ACCELERATED GROWTH OF BIRCH IN CONTROLLED ENVIRONMENTS

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Abstract. The growth of paper bırch (*Betula papyrifera* Marsh) and European whıte bırch (*Betula verrucosa Ehrh.*) plants was greatly accelerated by growıng them for 4 to 8 weeks during the seedling stage under controlled-envıronment conditions By provıdıng plants with a "head start" at the seedlıng stage, and then maıntaınıng them on long days, ıt was possıble to obtaın whıte bark on trees ın 2 years rather than after 3 or more years

INTRODUCTION

Durıng the past several years, a cooperative program has been carrıed out at Beltsville to determıne the optimum environment for seedling growth of selected herbaceous and woody plants Some of these results wer presented at the 18th Annual Meeting of the Plant Propagators' Society (8).

These studies have demonstrated the feasibility of using controlled environments to provide a "head-start" for a wide range of horticultural species, including F_1-hybrid annuals (4, 6, 7, 8, 9, 15), vegetables (3, 4, 5, 15), and woody plants (10, 11, 12, 13, 18).

In thıs paper I will briefly describe some of the highlights of the research done sınce 1968 to accelerate the growth of birch by the use of controlled environments.

ENVIRONMENTAL SYSTEM

Initially plants were grown under precisely controlled conditions ın experimental growth chambers (1, 4, 16). In 1970, a custom-made propagatıon unit was constructed by agticultural engineers Herschel H Kleuter and Willıam A. Bailey. This facility (2) has resulted in only modest control of the envıron ent and at far less cost. Plans of thıs unıt[3] may be of ınterest to nurserymen.

To extend the time of treatment from 4 weeks to 8 weeks or longer, large commercial walk-in growth chambers have also been used (10)

[1]Plant Physıologıst, Plant Stress Laboratory

[2]Mentıon of trademark name or a proprıetary product does not ımply ıts approval by the USDA to the exclusıon of other products that may also be avaılable

[3]Plan No 6101 — "Propagatıon Unıt for Plants" may be obtained from the Extensıon Agrıcultural Engıneer at each State University.

CULTURAL PROCEDURES

Plant material consisted initially (11) of European white birch (*Betula verrucosa* Ehrh), but during the past 3 years most of the work has been done with paper birch (*Betula papyrifera* Marsh) (10, 17).

In initial studies, seed were stratified at 1° C (34° F) for about 30 days, germinated on moist filter paper in petri dishes at 22° to 25° C (72° F), and selected for germination under a dissecting microscope when the radicle had begun to emerge. At that time, they were transplanted to 7.5 cm (3-inch) plastic pots containing a peat-vermiculite mix (sold commercially as Jiffy-Mix)[2] and placed in a greenhouse or growth chamber. The procedure proved to be a reliable method of assuring viable seedlings, but was too laborious to be useful

At present, the seed are planted directly in a shallow plastic tray of peat-vermiculite mix without prior stratification, then placed under mist in a propagation unit (2) or covered with plastic film and allowed to germinate in a controlled environment under about 1,000 ft-c (10.8 klx) of cool white fluorescent light.

Experimental treatment is usually begun when the first true leaf is 3 to 5 mm in length. At this time the seedlings are selected for uniformity, transferred to 7.5-cm pots of peat-vermiculite mix, and placed in a greenhouse or growth chamber. After 4 to 5 weeks they are shifted to 10 cm (4-inch) pots, and after 8 weeks to 15 cm (6-inch) pots. After 3 to 4 months they are transferred again to 20-cm (8-inch) or 25-cm (10-inch) pots.

TYPICAL RESULTS

Several studies were conducted on paper birch seedlings in a custom-designed propagation unit (2), which provided high light intensity (2,500 ft-c) (26.9 klx) and automatic watering, but otherwise only modest control of the environment. Day temperatures were 25° to 27° C (77° to 81° F), night temperatures 18° to 20° C (64° to 68° F). Relative humidity varied between 35 to 50% during the day and 45 to 65% during the night. CO_2 was either controlled at 400 ppm or remained near ambient levels (about 350 ppm). Seedlings were fertilized with an automatic watering system 4 to 6 times daily with 0.5 g/1 or 1.0 g/1 of 20-20-20 water-soluble fertilizer containing essential macronutrients and micronutrients

Plants grown for 4 to 6 weeks under these conditions and then transferred to a greenhouse under long-day conditions (natural daylight plus 200 ft-c (2.2 klx) of cool white fluorescent light from 4:00 a.m. until 8:00 p.m.) reached a height of 1 meter (39.4 in.) in 3 to 4 months from seed. Sample plants maintained under long-day conditions in the greenhouse during the first winter and transplanted outdoors as a clump in the spring when they were about 1½ years old, continued to grow rapidly and produced white bark the following winter when they were only 2 years old. These plants are now 3 years old, are nearly 4 meters tall, and have stems that are 5 cm in diameter at 30 cm above the ground.

