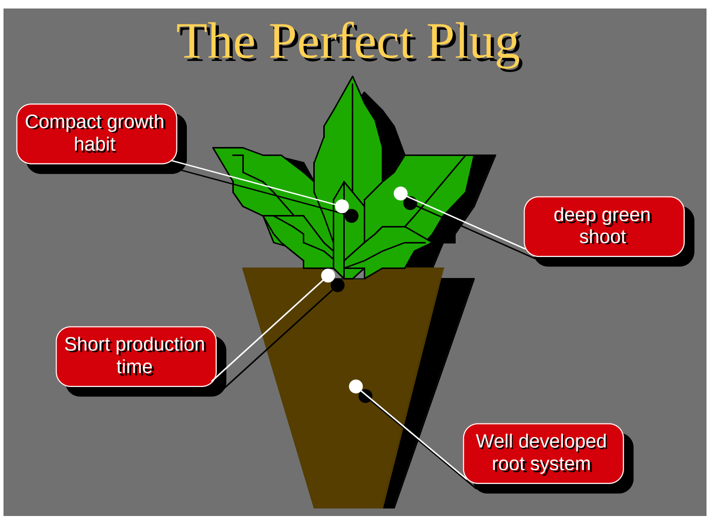
Plug fertilization strategies

by Paul V. Nelson, Jin-Sheng Huang, William C. Fonteno, and Douglas A. Bailey

The nutritional program used in plug production will affect your ability to produce the "perfect plug"

An ideal plug is one that ❶ is produced in a short period of time, ❷ has a compact shoot with the normal number of leaves but short internodes, ❸ is deep green in color, and ❹ has a large, well developed root system to facilitate transplanting (Fig. 1).



Schematic of an ideal plug.

The nutritional program impacts all of these factors, but not in a favorably coordinated manner (Table 1). If the seedling is supplied with all of the fertilizer that it has the genetic potential to use (high rate), a totally useless plug will result. This shoot on this plug will grow too large for the surface area provided by the plug cell in which it is growing. One seedling will shade the next causing each to stretch. Lower leaves will be pale green (etiolated) from the lack of light. When the quantity of total fertilizer is greatly reduced (low rate) a smaller, desirable shoot can be produced but the time of production is usually increased and the foliar color is undesirable light. The intermediate fertilizer rate produces a green seedling on schedule, but considerable chemical growth regulator must be used to keep the shoot size within bounds.

This situation defines two of the major camps of plug growers. One set uses a moderate rate of fertilizer along with sizeable quantities of chemical growth regulators while the second set greatly restricts fertilizer application thereby minimizing growth regulator use. Our NCSU Plug Research Group is studying the potential benefits of applying deficiency stresses of individual nutrients.

Fertilizer Application

Fertilizer programs consist of two stages, preplant and post-plant (Fig. 2). Preplant fertilizer is incorporated into the root substrate prior to planting, usually during formulation of the substrate. Post-plant fertilizer is typically applied as a solution periodically after planting.

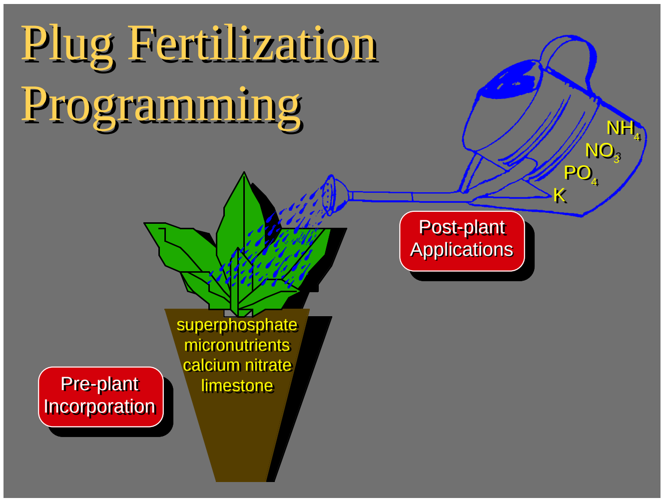
Preplant fertilization. Nearly all substrate used for seedling germination contains calcium (Ca) and magnesium (Mg). Beyond those two nutrients plug growers are divided in their opinion relevant to incorporating the remaining mineral nutrients into the substrate as pre plant fertilizer. Some do (Table 2) and some don't. Yet, both systems can result in excellent finish plugs.

