cern was the possibility that the use of carbon would protect weed seeds resulting in increased weed growth. Carbon bands over the rows often result in slight increases in weed stands when compared to the herbicide without carbon (5, 8, 12). The general results in this study show that weed stands were not greatly increased with the carbon protection systems (Tables 2–5). This was especially true at the high rate of metribuzin. It was interesting to note that no weeds existed when either diphenamid or metribuzin was used with the ground corn cob anticrustant (Table 4).

Preceding results showed that vermiculite plus carbon was effective in protecting tomatoes from metribuzin injury. The need for carbon protection is not as great with diphenamid as with metribuzin; however, there were some slight advantages with diphenamid. The use of carbon should be considered as a commercially acceptable approach for weed control with metribuzin in direct-seeded tomatoes. Similar results were obtained by Henne and Guest (3), Mullen (7), and William and Romanowski (12) using slightly modified carbon protection systems and different herbicides. One of the main benefits of the system used herein is the reduced amount of carbon used per ha resulting in an economic advantage.

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Tree Yield and Nut Characteristics of Pecan with Drip Irrigation under Humid Conditions[1]

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Abstract. **Drip irrigation on 1 and 2 sides of pecan [*Carya illinoensis* (Wang.) Koch.] trees was programmed to irrigate when soil water suction 61 cm from the emitter was greater than 0.1 bar at either 15, 30, or 45 cm depth. Results were compared with no irrigation. The data indicate little advantage of 2 lines of emitters over one line when the same number of emitters/tree are used. The data often favored 1 line over 2 lines. Total yield of pecans was increased substantially by drip irrigation on one side ('Desirable' and 'Elliott') or both sides of the tree ('Elliott'), but increases from 'Farley' were not significant. In 1968, an extremely dry year, ⅓–½ of the shucks did not dehisce completely on nonirrigated trees while 1 to 7% of the shucks did not dehisce on irrigated trees. Irrigation increased nut size. Percentage kernel was increased by irrigation in 1968 but not in other years. In 1968, percentage fancy kernels was almost doubled by irrigation for 'Desirable' but was reduced for 'Elliott'.**

The use of drip irrigation as a method of watering tree crops has increased tremendously over the last 10 years in the United States. Drip irrigation began commercially outside Israel in 1969 and over 64,000 ha had been installed worldwide by 1974 (2). Most of the installations were on arid land and only a few were on pecans (8, 9). It is estimated that Georgia now has over 3,000 ha (7,500 acres) of orchards under drip irrigation and will have over 8,000 ha (20,000 acres)[3] by 1985.

Most pecan production occurs in the humid southern U.S. where yearly rainfall is plentiful, but periods of moisture stress occur practically every year. Response to drip irrigation under these conditions has been excellent (5, 6) and returns from irrigation would often pay for the system in one year. Interest has developed in the use of drip irrigation to provide supplemental water to pecan trees during these periods of drouth stress. Many growers

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[3]Report by Robert E. Skinner, Extension Engineer-Irrigation, on use of drip irrigation in Georgia.

are now installing drip irrigation systems. Most growers are using two 1.5 cm (i.d.) lines of drip tubing on opposite sides of the tree with up to 8 emitters per tree on large trees. If a single dripline with the same number of emitters per tree would give equivalent results, then cost of dripline could be reduced and the single line could then be placed in the tree row where it could easily be seen and serviced and be less of an obstacle in the orchard. This study tested the feasibility of 1 vs. 2 lines per tree row and tested the effectiveness of drip irrigation vs. no irrigation on 3 different cultivars.

Materials and Methods

The experiment was initiated in 1975 in an orchard near Albany, Georgia, consisting of uniform 20-year-old 'Elliott', 'Desirable', and 'Farley' trees spaced 14 x 14 m apart on Orangeburg sandy loam (Typic Paleudult; fine loamy, siliceous, thermic). The irrigation study was part of a larger study which included irrigation and pruning. The pruning phase of the study will be reported later. The design was a split plot with 3 replications (cultivars) with 3 irrigation treatments as main plots, 4 pruning treatments as subplots and 4 trees per subplot. Each tree was harvested separately, thus each irrigation treatment mean is an average of 48 trees each year. Irrigation variables were no irrigation, irrigation with six 4 liter per hr emitters per tree on one side only and irrigation with six 4 liter per hr emitters per tree but with 3 on 1 side of the tree and 3 on the opposite side. Emitters were spaced 2.3 and 4.7 m apart, respectively. The drip irrigation tubing was spaced midway between the tree trunk and the outer edge of the tree canopy.

