we are looking for in many new introductions are minute differences rather than substantial market niches that will sell plants. Many of the differences we look for are not marked enough to be worthy of introductions.

Thursday Afternoon, December 10, 1987

The afternoon session was convened at 1:30 p.m. with Chris Graham serving as moderator.

RED OAK WHIP PRODUCTION IN CONTAINERS

DANIEL K. STRUVE

Department of Horticulture
Ohio State University
Columbus, Ohio 43210

MIKE A. ARNOLD

Department of Horticulture
North Carolina State University
Raleigh, North Carolina 27695

DAVID H. CHINERY

Department of Horticulture
Ohio State University
Columbus, Ohio 43210

Abstract. A system is described whereby the equivalent of 1-year-old red oak whips can be produced in 7 months, starting from seed.

INTRODUCTION

Currently red oak whips are produced as follows: In the first year, seeds are sown in fall or spring. The resulting 1- or 2-year-old seedlings are dug from seed beds and lined out in field rows. If the liners produce more than 18 in. of new growth the first season, they are cut back to 2 in. in height the next spring. If growth following lining out is poor, the cutting back is delayed one year. After cutting back the most vigorous young shoot is selected and trained vertically, resulting in 5 to 8 ft whips by the end of the growing season. Hence, the present whip production system requires 3 to 5 years to produce a 1-year whip.

Starting from seed, the system described in this paper can produce the equivalent of a 1-year whip in seven months. Seeds are germinated and container-grown under greenhouse conditions for 10 weeks. They are then acclimated to outdoor conditions for 2 weeks, up-canned and grown for the remainder of the season under standard container growing practices. The system combines the Accel-O-Gro concept (4) with growing plants in copper-treated containers (1,2,3,5,7).

Container production systems for oak have been described previously (5,8). However, these systems used greenhouses or polytunnels for the entire production cycle, where the present system uses greenhouse facilities for only the first 10 weeks.

SYSTEM DESCRIPTION

About March 1, red oak seeds were broadcast in flats on moist peat moss and the flats placed under intermittent mist for seeds to germinate. Germination uniformity can be increased by previously soaking the seeds overnight in tap water. When the radicles are at least 1 cm in length, the seeds are sown 1 cm deep in one gallon round plastic pots and covered with growing medium: pine bark: sand: peat moss (3:1:1,v/v/v). Containers were placed pot to pot at approximately 15 cm (6 in.) square spacing on greenhouse benches. Once the seedling shoots have emerged, a medium-saturating soil drench of micro-nutrients (S.T.E.M. at 170.4 g/22.7 liters of water (6 oz/5 gal), Peters Fertilizer Products, W. R. Grace and Co.), and 16 g (1 tablespoon) of 18-6-12 Osmocote (Sierra Chemical Co) was applied to each container. Once per week the plants were fertilized with 200 ppm N from 20-20-20 water soluble fertilizer (Peters Fertilizer Products).

The plants were grown under the following conditions: natural daylight supplemented from dusk with 45 to 60 $\mu mol/sec^{-1} 1/m^{-2}$ PAR from high pressure sodium lamps to give a 20-hr photoperiod, temperature set at 25/19°C day/night. Plants were watered as needed. Research conducted in 1987 showed that similar sized plants could be produced without the extended photoperiods of high intensity light (Chinery, unpublished data).

The inner container surfaces were painted with a mixture of 100 g $CuCO_3$/liter white latex paint and air dried before seeds were sown. The $CuCO_3$-treated surfaces inhibit root elongation upon contact (1). This eliminates the need to root prune to correct root system deformity caused by matted, kinked, or circling roots.

On May 15 (the last frost date in Columbus, Ohio) plants were transferred to 70% shade in the outdoor container growing area. After a two-week acclimation period the plants were repotted to 5 gallon fiber containers (Kord Products Limited, 390 Orenda Road, Bramalea, Ontario L6T 1G8). The 3R1109 fiber pots were specially formulated to control root growth in a manner similar to the $CuCO_3$-

treated plastic containers used previously. The same pine bark:sand:peat growing medium was used. After up-canning, the plants were placed in full sun on 41 × 46 cm (16 × 18 in.) spacing. The plants were given a second soil drenching with micro-nutrients and 32 g (2 tablespoons) of 18-6-12 Osmocote was added to each container. The plants were fertilized weekly with 280 ppm N 30-10-10 water soluble fertilizer (Plant Marvel, Chicago Heights, IL). Plants were staked to promote the development of a straight central leader and lateral buds were pinched off until plants reached 5 ft in height. Throughout the production cycle insect pests were controlled using commercially recommended sprays. In 1987 83% of the plants transferred from the greenhouse to the container area were ≥ 100 cm (3¼ ft) and 47% were ≥ 150 cm (5 ft) by September. The tallest plants approached 8 ft in height (Figure 1). To encourage caliper growth stakes were removed in September. Stem caliper ranged from 1 to 2 cm (½ to ¾ in.).

