Fertilizer Application: Balancing Precision, Efficacy, and Cost

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Abstract: Fertilizer prescriptions and application methods are unique for each nursery. The choice in application method must balance the accuracy of the application versus the cost and speed of the application. The major types of application equipment are compared.

Keywords: nutrient application, fertilizer application equipment, sprayer

Introduction

To continually grow high quality seedlings on the same nursery site, nutrients must be added to replace nutrients lost when seedlings are harvested. There are many factors that impact how effective the nutrient application will be for seedling growth. These factors include when and where the fertilizer is applied and availability of the various nutrients to the seedling. Nutrient availability will depend on both soil properties and the ability of the seedling to extract the nutrients from the soil. The emphasis in this paper will be on the physical means of applying nutrients to seedlings in a bareroot nursery using timely and economical procedures.

Basic Considerations

The need for a fertilizer application will probably be based on soil nutrient analysis, tissue analysis, stock performance, and historical trends. Fertilizer prescriptions are unique to each nursery (van den Driessche 1984). Once the nutrients to be applied and the type of fertilizer to use have been selected, options for application equipment and placement of the fertilizer are limited. The choice of application equipment will be just as unique to the nursery and the fertilizer prescription.

Nutrients can generally be selected in a soluble or insoluble form. The soluble form of some nutrients, like phosphorus, can be significantly more expensive than the insoluble form. In the bareroot nursery, these nutrients are primarily applied as dry material. Some fertilizers will combine a couple of nutrients in a single product. For example, ammonium phosphate supplies nitrogen and phosphorus; sulfate of potash magnesia supplies potassium, magnesium, and sulfur. Where multiple nutrients are needed that cannot be provided by a single fertilizer, either multiple applications or use of a blended fertilizer is necessary. The blended fertilizers are generally cheaper, and the single application is more efficient. There are drawbacks to this method that will be discussed under application methods.

Availability of the nutrients to the seedlings depends on the type of fertilizer, soil properties, nutrient properties, and fertilizer placement. The common forms of nitrogen fertilizer are readily leachable; use of sulfur-coated urea and other slow release forms of nitrogen can extend the time that the nitrogen will remain in the soil. Phosphorus is not readily leachable but chemically combines with other soil material. Over time, it changes from readily available phosphates to slower and slower available forms (Buckman and Brady 1969).

Fertilizer placement will determine how much and how readily the nutrients are available to the seedlings. The fertilizer can be spread over the entire area, including the area of the tractor paths. Alternatively, the material can be applied only to the area of the beds. After application, the material can be left on the surface to be washed into the soil with irrigation, or incorporated into the root zone. Banded placement, where fertilizer is drilled into the soil below or beside the seedlings, combines into one operation the distribution and incorporation of the fertilizer. Once again, there is no single correct answer.

Application Options

Once the fertilizer to apply and the desired location of the application have been selected, there are a variety of application equipment options. The chosen option will have a large impact on the efficiency and efficacy of the application and the cost of the fertilizer used. This must be balanced with the cost of the application equipment. The following types of equipment will be compared: rotary spin spreader, air-blast boom spreader, auger drop box spreader, liquid sprayer, and banding equipment. Uses for the various types of spreaders and advantages and disadvantages are summarized in Table 1.

Rotary Spin Spreader

The rotary spin spreader consists of a hopper for the fertilizer that is gravity-fed through a metering gate that is used for calibration. One or more rotating disks below the metering gate distribute the fertilizer. Typically, it spreads fertilizer in a 30- or 40-ft (9- or 12-m) width. This application method is not very efficient. With a small hopper that holds 700 lb (320 kg), you may only spread about 1 ac (0.4 ha) before you need to return to refill. If you are using bagged fertilizer in 50- or 80-lb (23- or 36-kg) bags, this can raise some concern for safety when bags must be emptied into the hopper that is at shoulder height. The safety concern can be eliminated by having fertilizer delivered from your fertilizer dealer in a tender with a power auger.

The distribution from a rotary spin spreader is not very accurate. The distribution on an acre basis is typically within ±5%, but the distribution across the working width can be ±35% or more. If you are using a blended fertilizer as compared with a single product, you can get some gravity separation between materials. Figure 1 shows the results from catch pan samples using a Lely Rotary Spreader. On a per acre basis, the application was 98% of plan. Fine particles were 92% of plan; the large particle sizes were 99% of plan. The difference between the highest rate per bed and the lowest rate per bed was almost 2:1. This type of spreader is generally used for preplant broadcast applications where 42% of the fertilizer would be placed in tractor paths that will not be used to grow seedlings. It can also be used for growing season applications.