When the time of controlled-environment treatment was extended from 4 weeks to 8 weeks, even more dramatic results were obtained with paper birch seedlings (10).

Plants were grown for 8 weeks from the cotyledon stage in a walk-in growth chamber or in a closely controlled greenhouse. Growth chamber conditions consisted of high light intensity (2,500 ft-c) (26.9 klx) provided by cool white fluorescent and incandescent lamps, a 16-hr photoperiod, 25/18° C (77° /64° F) day/night temperature, and ambient CO_2. Greenhouse conditions consisted of natural daylight supplemented by 200 ft-c (2.16 klx) of cool white fluorescent light, a 16-hr photoperiod, and 24/18° C (75° / 64° F) day/night temperature. Both sets of plants were fertilized 5 times daily with 0.5 g/1 or 1.0 g/1 of 20-20-20 water-soluble fertilizer.

Plants grown for 8 weeks under high light intensity weighed more than 40 times as much, were 6 times as tall, had twice as many leaves, and produced lateral shoots containing 17 times as much dry matter, as plants grown under low light intensity in the greenhouse.

CO_2 enrichment in the growth chamber may be used to provide an additional boost in growth. A preliminary experiment was conducted on European white birch seedlings under greenhouse and growth-chamber conditions (11). Greenhouse conditions consisted of a day/night temperature of 24/18° C (75/64° F), natural daylight (ca 12-hr photoperiod), and ambient CO_2 (ca 350 ppm). Growth-chamber conditions consisted of elevated day/night temperature (30/24° C) (86/75° F), high light intensity (2,500 ft-c) (26 9 klx) of cool white fluorescent and incandescent light (the latter providing about 20% of the total input wattage), and CO_2- enriched atmospheres (400 and 2,000 ppm). After 4 weeks, seedlings grown at 400 or 2,000 ppm CO_2 in controlled environments were nearly twice as tall as, and had several more leaves than, those grown in the greenhouse (11). Differences in leaf area and branching were especially marked between greenhouse and growth chamber-grown plants. Seedlings removed from the high CO_2 growth chamber at 4 weeks and placed in the greenhouse continued to show significantly more elongation during the next 4 weeks than greenhouse controls.

DISCUSSION

While the economic aspects of controlled-environment treatment must be carefully worked out to determine a practicable duration of treatment, it is clear that techniques for accelerating seedling production are now available to the grower of birch and other woody plants

The dramatic increase in seedling growth obtained by using high light intensity from the time the seeds are planted or at the cotyledon stage indicate that light is probably the most limiting factor in normal greenhouse production, and that the time to begin light treatment is early in the life of the seedling Other factors required for optimum seedling growth include warm day/night temperatures (about 25/18° C), long days (16 hr), good air movement, and adequate moisture and nutrition.

Our studies indicate that *Betula papyrifera* may be more responsive to light treatment than *Betula verrucosa*. Pinney and Peotter (14) have reported that *B. papyrifera* is a much more vigorous grower than *B. verrucosa* and *B. populifolia*. Such rapid-growing species of woody plants should be prime candidates for controlled-environment treatment, since they permit multiple cropping

The capital investment required to set up a program for accelerated culture of seedlings need not be exorbitant. The prospect of obtaining high-quality plants on a scheduled basis and accelerating seedling production affords the grower an unexcelled opportunity, whether he is starting woody plants, F_1 hybrid annuals, or vegetable seedlings.

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LITERATURE CITED

1 Klueter, H. H., W. A. Bailey, H. M. Cathey, and D. T. Krizek. 1967. Development of an experimental growth chamber system for studying the effects of major environmental factors on plant growth. ASAE Paper No. 67-112. Presented at Annual Meeting Amer. Soc. Agr. Eng., Saskatoon, Canada.

2 _______, _______, and D. T. Krizek. 1970. A propagation unit for accelerating growth of seedlings and cuttings. *HortScience* 5(4) Section 2:137 (Abstr.).

