IRRIGATION AND FERTILIZATION TYPE, RATE, AND FREQUENCY OF APPLICATION

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ABSTRACT—There is no "cookbook" formula for growing longleaf pine (*Pinus palustris* Mill.). However, some very definite minimum guidelines must be followed to successfully produce an acceptable crop of trees. Irrigation and fertilization are the two most important management practices in the growth of the seedlings. Specific guidelines and checkpoints for both the new nursery manager and the more experienced grower who desires to grow better longleaf are presented in this paper.

INTRODUCTION

The irrigation and fertilization of longleaf pine (*Pinus palustris* Mill.) is not simple or clear-cut. Nursery managers have their own programs that have generally been developed as the result of years of experience. Very seldom will you find any two nurseries that are following the same program. The purpose of the information in this paper is to provide usable information and resources to enable the nursery manager to be successful in growing longleaf pines.

BEFORE WE BEGIN…

Biological growth, whether it is longleaf trees or humans, can be broken down into three phases. The three phases of plant growth in seedling nurseries are:

1. Establishment Phase—covers emergence through cotyledon stage.
2. Rapid Growth Phase—period when growth is at an exponential rate.
3. Hardening Phase—period in which height growth is slowed or stopped.

Knowledge of these phases is important because your approach to irrigation and fertilization will be different in each phase. A well-designed fertilization program will make use of your understanding of these growth phases. For example, less fertilizer in both concentration and frequency are required in both the Establishment and Hardening Phases as compared to the Rapid Growth Phase. Specific recommendations will be presented later in this paper.

Before any irrigation or fertilization program can be initiated, a nursery manager must answer a very important question: "What are the quality standards for my seedlings?" You must know before you begin the season whether you want to grow short and fat seedlings, or tall and thin seedlings, or something in the middle. You must know at the start of the season if your customers have particular seedling quality specifications or if you are going to produce all your seedlings to a standard you have previously determined.

Experience will also show you that not all longleaf seedlots grow at the same rate. It will be necessary to adjust your irrigation and fertilization program to accommodate these differences in rate of growth. If you do not, you will have customers that are dissatisfied with your seedlings, which will be either too tall or too short.

Many nurseries routinely prune longleaf seedlings to obtain a desired height. In my opinion, this is an expensive and unnecessary labor cost that could be reduced or eliminated with a proper fertilization program.

IRRIGATION

The effectiveness of your fertilization program will depend upon your irrigation program. When irrigation is done correctly in terms of frequency and amount, you will obtain maximum benefits from your fertilization program.

HOW DO I IRRIGATE?

Irrigation may be successfully accomplished in many ways. The goal of any system should be to apply water uniformly over the total crop. Irregular irrigation is linked to irregular growth. Irregular growth results in differences in seedling quality. Differences in seedling quality results in dissatisfied customers, which directly translates as lost revenue.

The two methods of irrigation that produce the uniform crops are:

1. Mobile irrigation booms.
2. Fixed overhead sprinklers.

It is very important that frequent visual checks are made of any system to ensure the booms, nozzles, and/or sprinklers are operating properly. Monitoring the amount of water being emitted from the nozzles or sprinklers will tell you if uniform amounts of water are being applied.

There are two other less effective methods of irrigating:

1. Hand watering.
2. Impact head sprinklers

These systems do not produce uniform growth. Impact head sprinklers are especially vulnerable to windy conditions, which can cause irregular growth patterns.

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Citation for proceedings: Barnett, J.P.; Dumroese, R.K.; Moorhead, D.J., eds. 2002. Proceedings: Growing longleaf pine in containers—1999 and 2001 workshops. Gen. Tech. Rep. SRS-xx. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. xx p.

HOW DO I KNOW WHEN TO IRRIGATE?

There are three commonly used methods of determining when to irrigate:

1. Visual and Tactile—this method requires experience and is very subjective.
2. Container Weight—this method is both time consuming and tedious, especially when large areas must be sampled.
3. Moisture Meters—most moisture meters are designed to be used in soils as opposed to artificial substrates. They are also best used in large containers rather than the small cavities used to grow longleaf.