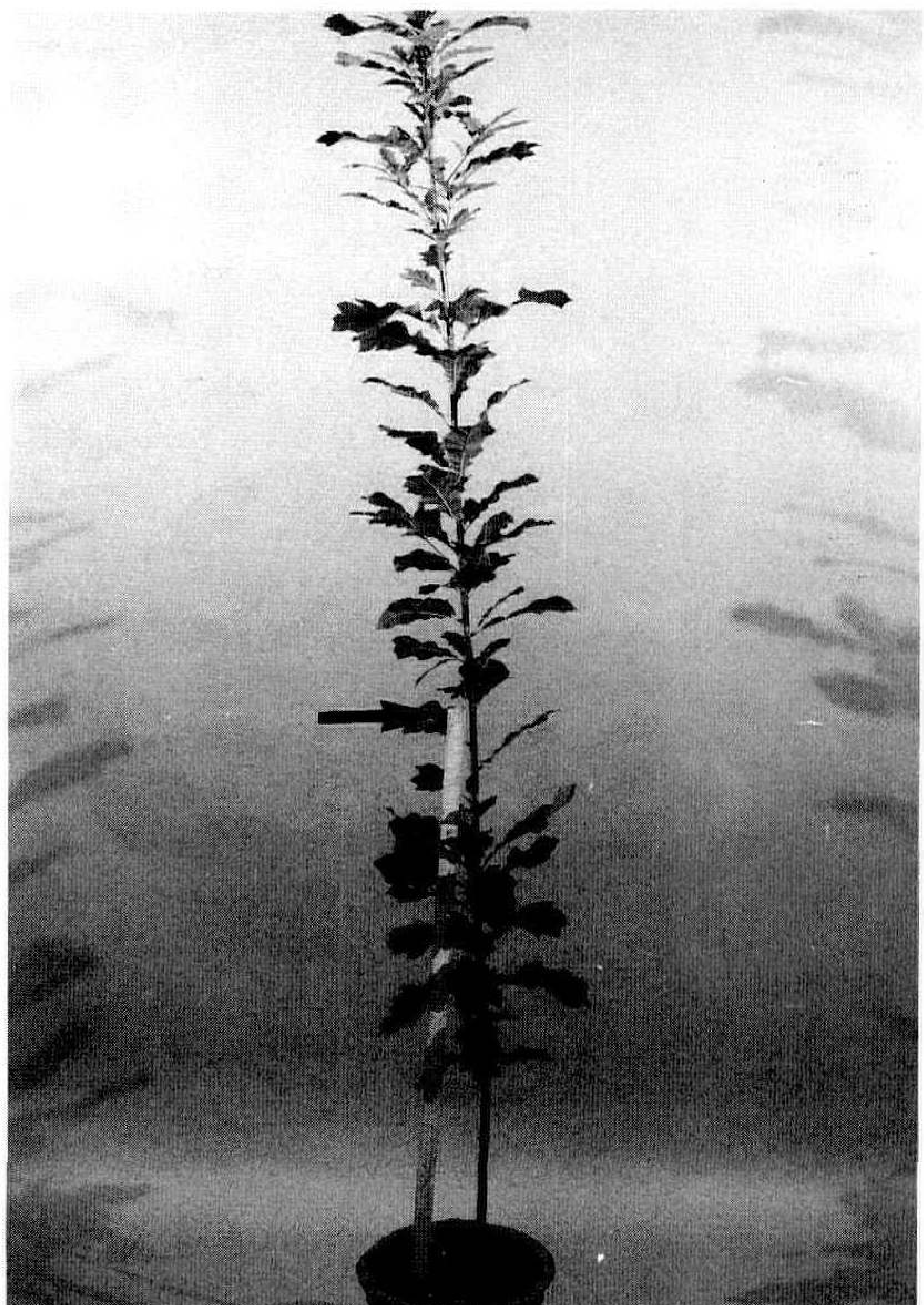

Figure 1. Red oak grown from seed to 8 ft height in 7 months under the conditions described in the text. The container is 13 in. diameter. The top of the meter stick is indicated by the arrow.

REGROWTH POTENTIAL

Red oak whips produced in containers in 1986 were field-planted in October, 1986. Plants were spaced 1.2 m within rows and 3.9 m between rows (4 × 10 ft). In March, 1987, overwintered container-produced whips were planted at similar spacing. At the same time 5 ft bareroot red oak whips were planted. In total, 120 container-grown (90 fall-planted, 30 spring-planted) and 30 bareroot whips were planted.

