deficiency and application of $MgSO_4$, MgO or K_2SO_4-$2MgSO_4$ appear to be a satisfactory solution to maintaining adequate Mg levels in pecan tissue. Delays in detection and correction may cause severe yield loss and tree damage requiring years to correct. Foliar sprays containing Mg as they were used in this study were not effective. Additional studies using several foliar spray concns. and dates appear warranted. The studies also indicate that the use of dolomite as a Mg source was not satisfactory.

Literature Cited

1. Alben, A. O. 1947. Analysis of pecan leaves as an aid in fertility studies. *Proc. Tex. Pecan Grow. Assoc.* 26:51–58.
2. Amling, H. J. 1965. Alabama pecan leaf analysis service. *Proc. Southeastern Pecan Grow. Assoc.* 58:25–33.
3. Boynton, D. 1947. Magnesium nutrition of apple trees. *Soil Sci.* 63:53–58.
4. Calvert, D. V. and H. J. Reitz. 1966. Response of citrus growing on calcareous soil to soil and foliar applications of magnesium. *Proc. Fla. Hort. Soc.* 79:1–6.
5. Camp, A. F. 1947. Magnesium in citrus fertilization in Florida. *Soil Sci.* 63:43–52.
6. Ford, Elsie M. 1964. The control of magnesium deficiency in apple rootstock stoolbeds. *J. Hort. Sci.* 39:212–223.
7. Gammon, N., Jr., K. D. Butson, and R. H. Sharpe. 1960. Magnesium content of pecan leaves as influenced by seasonal rainfall and soil type. *Proc. Soil and Crop Sci. Soc. Fla.* 20:154–158.
8. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. *Plant Dis. Reptr.* 48:692.
9. Jones, J. B. and M. H. Warner. 1969. Analysis of plant-ash solutions by spark-emission spectroscopy. *Dev. Appl. Spec.* 7A:152–160.
10. Koo, R. C. J. and D. V. Calvert. 1966. Magnesium oxides as sources of magnesium for citrus. *Proc. Fla. Hort. Soc.* 79:7–12.
11. Sharpe, R. H., G. H. Blackmon, and N. Gammon, Jr. 1950. Progress report of potash and magnesium fertilization of pecans in Florida. *Proc. Southeastern Pecan Grow. Assoc.* 43:86–89.
12. ———, ———, and ———. 1951. Magnesium deficiency of pecans. *Proc. Southeastern Pecan Grow. Assoc.* 44:23–27.
13. Tisdale, S. L. and W. L. Nelson. 1966. Soil fertility and fertilizers. 2nd Ed. The MacMillan Co., New York, NY 694 p.
14. Warner, M. H. and J. B. Jones. 1970. A rapid method for nitrogen determination in plant tissue. *Soil Sci. and Plant Anal.* 1:109–114.
15. Woodbridge, C. G. 1955. Magnesium deficiency in apple in British Columbia. *Can. J. Agr. Sci.* 35:350–357.
16. Worley, R. E. 1969. Pecan leaf analysis service summary, 1967. *Ga. Agr. Exp. Sta. Res. Rep.* 55. 26 p.
17. ———, S. A. Harmon, and R. L. Carter. 1974. Effect of repeated N, P, K, and lime applications on soil pH, P, and K under old and young pecan trees. *J. Amer. Soc. Hort. Sci.* 99:57–62.

Effect of Time of Pruning or Nonpruning On Fruit Set and Yield of Peach Trees Growing on New or Old Peach Sites[1]

Jeff W. Daniell[2]

Georgia Agricultural Experiment Station, Experiment

Abstract. Pruning dates as treatments were imposed on 4- to 6-year old peach trees [*Prunus persica* (L) Batsch], growing on new and old peach sites. May and July pruning reduced the number of blooms in 1971 but had no effect in 1972. Fruit set and yield resulting from spring pruning or non pruning averaged higher by an order of 2 than from winter pruning in 1971, a year when cold injury to blossoms reduced average peach yields in the area 50 percent. Time of pruning had no effect on fruit set in 1972, a year with no cold injury to blossoms. Therefore, the yields per hectare in 1972 reflected mostly the tree mortality where trees were growing on old peach sites. Significant increases in yield were obtained from February, March, and May pruning over November and January pruning. In addition, June pruning increased yields when compared to November, December, and January pruning. These data also provide further evidence that cold injury is involved at some point in the peach-tree decline process. The relationship of these findings to peach-tree decline is discussed.