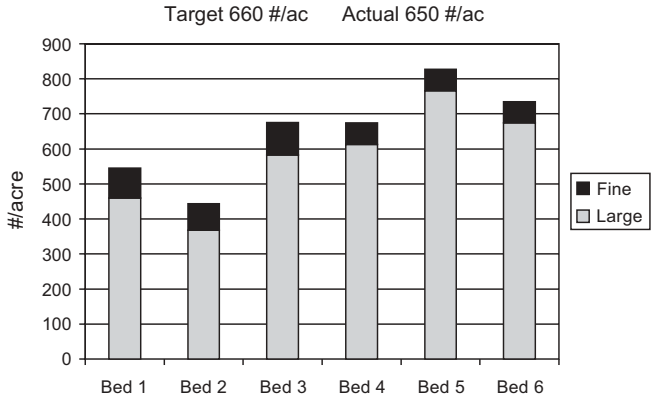

Figure 1—Fertilizer distribution with the Lely Rotary Spreader.

Air-Blast Boom Spreader

Most of the issues with the rotary spin spreader for preplant applications can be corrected by using an air-blast boom spreader. These spreaders consist of a larger hopper holding several tons of fertilizer. The fertilizer is metered and then distributed along a boom with many drop nozzles using air pressure. These spreaders come with wide floatation tires to distribute the heavy load. The air-blast boom spreader provides a more even distribution of fertilizer, and is not subject to the separation of particles sizes. These spreaders still fertilize the entire area, so a significant amount of fertilizer remains in the future tractor paths. The large floatation tires limit use of the air-blast boom spreader to preplant applications only. These spreaders are expensive. Because of the limited use they would receive, most nurseries would use the services of a commercial spreader to make these applications.

Auger Drop Box Spreader

For growing season applications of dry fertilizer without fertilization of the tractor paths, a drop box spreader can be used. A drop spreader uses a variable worm gear to evenly distribute the fertilizer along the base of the hopper. The fertilizer then falls by gravity onto the bed through small

Table 1—Application equipment uses and efficiency.

	Rotary spreader	Air-blast boom	Auger drop box	Banding spreader	Sprayer
Uses					
Pre-plant (before beds)	Yes	Yes	Possible	No	Possible
Pre-plant (after beds)	Yes	No	Yes	Yes	Yes
Growing season	Yes	No	Yes	No	Yes
Tractor paths fertilized	Yes	Yes	No	No	No
Type of fertilizer	Dry	Dry	Dry	Any	Liquid
Speed	Fair	Excellent	Poor	Poor	Excellent
Accuracy	OK	Good	Good	OK	Excellent
Uniformity	Poor	OK	OK	Good	Excellent
Calibration ease	Difficult	Easy	Average	Average	Excellent
Cost of equipment	<$1000	>$50000	<$1000	<$5000	<$5000

openings on the base. This type of spreader is more accurate than the rotary spin applicator, but it covers a much smaller area on each pass. A typical unit only covers a single bed; with a gang of spreaders, 2 or more beds can be fertilized on a single pass. The hoppers are generally small and require frequent refilling. The distribution is good regardless of particle distribution. The small openings can become plugged if there are impurities in the fertilizer or large particle sizes. It is difficult to see when this happens from the tractor. Until the hole clears itself, or is cleaned, the reduced amount of fertilizer distributed from the plugged hole results in the appearance of yellow striping in the crop 2 or 3 weeks after application.

Liquid Sprayer

A sprayer can also be used to apply any soluble fertilizer onto seedling beds very accurately and efficiently. A stock solution is diluted in the spray tank and then sprayed on the crop. This method can also be used for foliar feeding. Typically, however, the material is washed off the foliage into the soil for root uptake. The more concentrated the solution, the more important it is to get irrigation started to prevent burning of the foliage. On sensitive species or hot dry days, water needs to be started at or before the time spraying begins. On cooler, cloudy days or with less sensitive species, irrigations should start in less than 1 hour from when spraying begins. The use of computer controlled spray equipment allows for changes in application rates as necessary for species or areas requiring more or less nutrients. These changes can be made without stopping or changing the calibration.