All plant material produced one flush of growth during the dry (April to October rainfall averaged 6 to 9 in. below normal) 1987 growing season. The plants received no irrigation. Container-produced whips averaged 45 cm (18 in.) of shoot growth, while bareroot stock averaged 15 cm (6 in.). No container produced whips were lost during 1987. Five bareroot whips were lost.

REASONS FOR RAPID GROWTH

The rapid growth can be attributed to extending the growing season and eliminating transplant shock. Plant growth is exponential: i.e. the amount of growth a plant can produce is dependent on present plant size. By starting the seedlings in a greenhouse, 10 extra weeks are added to the growing season. Although seedlings are not large at the end of the 10-week greenhouse production phase, great dividends are paid at the end of the growing season (Figure 2).

Copper-treated pots eliminate root pruning to correct root system malformation. When roots contact the copper-treated surfaces root elongation is inhibited, and circling, matted, and girdling roots do not develop. However, root regeneration potential remains high once the copper-treated container is removed for transplanting. Within 3 to 6 days root elongation resumes at rates similar to roots which had not contacted copper treated surfaces (1).

In one study root pruning to correct root system malformation removed up to 75% of lateral root dry weight in green ash and red oak (1). Root-pruned plants also had lower root regeneration potential and reduced shoot growth compared with non-root-pruned plants grown in copper-treated containers (1).

BENEFITS OF CONTAINER-PRODUCED WHIPS

The system described for production of containerized red oak whips has several advantages over present production techniques:

1) Plants can be marketed more effectively. Orders for fall or spring delivery of 1-year-red oak whips could be taken until March of the year of production. Typically, orders are booked 3 years in advance, the minimum production time.