The decision whether or not to use preplant nutrients will impact the post-plant fertilization specifications and possibly the chemical growth regulator program. When preplant nutrients are not applied the concentration of post-plant liquid fertilizer is typically higher and sometimes begins earlier in Stage 2. Many vegetable seedling growers do not use preplant nutrients out of fear of hypocotyl stretch (elongation of the lower stem). This is prudent for these growers because of the lack of chemical growth regulator labels for vegetables.

Calcium and Mg are nearly always incorporated into plug substrate because they are supplied in the limestone used to adjust the substrate pH. A substrate pH of 5.4 to 6.0 is desirable for most bedding plant species. When this level is achieved and held the supply of Ca and Mg generally remains satisfactory. The next nutrient most often applied in preplant fashion is phosphorus (P). When used, rates for a triple superphosphate form range from 0.5 lbs up to a maximum of 1.0 lb per cubic yard of sub-

Table 1. Effects of the rate of complete (nitrogen-phosphorus-potassium) fertilizer on plug seedling quality indices.

	Fertilizer Rate		
Index	low	intermediate	high
production time	slow	good	good
shoot size	compact	moderately large	too large
shoot color	light green	good	etiolated
root size	favorably large	normal	possibly small



Plug fertilization programs have potentially two phases, preplant and post-plant.

strate. The source of nitrogen (N) generally used is calcium nitrate. Like superphosphate, rates generally range from 0.5 lbs up to 1.0 lb per cubic yard. Potassium (K) is rarely applied as a preplant nutrient. Our data to date shows no benefit from it during Stage 1 and early Stage 2. The post-plant program begins early enough to meet the needs for K. The macronutrient least frequently added is sulfur (S). When added in preplant fashion the source is usually Epsom salt (magnesium sulfate). The rate can extend up to 0.5 lbs per cubic yard of substrate. When macronutrients are applied in preplant form micronutrients are generally also applied. Several packages of all six fertilizer micronutrients are available on the market. Generally these are used at half of the rate recommended for greenhouse crops in general. Post-plant fertilization. Fertilizers typically used for post-plant application have approximately a 1 nitrogen (N) to 1 potassium (K_2O) ratio. When substrate tests or visual signs of N or K deficiency indicate a change, other ratios are used for correction. The concentration of fertilizer to use depends on five main factors: ❶ stage of seedling development; ❷ leaching percentage during watering or fertilization; ❸ frequency of fertilizer application; ❹ the crop grown; and ❺ presence or absence of preplant fertilizer in substrate.

Most firms use two concentrations of fertilizer (Fig. 3). A low concentration is applied during Stage 2 (the period after emergence of the radicle but before appearance of a true leaf) and the early part of Stage 3 (the period from the first appearance of a true leaf up to the time when the seedling can be transplanted) and a higher concentration for the remainder of the production time. The shift in concentration occurs when seedlings enter into a rapid rate of expansion. This point becomes obvious when foliage turns lighter due to insufficient nutrition.

Two additional factors that govern fertilizer concentration are the leaching percentage and the frequency of irrigation. Leaching percentage is the percent of the water or fertilizer applied to a plug tray that passes out the bottom of the tray. Most firms leach while they water or fertilize. Although the leaching percentage used in the plug industry is unknown, an estimate of 25% would seem reasonable. A few firms use a zero leach system. Variation among plug growers is also seen in the frequency of fertilizer application. Fertilizer might be applied at each irrigation, every second, or every third, or even on a time schedule such as three times per week. The impact of these variations on fertilizer concentration is seen in Fig. 3. A zero leach grower applying fertilizer at each irrigation could start with 30 ppm N in Stage 2 and increase to 50 ppm N somewhere in Stage 3. If this zero leach grower was applying fertilizer at every third watering the equivalent N concentrations would be 50 and 80 ppm. On the other hand, a grower who practices leaching and applies fertilizer at each irrigation would use 50 and 90 ppm N in Stages two and three, respectively.

