concentration had almost the same R^2 values (0.54, 0.31, and 0.42, respectively for the extra fancy and fancy, No. 1, and utility categories) as compared to the cubic models. The square root model is presented because it had fewer parameters and there was no significant lack of fit (5% level).

The data on percentage distribution of fruit in the USDA grade categories for russet for trial 8 were analyzed using orthogonal comparisons. The data from trial 9 were analyzed with analysis of variance.

Flower clusters were counted on the 'Frazier' and 'Sundale' trees at Cobden, Ill. in 1983 and on the 'Starkspur' trees at Urbana, Ill. in 1983 and 1984. Two limbs per plot at Cobden and six limbs per plot at Urbana were taken at random for the cluster counts. Results were expressed as flower clusters per square centimeter of limb cross section and were analyzed with regression analysis.

Application of GA_{4+7} sprays consistently reduced the severity of 'Golden Delicious' russet among all strains, locations, and years tested. The grade distribution, based on the amount of russet on fruit finish, was related to $[GA_{4+7}]$. The relationship between the percent of extra fancy and fancy fruit was positively related to $[GA_{4+7}]$ in a diminishing return relationship (Fig. 1). The grade distribution responses were predicted with the equations: % extra fancy and fancy = $39.7 + 17.1\sqrt{[GA_{4+7}]} - 2[GA_{4+7}]$; % no. 1 = $34.2 - 4.2\sqrt{[GA_{4+7}]}$; and % utility = $25.1 - 10.4\sqrt{[GA_{4+7}]} + 1.4[GA_{4+7}]$.

The regression analysis of data pooled from trials 1 through 7 predicted for the 5-, 10-, and 20-ppm GA_{4+7} sprays were, respectively, 68%, 74%, and 76% of the fruit falling in the combined category of extra fancy plus fancy grade as compared to 40% on the untreated control trees. The GA_{4+7} treatments reduced the percent of utility grade apples to very low levels, even on 'Frazier' and 'Sundale' trees (separate means not presented) previously described as very russet prone under midwest growing conditions (5).

The improvements in fruit grade distribution for russet with use of GA_{4+7} sprays were comparable to those reported by Wertheim (15), where early season sprays of 10 ppm GA_{4+7} improved the percentage yield of Grade I (completely smooth and slightly russeted fruit) from 62% for the untreated trees to 88% on the treated trees.

Additional improvement of fruit finish by using GA_{4+7} concentrations above the 20 ppm level would not be expected based on the diminishing response of the fruit predicted in the extra fancy and fancy grade as $[GA_{4+7}]$ increased from 10 to 20 ppm (Fig. 1) and supported by previous reports (10).

Mixing the GA_{4+7} with standard pesti-

Table 2. Effect of GA_{4+7} sprays applied as a tank mix, with or without standard pesticides, on the USDA grade for russet of Frazier 'Golden Delicious' apples (trial 8).

GA_{4+7} (ppm)	Pesticide[z] tank mix	Grade distribution percentage			
		Extra fancy	Fancy	No. 1	Utility
0	+	2	38	49	11
5	−	10	52	35	3
5	+	2	37	51	10
20	−	7	56	36	1
20	+	4	42	49	5
Orthogonal comparisons					
C_1 GA treated vs. untreated		NS	NS	NS	NS
C_2 GA (−) tank mix vs. GA sprays (+) tank mix		NS	*	*	*
C_3 5 ppm GA vs. 20 ppm GA sprays		NS	NS	NS	*
C_4 GA concn × tank mix interaction ($c_2 \times c_3$)		NS	NS	NS	NS

[z] + = tank mix with standard pesticides; − = GA_{4+7} applied alone, pesticides applied in separate sprays.
* Significance of the orthoganal comparison at the 0.05 level.

Table 3. The effect of GA_{4+7} sprays applied at 5 or 10 ppm in a tank mix of standard pesticides on USDA grade distribution (for russet only) of Starkspur 'Golden Delicious' apples (trial 9).

