From Forest Nursery Notes, Winter 2009

63. Field nutrition. Mickelbart, M. V. American Nurseryman 208(7):28-31. 2008.

Field Nutrition

by MICHAEL V. MICKELBART

Effective fertilization in field nursery production depends on the balance of three interacting factors — the plant, the environment and the applied nutrient.

Two major factors are affecting how growers think about fertilization: the rising cost of fertilizers and an increasing awareness of the environmental consequences of nutrient runoff and leaching. Much of the recent work on fertilizer efficiency has focused on container production. This is for good reason: Container production is increasing in areas like the Midwest, plants grown in containers are a more concentrated source of potential pollutants (more plants per area), and the potential for leaching and runoff is greater in soilless media than in most field soils. However, efficient fertilizer application is also important in field nursery production.

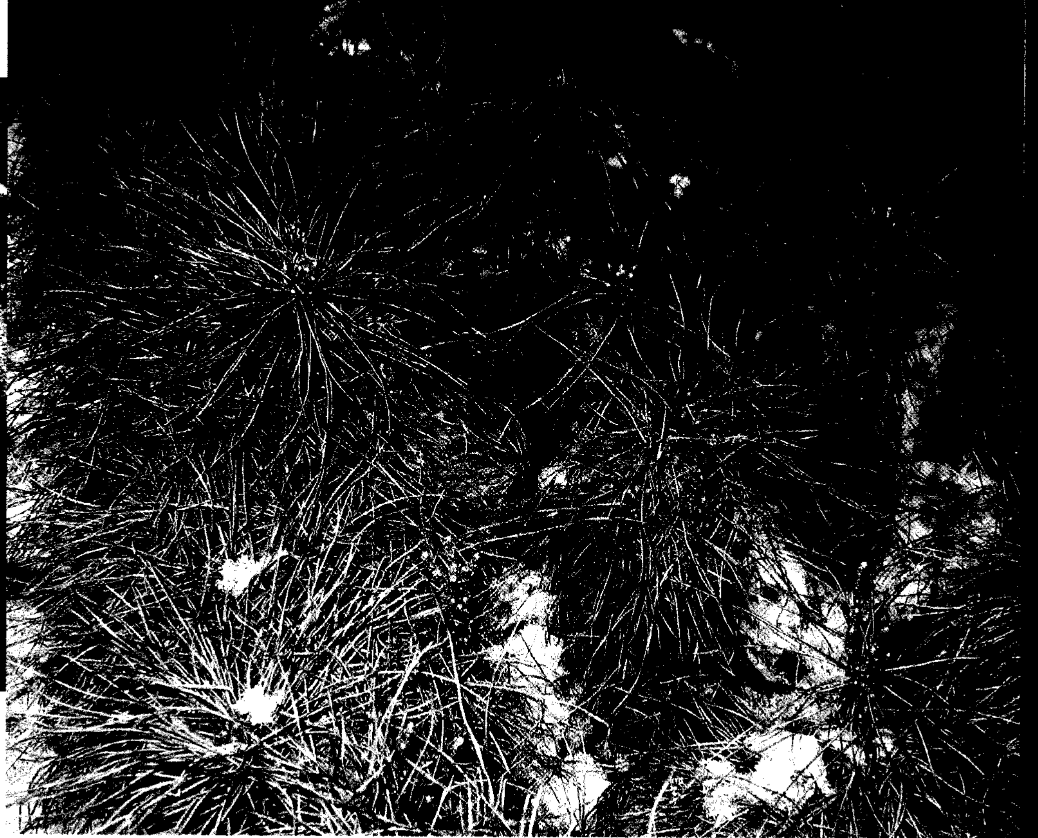
The effectiveness of a field nutrition program can be thought of in much the same way as the disease triangle — a common model used to describe the interaction between the environment, the host plant and the disease-causing organism. For a disease to occur, all three factors must work together. Likewise, to prevent the disease, one factor can be eliminated or modified. In much the same way, effective fertilization depends on three interacting factors — the plant, the environment and the nutrient being applied. The level of interaction among these three components can be quite complicated, but understanding how each component relates to nutrition is a good start.

The plant. There are two major factors to consider regarding how different plants respond to nutrients — the genetic makeup of the plant and the stage of development. By genetic makeup, we mean either the species or the cultivar within a species. Each species and cultivar has a different genetic background that allows it to respond in a certain way to fertilization. For example, the relative nutrient demand of some conifer species is given in Table 1 (opposite). Likewise, broad-leaved species have different nutrient demands. Often, experience will guide you on which species requires greater amounts of fertilizer each year.

