SEED TREATMENT PRACTICES

AT

JASPER-PULASKI STATE TREE NURSERY

INDIANA DIVISION OF FORESTRY

BY

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INTRODUCTION

It is a reasonable assumption that seed treatment practices will vary greatly among bare-root nursery systems in the Northeastern Area- given the species diversity, site variability, manpower/equipment available, and nurserymen's expertise.

The following information details those seed treatment practices currently in use at the Jasper-Pulaski State Nursery, in northwestern Indiana. These practices are dynamic in many respects, and change to some degree each year. Such changes are often intended to gain additional knowledge and expertise that can help the nurseryman produce adequate supplies of quality seedlings more efficiently and consistently. (Please keep in mind that specific practices which work well at J-P, may produce different results at another facility.)

As a reference point, the nursery currently produces (18) different tree and shrub species (both deciduous and coniferous), for a total annual sales volume of 1.8 - 2 million seedlings. Included in this total is 600,000 (2-2) transplants. Collectively, conifer production makes up approximately one-half of the total sales volume.

Effective Spring, 1993, these species will be marketed in (25) species-age class combinations, including 1-0, 2-0, 3-0, and 2-2 seedlings. Only those species comprising a regular part of the annual production schedule, will be discussed in the text of this paper.

At the outset, there are a number of different ways to categorize seed treatment practices, such as by: (1) physical/physiological seed condition (dormant vs non-dormant) (2) sowing season, and (3) species with similar treatments. Because of the diversity that occurs within these first two categories, I have chosen to present this information by grouping species with similar treatments under the general headings of 'seed condition'.

Certain practices will be mentioned repeatedly during the course of this text. Some are performed in the same manner for a number of different species- irregardless of other distinctions. Such practices will be described in more detail initially, but only briefly mentioned later on, to minimize repetition.

It should also be noted that new production areas (including transplant areas) are commercially fumigated each fall (August) with methyl bromide (MC-2) at 400 lbs./Ac. to help control initial pest problems. This soil sterilization process has a direct impact on many of the seed treatment practices that are used (or not used) at J-P. It is considered a critical operation, in itself, for the successful establishment of new seedbeds on this facility.

SPECIES WITH INTERNAL (EMBRYO) DORMANCY

This seed classification includes the majority of tree and shrub species raised at J-P. Since the seed physiology of these species prevents germination after dispersal without adequate cold and (in most cases) moisture stratification, many of them are fall-sown. The natural stratification that ensues, overwinter, is the nurseryman's best assurance of good seed germination the following spring- barring adverse weather conditions and rodent predation. Fall-sowing is the only logical recourse for such large-volume species as oak and walnut, which would otherwise require a large, carefully monitored, stratification facility (cooler) for proper overwinter storage, prior to sowing.

There are, however, other considerations that dictate sowing season (besides internal dormancy), causing a few of these species to be spring-sown. Following is a detailed account of seed treatment practices for those species in this classification:

A. BLACK WALNUT (Juglans nigra)

Current Annual Needs:
300-350 bushel sowable seed....150M-160M shippable 1-0
Desired Sowing Rate: 7-8 seeds/ft^2
Storage Life: Fall-sow current year's crop only
Germination: Hypogeal

Fruit is initially purchased from private (in-state) collectors in latter September-October, at $2.50/bushel. Care must be taken to prevent overheating, during the collection process. The nursery requires approximately 1200 bushel of fruit per year.

Seed husks are then removed with a commercial walnut huller. Resulting seed is floated to remove the majority of bad seed. (No fungicide treatment applied at this stage.) Sowable seed is then placed in containers to facilitate

loading, transport, and field-sowing. It may require temporary cold storage to prevent excess drying/rodent predation.

Seed is drill-sown, in October, with a homemade (5-row) walnut seeder, at the specified density, in tiller-formed beds. Beds are then broadcast-sown in generic winter wheat (certified weed free) at 2 bushel/Ac. rate, using an 'E-Z Flow' spreader, to establish a protective winter cover over the seed. Seedbeds are then covered/shaped with a Larchmont bedformer to a seed depth of 1 1/2-2 inches. Lastly, beds are hydromulched using a wood fiber slurry with tackifier (to improve adhesive to bed surface over winter) at the rate of 45-50 lbs. of dry material per 1200 ft of bed surface.