Effects of pruning on yield of peach trees (6, 10, 16, 23) has been studied extensively and there appears to be good agreement in the literature as to the effects of severity of pruning. Severe pruning has been shown to decrease yields and tree growth (3, 14, 17, 19, 20, 21), delay maturity of fruits (5, 13, 22) and increase cold injury (4). However, most research appears to have been based on the assumption that the best time for pruning is during the winter; both from the standpoint of less injury to trees and for better utilization of farm labor. At the present time in Georgia, however, pruning is done mostly by off-farm labor during the winter.

There are conflicting reports on the effects of summer pruning. Summer pruning has been shown to decrease yields (1, 12, 18) and also to increase yields (2, 11, 15). This paper reports the effects of time of pruning or non-pruning on number of blooms, fruit set, yield of peach trees, and tree decline.

Materials and Methods

Tests were initiated in 1967 on 2-yr-old trees at Plains, and on 1-yr-old trees at Ft. Valley, Georgia and in 1968 on 1-yr-old trees at Ft. Valley. Both tests at Ft. Valley using 'Loring' trees on 'Elberta' rootstock were conducted on old peach sites with a history of severe decline. The test at Plains using 'Suwanee' trees on 'Elberta' rootstock was conducted on a new peach site with no known history of a peach planting. Time of pruning in tests at Ft. Valley consisted of 12 treatments; an individual pruning for each month of the year, with an unpruned control in the 1968 test. Ten treatments were used at Plains with the December and June pruning omitted.

Data presented in an earlier paper (7) showed that time of pruning had an effect on tree mortality. In addition, early observations indicated that time of pruning also had an effect on number of blooms, fruit set, and yield of peaches. Consequently, bloom counts and fruit set was determined in 1971 and 1972. Fruit size and yield data were also taken in 1971 and 1972 but in the 1968 planting at Ft. Valley only. Cold injury to blossoms occurred in 1971 from a recorded low in the orchard of −2.7°C on March 4th and −3.3°C on March 5, but no cold injury to blossoms occurred in 1972.

In this study, months were grouped into seasons as follows:

December, January and February, designated as winter season
March, April and May, designated as spring season
June, July and August, designated as summer season
September, October and November, designated as fall season

[1] Received for publication November 13, 1974.

[2] Assistant Horticulturist, Department of Horticulture

A detailed description of pruning treatments was presented in an earlier paper (7). Bloom and/or fruit set counts were determined from 4 places on each tree. Peaches were harvested in July by multiple harvest of each tree and expressed in kgs per hectare. Fruit size was determined by counting fruits in a half-bushel basket and relating number to size on a previously prepared curve.

Results and Discussion

Number of blooms. A significant reduction in number of blooms occurred from May and July pruning at Plains in 1971 (Table 1). This reduction resulted from excessive vigorous growth which occurred after the May and July pruning. This vigorous growth had excessive space between bloom buds resulting in a low count at blooming time. The following year, excessive vigorous growth did not result from the May and July pruning, so no differences in number of blooms occurred in 1972 (data not presented).

Bloom data are presented in the test at Plains only (Table 1), as the number of blooms had little significance in final fruit set and yield of peaches in the tests at Ft. Valley.

Fruit set. The winter season is the conventional time that trees are pruned in Georgia. However, preliminary observations made in 1970 suggested that cold injury to blossoms was more severe on trees pruned in late fall or early winter than on trees pruned at other times. Data obtained in 1971 at Ft. Valley (Table 1), against a year with cold injury to blossoms, show the effect of winter pruning on fruit set. It was evident by observations made during blooming that winter pruning increased cold injury in blossoms. With differential effect on blossoms from the cold temperatures, fruit set on trees pruned in the winter was reduced 50 percent or more as compared to trees pruned in the spring or not pruned (Table 1).