GA_{4+7} (ppm)	Percent of apples in USDA grades		
	Extra fancy	Fancy	No. 1
0	41	44	15
5	56	38	6
10	56	40	4
10 (in two applications only)	60	36	4
LSD 0.05	14	16	8

cides reduced its efficacy in one trial on 'Frazier' trees (trial 8) in 1983 (Table 2). Tank-mixing GA_{4+7} with pesticides shifted the major distribution of fruit from the fancy grade to the utility grade. There was not a significant interaction between $[GA_{4+7}]$ and tank mixing; therefore, increasing the $[GA_{4+7}]$ from 5 to 20 ppm did not overcome the pesticides' interference with GA_{4+7} activity on russet suppression. However, application of GA_{4+7} sprays at 5 or 10 ppm tank-mixed with standard pesticides increased the percent of extra fancy fruit on 'Starkspur' trees in trial 9 (Table 3). The interference on GA_{4+7} efficacy by pesticides in trial 8 occurred where a handgun was used to apply tank mix sprays. Perhaps use of an airblast sprayer for the GA_{4+7} tank mix sprays applied in trial 9 prevented the masking of GA_{4+7} response.

Return bloom was diminished on trees sprayed with GA_{4+7} in the previous year, and the reduction in flower cluster density was related to increased concentration of GA_{4+7} (Fig. 2). In 1983, return bloom reduction in relation to $[GA_{4+7}]$ was linear and significant for all three cultivars. In 1984, the 'Starkspur' response to previous season's $[GA_{4+7}]$ was significant and quadratic, which suggests that the reduced 1983 crop load on 'Starkspur' trees treated in 1982 with 20 ppm GA_{4+7} caused them to have higher levels of return bloom than the trees treated with 5 or 10 ppm GA_{4+7} (which had larger crops in 1983). Cluster density was reduced by 45% to 68% by the 20-ppm GA_{4+7} treatment in

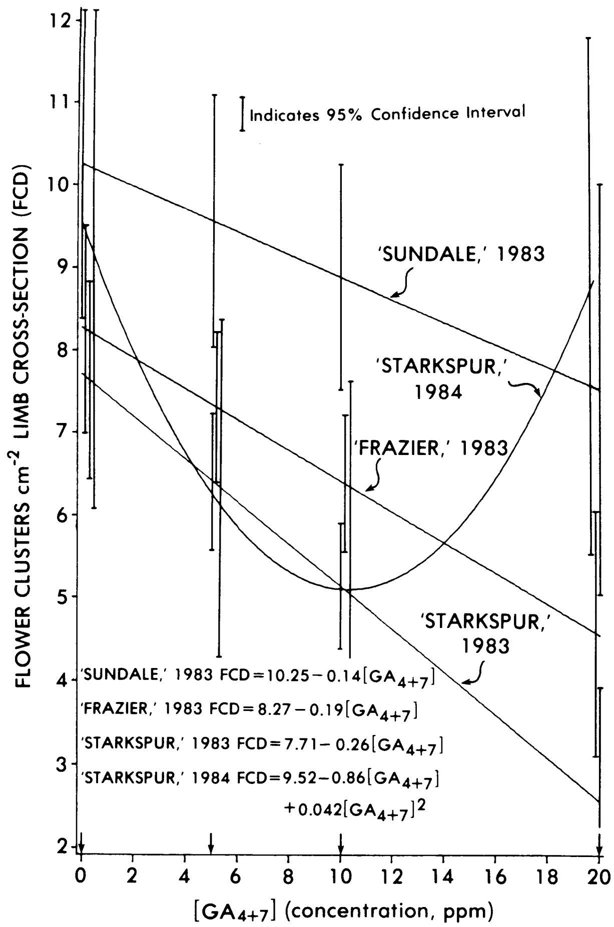

Fig. 2. Flower cluster density as influenced by the GA_{4+7} of four consecutive sprays applied to 'Golden Delicious' trees at 10-day intervals starting at late bloom in the previous season in trials 1, 3, 5, and 6. Vertical bars represent 95% confidence intervals.

the four trials where return bloom was measured. The application of the early season GA_{4+7} sprays to control russet did not greatly affect blossom cluster density in the succeeding season when 5- or 10-ppm concentrations were used. These data suggest concentrations of >10 ppm of GA_{4+7} should not be used in blocks where reduction in return bloom possibly could lead to reduced yields.

Multiple applications of 5- to 20-ppm GA_{4+7} during the 30-day period after bloom consistently improved the 'Golden Delicious' fruit grade distribution based on incidence of russet in nine separate trials. Furthermore, these results are encouraging because the potentially adverse GA_{4+7} side effects of reducing return bloom were not excessive at the 5- and 10-ppm concentrations. These results suggest commercial use is warranted on a trial basis. However, further investigation should be conducted on the influence of tank mixing GA_{4+7} with fungicides and insecticides.