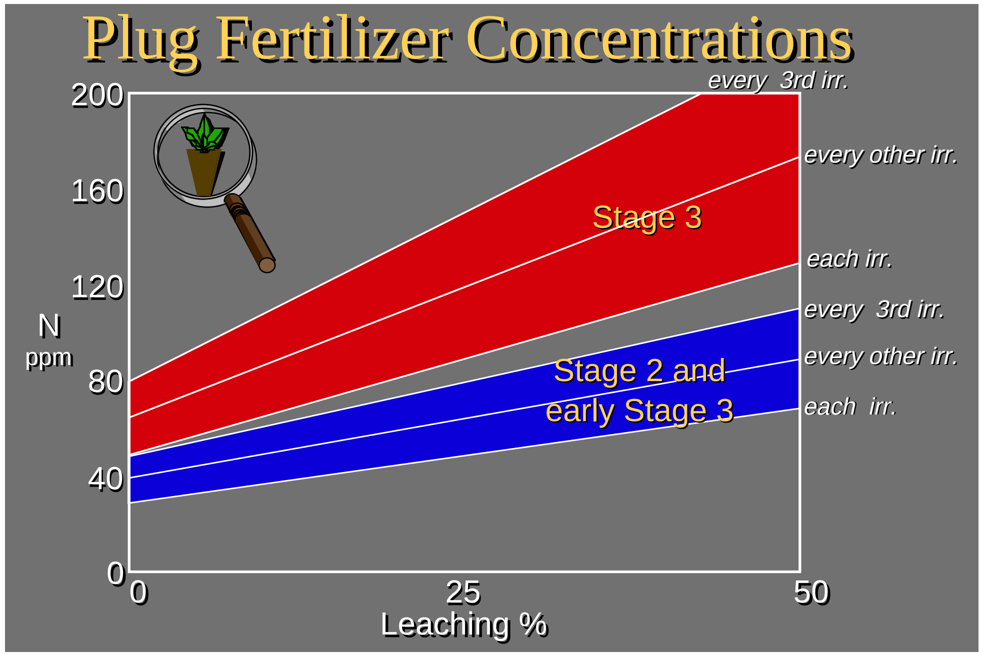
The fertilizer concentrations presented in Fig. 3 apply to crops with an average nutrient requirement. Lower rates would be necessary for crops such as impatiens and pansy that have a low requirement. The lower rate could be accomplished by reducing the concentration or by less frequent application. Some pansy growers rely on a light rate of preplant nutrients (substrate saturated paste EC of 0.5 dS/m) followed by only two or three fertilizer applications during the entire plug production program. Crops with a heavy nutrient requirement such as gomphrena and verbena and to a lesser degree begonia, dusty miller and vinca might require heavier rates of fertilization.

Finally, preplant fertilizer has an influence on the post-plant fertilizer timing and concentration. Growers who use substrate without preplant fertilizer in it tend to use higher concentrations and/or start post-plant fertilization earlier in stage two. There are no definitive guidelines for these adjustments. The fertilizer concentrations presented in Fig. 3

Table 2. Sources and rates of preplant nutrients often incorporated into plug substrate.

Nutrient	Source	Rate (lbs/cu. yd.)
calcium & magnesium	dolomitic & regular limestone	amount to achieve pH 5.4 to 6.0
phosphorus	triple superphosphate	up to 1.0 lb
nitrogen	calcium nitrate	up to 1.0 lb
sulfur	Epsom salt	up to 0.5 lb
micronutrients	various commercial packages sold for greenhouse crops	half the rate recommended for general greenhouse crops
EC (total soluble salt)	the combination of all nutrient sources must not exceed an EC level of 0.5 dS/m (mmho/cm) for sensitive crops and 0.75 for other crops as determined by the saturated paste extract procedure	

apply to crops grown in substrate that has preplant fertilizer in it. Generally, post-plant fertilization for average nutrient requirement crops grown in substrate without preplant fertilizer starts within two or three irrigations after being removed from the germination chamber (the start of Stage 2). Fertilization for similar crops in substrate with preplant fertilizer might start at the beginning of Stage 3.



