v raznykh usloviyakh vlazhrosti sredy (Changes in sex of plants under various environmental moisture conditions). *Doklady Akademii Nauk* 12:323-326.

19. Mizrahi, Y., and A.E. Richmond. 1972. Hormonal modification of plant response to water stress. *Aust. J. Biol. Sci.* 25:437-442.
20. Negi, S.S., and H.P. Olmo. 1966. Sex conversion in a male *Vitis vinifera* L. by a kinin. *Science* 152:1624-1625.
21. Reid, D.M., and I.D. Railton. 1974. Effect of flooding on the growth of tomato plants: Involvement of cytokinins and gibberellins. *R. Soc. N.Z. Bull.* 12:789-792.
22. Santamour, Frank S. 1959. Bisexual conelets in spruce. Morris Arbor. Bull. 10(1):10-11, Univ. Pa., Phila.
23. Skene, K.G.M. 1972. Cytokinins in bleeding sap of the grape vine. p. 476-483. *In* D.J. Carr (ed.), Plant growth substances. Springer-Verlag, New York.
24. Torrey, J.G. 1975. Root hormones and plant growth. *Ann. Rev. Plant Physiol.* 27:435-459.
25. Wittrock, V.B. 1886. Uber die Geschlecterverteilung bei *Acer platanoides* L. und einige anderen *Acer. Arten Bot. Centralblat.* 25(2):55-68.

MAXIMIZING SEEDLING GROWTH UNDER MIDWEST CONDITIONS

HUGH STEAVENSON

Forrest Keeling Nursery

Elsberry, Missouri 63343

The economics of nursery production today call for growing the plant to desired size and finish in the shortest possible time. I suppose this would be true with any nursery crop, save possibly bonsai. And even here, to be economically feasible, the rule would apply.

One of the more sage nurseryman put it this way: "We used to take two or three years to produce a gallon can plant. Now they never see a birthday."

We are in-ground, or field growers. A specialty with us is hardy deciduous tree and shrub seedlings of which we grow several million and almost 100 species. About 100 acres, or one-fourth of our nursery area, is devoted to seedling production. These find their way into a number of markets in 49 states — for canning and field lining, for understock, for various conservation and highway plantings. Many are of ideal size for mail-order nurseries, for packaging, for hedging and other direct uses.

With few exceptions, it is desirable, indeed economically necessary, to produce the largest seedling in the shortest possible time.

Of even greater importance is the fact that the younger seedling is a superior performer. Time and again, over the years, we have observed that, size for size, a one-year seedling is far superior to a two-year or older seedling as to survival and growth upon transplanting. The presumption is there is less shock in transplanting the younger plant.

For example, one-year bald cypress (*Taxodium distichum*) seedlings transplant readily. Two-year cypress seedlings are almost impossible to transplant. One year oaks (*Quercus* spp.) transplant much better than two- or three-year seedlings. One has to be some kind of a genius to get satisfactory survival with two-year seedlings of white or scarlet oak, for example. Redbud (*Cercis canadensis*), hawthorns (*Crataegus* spp.) Chinese chestnut (*Castanea mollisima*), birch (*Betula* spp.), most dogwoods (*Cornus* spp.), *Rosa* spp., mountain ash (*Sorbus aucuparia*) all move with ease as one-year subjects but become problem children when they remain in the seedbed longer.

Sweet gum (*Liquidambar styraciflua*) and tulip tree (*Liriodendron tulipifera*) must be harvested with care even as one-year subjects but are almost worthless as older seedlings.

One should never accept silver maple (*Acer saccharinum*) liners older than one year. It is a challenge to get sugar maple (*A. saccharum*) seedlings to the desired size in one year, but they are definitely superior where this can be accomplished.

Many understock growers believe they need two-year Norway maple (*A. platanoides*) to get suitable caliper for budding, but with the right seed source and cultural practices, we have produced Norway maples of very adequate size in a single season.

Because of this general superiority of the one-year seedling, we take several steps to push our seedlings to desired size in a single growing season. This, of course, involves suitable seed source and proper timing and/or pre-treatment of the seed. (The subject of seed source, or provenance, as well as virus-indexing is of critical importance. But this is another topic).

Generally speaking, we want emergence to occur as soon as possible after danger of the last killing frost. Seedlings respond best to their natural growing cycle; in addition, the longer the growing period the greater the growth.

