Table 4. Mean value for mineral leaf content of pecan seedlings grown in 11.4-liter containers for 16 weeks (June 15–October 5, 1981).

	Leaf concn (dry-wt basis)						
Main effects	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)
Medium[z]							
1 : 1 mix	3.41 a [y]	0.46 a	1.53 a	1.07 b	0.81 a	83 a	94 a
1 : 4 mix	4.02 b	0.68 b	1.70 a	0.97 a	0.89 b	78 a	147 b
Cultivar							
Davis	3.47 ab[y]	0.69 a	1.55 a	1.04 a	0.80 b	82 a	137 a
Farley	3.57 ab	0.46 a	1.75 a	1.05 a	0.85 ab	91 a	111 a
Harris Super	3.33 b	0.44 a	1.60 a	1.00 a	0.79 b	81 a	129 a
Lewis	3.89 ab	0.61 a	1.50 a	1.09 a	0.94 a	70 a	129 a
Yawn School	4.04 a	0.65 a	1.67 a	0.93 a	0.87 ab	79 a	96 a

[z]Pinebark:sand
[y]Mean separation in columns by Student Newman Keuls' multiple range test, 5% level.

growing media have been shown to affect partitioning. Increasing soil moisture has been related to reduced root/shoot ratios (2). However, water-holding capacities between the 2 media studied were not very different (Table 2) and moisture release curves from 0.1 to 1 bar pressure were very similar (not shown).

Soil aeration is known to influence root behavior. Greenwood (5) concluded that root growth was affected severely only in soils containing less than 1% oxygen by volume in air spaces. The aeration porosity of the 2 media studied were different. However, pore space of both were adequate for gaseous exchange (Table 2).

Increased nutrient concentration in the growing medium has been found to correlate with a lower root/shoot ratio (2, 8). The 4 : 1 mixture should theoretically have a greater capacity for retaining nutrients (Table 2). On this basis, rootstocks in the 4:1 mixture should have a lower root/shoot ratio than those grown in the 1 : 1 mixture. In fact, the root/shoot ratio was larger (Table 1).

Bulk density of soils affects root penetration (12), with lighter soils favoring root penetration. The 4 : 1 mixture had a much lower bulk density (Table 2). Taproots of seedlings grown in this mixture had significantly greater penetration into the medium. Mean taproot depth was 14.9 cm for these seedlings, whereas taproots in the 1 : 1 mixture had a mean depth of only 9.8 cm. The lower mechanical resistance to root growth in the 4 : 1 mixture might have influenced root/shoot ratios.

Cultivar effects. Dry-matter partitioning differed among the cultivars studied. 'Yawn School' had the smallest proportion of total dry weight in the root, while 'Harris Super' had the largest (Table 1).

Media × cultivar interaction. The total dry weight of 'Farley' and 'Yawn School' seedlings was affected adversely by the 4 : 1 mixture (Table 3). Lunt and Clark (7) found that growth depression of some plant species grown in bark was overcome by N fertilization. However, nutrient status of the plants as measured by leaf analysis did not explain the adverse effect of the 4 : 1 mixture in this experiment. Leaf content of plants in that medium had higher N, P, Mg, and Mn levels, lower Ca levels, and no differences in K or Fe content compared with plants in the 1 : 1 mixture (Table 4).

The pH of the 2 media was too high (Table 2), indicating the application of excessive dolomitic limestone. The pH does not account for the differences in cultivar response to the media, however, since the medium with the pH nearer the acceptable range was the mixture that affected some cultivars adversely.

The reason for the cultivar response to different media has not been explained. Since differences exist, it is important to ensure that the cultivar and the growing medium are compatible so that strong, healthy pecan rootstocks may be produced.