My personal choice is the Visual and Tactile method. With experience, a manager can be very consistent in evaluating of the need for irrigation. This system also provides a regular opportunity to evaluate the status of root development. Experienced nursery managers can use this system when advising other nurseries as to proper moisture levels. They are not limited by the need for equipment that would be required for the other two methods.

KEY POINTS TO REMEMBER ON IRRIGATION

Each time you irrigate or fertilize, apply sufficient water to wet the entire plug. This amount of water is not fixed throughout the growing season. How much water will depend upon many factors. These factors include: age of the seedlings, time of year and weather conditions (temperature, humidity, wind). Wetting the entire plug to the point that water is dripping out of the bottom of the cavity will prevent the buildup of fertilizer salts.

Low water content in the plug will drastically reduce the effectiveness of your fertilization program. Water is needed in the plug to permit the flow of nutrient ions into the root system.

Improper irrigation can lead to:

1. Poor root growth in the cavity bottom.
2. Potential salt buildup which can injure or kill the seedlings.
3. Stressing the trees so that the growth is halted.

During the heat of the summer, apply sufficient irrigation water to avoid stressing the trees. A common method of hardening off the seedlings at the end of the growing season in preparation for shipping and cold weather is to withhold water. Seedling growth can be slowed during the growing season by water stress.

Between periods of irrigation there needs to be a time in which the cavity is allowed to dry down. Roots will not grow in a saturated plug due to the lack of oxygen. Too much water can be a serious stress factor that can also open the door to fungal problems. The common point that many nursery mangers use is to irrigate when the plug has 50 to 75 percent moisture. How do you determine this point? If you are using the visual and tactile method, it will take experience from looking at many root plugs at different levels of moisture content. If you are using the weighing method, you will need to establish a curve relating weight to available moisture and seedling condition.

Nursery managers must monitor the pH and electrical conductivity (EC) of the medium and irrigation water or substrate leachate. The pH is a measure of the degree of acidity or alkalinity of your medium or irrigation water. The EC is a measure of the salinity (dissolved total salts) of your irrigation water or the substrate leachate. Monitoring should be done on a regular basis throughout the growing season.

The availability of nutrients in the substrate is closely correlated to pH (Figure 1, organic potting media). It is necessary to maintain the medium and irrigation water at a proper pH. If the pH is allowed to deviate, nutrients will no longer be available (even though they are in the medium), and the tree will begin exhibiting symptoms of nutrient deficiencies. One common late-season problem in container nurseries is a yellowing of the new growth of pines. This may be related to an increase in the pH of the medium above 6.5 resulting in iron no longer being available to the tree.

FERTILIZATION

Although the use of slow release fertilizers is a common practice in container nurseries, this method of fertilization will not be discussed here because of the many variations in release rates and formulations. All recommendations are based upon the assumption that only water-soluble fertilizers are used.

Fertilizer mixes are normally expressed as a ratio of nitrogen, phosphorus, and potassium (NPK). For example, a bag of 18-6-12 would contain 18 percent nitrogen; 6 percent phosphorus, expressed as P_2O_5; and 12 percent potassium, expressed as K_2O.

There are two commonly used methods of applying water soluble fertilizer in a container nursery. The first method is by injector. In this method, a concentrate of the fertilizer is mixed and then injected into the water stream before reaching the crop. Some of the commonly used injectors are as follows: Smith®, Dosatron®, Dosamatic® and the MP Proportionator® . Another method is to mix the fertilizer directly in a large stock tank and apply the fertilizer solution directly to the plants.

HOW FREQUENTLY DO I FERTILIZE?

The answer to this question is very simple: “That depends....” Unfortunately, there is no straightforward answer to this question. The frequency of fertilizer applications very much depends upon a number of factors, including:

1. How fast your media dries down—this is a function of the media mix and degree of compaction.
2. How much rainfall you receive.
3. How your seedlings are developing—is the growth on target?