The irrigation system was installed in May 1975, but was not fully automated until July 7, 1976. Plots were checked weekly to verify performance of the switching tensiometers, pressure regulators and emitters. Line pressure was maintained at 1.06 kg cm^2 (15 psi) at the end of the dripline by use of a pressure regulator on each line. Water application was controlled by tensiometers fitted with electrical switches (Irrometer Company, P.O. Box 2424, Riverside, California) which operated a solenoid valve. Tensiometers were set 15, 30, and 45 cm deep and wired in parallel so that irrigation began when soil reached 0.1 bar at any of the depths. A station, consisting of 3 switching tensiometers, was placed at each replication so that each replication was watered independently of the others. A water meter placed near the pump measured the total amount of water used in 1977–79. The orchard was fertilized and sprayed uniformly by the grower in accordance with Georgia Cooperative Extension Service recommendations.

Yields were sampled by harvesting nuts falling within a 3.6° circle sector on the NE, NW, SE, and SW sides of each tree. The sampling device consisted of a flexible steel band, 2 chains, and appropriate spacers. The band was fastened around the tree trunk and spiked into the ground with 4 large nails bolted to the band. The 2 chains with appropriate spacers attached to this band when stretched marked the boundaries of a 3.6° sector of a circle. The 4 sectors permitted sampling 1/25 of the area underneath the tree. The same location was measured under each tree. The nuts were weighed, and a 50-nut subsample was sized, cracked, and the kernels graded into fancy, standard, and amber in accordance with grading standards used commercially. The percentage of each nut size and kernel grade was calculated. Fancy kernels are bright-colored, well-filled kernels with no defects. Standard kernels are similar, but color is darker. Amber kernels are still darker and also include edible kernels with some defects. Percentages given are percentages of the inshell nut. Percentage of nuts that were shaken from the tree in the shuck was determined for the 1978 and 1979 harvests.

Results and Discussion

Southern Georgia usually has dry periods in the spring and fall with frequent afternoon and evening showers during July. These July showers are often of low amounts of rain per shower (Fig. 1). Average evaporation over the 31-year period of 1937–67 is 15.1, 18.3, 17.5, 16.9, 15.8, 12.8, and 10.5 cm per month, respectively, for the April–October growing season. Average rainfall for the 1922–67 period for the same months was 10.6, 8.1, 12.0, 15.2, 12.6, 9.5 and 5.0, respectively. Evaporation thus exceeds rainfall on the average during each month of the pecan growing season. Pecans require a great deal of water in late July and early August to size the shell and in late August and September to fill the shell with high quality kernel. The period of greatest moisture stress was during September of 1978 when only 1 cm of rainfall fell during the filling period. Many nonirrigated trees were partially defoliated and shucks did not open. Similar conditions existed in the fall of 1973 and 1980, but these years were not in the study. Total water added to the irrigated plots was 14.7 in 1977, 22.7 in 1978, and 14.5 cm in 1979.

Yields. Overall yield increased by 100 kg/ha over the 1976–79 period when irrigation was applied to both sides of the tree compared with no irrigation. An additional increase of 114 kg/ha was obtained when all 6 of the emitters were placed on one side of the tree (Table 1). Although these differences were significant, there were significant interactions between cultivars (replications) and irrigation systems. Irrigation on one side of the tree increased yield of 'Desirable' by 350 kg/ha (Table 1), but the increase of 131 kg/ha obtained when irrigation was applied on both sides was not significant. For 'Elliott', both irrigation systems increased yield by over 250 kg/ha. Yields were low for 'Farley' and not affected significantly by irrigation. There was no yield advantage for the second dripline.

Yields in Table 1 are totals of all ungraded nuts that came from the tree including deshucked "sticktights." "Sticktights" are nuts that do not fall free of the shuck. These nuts must be deshucked by machine or by hand before they can be marketed. This process is often so expensive that "sticktights" are often discarded. In 1978, conditions were so dry that 31–52% of the nuts remained in the shuck when harvested if drip irrigation was not provided (Table 2). With irrigation, however, only 1–7% of the nuts were "sticktights." When the yield of nuts that fell free of the shuck is considered (Table 2), excellent yield responses were obtained from one or both irrigation treatments.