Within a species, there are also cultivar differences. The graph (Figure 1, opposite) shows the change in leaf manganese (Mn) concentration with different rates of soluble fertilizer and slow-release fertilizer. The foliar concentration of Mn increases with respect to fertilization in *Acer rubrum* 'Red Sunset', but less so in the hybrid *A.* × *freemanii* 'Celebration'. These trees are part of a field experiment at Purdue University, West Lafayette, IN, to examine the effects of soluble fertilizer and slow-release fertilizer on the growth and appearance of red maples. This is only one aspect that makes nutrient management in ornamentals difficult. If you are an apple grower, you are probably dealing with

PHOTOS COURTESY OF SCOTT HEEREN, HENSLER NURSERY INC.

208(7): 28-31



White pine seedlings in the foreground (detail, right) exhibit symptoms of salinity stress after being fertilized with calcium nitrate during a hot and dry growing season, while seedlings in the background show no symptoms. This demonstrates relative differences in response to fertilization.

PHOTOS COURTESY OF SCOTT HEEREN, HENSLER NURSERY INC.

a few cultivars that many other growers have managed and research has been completed on. With ornamentals, we are dealing with thousands of different species and varieties. It is impossible to know the exact nutrient requirements for each cultivar, so experience often has to be our guide.

The stage of development, either within a season or age of the plant, is also an important factor for fertilization. Phenology is the study of periodic biological events that occur in response to climate, but have a genetic basis. For example, budbreak, flowering and fall color all have a genetic basis (some trees turn color in the fall earlier than others), but are influenced by the weather. Root growth is one of these biological events. Root growth does not occur during the winter in cold climates and is reduced in warmer parts of the US. Nutrient uptake can only occur when root growth is active, so applying nutrients outside of the time period when root growth is occurring will lead to wasted fertilizer because nutrients may leach through the soil without being taken up by the plant.

However, this must be balanced with missing the opportunity to deliver the nutrient prior to budbreak. In areas with high rainfall, it is often difficult to get into the field to fertilize in the spring. For this reason, many growers prefer to apply fertilizer during the winter when the ground is hard. However, if a soluble fertilizer is used, this practice may lead to excessive loss of fertilizer.

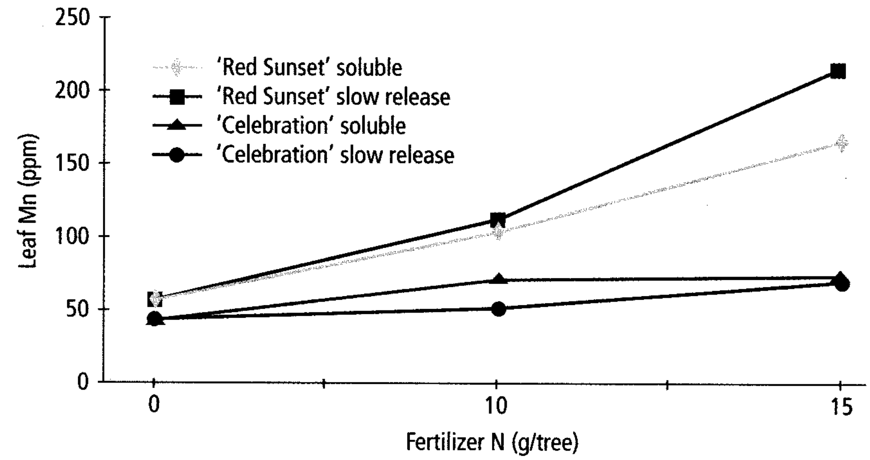
An alternative to winter fertilization is fall fertilization. This ensures that plants are at a maximum nutrient status prior to dormancy, and nutrients are stored in woody tissue and roots over the winter. Potassium is one nutrient that has low availability in some areas at the end of the growing season. Potassium can be applied in the fall to enhance spring growth. Use a potassium source low in nitrogen, such as 5-3-15, 5-5-30 or 5-0-20, and apply from late August to early September. This will give the plant time to take up the nutrients. Fall fertilization allows for nutrient assimilation into organic compounds and subsequent nutrient storage in the trunk, stems and roots of trees during the winter.