I would recommend that the goal of a new grower be apply fertilizer three times per week, and irrigate on the other days as required. Note that this is a goal; you may not be able to reach this goal some weeks due to rainfall. When there is excessive rainfall, you need to adjust your fertilization

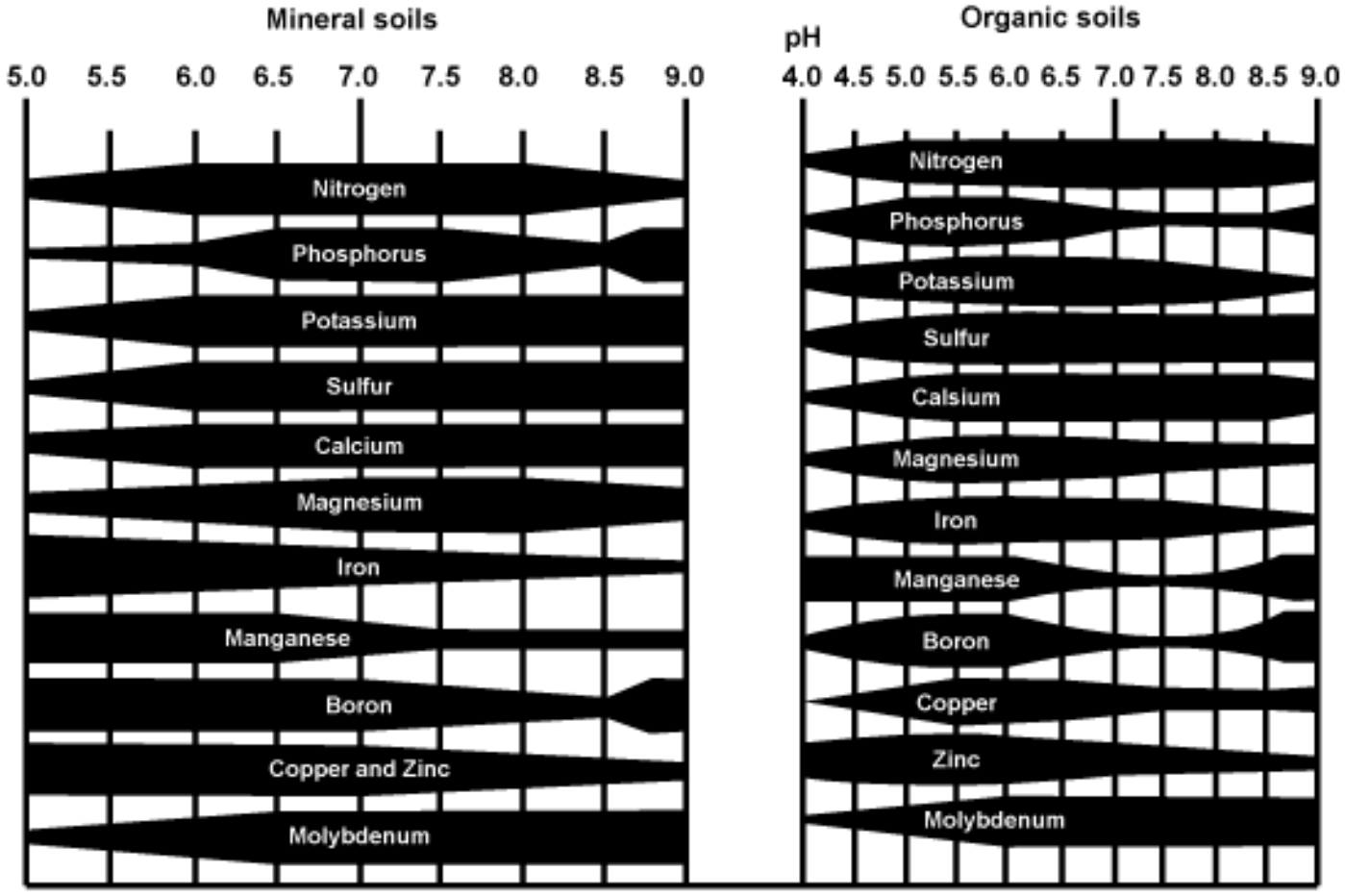

Figure 1—The relative availability (the wider the band, the more available the nutrient) of the various mineral nutrients is different for mineral-based and organic-based soils. From: Kuhns, L.J. 1985. Fertilizing woody ornamentals. University Park, PA: Pennsylvania State University, College of Agriculture. 16 p.

schedule since many of the nutrients may have been leached out of the cavity. The frequency of fertilization also depends upon the specific seedlots you are growing. As mentioned earlier, some seedlots requires less fertilizer than others to reach your seedling quality standards.

TYPE OF FERTILIZER

It is recommended that a new grower begin with a balanced fertilizer such as a 20-20-20 or a 15-15-15. Another very suitable fertilizer to use is one of the “peat special” fertilizers such as “20-10-20 peat-lite”. This formulation is available through many distributors. A nursery grower can produce an excellent crop of trees with these fertilizers. I personally do not feel that the conifer-specific fertilizers on the market are worth the additional cost.

Most established nurseries probably began with any one of these fertilizers but through experience and the necessity to meet certain quality standards, have changed the type of fertilizer they are currently using. There are many options open to the grower who wishes to experiment with a different fertilizer.

TOO MUCH TOO SOON

A common mistake among new growers is to apply too much fertilizer early in the season. These high levels of nutrients reflect improper management, particularly where nitrogen is concerned. High nutrients are wasteful. Often the excess fertilizer is leached out of the cavities. High levels of nitrogen promote a beautiful and lush top at the expense of root system development. The real skill and finesse of a nursery grower is shown by the quality of the root system, not the green stem. High levels of nutrients also inhibit the establishment of mycorrhizae. Mycorrhizae are beneficial in the nursery because they aid in the absorption of nutrients, especially phosphorus and they serve as a barrier against pathogenic fungi. High levels of nutrients early in the season also increase the susceptibility of the plant-to-plant pathogens.

There is a common saying that “if a little is good, more is better”. This is not true when fertilizing your crop (Figure 2). As nutrient levels increase in the plant, an optimum range is reached for the growth response of the crop. Beyond this point, no additional growth is obtained, fertilizer is wasted, and the potential for nutrient toxicity exists.