Literature Cited

1. Acock, M.C. 1981. Mineral nutrition and sources of variability in container grown pecan seedlings. MS Thesis, Mississippi State Univ., Mississippi State.
2. Brouwer, R. 1965. Root growth of cereals and grasses, p. 153–166. In: F.L. Milthorpe and J.D. Ivins (eds.). The growth of cereals and grasses. Butterworths, London.
3. Brown, E.F. and F.A. Pokorny. 1975. Physical and chemical properties of media composed of milled pine bark and sand. J. Amer. Soc. Hort. Sci. 100:119–121.
4. Criley, R.A. and R.T. Watanabe. 1974. Response of chrysanthemum in four soilless media. HortScience 9:385–387.
5. Greenwood, D.J. 1969. Effect of oxygen distribution in the soil on plant growth, p. 202–221. In: W.J. Whittington (ed.). Root growth. Butterworths, London.
6. Laiche, A.J., Jr. 1976. Growth evaluation studies of one year pecan seedlings of selected varieties, seed treatments and growing methods. Proc. S.E. Pecan Grow. Assn. 69:169–177.
7. Lunt, O.R. and B. Clark. 1959. Bark and wood fragments. For. Prod. J. 9(4):39A–42A.
8. Nielsen, K.F. and R.K. Cunningham. 1964. The effects of soil temperature, form and level of N on growth and chemical composition of Italian ryegrass. Proc. Soil Sci. Soc. Amer. 28:213–218.
9. Overcash, J.P. 1981. Pecans—their first love. Pecan South 8:40–44.
10. Polizotto, K.R., G.E. Wilcox, and C.M. Jones. 1975. Response of growth and mineral composition of potato to nitrate and ammonium nitrogen. J. Amer. Soc. Hort. Sci. 100:165–168.
11. Sloan, R.C. and J.P. Overcash. 1980. Growing pecan nursery trees in containers. Proc. S.E. Pecan Grow. Assn. 73:149–157.
12. Taylor, H.M., G.M. Roberson, and J.J. Parker. 1966. Soil strength–root penetration relations for medium to coarse-textured soil materials. Soil Sci. 102:18–22.
13. Waters, W.E., W. Llewellyn, and J. NeSmith. 1970. The chemical, physical and salinity characteristics of twenty-seven soil media. Proc. Fla. State Hort. Soc. 83:482–488.

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Cotyledon Detachment and Growth of Pecan Seedlings

Hazel Y. Wetzstein, Darrell Sparks, and Gregory A. Lang
Department of Horticulture, University of Georgia, Athens, GA 30602

Additional index words. shoot elongation, dry weight, survival mechanism, *Carya illinoensis*

Abstract. **The cotyledons of pecan [*Carya illinoensis* (Wang.) K. Koch] seed remain fleshy and turgid throughout an attachment period of several weeks after germination. The growth (dry weight) of the developing seedling was dependent on the cotyledons for the first 3 weeks of the 6–10 week attachment period.**

The kernel of the pecan nut contains about 70% fat (8, 14). This is more than other nut crops; i.e., cashew, pistachio, almond, and filbert have 47%, 55%, 58%, and 64% fat, respectively (3, 14). The pecan seed is large; 'Curtis', a nut commonly used in nurseries, weighs about 5.5 g and contains about 59% kernel. A single pecan seed thus contains appreciable quantities of food reserves.

Germination of pecan seed is hypogeous with the cotyledons remaining enclosed within the stony endocarp. The cotyledons remain attached to the seedling in a fleshy and turgid condition for several weeks after germina-