3. ______, and D. T. Krizek. 1972. How to use controlled lighting to propagate and grow plants. Pp. 205-209. *In Landscape for living. 1972 Yearbook of Agriculture.* U.S Dept. of Agriculture, Wash., D.C.

4. Krizek, D. T. 1969. Enriched environments for starting seedlings. *Proc. 24th Ann. Amer. Hort. Cong.* Phila., Pa. Pp 12-16.

5 ______. 1972 Day and night in the plant world, or the rhythm must be right. Pp 218-221 *In Landscape for living. 1972 Yearbook of Agriculture.* U.S. Dept. of Agriculture, Wash., D.C.

6. ______ W. A. Bailey, and H. H. Klueter. 1970 A "head start" program for bedding plants through controlled environments. Pp. 43-53. *In* W. H. Carlson (ed.), *Proc. Third Nat. Bedding Plant Conf.* Michigan State Univ., East Lansing.

7 ______, ______, and ______. 1971. Effects of relative humidity and type of container on the growth of F_1 hybrid annuals in controlled environments. *Amer. J. Bot.* 58:544-551.

8. ______, ______, ______, and H. M. Cathey. 1968. Controlled environments for seedling production. *Proc. Int. Plant Prop. Soc.* 18:273-280.

9. ______, H. H. Klueter, and W. A. Bailey. 1972. Effects of day and night temperature and type of container on the growth of F_1 hybrid annuals in controlled environments. *Amer. J. Bot.* 59:284-289.

10. ______, and R. H. Zimmerman. 1973. Comparative growth of birch seedlings grown in the greenhouse and growth chamber. *J. Amer. Soc. Hort. Sci. 98:370-373.*

11 ______, ______, H H Klueter, and W. A Bailey. 1969. Accelerated growth of birch and crabapple seedlings under CO_2 enriched atmospheres *Plant Physiol.* 44 (Suppl.) :15. (Abstr)

12. ______, ______, ______, and ______. 1970 Growth and development of crabapple seedlings in controlled environments. Effects of light intensity and CO_2 concentration *Plant Physiol.* 46 (Suppl) ·7. (Abstr.).

13 ______, ______, ______, and ______ 1971 Growth of crabapple seedlings in controlled environments. Effect of CO_2 level, and time and duration of CO_2 treatment *J Amer. Soc. Hort. Sci.* 96:285-288.

14. Pinney, T. S., Jr., and G. W. Peotter. 1966. The propagation of birch. *Proc. Int. Plant Prop. Soc.* 16:193-202.

15. U. S. Department of Agriculture. 1969. From seed to flower, fast, in controlled environments. *Agr. Res.* 17(9):3-4.

16 ______. 1969. Plant growth chambers for engineered environments. *Agr. Res.* 17(9):5.

17. Worley, J F., and D T. Krizek. 1972. Influence of brassins on the growth of woody plants. *HortScience.* 7:480-481.

18 Zimmerman, R. H., D. T. Krizek, W.A. Bailey, and H. H Klueter. 1970. Growth of crabapple seedlings in controlled environments: Influence of seedling age and CO_2 content of the atmosphere *J. Amer. Soc. Hort. Sci.* 95:323-325.

RALPH SHUGERT· Dr Krizek, while you are up here perhaps you would comment on any further developments in the work you have been doing on crabapple

DON KRIZEK: The work on crabapple has been followed up by Dr Zimmerman. He has been using a combination of long day treatments and growth regulators to get flowers buds to develop at fairly young ages. This involves providing incandescent light at the early stages and then giving them either a cold treatment or hormone treatment (as a mixture of cytokinin and gibberellin) which then allows the buds to develop. He has been able to get flowers in 9 to 11 months The magic of getting early flowering is getting enough nodes produced and, with *Malus*, the magic number appears to be about 75 nodes

The best time to begin treatment is when the plants are very young. If you wait even 2 weeks it is too long. The proper time to start is when the seed are planted. There is also a minimum time which the plants must be treated in order to obtain maximum effect, it is possible that with *Betula* the time may be as little as 4 weeks We got a tremendous boost in growth between week 4 and week 6 - as much as 1 inch per day with an average of 1/2 inch per day growth over the 8 week period. This may be contrasted to 1/10 inch of growth per day in the greenhouse.

RALPH SHUGERT: Thank you, Don. You certainly have brought us up to date. There are certainly some interesting and exciting things happenning in the area of controlled environment growing

Our next speaker is Dr. Elton Smith who will discuss the use of plastic houses for accelerating plant growth.