NOTE: Winter wheat is currently being used on an experimental basis in all fall-sown seedbeds as a possible replacement for hydromulch fiber. It is quick and easy to apply, and requires no special equipment. Material cost, alone, is far ess than that of fiber (approx. $1.00 versus $10.00 per 1200 ft^2). When sufficiently developed, its extensive root system locks firmly around the tree seed, holding it and the adjacent soil in place-even under erosive wind/water conditions. (Alternative vegetative mulches have not provided adequate bed protection.) Hydromulch fiber has a tendency to erode or peel off of bed surfaces under adverse weather conditions. (Tackifier has reduced this problem.)

The current problem with an organic wheat mulch, by itself, is a lack of adequate plant development (cover) in some new seedbeds, due to the lateness of the sowing operation. (Fall, 1991 sowing trials, in general, revealed better seed germination in those beds containing both wheat and hydromulch cover, than those with inadequately developed wheat, alone.) Corrective measures will be attempted this fall, to remedy this situation. Meanwhile, both seed protection practices will be continued, until a determination on its status can be made (added protection for those beds receiving both seed treatments).

For purposes of this text, it can be assumed that all fall-sown seedbeds are sprayed by early spring (after green-up) with Fusilade 2000 (systemic grass herbicide) at 1/4 lb. active ingredient per acre, to kill the wheat before it hinders seed germination/development. (Roundup herbicide can be safely applied, as long as no seedlings have yet emerged.)

B. RED OAK (Quercus rubra)
BLACK OAK (Quercus velutina)
BUR OAK (Quercus macrocarpa)

Current Annual Needs:

(Red Oak) ....400M-600M good seeds....200M shippable 1-0
(Black Oak) ..100M-150M good seeds .... 50M shippable 2-0
(Bur Oak) ....100M-150M good seeds .... 50M shippable 1-0

Desired Sowing Rate: 8 good seeds/ft^2 (all species)
Storage Life: Fall-sow current year's crop only
Germination: Hypogeal

Acorns are currently purchased from private (in-state) collectors at the rate of $0.01 per good seed. ('Good' as defined by cut test- does not guarantee germination.) Though time-consuming to process seedlots in this manner, this purchasing method encourages selective picking and higher seed quality. Since sowing is conducted on the same basis (good seeds/ft^2) , this approach allows the nursery to more accurately estimate the total volume of seed needed (by species) without over-purchasing. Collectors are advised to communicate with the nursery in advance of picking operations, to make certain they are aware of specific collection criteria (eg. species/quantities desired, what to pick & not pick, etc.) The nursery reserves the right to refuse any seedlot on the basis of size, quality, or species composition.

Seed is purchased within a specified time frame in the fall (September-October), utilizing the following procedure:

a) As seed comes in, each seedlot tagged with customer information (and subsequently, collection data below).
b) Each seedlot then processed to determined approximate number of good seeds present by:
   (1) performing cut test
   (2) running sample count to determine number of acorns per unit volume
   (3) measuring volume of seedlot
c) When targets achieved, purchasing stopped. (Experience suggests that- like walnut- it takes 2-3 good seeds for every 1 shippable seedling produced.)

Once purchased and 'initially' processed, seed is placed in refrigeration until sowing time. This prevents excess drying/animal poaching. All seed is stored in onion skin bags and labeled with pertinent collection data (species name, % G, # seeds/gal., # of gal.) . Immediately prior to sowing, individual seedlots are 'batched' by species and collection criteria. This mixing procedure is designed to help insure uniform sowing (and seedling) density across all beds of a given species, with fewer calibration trials. (It also maintains genetic diversity in outplantings.)

If total seed volume of a given species is small, it is all

mixed into a single, uniform batch. If too large to mix in one batch, individual seedlots are initially grouped into 10-percentile germination categories (80-90%, etc.) by seed size (200-300 seeds/gal., etc.). Seed volume is then divided into two or more batches, with each batch receiving the same proportion of seed from each germination and size category. Once mixed, each batch should closely resemble the other(s) in average seed size and percent germination.

At sowing time, in October, each separately mixed batch of seed is calibrated in the walnut seeder (modified to sow oak seed, as well) to achieve the desired drop rate. It is necessary to perform a cut test on each batch, as part of this process. Each calibrated batch of seed is then machine-sown in tiller-formed beds, 1-1 1/2 inches deep. Beds are, again, broadcast-sown in winter wheat at 2 bushel/Ac. rate (as previously described) before covering/shaping with the bedformer. Hydromulch fiber is then applied at the designated rate.