Table 1. Relative nutrient demand of some conifer species

Low	Medium	High
Scotch pine	White spruce	Douglas fir
Virginia pine	Norway spruce	Blue spruce
	European black pine	Fraser fir
	Red pine	Balsam fir
	White pine	Canaan fir

Figure 1

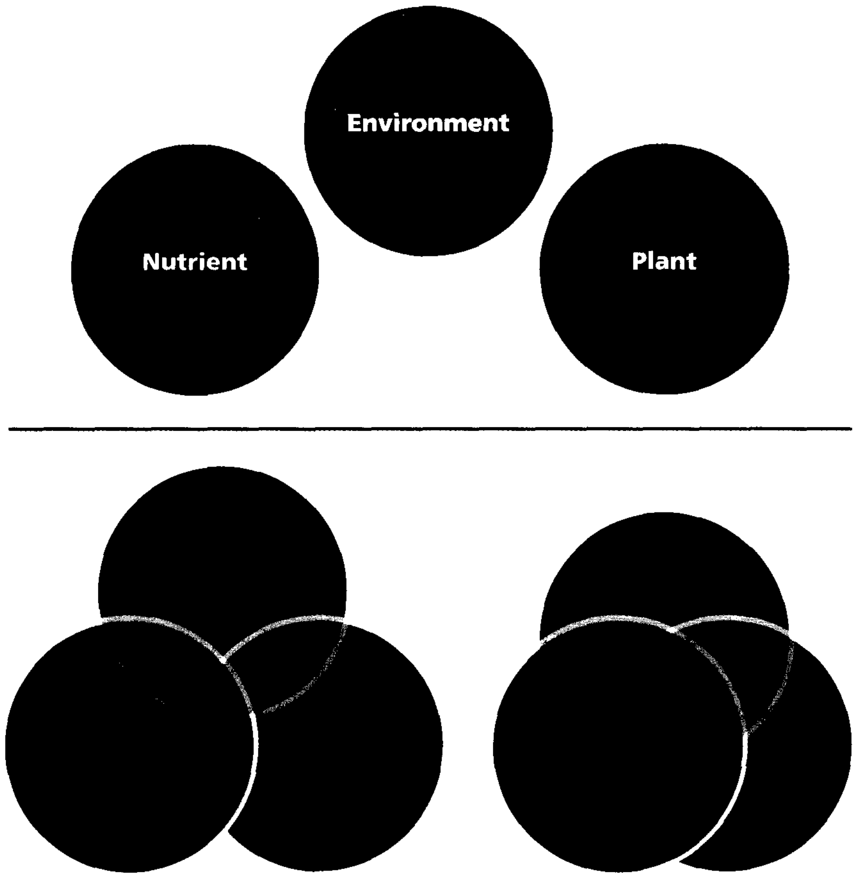
Effect of nitrogen fertilizer on leaf manganese concentration in *Acer rubrum* 'Red Sunset' and *A.* × *freemanii* 'Celebration'

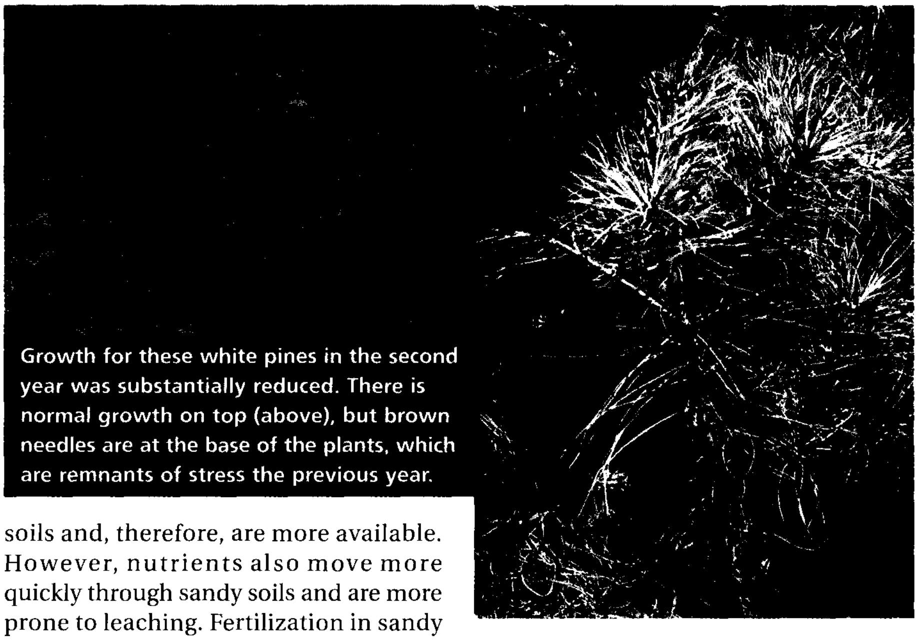


The environment. In a field-production site, soil is a major determinant of the availability of nutrients. In sandy soils, nutrients are in solution more than in clay

Figure 2

Interaction of environment, plant and nutrient on fertilizer efficiency (the amount of overlap of the three circles indicates relative efficiency)





Growth for these white pines in the second year was substantially reduced. There is normal growth on top (above), but brown needles are at the base of the plants, which are remnants of stress the previous year.