Fertilizer dealers can often provide solutions of several basic blends. The solution is delivered in a tank truck and pumped into your storage tank. Fertilizers purchased in solution are generally less expensive per pound of nutrient than when purchased dry (Yeager 1999). Storage tanks should be plastic with PVC fittings to prevent corrosion and rust. A small transfer pump can be used to pump the stock solution into a measuring container. The measuring container can be a graduated plastic container of 100 gal (380 l) or more with a drain valve at the bottom. The measured solution can be lifted by forklift to drain into the spray tank. This system is easy and safe to use. Goggles should be worn when working with the concentrated solution to prevent splashing in the eyes. There is very little physical labor involved with this method.

If solutions cannot be delivered in your area, you can mix your own. The system can be very simple or more elaborate depending on how much it will be used. A mixing tank of sufficient volume to dissolve the desired chemical is necessary. A table of solubility of fertilizer materials can be found *The Farm Chemical Handbook*. Water is added to the mixing tank followed by the dry fertilizer with some type of agitation. Agitation can be mechanical, jet agitation using a circulating pump, or a pneumatic agitator using air pressure. After the fertilizer is dissolved, it can be transferred to the spray tank with a pump, or gravity fed using the forklift method described above. Use of a platform to stand on and a scissor lift to raise the fertilizer bags to tank height makes the operation safer. Once again, use of goggles when mixing the solution is necessary to prevent splashing in the eyes.

All of the application methods discussed can be used to distribute fertilizers to the seedlings with certain limitations. The commercial air-blast spreader can only be used as a preplant application system. The sprayer is limited to fertilizers that are readily soluble. When we apply fertilizer, we want to get the material on in a timely manner; there are great differences between the application methods in how long it will take to make the application. The choice in application method must balance the accuracy of the application compared with the speed of the application. Use of a drop box spreader could take 2 weeks to cover the nursery. By using a rotary spin applicator, the job could be done in 2 days. Figure 2 shows the comparison between the different application methods.

Other Options

In addition to the standard broadcast methods, other methods for fertilizer application have some applicability. Banding application of fertilizer at the time of sowing is one of these alternatives. For immobile nutrients, like phosphorus, this may be advantageous, although it might not result in an improvement in yield (Murrell 1998). Fertilizer is only placed where it is necessary, and if it does not slow the sowing operation down, it would be an acceptable practice. Banding is probably not an option with transplant seedlings because of the disruption to the bed that would be necessary to place fertilizer below the transplants.

Use of the sprayer for foliar feeding of nutrients is not widely practiced in bareroot nurseries (van den Driessche 1984). Concentration of nutrients must be kept low to prevent foliage burning; thus frequent applications are necessary. Concentrations would only be about one-tenth of the concentration used when the sprayer is used for broadcast spreading followed by irrigation.

Application of nutrients through the irrigation system is only used in very few bareroot nurseries. The practice known as fertigation is common in the greenhouse; irrigation in the bareroot nursery is not as uniform because of wind and topography, and is subject to runoff. A nursery using a

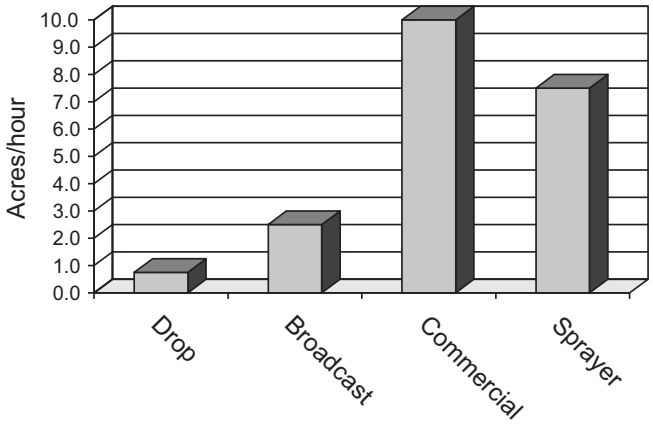

Figure 2—Efficiency of application methods.

center-pivot irrigation system successfully uses this method (Triebwasser and Altsuler 1995).

Conclusions

Each nursery develops its own reliable process for selection of fertilizer and fertilizer equipment to use in growing quality seedlings. This process is based on what has worked in the past and the equipment that is available. In every case, the application method must balance the accuracy of the application versus the cost and speed of the application. There is no single answer that is always best.

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