C. SILKY DOGWOOD (Cornus amomum)
WASHINGTON HAWTHORN (Cratageus phaenopyrum)
FLOWERING CRABAPPLE (Malus sargentii Roselow)
AUTUMN OLIVE (Elaeagnus umbellata)

Current Annual Needs:
(Dogwood)...15-20 lbs. clean seed..80M-100M shippable 1-0
(Hawthorn) .. 16-22 lbs. clean seed..50M-80M shippable 1-0
(Crabapple) . 10-15 lbs. clean seed..50M-90M shippable 1-0
(Olive) ..... 10-15 lbs. clean seed..50M-80M shippable 1-0
Desired Sowing Rate: 20-25 good seeds/ft^2 (all species)
Storage Life: (Dogwood) ..... 2+ years
(Hawthorn) ..... 1 year
(Crabapple) ..... ±4 years
(Olive) ..... 2 years
Germination: Epigeal

Fruit of all four species is collected by property personnel (inmates) from Nursery seed orchards, at respective ripeness dates in the fall, between August and November. A limited amount is picked annually to insure usage before a loss of viability in cold storage. These species are purchased only if unavailable locally.

Once collected, the fleshy pericarp (fruit wall) is removed by macerating in water, using a Dybvig seed cleaner. The cleaned seed is then air-dried, and subsequently fanned/screened (as needed) to remove impurities (sticks, leaves, peelings) before placing in cold storage at 34 -38 F, in labeled, sealed containers.

All four species are normally fall-sown, in October, using an 8-row Whitfield tree seeder, **at a** depth of 3/8-inch. Seedlots must initially be checked (cut test) and calibrated in the machine in order to approximate the desired sowing density. Supposedly, all four species can be spring-sown, as well, with a minimal period of cold stratification. But with dormancy variations among seedlots, additional moisture stratification would be less risky. (Moisture-stratified crabapple seed has been successfully spring-sown the last two years, at 1/4-inch depth, to avoid potential problems with fall emergence/early frost irrigation.) Nevertheless, fall-sowing is desired to maximize seedling size.

Seedbeds are initially prepared with the Larchmont bedformer; then broadcast-sown (on the surface) with winter wheat at the designated rate (fall-sowing only). Pressing wheat seed into the soil surface with a light roller will facilitate germination. (NOTE: If winter wheat continues to be utilized in the future, as a vegetative mulch, it may be mixed with the tree seed, re-calibrated, and sown together, to simplify the operation/assure soil incorporation.)

Before drill-sowing, a measured amount of tree seed is removed from refrigeration and treated with 'Arasan 50-Red' seed protectant (thiram) by DuPont Chemical. This seed treatment is adhered to the tree seed using a water-soluble cellulose gum known as 'Methocel' (methylcellulose) by Dow Chemical. Mixing is accomplished using a small cement mixer. Once treated, the seed is sown directly over the wheat, Beds are then hydromulched at the specified rate.

NOTE: Chemical seed treatment is used as an added protective measure on all 'treatable', small-seeded species (fall and spring-sown).

D. HIGHBUSH CRANBERRY (Viburnum opulus)

Current Annual Needs:
12-22 lbs. clean seed ..... 20M-30M shippable 2-0
Desired Sowing Rate:
2 1/2-3 1/2 oz./60ft^2 (approx. 20-30 good seeds/ft2)
Storage Life: 5-10 years
Germination: Epigeal

A designated quantity of fruit is hand-picked by property personnel (inmates) each year from the Nursery seed orchard-after the berries soften (usually latter October).

The fleshy pericarp is then (more easily) removed by macerating the fruit in water using the Dybvig seed cleaner. Once dry, the seed is manually screened to remove uncleaned

berries and other debris, before placement in cold storage in labeled, sealed containers.

At sowing time, in October, cleaned seed is hand-sown in shallow trenches (made by a five-row cultivator device) on prepared beds, at the desired sowing rate for that particular seedlot. Beds are then sown in winter wheat at the specified rate, before lightly covering with the bedformer (or by hand) to a depth of approximately 3/4-inch. No chemical seed treatment is (normally) used prior to sowing. Beds are subsequently hydromulched.