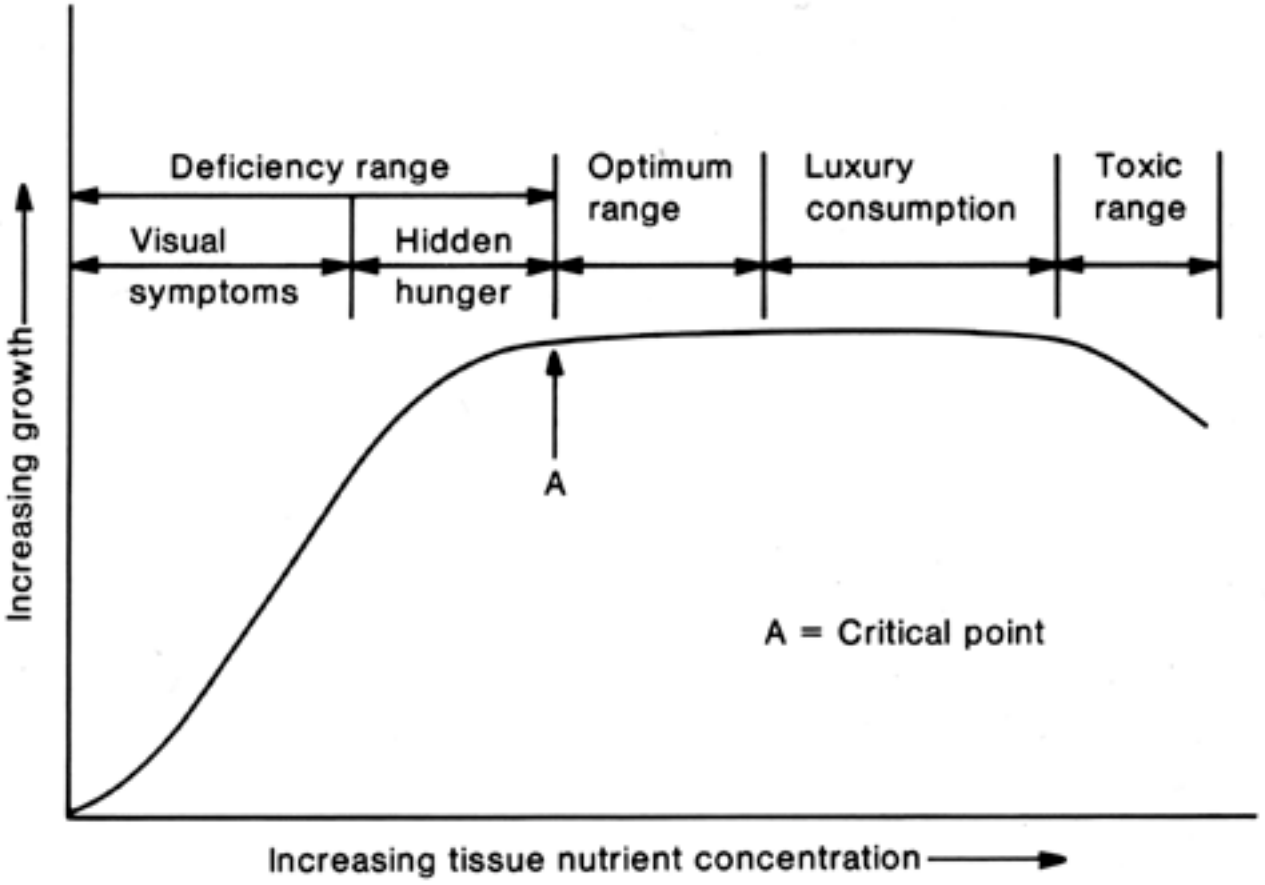

Figure 2—The relationship between seedling growth and seedling tissue nutrient levels follows a characteristic pattern. Point "A" represents the critical level. Beyond this point, increasing nutrient levels do not result in more growth; instead, it can lead to luxury consumption or even toxicity. From: Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. Seedling nutrition and irrigation. Vol. 4. The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: Department of Agriculture. p. 8.

GENERAL GUIDELINES FOR LONGLEAF FERTILIZATION

Listed below are general recommendations for fertilizing longleaf. These recommendations are based upon not using a slow release fertilizer in the media. These suggestions will have to be modified based upon the demands of specific seedlots. Also, remember that a fertilization program must be geared to the specific growth phase of the crop. Here are the general recommendations:

1. Establishment Phase—after germination is completed - 50 ppm for approximately 2 weeks.
2. Rapid Growth Phase—buildup to approximately 200 ppm for 14 to 16 weeks.
3. Hardening Phase—25 to 50 ppm for 4 to 6 weeks.

MONITOR AND RECORD GROWTH

Throughout the growing season, measurements of the height growth, root collar diameter and root growth should be recorded for each seedlot. This information, commonly called "History Plots/Data" or "Life History Data", will provide a valuable foundation for evaluating the growth of future year's crops.

CONCLUSIONS

There are many equally good approaches to producing an excellent crop of longleaf pine seedlings. There are several important points to always be aware of. Know your goal for seedling quality and where you are compared to your goal at any point in time. Monitor and record pH, EC, and growth data on a regular basis. Always be looking for ways to change your fertilization program to make your seedlings a little bit better than your competitor's.