PHOTOS COURTESY OF MICHAEL V. MICKELBART

soils and, therefore, are more available. However, nutrients also move more quickly through sandy soils and are more prone to leaching. Fertilization in sandy soils usually results in quick response, but leaching potential is higher. This can be dealt with by performing split applications. In clay soils, nutrients are more bound to soil particles and move more slowly through soil. This results in a relatively slow response to fertilization, but leaching potential is lower. Split applications are typically not necessary in these types of soils.

One of the most important soil properties is pH because of its effect on nutrient availability. Most growers have seen the chart showing nutrient availabilities at various soil pH values. Some of the most common nutrient deficiencies, including iron and manganese, occur in soils where the nutrient is present, but not available because of pH. Choice of nitrogen fertilizer is also dependent on pH. Ammonium nitrogen (NH_4) is more available in higher pH soils, whereas nitrate nitrogen (NO_3) is more available in lower pH soils. However, we come back to the triangle: Under warm temperatures, the conversion of ammonium to nitrate occurs so quickly that the applied form does not matter as much.

There are two major factors to consider in terms of how different plants respond to nutrients — the genetic makeup of the plant and the stage of development.

Soil moisture is another environmental factor affecting the solubility and release speed of various nutrients. For example, NO_3 moves very quickly in soil water, whereas NH_4 moves more slowly. When weather conditions are warm and there is sufficient moisture, soil bacteria quickly converts the ammonium to nitrate, and the nitrate is taken up by actively growing plant roots. If NO_3 is applied to wet, sandy soil (with low nutrient-holding capacity), nitrate can more readily leach into groundwater.

The nutrient. Finally, there is the nutrient itself. The properties of various nutrients that dictate how they act in the soil and in the plant include the charge (positive, negative or neutral), how quickly it is converted into other forms and how readily it interacts with other elements. Once again, we must keep in mind that interaction of the nutrient with the environment is important. Nitrogen is taken up as ammonium or nitrate by plants. We can apply nitrogen in either of these forms or as urea. Urea quickly breaks down into ammonium ions under warm-weather conditions with adequate moisture. Likewise, ammonium is quickly converted to nitrate under these conditions. However, in cooler weather, these processes are slowed down.

It is not only the amount of an individual nutrient that is important, but also the relative proportion of other nutrients. For example, both potassium and molybdenum are required for efficient nitrogen uptake in the plant. So, if either of these nutrients is lacking, nitrogen-deficiency

Table 2. Nutrient deficiencies

Induced deficiencies resulting from excess nutrient concentrations in soils

Nutrient in excess	Induced deficiency	KEY
N	K	N = nitrogen
P	Cu	P = phosphorus
K	N, Ca, Mg	K = potassium
Na	K, Ca, Mg	Na = sodium
Ca	Mg, B	Ca = calcium
Mg	Ca	Mg = magnesium
Fe	Mn	Fe = iron
Mn	Fe	Mn = manganese
Cu	Fe	Cu = copper
		B = boron

One tree (left) received soluble fertilizer, while the other received the same amount of slow-release fertilizer. This shows the effects of fertilizer formulations on late-season growth.

PHOTOS COURTESY OF MICHAEL V. MICKELBART

symptoms can appear even though there is plenty of nitrogen available. This is why soil and tissue analyses are so important: They tell you what is going on beyond the visual symptoms. On the other hand, if certain elements are present in high amounts, they can inhibit the uptake of other elements. Table 2 (above) shows the induced deficiencies that can occur when certain elements are present in excess. This is another reason why fertilization should not be done without evaluating soil and leaf nutrient analyses.

Another way to ensure consistent nutrient supply is through the use of slow-release fertilizers. With soluble fertilizers, nutrients dissolve into the soil solution very quickly. Especially under conditions of warm weather or high rainfall, many nutrients, like NO_3, can quickly leach through the soil profile. This may result in nutrient deficiencies late in the growing season. Slow-release fertilizers provide a steady supply of nutrition throughout the growing season. If a single application of soluble fertilizer is made at the beginning of the growing season, late-season deficiencies can occur. Slow-release fertilizers are also a good option if growers want to fertilize in the winter.

Thinking about the three major factors that affect nutrient uptake and use in plants can be a little complicated. The goal of any program should be a balance between good plant growth, appearance and efficient delivery of nutrients. There are many more potential interactions than the ones discussed here, but keeping these interactions in mind will hopefully help you think through your fertilization program.

Michael V. Mickelbart is an assistant professor in the department of horticulture and landscape architecture at Purdue University, West Lafayette, IN. He can be reached at (765) 494-7902.