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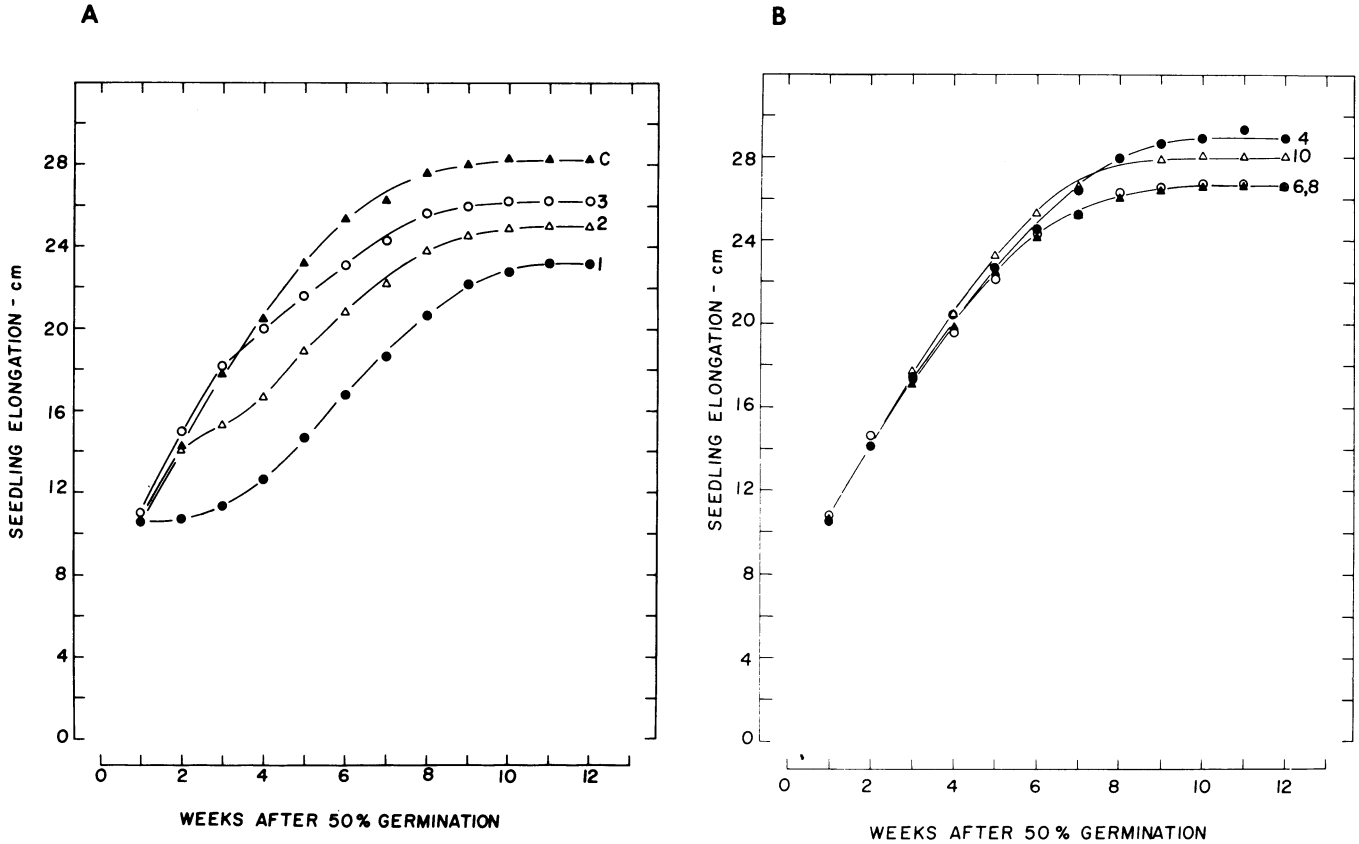

Fig. 1. Shoot elongation of pecan seedlings as affected by time of cotyledon removal. C = control; 1, 2, 3, 4, 6, 8, and 10 = cotyledons removed at corresponding weeks after 50% germination. Elongation rate was suppressed when cotyledons were removed during the first three weeks.

tion. This contrasts with the rapid breakdown and mobilization of reserves during early seedling development of many other species (12) and suggests that the pecan seedling is dependent on the cotyledons for an extended period of time. The objectives of this study were to determine how long and to what extent the seedling is dependent on reserves stored in the cotyledons.

Stratified seeds (10) of 'Curtis' pecan were planted in a greenhouse in 28-cm pots filled with perlite, with one seed per pot. Water and Hoagland's solution (5) were applied as previously described (11). Cotyledons were excised from seedlings 1, 2, 3, 4, 6, 8, and 10 weeks after germination. Germination (the time when the epicotyl of 50% of the seeds had emerged) occurred 13 days after planting. The seedlings were in the initial leaf-expansion stage on the first removal date (one week after germination). Prior to each treatment time and after 12 weeks, notations were made as to whether the cotyledons were still attached to the seedlings. The experimental design was a randomized complete block replicated 8 times with 3 seedlings per plot.

Shoot elongation was determined weekly. Plants were harvested after 12 weeks and leaves per seedling counted. Plants were oven-dried for 72 hr at 70°C and weighed.

The cotyledons remained attached for at least 6 weeks following germination (Table 1). The cotyledons did not show the shriveling generally associated with exhaustion of reserves. The cotyledons separated from the seedling at the cotyledonary petioles.