Nut characteristics. Percentage kernel, nut size, and kernel grade are quality factors which greatly influence the price obtained for nuts. Data for these factors revealed large seasonal and cultivar effects on the responses to irrigation. Percentage kernel was increased on the average over all years from 49.9 for no irrigation to 50.4 for irrigation on one side and 50.8 for irrigation on both sides. Only the last value was significantly greater than that for the nonirrigated control. A significant year x cultivar x irrigation interaction revealed that the differences were significant only for the dry year of 1978 (Table 3). Significant increases in percentage kernel were obtained for all cultivars when irrigated on both sides. For 'Desirable', the increase was substantial for either irrigation system. Although the increases in percentage kernel favored the two side irrigation method, the differences between the 2 methods were never significant.

The fancy grade is the highest quality grade for pecan kernels. Irrigation did not affect the overall average for percentage fancy kernels; however, a significant (prob. $> F = .0001$) year x cultivar x irrigation interaction revealed that irrigation affected percentage fancy kernels differently for different cultivars and years.

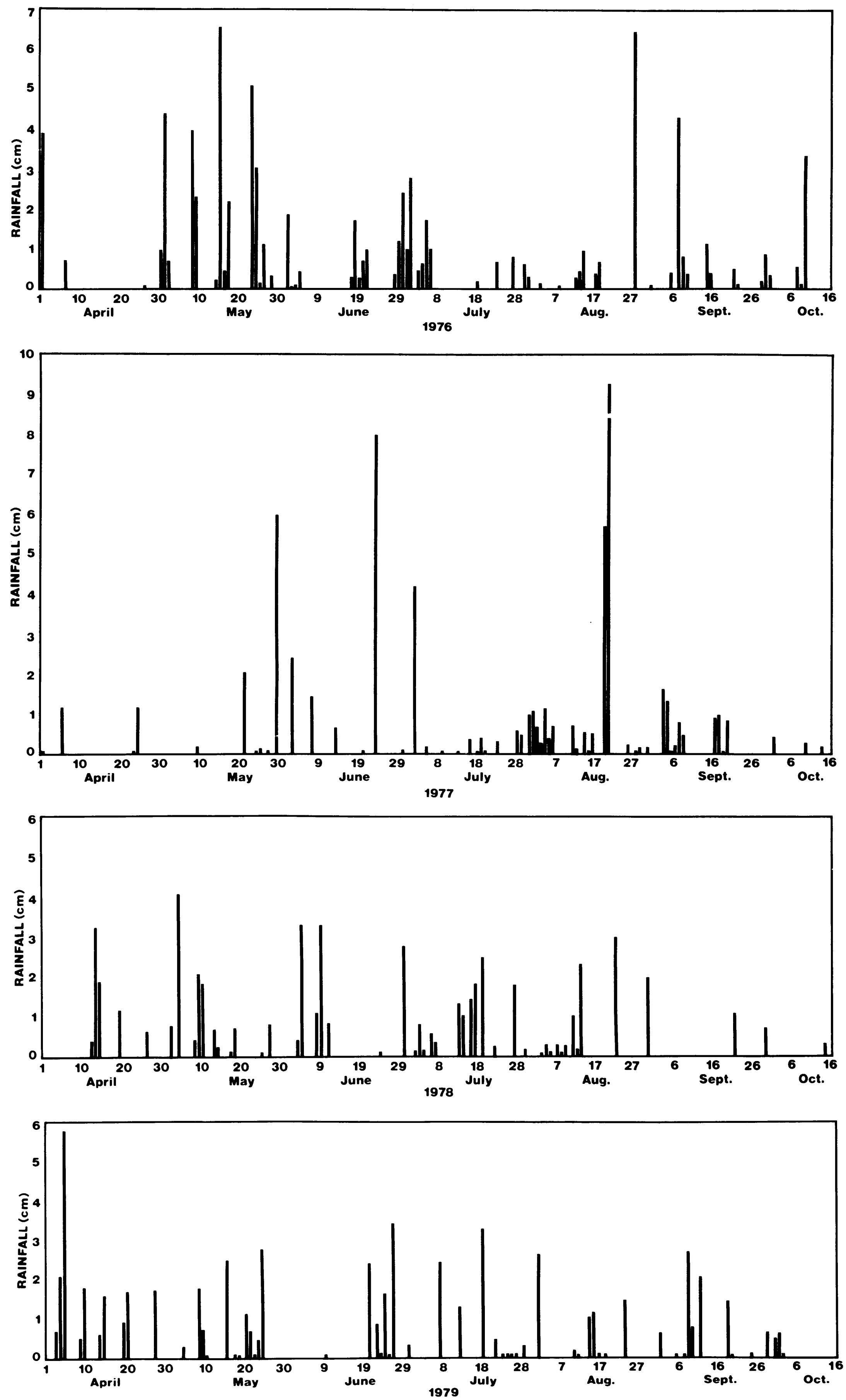

Fig. 1. Rainfall distribution during the pecan growing season. 1976–1979, Tifton, Georgia.