Cranberry seed is unique in that it exhibits epicotyl dormancy. Though normally fall-sown, it can be spring-sown. Warm stratification the first growing season after sowing, permits development of the radicle. Subsequent cold stratification over winter breaks epicotyl dormancy, allowing shoot emergence the second spring after sowing. The plant (top) is grown one additional year to increase top size/ % recovery.

E. HAZELNUT (Corylus spp.)

Current Annual Needs:
50M-75M good seeds....25M shippable 1-0
Desired Sowing Rate: 8-10 good seeds/ft2
Storage Life: Fall-sow current year's crop only
Germination: Hypogeal

Fruit is collected by property personnel (inmates) from the Nursery seed orchard, in October, at the appropriate stage of ripeness. The browned husks are air-dried briefly until the seed can be manually extracted.

No chemical treatment is applied to the seed at sowing time (October). However, a cut test is performed to determine the approximate (%) germination (as with all other species).

For small seedlots, beds are prepared with the bedformer and trenched with the five-row cultivator apparatus. Seed is then hand-sown in these trenches at the desired density (various techniques). A larger seed volume would be machine-sown in tiller-formed beds using the walnut seeder- once calibrated. In either case, winter wheat is then applied with the E-Z Flow spreader- if not too late for proper establishment. Beds are then covered/shaped with the bedformer to a seed depth of 1-1 1/2 inches, and hydromulched.

F. EUROPEAN BLACK ALDER (Alnus glutinosa)

Current Annual Needs:
6-8 lbs. clean seed....30M-50M shippable 1-0
Desired Sowing Rate: 1 1/2-2 oz./60 ft^2
Storage Life: 1-2 years
Germination: Epigeal

Woody strobiles (fruit) are collected by property personnel at Greene-Sullivan State Forest (S. Indiana) , each fall, and transported to the Nursery for processing.

There, cones are spread to dry, and later shaken in a tumbler drum to extract the seed. Impurities are then screened out before placing the seed in labeled, sealed containers for refrigerated storage. Only cold stratification is needed to break dormancy in this species.

Since the (tiny) seed must be sown very shallow to germinate effectively (1/8-inch) , it is not drill-sown until spring (early May). This enables it to avoid the added dangers of overwintering in the seedbeds at that depth. No chemical seed treatment is used. Beds are immediately hydromulched to enhance germination and reduce soil splash/bed erosion.

G. EASTERN WHITE PINE <u>(Pines strobus)</u>

Current Annual Needs:
65-75 lbs. clean seed....(2-2 transplant production)....
350M-400M shippable 2-2
30-40 lbs. clean seed.... (2-0 sales) .....
180M-240M shippable 2-0
20-25 lbs. clean seed....(3-0 production) .....
85M-150M shippable 3-0
Desired Sowing Rate:
45-55 good seeds/ft^2 .... (2-2 transplant production)
30-40 good seeds/ft^2 .... (2-0 sales)
12-24 good seeds/ft^2 .... (3-0 production, <u>Experimental)</u>
Storage Life: + 10 years
Germination: Epigeal

White Pine is the single largest component of salable production at J-P, making up 25-35% of total sales volume. It is currently present in five age classes- three of which will be salable for Spring, 1993 (ie. 2-0, 3-0, 2-2). Current production efforts are aimed at phasing out transplants (all species) in the near future, and replacing them with more economical 3-0 seedlings, if production problems can be resolved and quality 3-0 seedlings <u>consistently</u> produced.

Like other coniferous species, white pine is purchased from commercial seed dealers, due to a lack of local collection

3-0 seedlings with minimal root damage.)

H. NORWAY SPRUCE (Picea abies)

Current Annual Needs:
7-9 lbs. clean seed ..... (2-2 transplant production).. 80M-100M shippable 2-2
3 1/2-4 1/2 lbs. clean seed.. (3-0 production) ..... 40M-60M shippable 3-0
Desired Sowing Rate:
70-80 good seeds/ft^2 ....(2-2 transplant production)
12-24 good seeds/ft ....(3-0 production, Experimental)
Storage Life: approx. 5-17 years
Germination: Epigeal

Seed, meeting specifications, is purchased from commercial seed dealers, and processed for cold storage (like white pine) in labeled, sealed containers, until use. As a precaution, efforts are made to use seedlots before they (noticeably) exceed five years of age.