Manual detachment of the cotyledons during the first 3 weeks following germination suppressed seedling dry weight and shoot length, but not the number of leaves per seedling (Table 2). Detachment also affected rate of shoot elongation (Fig. 1). Elongation was initially suppressed with a subsequent resumption of more rapid rates. Seedling growth was dependent on cotyledonary reserves for 3 of the 6–10 week attachment period (Tables 1 and 2).

Varner (12) stressed that the most conspicuous feature of the metabolism of the cotyledons and the endosperm of germinating seeds is the dramatic disappearance of the reserve materials. Germination data for fatty seeds confirm this contention. For example, in Douglas fir seed, stored materials were exhausted within 9 days from radicle emergence (1, 2). Two-thirds of the fat had disappeared from sunflower cotyledons in 7 days and nearly 95% in 14 days after germination (9). Fats were largely used in soybean 4 days after germination (13), and in cotton more

Table 1. Percentage of pecan seedlings with attached cotyledons.

Weeks after 50% germination	Seedlings with attached cotyledons (%)
1	100
2	100
3	100
4	100
6	100
8	62
10	29
12	0

Table 2. Effect of cotyledon detachment on pecan seedling growth (12 weeks after 50% germination).

Time of cotyledon detachment after 50% germination (wk)	Shoot length (cm)	Leaves (no./seedling)	Dry wt/seedling (g)
1	23.4 a[z]	11.6 a	10.7 a
2	25.1 ab	11.6 a	17.3 b
3	26.3 bc	11.4 a	20.0 c
4	28.9 c	12.4 a	22.3 d
6	26.7 bc	11.4 a	23.9 d
8	26.7 bc	11.1 a	22.6 d
10	28.1 c	11.0 a	23.2 d
Control	28.1 c	11.6 a	23.2 d

[z]Mean separation for a given column by Duncan's multiple range test, 5% level.

than 90% was used within 5 days (15). Pecan differs markedly. Stratified cotyledons, just prior to planting, contained 62% lipids. Four weeks following germination, the cotyledons still contained 32% lipids (unpublished data).

The unusually high fat content in the pecan seed and the long dependency period of the seedling on these reserves appear to be an adaptive survival mechanism that makes it possible for the seedling to become established under adverse environmental conditions. Observations show that taproot elongation is extensive during the dependency period. A deep root system would increase the chance for survival. In other tree species that begin their life cycle in deep forests, maximal height, survival, and presumably root growth increase with mean seed weight (4). The continued attachment of apparently healthy cotyledons after the pecan seedling is self-sufficient may be an additional survival mechanism that allows regeneration of the top when it is destroyed early in its development. This is supported by the common observation that pecan seedlings that have been damaged or have died back frequently resume growth from axillary buds.

The use of carbon from stored reserves for early shoot, root, flower, and fruit development has been demonstrated in pecan (6, 7). However, information on the use of cotyledonary reserves during germination is lacking. To what extent these reserves are used needs further investigation.

Literature Cited

1. Ching, T.M. 1963. Fat utilization in germinating Douglas fir seed. Plant Physiol. 38:722–728.
2. Ching, T.M. 1966. Compositional changes of Douglas fir seeds during germination. Plant Physiol. 41:1313–1319.
3. Eagan, K.J. 1979. The role of nuts in human nutrition, p. 448–450. In: R.A. Jaynes (ed.). Nut tree culture in North America. No. Nut Growers Assn., Hamden, Conn.
4. Grime, J.P. and D.W. Jeffrey. 1965. Seedling establishment in vertical gradients of sunlight. J. Ecol. 53:621–642.
5. Hoagland, D.C. and D.I. Arnon. 1950. The water culture method for growing plants without soil. Calif. Agr. Expt. Sta. Cir. 347.
6. Lockwood, D.W. and D. Sparks. 1978. Translocation of ^{14}C in 'Stuart' pecan in the spring following assimilation of $^{14}CO_2$ during the previous growing season. J. Amer. Soc. Hort. Sci. 103:38–45.
7. Lockwood, D.W. and D. Sparks. 1978. Translation of ^{14}C from tops and roots of pecan in the spring following assimilation of $^{14}CO_2$ during the previous growing season. J. Amer. Soc. Hort. Sci. 103:45–49.
8. Melville, R. 1947. The nutritive value of nuts. Chem. Indus. 22:304–306.
9. Miller, E.C. 1938. Plant physiology. McGraw-Hill, New York.
10. Sparks, D., J.W. Chapman, and D.W. Lockwood. 1974. Stratification promotes germination. Pecan Quart. 8(1):13.
11. Sparks, D. 1977. Effect of nutrition on dieback of germinating 'Curtis' pecan seedlings. HortScience 12:496–497.
12. Varner, J.E. 1963. Seed development and germination, p. 763–792. In: J. Bonner and J.E. Varner (eds.). Plant biochemistry. Academic Press, New York.
13. Von Ohlen, F.W. 1931. A microchemical study of soybean during germination. Amer. J. Bot. 18:30–49.
14. Watt, B.K. and A.L. Merrill. 1963. Composition of foods. Agr. Handb. 8.
15. White, H.B., Jr. 1958. Fat utilization and composition in germinating cotton seeds. Plant Physiol. 33:218–226.