Of paramount importance is to locate seed beds on a choice horticultural soil with ideal soil and air drainage. The production of seedlings is such an intensive, costly pursuit that nothing could be so penny wise and pound foolish as to accept any but the best agricultural site and soil. In our case this is the first row of hills hugging the Mississippi flood-plain. Here the

wind-blown loessal soil is the deepest and coarsest, occurring in narrow ridges where soil and air drainage are excellent.

Again, this intense culture (about 50 times as intense as general farm cropping) justifies a fertility and soil building program as best we know. We like to go through a perennial sod crop of brome grass or fescue for two or more years, using this period to make additional of major or minor elements to bring the chemical fertility level and pH to an ideal, balanced state. During this period the land may be grazed (and repeatedly fertilized) but no forage is otherwise removed. The fibrous root growth of these perennial grasses is unbeatable for building soil structure.

This sod crop is then plowed under at least six months before preparing seed beds. Depending upon the season, a green manure crop of grain sorghum or rye may be grown and plowed down during this intervening period.

Now the soil is in prime shape, both chemically and physically, for growing seedlings.

But our soil building process does not stop here. At any one time at least half of our seed-bed area is in green manure crops. The one we really dote on is a hybrid grain sorghum called 'Tri-span.' This is a fantastic grower, jumping up to six feet in a matter of six or eight weeks. In addition to a large amount of forage to turn order, 40 tons or more of dry matter per acre, the vegetation is so thick and heavy that weed growth is completely suppressed, thus depressing weed population in the seed-beds that follow. We mow the 'Tri-span' three to five times during the summer, allowing a build-up of organic material on the soil surface.

We like to allow 'Tri-span' to grow right up to the time of seeding the nursery crop. This means a tremendous amount of "trash" to work into the soil surface by discing and does make a somewhat rough, lumpy seed-bed. But the resulting soil aeration has a definite beneficial effect on seed germination, emergence and seedling growth. Indeed, the increase in germination percentage of this practice has allowed us to substantially reduce our seeding rate. With the sky-rocketing cost of tree and shrub seed, this is a most important plus.

Anyone who has surveyed in-ground growers across the country is aware that many of the best of them use tremendous quantities of animal manure with cover crops preceding their nursery crops. There is no question that such manuring results in lush, vigorous growth of nursery stock far beyond what can be accounted for by the fertility elements contained in the manure. Space does not permit a discussion of these extra benefits, but they are profound.

The only trouble is that manure is often not easy to obtain and is costly to haul and apply. Several years ago we tied in with an "egg factory" operating with 40,000 layer chickens. The chicken manure accumulates in a large vat as a slurry and must be pumped into a tank truck and hauled away almost daily. By agreeing to take the product throughout the year, the hennery operator actually subsidizes us to keep it hauled away. During the days we can't get on our nursery fields with the tank truck we spread the stuff on our pasture lands. It does stink to high heaven and we try to catch the wind blowing away from neighboring residences to keep peace in the community.

We apply four 1500 gallon tank-loads of the slurry per acre. This gives us, in nutrients, about 264 lbs actual N; 324 lbs P_2O_5; 112 lbs. K_2O; 3700 lbs. calcium; 200 lbs. magnesium; and small amounts of copper, zinc, iron and boron.

All seed are sown on or near the soil surface, rolled in with roller with narrow corrugations and covered with a bark-sawdust mixture. We apply as heavy an application of this mix, through a flail-type spreader to shred the bark, as we can and still permit germinating seedlings to emerge. The rule of thumb with a covering of soil or sand is twice the diameter of the seed; however tree and shrub seedlings will readily emerge through a much thicker layer of bark-sawdust — at least four or five times the seed diameter.

There are obvious benefits from such a heavy organic mulch cover. Many weed seedlings are suppressed. Surface moisture is retained. Porosity of the soil profile is improved. Moisture penetration is facilitated. Soil erosion and seed-bed washing are reduced. Soil temperature and moisture at the seed germination zone are more uniform, resulting in even stands of seedlings.