Since cold stratification is the only pre-germination requirement, spruce seed is spring-sown (May) at varying seed densities for different production purposes, at 1/4-inch depth. As with other purchased species, a preliminary cut test is performed on each seedlot to double check germination 'rating'- recognizing that the two are not synonymous. (Locally collected seed is automatically cut-tested for calibration purposes.) Seed is then treated with Arasan seed protectant, drill-sown, and hydromulched.

Spruce seed used for experimental 3-0 production is mixed 50:50 by volume with (old) fumigated spruce seed to achieve better uniformity at 'low' sowing densities. As with red and white pine, this practice enables the drill to sow at a higher total seed density, resulting in greater drop uniformity.

I. NORTHERN WHITE CEDAR (Thuja occidentalis)

Current Annual Needs:
4-5 lbs. clean seed ..... (2-2 transplant production 60M-80M shippable 2-2
1-2 lbs. clean seed ..... (3-0 production) ..... 10M-30M shippable S-0
Desired Sowing Rate: (unstratified seed)
3/4-1 oz./60 ft^2 ..... (2-2 transplant production)...
1/4-1/2 oz./60 ft^2 ..... (3-0 production, Experimental)
Storage Life: + 5 years
Germination: Epigeal

This species was previously collected by property personnel from Nursery windbreaks. However, budgetary constraints and inconsistent seed crops, in recent years, have lead to its purchase. As previously described, new seedlots are placed in labeled, sealed containers, and stored in refrigeration until use.

Because white cedar is sown directly on the bed surface, it is not sown until spring. Most seedlots need only cold stratification to break embryo dormancy. But occasionally, one will require 30-60 days of moisture stratification before germinating. (This stratification procedure is the same as that described for spring-sown white pine.) No chemical seed treatment is used prior to sowing.

Normally, the seed is hand-sown in broadcast fashion on the surface of prepared beds (at varying densities), by early May. As part of the sowing process, it is lightly incorporated into the soil surface with leaf rakes (one stroke per unit area), before hydromulching at the previously specified rate. Beds are then covered with 'Thinsulate' spunbonded polypropylene cloth, for 3-5 weeks, to enhance/accelerate seed germination, before shading. The cloth is pinned directly to the ground along the bed edges, permitting sunlight and moisture penetration- while blocking drying winds. The moist environment created, appears to be the key ingredient necessary to assure good seed germination (more so than cooler surface temperatures).

Once germination is complete, the cloth is carefully removed (for reuse) and replaced with shade frames. Presently made out of galvanized irrigation pipe and snow fence, these frames permit further seedling development the first year, under cooler surface temperatures. (NOTE: Portable shade frames are presently being constructed out of treated 1" x 6" lumber and 55% polypropylene woven shade cloth. When complete, they will replace the need for both the cloth and older, more labor intensive frames. Prototypes indicate they will provide the proper environment for good seed germination and growth the first year.) The frames remain on the beds through the first winter to further help reduce potential frost heaval.

J. RED PINE (Pinus resinosa)

Current Annual Needs:

4-5 lbs. clean seed.... (2-2 transplant production) .... 50M-75M shippable 2-2

3-4 lbs. clean seed.... (2-0 sales) ..... 60M-100M shippable 2-0

2-3 lbs. clean seed....(3-0 production) .....

40M-60M shippable 3-0

Desired Sowing Rate:
55-65 good seeds/ft^2 ..(2-2 transplant production)
35-45 good seeds/ft^2 ..(2-0 sales)
15-25 good seeds/ft^2 ..(3-0 production, Experimental)
Storage Life: < 30 years
Germination: Epigeal

Seed, meeting specifications, is purchased from commercial seed dealers, and stored under refrigeration in labeled, sealed containers until use.

Needing only cold stratification to germinate, it is spring-sown (May) with the Whitfield seeder at various sowing densities, for different production purposes, at 1/4-inch depth. Seed is treated with Arasan seed protectant before sowing. Beds are subsequently hydromulched.

More so than white pine, the high sowing density for 'transplant' beds is necessary to keep stock smaller, so that it will machine-plant more efficiently. Proposed sowing densities for 3-0 production are merely current estimates of what might be needed to produce quality 3-0 red pine seedlings at J-P. Production is still experimental, and sowing densities are subject to change with new findings.

Seed used for 3-0 production is currently mixed 50:50 by volume with (old) fumigated red pine seed, to acheve greater seed drop uniformity at low sowing densities.