RESOURCE MATERIALS

There are many resource materials available on growing pine trees in containers. The amount of specific information on longleaf pines is much less. The materials listed below are not specific to longleaf pine, but are resources I consider very useful. Over the years, I have narrowed down the number of resources that I consult on a regular basis. Some are available at no charge; others have an associated cost.

The first resource that every nursery manager should have is the USDA Forest Service series on Container Tree Nurseries. These publications cover all aspects of container growing. Do not expect a "cook-book" approach. What you

will find is all the necessary fundamental information required to grow container trees. You will need to choose a specific method or technique from those presented. The information is very balanced and complete. The citation is listed below:

Landis, T.D.; Tinus, R.W.; Mcdonald, S.E., Barnett, J.P. The Container Tree Nursery Manual. Agric. Handb. 674. Washington, DC: U.S. Department of Agriculture.

As of this publication, there are six volumes in print.

Volume One—Nursery Planning, Development, and Management. 1994. 188 p.

Volume Two—Containers and Growing Media. 1990. 88 p.

Volume Three—Atmospheric Environment. 1992. 145 p.

Volume Four—Seedling Nutrition and Irrigation. 1989. 119 p.

Volume Five—The Biological Component: Nursery Pests and Mycorrhizae. 1989. 171 p.

Volume Six—Seedling Propagation. 1999. 167 p.

For information on these manuals, you may contact Tom D. Landis at the following address:

USDA Forest Service
Cooperative Programs
J.H. Stone Nursery
2606 Old Stage Road
Central Point, OR 97502-1300
TEL: 541-858-6166
FAX: 541-858-6110
E-MAIL: tdlandis@fs.fed.us

A second valuable resource is a book titled “Growing Media for Ornamental Plants”. This book covers a wide variety of topics including:

- Growing Media—both the theory and practical aspects behind a good media.
- pH and electrical conductivity.
- Composting.
- Plant Nutrients and Fertilization—also the theory and practical aspects.
- Turf.
- Salinity.
- Irrigation—when and how much.
- Collecting samples for analysis and simple tests that can be performed of growing media.

Although this book emphasizes the horticultural market, it provides a great resource on much of the necessary theory behind growing trees in containers.

The complete citation is:

Handreck, K.A.; Black, N.D. 1994. Growing Media for Ornamental Plants. University of New South Wales Press. Randwick NSW, Australia. 448 p.

The ISBN number is 0 86840 333 4.

It is available in North America through:

ISBS, Inc.
Portland, OR 97213-3644
TEL: 503-287-3093
FAX: 503-280-8832

A third valuable resource is the “Forestry Nursery Notes” (FNN) published by the Forest Service. A subscription is free. This publication has recently undergone a major format change. Technical articles, which were at one time published in FNN, will now be published in “Tree Planter’s Notes.” The FNN is still an excellent way to keep abreast of publications available on a wide variety of topics.

For information on “Forest Nursery Notes,” you may contact Tom D. Landis as described above.

Another publication that is worth obtaining is a real bargain at $10 per year. “Tree Planters’ Notes” (TPN) is also published by the Forest Service. There is an on-going effort to improve the quality of this publication. Articles are not solely related to container trees or container nurseries but rather cover a wide variety of topics in this field.

For further information, contact:

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Many nursery managers struggle with calculating parts per million of a fertilizer solution. A handy part per million (ppm) calculator is available for your use on your computer. It will allow for metric or nonmetric unit inputs. You must provide the (1) N-P-K formulation of the fertilizer you are using, (2) the desired parts per million, (3) the injector dilution ratio, and (4) the gallons of water in your stock tank. It will then calculate the amount of fertilizer you must add to your stock tank to obtain your specified ppm of nitrogen (most common), phosphorus, or potassium.

This calculator can be obtained from:

Truett Software Development
2823 Pennsylvania Ave.
Erie, PA 16504
TEL: 814-456-9840.

or from:

Grower Talks Bookshelf
TEL: 888-888-0013
FAX: 888-888-0014

The cost of this program is $29.95 plus shipping.