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Hoeing and Hand-held Wiper Application of Glyphosate for Weed Control in Vegetables

Howard F. Harrison, Jr.[1]
U.S. Vegetable Laboratory, ARS, U.S. Department of Agriculture, 2875 Savannah Highway, Charleston, SC 29407

Additional index word. herbicide

Abstract. **Hoeing and glyphosate (*N*-(phosphomomethyl)glycine) application with a hand-held wiper were compared for weed control in mixed vegetable plantings. Weed control with wiper-applied glyphosate required significantly less labor and expense than hoeing. Vegetable yields were similar in hoed and wiper-weeded plots and both methods increased the yields of some vegetable species over yields from unweeded plots. Yellow nutsedge (*Cyperus esculentus* L.) shoot populations were reduced significantly by wiper weeding but not by hoeing.**

In recent years, glyphosate applied with rope wick and other types of wiper applicators has become an effective weed control technique for several crops (3, 4). Wiper applicators allow the selective application of nonselective herbicides. They also use less herbicide than conventional sprayers, and reduce expense and the risk of harmful environmental effects. Several hand-held wipers are marketed for use by growers or homeowners. These devices generally consist of a small rope or sponge wiper attached to a PVC pipe handle which contains the herbicide solution in a reservoir (2). Hand-held wipers are relatively inexpensive and appear to offer an attractive alternative to the labor-intensive practices of hoeing or pulling weeds. The purpose of this study was to compare glyphosate application with a hand-held wiper with hoeing for weed control in vegetable crops.

Field experiments were conducted in 1981 and 1982. Plots consisted of one 7.6 m row each of 4 vegetable species with 1 m between rows. Lima beans (*Phaseolus lunatus* L. cv. Jackson Wonder), southernpeas [*Vigna unguiculata* (L.) Walp. cv. Mississippi Silver], eggplant (*Solanum melongena* L. cv. Florida Market), and squash (*Cucurbita pepo* L. cv. Yellow Crookneck) were planted in 1981 and southernpea, lima bean, tomato (*Lycopersicon esculentum* L. cv. Patriot), and okra [*Abelmoschus esculentus* (L.) Moench. cv. Clemson Spineless] were planted in 1982. Okra and tomato were planted in 1982 because they are better adapted to the late season than squash or eggplant. Seeds of lima bean, southernpea, and okra were planted, and seedlings of eggplant, squash, and to-

Table 1. Effect of weeding by hoeing and by glyphosate application with a hand-held wiper on vegetable yields.[z]

Weed control practice	Yield (MT/ha)							
	1981				1982			
	Squash	Eggplant	Southernpea	Lima bean	Tomato	Okra	Southernpea	Lima bean
Control	0.5 b	0 b	2.0 b	6.2 b	1.3 b	1.0 a	3.1 b	2.4 b
Hoed	4.7 a	1.7 a	7.1 a	5.0 a	4.2 a	1.5 a	4.2 a	5.8 a
Wiper-weeded	3.2 ab	1.1 a	5.9 a	4.0 a	4.3 a	1.4 a	4.7 a	5.2 a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

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[1]Research Agronomist.