Then there are other profound benefits from these organic additions. The organic level and structure of the soil is enhanced. Indeed, it does take a lot of extra N to prevent nitrogen deficiency as the soil organisms break down the bark-sawdust applications, but this is like putting money in the soil bank — the interest pay-back is great with such a high-intensive crop as seedlings.[1]

---

[1] How much added nitrogen is needed to off-set any "nitrogen starvation" as a result of bark-sawdust mulching will vary with the kind and proportion of bark and sawdust. Bark breaks down much more slowly than sawdust and is not such a nitrogen "grabber" H.A.J. Hoitink in discussing composting of bark states; "Pine bark generally requires 1 lb actual N per cubic yard to avoid nitrogen deficiency on plants produced in the mix after composting. Hardwood bark in the Midwest requires at least twice as much N per cubic yard."

On the other hand USDA studies point out that "hardwood" sawdust

Perhaps more important is the affect these organic additions, including the chicken manure, have on the soil fauna and flora. Though root nematodes are common with many species we have been free of these pests for years and until recently couldn't account for this happy state. Then Dr. John B. Gartner of the University of Illinois, visiting the nursery, pointed to the work of Hoitink, *et al*, which demonstrated that hardwood bark in a growing medium had a profound effect on the suppression or elimination of nematodes.

The role of mycorrhiza in stimulating growth is well recognized. For whatever reason most species of plants, following generous chicken manure applications, exhibit heavy mycorrhizal mantles. Presumably this is a factor in the growth response from the manure application.

One observes the stimulating effect of high organic soils in other situations. Seedling growers in Tennessee and elsewhere have followed a practice of sowing their seed in the duff of freshly-cleared forest land. Here the growth can be phenomenal and weed competition almost non-existent. This practice does present the problem of constantly finding new forest land to clear.

It goes without saying that proper soil moisture and pest control must be maintained to achieve maximum growth.

Though our annual rainfall (35+ inches) is adequate for normal plant growth, it does not necessarily come when needed. Summer drought periods occur virtually every year and supplemental irrigation is a must. We have considered every type of irrigation system available and are convinced that solid-set rotary sprinklers is the most feasible for our seed-bed type production. This system has been highly developed by people on the West Coast, and we have adopted it whole cloth for our own use.

Regular spraying is done as required to control specific insect and disease pests. The most pernicious pest in slowing

---

contains only about 0.2 percent nitrogen and must be brought up to approximately 1.2 to 1.5 percent values if initial harmful effect on crops is to be avoided. This would require the addition of approximately 24 lbs of nitrogen per ton of dry wood.

From a practical standpoint the addition of needed N or P or other elements is no great problem. As a surface seedbed covering bark-sawdust mixes do not "blot up" N as when these fresh materials are worked into the soil. Furthermore, the cost of fertilizer is such a small percent of the total cost of producing a seedling crop that frequent applications will be made to the soil at a high-level optimum for plant production. Under our fertility program we rarely see any indication of nitrogen hunger to the crop from bark-sawdust applications.

growth with a number of our species is leaf hopper. When kept under control, growth will double or triple with some maples, sophora, wisteria, koelreuteria, some oaks and certain other species.

Aside from sanitation and cultural practices to hold down weed populations, there are two basic approaches to controlling weed competition. One is soil fumigation; the other is herbicides. We have used fumigation and have nothing against this procedure. However, the complex of herbicides now available seem to make this route more feasible for us. Herbicides are treacherous, of course, and one error can be disastrous. But by working closely with our college people, herbicides have reduced hand weeding to a minimum with minimal hazard to the crop.

Lastly, control of seed-bed population is essential to producing the size plant desired. We used to shoot for a stand at digging time of around 25 or 30 plants per square foot. Now the typical stand is down around 10 p.s.f. With particularly high-value crops such as Carpathian English walnut the stand will be two or three plants p.s.f. Stand population is controlled almost entirely by seeding rate, as thinning is usually impracticable.

ROOTING OF DORMANT CONIFER CUTTINGS

LARRY CARVILLE

Horticultural Associates
P.O. Box 235
Tolland, Connecticut 06084

The information presented herewith is based upon my experience as a propagator at wholesale nurseries in the Northeastern U.S. The methods described are generally acceptable by most successful growing operations east of the Mississippi River. Specific references to Rhode Island Nurseries, Middletown, Rhode Island result from my recent eleven years in their employment as Production Horticulturist.

One of the keys to successful propagation is to do things at the proper time. This is true whether it involves taking cuttings, transplanting into beds, or any of the other myriad operations associated with nursery production. At Rhode Island Nurseries, between 600,000 and 750,000 units are propagated each year with a labor force of seven full-time employees in the propagation department. All cuttings are taken from plants growing in fields of the parent operation.