A high fruit set was also obtained from some summer and early fall pruning treatments. With the exception of July, however, consistent results were not obtained in both the 1967 and the 1968 plantings (Table 1).

Pruning time had no effect on fruit set in 1972 (Table 2), a year with no cold injury to blossoms. Thus, the low fruit set produced by winter pruning in 1971 reflects a predisposing effect on blossoms to cold injury rather than some other possible physiological effects.

Fruit size and yield. More than a 2-fold increase in average yield occurred in 1971 from spring pruning over that from winter pruning. This resulted primarily from the higher fruit set on spring pruned trees (Table 1). There was a negative relationship between yield and size of fruit. In general, as yield increased fruit size decreased. Marketable fruit size was obtained in all pruning treatments.

Pruning in July, August and September also resulted in an increase in yield over winter pruning in 1971 (Table 1). The low yield for June pruning relative to other summer pruning, resulted from the removal of large fruit during the pruning operation preceding harvest in July. Because the July pruning each year was done after harvest, a high yield was obtained for the July treatment, indicating the fruit thinning effect from pruning any time between fruit bud formation in the fall until harvest in the next summer.

There were more twigs containing leaves and peaches on non pruned trees than on pruned trees, which contributed to the significant increase in yield of non pruned trees over all pruned trees in 1971 (Table 1). In 1972, significant increases in yield were obtained from February, March, and May pruning over November and January pruning. In addition, June pruning resulted in a significant increase in yield over November, December, and January pruning. Based on data obtained in this study, highest yields can be obtained in years when

Table 2. Effect of pruning time or non-pruning on fruit set, size, and yield of 'Loring' peaches at Ft. Valley in 1972.

Treatment	1968 Planting[z]		
	Fruit set	Fruit diam.	Yield
	(no/m)	(cm)	(kg/h)
January	20.66 a[y]	5.63 a	998.1 a
February	20.66 a	5.84 a	2227.4 bcd
March	20.66 a	5.79 a	2258.0 bcd
April	20.66 a	5.84 a	1861.4 abc
May	20.01 a	5.81 a	2331.4 bcd
June	21.65 a	5.74 a	2565.8 cd
July	20.99 a	5.79 a	1965.4 abc
August	20.34 a	5.76 a	1755.0 abc
September	26.57 a	5.96 a	2012.6 abc
October	20.34 a	5.86 a	1402.5 ab
November	21.32 a	5.71 a	963.1 a
December	20.66 a	5.79 a	1298.5 ab
Non-Pruned	20.99 a	5.74 a	3223.5 d

[z] Five-year-old trees.
[y] Means separation, within columns, by Duncan's multiple range test at 5% level.

Table 1. Effect of purning time or non-pruning on number of blooms on 'Suwanee' trees at Plains; fruit set, size and yield of 'Loring' peaches at Ft. Valley in 1971.

Treatment	Plains[z]	Ft. Valley			
		1967 Planting[y]	1968 Planting[x]		
	Blooms	Fruit set	Fruit set	Fruit diam.	Yield
	(no/m)	(no/m)	(no/m)	(cm)	(kg/h)
January	40.68 c[w]	1.37 ab	1.08 a	8.50 e	415.6 a
February	42.47 cd	1.73 abc	1.87 a	8.38 e	527.2 ab
March	42.32 cd	3.08 de	2.29 ab	8.07 cde	1205.7 cd
April	42.97 cd	2.32 bcd	3.90 ab	7.95 cde	1437.7 de
May	32.15 b	3.93 e	4.17 ab	7.74 bcd	1804.9 ef
June	—	2.91 cde	1.90 a	7.89 cde	856.2 bc
July	21.98 a	2.46 bcd	4.69 b	6.90 a	2420.3 g
August	38.71 c	.91 a	2.72 ab	7.16 ab	1468.6 de
September	48.88 d	1.57 abc	1.80 a	7.56 bc	1879.8 f
October	42.32 cd	1.60 abc	1.90 a	7.97 cde	941.4 c
November	—	1.67 abc	3.54 ab	8.02 de	1261.5 cd
December	44.61 cd	.88 a	1.64 a	8.02 de	873.8 bc
Non-Pruned	—	—	4.75 b	7.19 ab	3280.9 h