SPECIES WITH NON-DORMANT SEED

K. RIVER BIRCH (Betula nigra)

Current Annual Needs:
5-8 lbs. clean seed ..... 75M-90M shippable 1-0
Desired Sowing Rate: 1-1 1/2 oz./60 ft2
Storage Life: 1 year only
Germination: Epigeal

Seed is collected locally by nursery personnel in late May/early June by felling selected trees onto tarps at exactly the right stage of ripeness, so that the fruit will shatter upon impact. There is a very narrow time frame to collect in this manner (1-2 days). If felled too early, the strobiles will not shatter and must be hand-picked from the tree. (This method is less risky, but more expensive and time-consuming.) If delayed one day too much, the seed can disseminate overnight, and be lost. Either way, the

strobiles must show signs of distinctive browning before collection efforts begin, to assure that the seed is physiologically mature- or it will not germinate.

Once collected, the seed is dried briefly and screened to remove impurities (sticks/leaves) before placing in cold storage in sealed containers. Though non-dormant, it is normally sown as one year old seed, to increase the length of the growing season and guard against years that result in crop failure. Storage life is limited to one year.

By early May, the seed is hand-sown (broadcast) on the surface of prepared beds, at the desired sowing rate. It is lightly incorporated into the bed surface with leaf rakes, and immediately hydromulched. No chemical seed treatment is applied prior to spring-sowing.

SPECIES WITH EXTERNAL (SEEDCOAT) DORMANCY

L. BLACK LOCUST (Robinia pseudoacacia)

Current Annual Needs:
14-20 lbs. clean seed ..... 50M-70M shippable 1-0
Desired Sowing Rate: 20-25 good seeds/ft2
Storage Life: + 10 years
Germination: Epigeal

Seed is initially purchased from commercial seed dealers and placed in refrigerated storage in labeled, sealed containers until use.

Immediately prior to June-sowing, a measured amount of seed is acid-treated with 66° Technical sulfuric acid for 60-90 minutes. This chemical scarification procedure is used to break down the hard, impermeable seedcoat, (Hot water treatment was used successfully on one seedlot.) After rinsing thoroughly, the seed is treated with 'Arasan-50' seed protectant and nitrogen inoculant.

It is then drill-sown on prepared seedbeds at the specified density, 1/4-inch deep. No hydromulch is used, due to rapid seed germination. Earlier sowing is not feasible due to excessive seedling size.

M. SHRUB LESPEDEZA (Lespedeza bicolor)

Current Annual Needs:
5-7 lbs. clean seed ..... 60M-80M shippable 1-0
Desired Sowing Rate: 20-25 good seeds/ft2

Storage Life: Variable, up to 20 years
Germination: Epigeal

Seed is initially purchased from commercial seed dealers (within specified guidelines), or acquired through the SCS Plant Materials Center in E. Lansing, Michigan. Any one purchase is limited to a five year supply (or less) to insure use before loss of viability. As with other small seed, it is placed in labeled, sealed containers, and stored in refrigeration at 34°-38° F, until use.

Like black locust, lespedeza is one of the last species to be spring-sown (early to mid-June) . Although most seedlots can be sown without special treatment, some require acid scarification (as above) for approximately one hour, to breakdown the hard, impermeable seedcoat. (Hot water treatment may be equally effective for most seedlots- if preferred.)

Prior to drill-sowing on prepared beds, the seed is treated with Arasan seed protectant and nitrogen inoculant (Group 4 'Cowpea'). It is then sown at the specified density, 1/4-inch deep. No hydromulch is used, due to rapid seed germination.

MISCELLANEOUS SPECIES

Other species, currently produced at J-P in very small quantities, include butternut, Kentucky coffeetree, buckeye spp., blue and white spruce, and American basswood, among others. Seed treatment practices for these species are not included in this paper, due to their minor importance. However, should current experimentation with A. basswood production prove successful, that-species may be added to the regular stock production schedule.

SUMMARY

This text represents an abbreviated description of seed treatment practices for all major species currently produced at J-P. In reviewing, it should be recognized that their (same) application on other nursery facilities may- in some cases- produce different results.

These practices continue to change annually with species (additions) , goals, and modifications in production techniques. These changes, in most cases, represent an ongoing effort to

find new or improved ways to produce adequate supplies of quality seedlings more efficiently and consistently. With each new change (successful or not) the nurseryman's knowledge and expertise will strengthen.