Table 1. Yield of 3 cultivars of pecans as affected by cultivar and drip irrigation, Bedenbough Orchard, Albany, Ga., 1976–1979.

Irrigation treatment	Yield kg/ha[z]			
	Elliott	Desirable	Farley	Average
No irrigation	927a	1112a	550a	852a
Irrigation on 1 side	1184b	1462b	581a	1066c
Irrigation on 2 sides	1179b	1243ab	501a	952b

[z]Mean separation withincolumn by General Linear Models Procedures (1) (average of 4 years, 4 pruning treatments, and 4 trees/pruning treatment).

In the dry year of 1978, percentage kernels was almost doubled for 'Desirable' (Table 3). Irrigation did not influence percentage fancy kernels in 1976 or 1977. In 1978, even though 'Elliott' had a high percentage of "sticktights," when the shucks were removed and the nuts were cracked, the nonirrigated kernels were of high quality. For 'Farley', percentage fancy kernels were almost tripled when irrigation was provided on both sides, but was not affected when irrigation was applied on one side in 1978. Both irrigation treatments increased percentage fancy kernels for 'Elliott' in 1979, 38.6 vs. 47.6 and 53.5% for no irrigation, irrigation on one side and irrigation on 2 sides, respectively. Other cultivars were unaffected in 1979.

Nuts/kg is a measure of size and/or filling of the nut. Irrigated nuts were on the average larger or better filled than nonirrigated nuts. Nonirrigated nuts required 149/kg compared with 142 and 143 for nuts irrigated on one side and two sides of the tree, respectively. Irrigation x year and cultivar x irrigation x year interactions were significant, thus a general statement cannot be made to cover all years and cultivars. The greatest differences were in the dry year of 1978 when all irrigated nuts were larger or better filled than nonirrigated nuts (Table 3). Fewer 'Desirable' were also required per kg in 1978 when irrigation was on one side than when provided on 2 sides. In 1977, both irrigation methods reduced the number of nuts/kg but the reduction was significant only for 'Farley'. Nuts/kg was 157, 144, and 144, respectively, for nuts nonirrigated and irrigated on 1 and 2 sides, respectively. 'Elliott' nuts required 167/kg, 162, and 153 nuts/kg when nonirrigated, irrigated on 1 and 2 sides, respectively, in 1979. Irrigation did not influence nuts/kg count in 1976.

Most of the inshell nuts graded 14/16 (2.0–2.2 cm diameter) or larger with 'Desirable' being much larger than 'Elliott' and 'Farley'. Results for size grade and nut volume revealed similar trends to nuts/kg with irrigation usually increasing percentage of large nuts or increasing nut volume.

Other parameters studied were specific gravity of nuts, terminal growth, circumference growth, and nutlet counts. These parameters showed increases from drip irrigation, but they were not consistent over years, pruning treatments, and cultivars as revealed by significant interactions.

Summary and Conclusions

Favorable responses from irrigation of increased yield and quality were greater in the year of severe drouth during the filling period in the fall, and these responses were greater for 'Desirable' than for other cultivars perhaps because 'Desirable' was not affected as much by alternate bearing. 'Desirable' is a large nut and yield was relatively high over the 1976–78 period thus the requirement for water was also perhaps greater than other cultivars. 'Desirable' is by far the cultivar being planted in greatest numbers in the Southeast, thus the data indicate that growers could expect yield increases from drip irrigation on this cultivar.

Early responses to drip irrigation were small perhaps due to the uniform distribution of rainfall in 1976 and due to the time required for root proliferation in the wetted zone around an emitter.

There was little evidence to indicate that yield or quality of nuts was greater when 2 driplines were used instead of one. Growers can thus save on installation expenses by putting all the emitters on one line. Both irrigation methods provided the same amount of water per tree, and water can be translocated from one side of the tree to the other; therefore, large differences between the 2 methods were not expected. The reason that yield was slightly greater for irrigation on 1 side than on 2 sides is a subject for speculation. With one side irrigation, the wetted zones under the emitters were practically joined, whereas with 2 side irrigation there were 6 distinct wet spots. This difference in configuration of the wetted zone thus might favor the one-side irrigation system.

Table 2. Yield of nuts (kg/ha) free of the shuck and percentage of sticktights as affected by drip irrigation, Bedenbough Orchard, Albany, Ga., 1978.