[z] Bloom count only recorded at Plains. Six-year-old trees, planted in 1966.
[y] Five-year-old trees.
[x] Four-year-old trees.
[w] Means separation, within columns, by Duncan's multiple range test at 5% level.

cold injury may cause low fruit set by delaying pruning until after harvest.

In an earlier paper on tree decline (7) we showed that trees growing on old peach land and pruned in late fall or early winter had greater mortality than non pruned or trees pruned in the spring. As yields in the present study are presented as wt of peaches per area (kg/h), and fruit set per tree was not affected, the difference in the yield from time of pruning in 1972 (Table 2) reflects mostly the tree mortality. Most tree deaths occurred in the spring of 1972 in plots pruned in late fall or early winter. Therefore, the close relationship between yield and mortality of pruned trees was expected with no cold injury to blossoms.

The yield from non-pruned trees in 1972 was higher than analysis of mortality data would indicate. In addition to having less mortality than winter pruned trees (7), non-pruned trees had more bearing surface than pruned trees which contributed to the higher yield in 1972.

Mechanisms involved in reduction in tree decline by the time of pruning are not known. Although cold injury reduction has been suggested (11), it has not been established. We have previously shown an association between cold injury and tree mortality (9). Data presented in the present study show that winter pruning increases susceptibility to cold injury of blossoms which suggests strongly that it would also increase susceptibility to cold injury of the wood and thereby contribute to decline. Trees that are in a state of decline exhibit discoloration in the cambium zone which resembles cold injury. However, observations made in the cambium area after cold temperature periods during the course of this study failed to establish that winter pruning increased cold injury to the wood. Based on data obtained in this study, I suggest that a subtle type of cold injury is involved in decline which is not easily discernible by the naked eye. We have shown (8) that cold injury can result in occlusion of xylem elements in peach trees which could account for an accumulative injury. Several factors are probably involved in peach tree decline. Data obtained in the present study give further evidence that cold injury is involved at some point in the decline process.