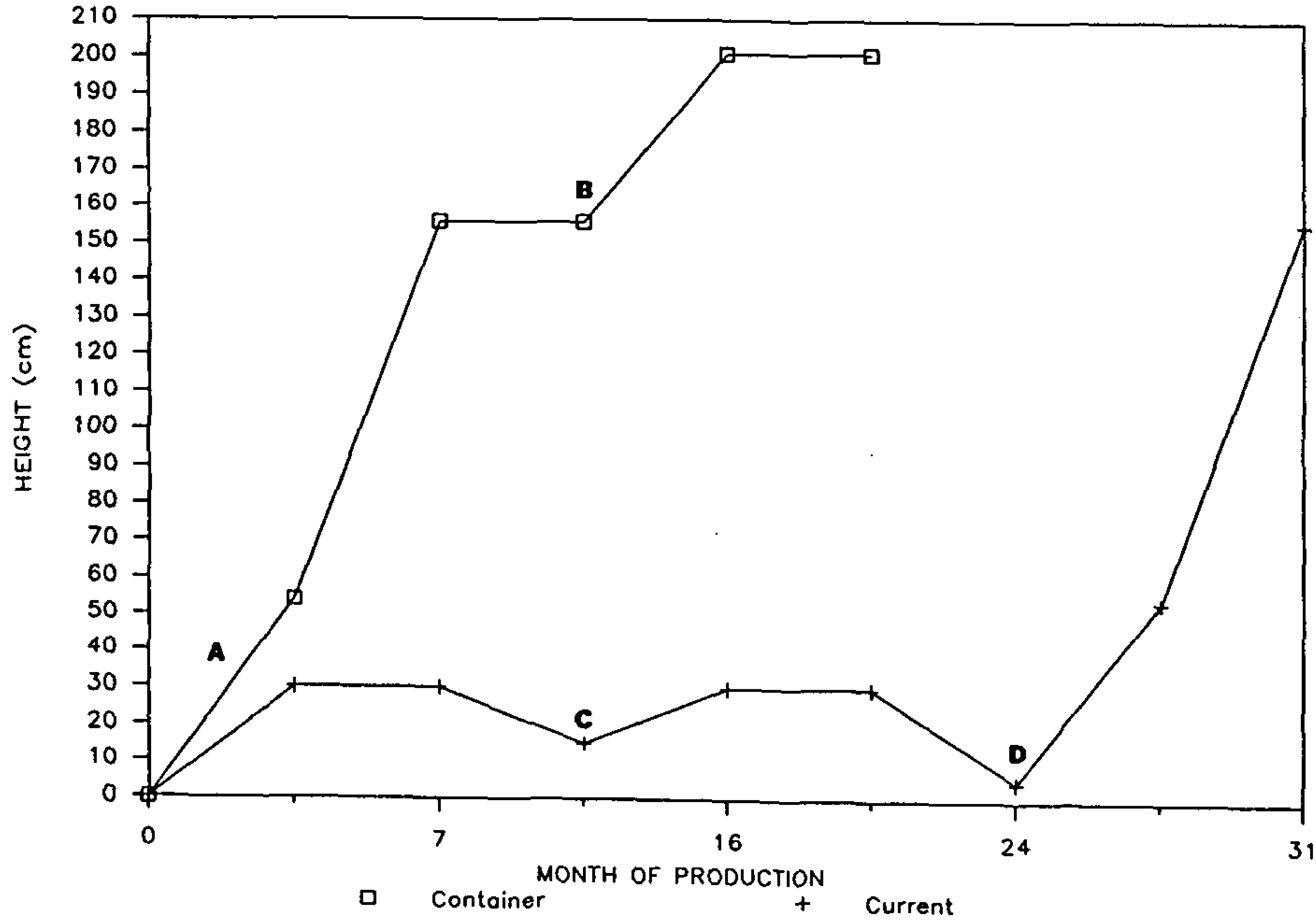

Figure 2. Growth of red oak whips produced under conditions described in the text (□) and under typical production practices (+). "A" is the point where seedlings are transferred from the greenhouse to the container production area, "B" is the point where container grown whips were transplanted to the field, "C" is the point where 1-year-old seedlings are pruned and lined out in the field and "D" is the point where the lined out stock is cut back and whip training begins.

2) Production efficiency is increased. Only enough acorns to cover orders for whips need to be sown (with an additional allowance for grade-out or speculation), thus avoiding speculating on market conditions 3 to 5 years in the future.

3) The container-produced whips have high root regeneration potential, allowing for rapid establishment upon field planting or up-canning. We expect to be able to produce 1½ to 1¾ in. caliper red oaks within 4 years, starting from seed.

4) The system can be used to grow other oak species and other genera (i.e. 8 ft 'Autumn Flame' red maple were produced in 7 months starting with 4 in. tall rooted microcuttings).

Acknowledgment: This research was supported in part by grants from Kord Products, Ltd., Bramalea, Ontario L6T 1G8 and from the Long Island Nurserymen's Association, Inc. Riverhead, N.Y.

LITERATURE CITED

1. Arnold, M. A. 1987. Cupric carbonate modification of *Quercus rubra* and *Fraxinus pennsylvanica* root systems and implications for production and trans-

plant. M.S. Thesis. The Ohio State University.

2. Burdett, A. N. 1978. Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine. *Can. Jour. For. Res.* 8:483–486.
3. Burdett, A. N. and P. A. F. Martin. 1982. Chemical root pruning of coniferous seedlings. *HortScience* 17:622–624.
4. Hanover, J. W., E. Young, W. A. Lemmien, and M. Van Slotten. 1976. Accelerated-Optimal-Growth: A new concept in tree production. Res. Rept. 317, Michigan State University. Agr Extp. Stat., East Lansing.
5. McDonald, S. E., R. W. Tinus, and C. P. B. Reid. 1984. Modification of ponderosa pine root systems in containers. *Jour. Env. Hort.* 2:1–5.
6. Maxfield. S. J. F. 1975. Speeding up oak production with extended daylength. *Proc. Inter. Plant Prop. Soc.* 25:171–178.
7. Ruehle. J. L. 1985. The effect of cupric carbonate on root morphology of containerized mycorrhizal pine seedlings. *Can. Jour. For. Res.* 15:583–592.
8. Wells, P. 1977. Seedling oak production in containers. *Proc. Inter. Plant Prop. Soc.* 27:75–78.

ETIOLATION TO IMPROVE SOFTWOOD CUTTING PROPAGATION: ASPECTS OF HORMONE APPLICATION AND TIMING OF TAKING CUTTINGS

BRIAN K. MAYNARD AND NINA L. BASSUK

Department of Floriculture and Ornamental Horticulture
Cornell University
Ithaca, New York 14853

Abstract. The research presented here focuses on the factors affecting hormone application and timing of taking etiolated cuttings, with the goal of developing etiolation and banding into practical methods for use by the plant propagator. Etiolation was found to be more beneficial than banding when applied to 4 cultivars of *Fagus sylvatica* and 2 of 4 cultivars of *Acer saccharum*. In experiments with 2 cultivars of *Syringa reticulata*, banding, with or without etiolation, was most beneficial in stimulating rooting. The treatment of *S. reticulata* cuttings with 4000 ppm IBA was of little additional benefit. Conversely, cuttings from etiolated shoots of *Stewartia pseudocamellia* rooted best, the effect still evident after 2 months greening. Hormone applied at sticking was of a significant benefit to the rooting of *Stewartia* cuttings.

INTRODUCTION

Etiolation is a process which involves growing shoots in the dark. This technology has had a place in the efforts of plant propagators to improve the rooting of softwood cuttings since F. E. Gardner reported in 1937 on his success in rooting etiolated apple cultivar cuttings (4). In the past 50 years perhaps the greatest contribution toward developing etiolation and its related technique of banding into methods of practicality to the nurseryman has been made by Howard and co-workers at the East Malling Research