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Productivity in a Strip Tillage Vegetable Production System

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Abstract. **Strip tillage was evaluated over a 2-year period as a cropping system for sites unsuitable for conventional tillage. Yields in clean cultivation and in 0.5- and 1.1-m strips tilled in established grass or grass/clover sod were compared in 1982 for sweet pepper (*Capsicum annuum* L.) and winter squash (*Cucurbita maxima* L.). Both interspecific and intraspecific competition were determined in 1983 for pepper. Squash yield was improved by a grass/legume sod, but pepper yield was unaffected. Both crops suffered severe competition in 1982 when grown in 0.5-m-wide strips, but yields per hectare in strips 1.1 m wide equaled that in clean cultivation. In 1983, however, number of marketable fruit per hectare of marketable yield of pepper in 1.1-m strips was less than that in clean cultivated plots, although total number of harvested fruit did not differ. Both marketable and total pepper yields per hectare were significantly higher in clean cultivation in 1983 than in strips. Increasing the population density of pepper in the strip increased number of fruit harvested and total weight per hectare, and there was a significant benefit in using double rows. Competition in strips accompanying increasing population density seemed to be associated with increased water deficits.**

Limited acreage of high-value land in the northeastern United States necessitates intensive, careful cropping practices. In many areas, land that is available or affordable to new farmers often is marginal because of excessive slope, small tillable areas, stoniness, or poor fertility. Conventional cultural systems and equipment may be inappropriate for this land. If such areas are to be adapted to row crop production, a cultural system must be developed that will allow intensive production, use small equipment, and prevent erosion.

Strip tillage of one or two rows of a vegetable alternated with narrow strips of cover crop may reduce erosion, and equipment needs might be more modest than for conventional farming. Strip tillage, conceptually, is similar to intercropping. While most intercropping systems involve two cash crops, the second intercrop in this instance is sod. Yields of two or more intercropped species depend on the degree of competition between, as well as within, each crop species (5, 6). The extent of intraspecific competition depends on planting density and planting design (1–4). Competition of any type is accentuated by water or nutrient deficits (6).

The study reported herein was designed to determine source and extent of plant competition as a basis for evaluating the biological feasibility of a strip tillage system. The objectives were: a) to study interspecific competition of row crops with a cover crop, and b) to analyze intraspecific competition at various planting densities within a strip tillage system.

Plots were established at the Kingman Agronomy Farm, Univ. of New Hampshire, in a Hollis-Charlton fine sandy loam (loamy, mixed, mesic, Entic Lithic Haplorthods; coarse-loamy, mixed, mesic, Entic Haplorthods), 3–8% slope.

In 1982, pepper ('Green Boy') and a bush winter squash ('Autumn Pride') were studied in identical experiments. The design for each was a split-plot with four replications. The main two plots, each 10.4 × 23.8 m, were grass or grass/legume. The grass plot was sown with 50% Kentucky bluegrass (*Poa pratensis* L.), 30% creeping red fescue (*Festuca rubra* L.) and 20% perennial ryegrass (*Lolium perenne* L.) (by weight). For the grass/legume, Dutch white clover (*Trifolium repens* L.) was added to the grass mixture (50% by weight). These plots were seeded 15 May 1981, at the rate of 67 $kg \cdot ha^{-1}$, using a Brillion seeder. A chopped straw mulch was applied to enhance establishment. Each main plot included four subplots, one of which was a clean cultivation control. The control plot consisted of three crop rows, the two outer rows serving as guard plants, with no interrow sod. The other three subplots consisted of methods for interrow sod height control: a) a one-time application of the growth suppressant *N*-[2,4-dimethyl-5-[[(trifluoromethyl)sulfonyl]amino]-phenyl]acetamide (mefluidide) at the rate of 1.2 $liters \cdot ha^{-1}$, using a CO_2 backpack sprayer; b) a one-time application of mefluidide at the same rate combined with mowing when the sod reached 15–20 cm; and c) mowing when vegetation reached a height of 15–20 cm. The final split involved tilling strips either 0.5- or 1.1-m wide, using a hand-operated rototiller and tractor-mounted tiller, respectively. The clean cultivation control plots

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