Literature Cited

1. Blake, M. A. 1921. Some results of pruning investigations with peaches. *Proc. Amer. Soc. Hort. Sci.* 18:213–222.
2. Brown, D. S., and R. W. Harris. 1958. Summer pruning of trees of early maturing peach varieties. *Proc. Amer. Soc. Hort. Sci.* 72:79–84.
3. Cain, J. C., and R. J. Mehlenbacher. 1956. Effects of nitrogen and pruning on trunk growth in peaches. *Proc. Amer. Soc. Hort. Sci.* 67:139–143.
4. Chandler, W. H. 1913. The killing of plant tissue by low temperature. *MO. Agr. Exp. Sta. Res. Bul.* 8:141–309.
5. ———. 1923. Results of some experiments in pruning fruit trees. *Cornell Agr. Exp. Sta. Bul.* 415.
6. Cullinan, F. P. 1925. Peach pruning studies. *Proc. Amer. Soc. Hort. Sci.* 22:246–252.
7. Daniell, J. W. 1973. Effects of time of pruning on growth and longevity of peach trees. *J. Amer. Soc. Hort. Sci.* 98:383–386.
8. ———, and F. L. Crosby. 1969. Occlusion of xylem elements in peach trees resulting from cold injury. *J. Amer. Soc. Hort. Sci.* 93:128–134.
9. ———, and ———. 1971. The relation of physiological stage, preconditioning, and rate of fall of temperature to cold injury and decline of peach trees. *J. Amer. Soc. Hort. Sci.* 96:50–53.
10. Harmon, F. N. 1933. Relation of pruning and thinning to fruit size and yield of Paloro peaches. *Proc. Amer. Soc. Hort. Sci.* 30:219–222.
11. Harris, R. W., and D. S. Brown. 1958. Summer pruning mature Merrill Beauty peach trees. *Proc. Amer. Soc. Hort. Sci.* 71:88–94.
12. Havis, L. 1951. Pruning peach trees at different periods in the spring. *Proc. Amer. Soc. Hort. Sci.* 58:14–18.
13. ———, and A. L. Gilkeson. 1951. Interrelationship of nitrogen and potassium fertilization and pruning practice in mature peach trees. *Proc. Amer. Soc. Hort. Sci.* 57:24–30.
14. Hibbard, A. D. 1948. The effect of severity of pruning on the performance of young 'Elberta' peach trees. *Proc. Amer. Soc. Hort. Sci.* 52:131–136.
15. Keffer, C. A. 1914. Summer-pruning the peach. *TE Agr. Exp. Sta. Bul.* 108.
16. Morris, J. R., A. A. Kattan, and E. H. Arrington. 1962. Responses of Elberta peaches to the interactive effects of irrigation, pruning, and thinning. *Proc. Amer. Soc. Hort. Sci.* 80:177–189.
17. Savage, E. F., and F. F. Cowart. 1942. The effect of pruning upon the root distribution of peach trees. *Proc. Amer. Soc. Hort. Sci.* 41:67–70.
18. ———, R. A. Hayden, and W. E. Ward. 1963. The effect of type and season of pruning on growth and yield of Dixigem peach trees. *GA Agr. Exp. Sta. Bul.* 109. p. 18.
19. ———, ———, and ———. 1964. Severity of pruning of 'Elberta' peach trees as it affects growth and yield. *GA Agr. Exp. Sta. Bul.* 127.
20. Schrader, A. L., and E. C. Auchter. 1928. Peach pruning in Maryland. *MD Agr. Exp. Sta. Bul.* 299.
21. Schneider, G. W., and F. E. Correll. 1956. Peach pruning studies in the North Carolina Sandhills. *Proc. Amer. Soc. Hort. Sci.* 67:144–152.
22. ———, and A. C. McClung. 1957. Interrelationships of pruning, nitrogen rate and time of nitrogen application in Halehaven peach. *Proc. Amer. Soc. Hort. Sci.* 69:141–147.
23. Westwood, M. N., and R. K. Gerber. 1958. Seasonal light intensity and fruit quality factors as related to the method of pruning peach trees. *Proc. Amer. Soc. Hort. Sci.* 72:85–91.

Effect of Short-Term High CO_2 Treatment on Storage of 'd'Anjou' Pear[1]

C. Y. Wang and W. M. Mellenthin

Mid-Columbia Experiment Station, Hood River, OR

Abstract. Treatment of 'd'Anjou' pears (*Pyrus communis* L.) with high CO_2 atmosphere for a short period immediately following harvest prolonged storage life, retarded ethylene production, delayed the climacteric rise in respiration, reduced loss of malic acid, suppressed increase in protein N, retained firmness, quality and the capacity to ripen after long storage. Treatment with 12% CO_2 for 2 or 4 weeks provided the best results without injury.

The use of high CO_2 atmosphere for a short period immediately following harvest to retain fruit quality has recently attracted considerable interest. Couey and Olsen (5) treated 'Golden Delicious' apples with 20% CO_2 for 10 days at the beginning of storage and found that the rapid softening was delayed and loss of titratable acidity reduced. Looney (12) reported that exposure of 'McIntosh' apples to 10% CO_2 for 6 days immediately following harvest suppressed both ethylene production and softening.

Long term storage with atmospheres containing CO_2 levels above

[1] Received for publication November 23, 1974. Technical paper 3933. OR Agricultural Experiment Station. This study was supported by the Washington State Tree Fruit Research Commission and the Hood River Grower-Shipper Association.