Irrigation treatment	Elliott		Desirable		Farley[z]	
	Yield (kg/ha)	Sticktights (%)	Yield (kg/ha)	Sticktights (%)	Yield (kg/ha)	Sticktights (%)
No irrigation	599a	35b	896a	52b	508a	31b
6 emitters on one side	930ab	4a	2292b	1b	900b	7a
3 emitters on 2 sides	1155b	2a	2293b	3a	638ab	5a

[z]Mean separation within column by General Linear Models Procedures (1).

Table 3. Percentage kernel, percentage fancy kernels, and nuts/kg for 3 cultivars of pecans as affected by drip irrigation, Bedenbough Orchard, Albany, Ga., 1978.

Irrigation treatment	Elliott			Desirable			Farley[z]		
	Kernel (%)	Fancy kernels (%)	Nuts/kg	Kernel (%)	Fancy kernels (%)	Nuts/kg	Kernel (%)	Fancy kernels (%)	Nuts/kg
No irrigation	49.8a	41.5c	179b	41.8a	16.2a	143a	45.3a	10.7a	179b
Irrigation on 1 side	51.5ab	31.5b	169a	48.7b	28.9b	120a	46.3ab	9.1a	171a
Irrigation on 2 sides	52.1b	23.5a	171a	50.3b	30.7b	128b	48.1b	27.0b	164a

[z]Mean separation within column by General Linear Models Procedures (1).

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Growth and Flowering of Vigorous Apple Trees as Affected by Summer or Dormant Pruning[1]

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Additional index words. Malus domestica, naphthaleneacetic acid

Abstract. **Summer pruning of 'Starking Delicious', 'Golden Delicious', or 'Stayman' apple (*Malus domestica* Borkh.) trees in mid-August (about 14 weeks after full bloom) did not suppress shoot growth the following year, as compared to similar pruning prior to budbreak in early April. 'Stayman' trees pruned in June had more regrowth than those pruned in August. A 1% naphthaleneacetic acid (NAA) solution applied to the summer pruning cut prevented regrowth. The increase in trunk and branch circumference was reduced by August pruning, as compared to dormant pruning. Summer pruning did not influence total bloom the year following treatment, but summer pruning for 2 consecutive years reduced the amount of bloom on 2-yr-wood. Cutting to the first spur on 2-year-wood in August did not suppress shoot growth the following year as compared to heading back to 4 leaves on current season's wood.**

Pruning fruit trees during the summer has long been regarded as devitalizing, while dormant pruning encourages vegetative growth (2). Experimental data pertaining to growth and fruiting of apple trees following summer pruning are conflicting. Evaluation and comparison of the early studies are difficult because of different locations, poor designs or lack of statistical analysis, different treatments, and incomplete descriptions. The primary objective was usually to promote earlier flowering of young trees on vigorous rootstocks, and sometimes to control vigorous growth. Response to summer pruning varied with the timing and type of pruning, tree vigor, cultivar, and environmental conditions (6, 12, 14).

When measured in November of the same year, trees pruned in early summer usually had more shoots and longer shoots than trees pruned in late summer (8, 9). Compared to trees that were severely pruned in winter, trees comparably pruned in June had similar shoot growth, while pruning in mid-summer suppressed growth for the next 3 years (1). In other experiments, pruning in early July (13) or mid-August (22) did not restrict shoot growth the year following treatment more than did similar dormant pruning. Heading current season shoots to 4 to 6 leaves or pinching the growing point between early July and early August did not restrict shoot growth the following year as compared to unpruned controls (16). Regrowth developing from axillary buds below the pruning cut (3, 5, 6, 11) and flower bud formation (8, 9, 18, 19) were encouraged more by pruning in early summer than in late summer. When current season shoots on 'Delicious' and 'Cortland' trees were headed to 4 to 6 leaves, pinched to remove the growing point, or pruned to 0.5 to 1.0 cm stubs, flower bud initiation was no greater than on unpruned controls (16).

Growers are currently planting apple trees at closer spacings to increse yield per unit land area. Use of size-controlling rootstocks, spur-type strains, growth retardants, and dormant pruning are often not adequate to prevent crowding and shading. Some growers are now attempting to control tree size with summer pruning. The type of summer pruning performed by Europeans to regulate form and productivity of trees on size-controlling rootstocks involves repeated pruning during the summer (19), which is not practical in large plantings of trees on more vigorous rootstocks. Thus, some growers are mowing trees or heading current season shoots during the summer. Although heading current season shoots reportedly lowers limb vigor, encourages flower bud formation, and improves fruit quality (20), we are un-

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