Nitrogen fertilization rates for average nutrient requirement plugs showing the effects of stage of growth, leaching percentage, and frequency of fertilizer application.

Shoot Compactness Through Fertilization

As indicated, plug seedlings must not be supplied with all of the fertilizer they have the facility to use. The first approach to compact shoots should be a reduction in fertilizer application. Chemical growth regulators should be the last resort. If excessively large shoots result from the use of the fertilizer rates in Fig. 3 along with substrate containing preplant nutrients, it will be necessary to further reduce fertilizer application. This can be done by eliminating some nutrients in the substrate along with a reduction in the post-plant fertilizer concentration. There are no published guidelines for these cuts. However, growers use two methods. The first is most common and involves restricting application of the complete nitrogen-phosphorus-potassium fertilizer. The second system has been trialed by a few growers and calls for restriction of phosphorus only.

Complete fertilizer reduction. Shoot compaction can be enhanced by eliminating preplant N, P, and K from the substrate along with a reduction in the concentration of the complete fertilizer used in the post plant program. The extent of fertilizer reduction is generally worked out by each grower. The results of such a program are compact shoots along with adversely light colored foliage. The light foliage is objectionable to some purchasers of plug seedlings. Others accept the color because they know that it will re-green in the finish flats a few days after fertilization. Our studies to date have shown no delay in the finish flat production of bedding plants handled in this manner.

Phosphorus reduction. An even less well defined procedure for achieving compact shoots is the reduction of P application. Our current research suggests the following program (Fig. 4). Use no preplant P in the substrate. Then restrict P in the post-plant fertilizer program to 15 to 20% of the N level. This may be done with a 13-2-13 or 20-2-20 fertilizer or by alternating two fertilizers that add up to a P quantity equal to 15 to 20% of the N quantity. It will be necessary to make adjustments in the P delivery rate to keep the plants at the proper level of P stress.

The first symptoms of P deficiency are smaller leaves, shorter internodes, and deeper green foliar color than normal. This is followed by purpling of leaves in some species, then chlorosis of older leaves, and finally necrosis beginning on older leaves. It is this first set of symptoms that needs to be maintained in this reduced P program. If chlorosis appears the rate of P fertilization needs to be increased.

The resulting seedlings in this program are compact and deeper green than normal. This eliminates the objection of chlorosis that results in the program where the complete fertilizer is reduced. However, there is a trade-off for using the low P program. The finish flat crop of bedding plants resulting from these seedlings may be delayed. While African marigold was not delayed in our studies, impatiens and gomphrena were delayed by five days. This may not be longer than delays encountered with some chemical growth regulators.

Post-plant phosphorus applications affect elongation of many plugs, including African marigold. Levels shown here are (left to right) 2, 4, 6, and 20 ppm P and equate into 5, 10, 15, and 50% of the nitrogen rate used.

Authors' Note

It is always frustrating to write an article on plug seedling fertilization. Definitive recommendations are missing in the literature. And to make matters worse, plug growers use such a wide diversity of fertilization procedures it is not possible to average these into good quantitative directions. Recommendations in this article stem from our own research data in combination with observations from commercial firms. Where our recommendations have been more qualitative than quantitative it will be necessary for you to experiment to find the exact rates for various crops. This subject constitutes a major effort in our current research program.

Appreciation is expressed to The Bedding Plants Foundation, Inc. and to The Fred C. Gloeckner Foundation for their financial support of the research that helped form the basis for this article. For more information about this article, contact Paul Nelson at (919) 515-1191 or e-mail him at paul_nelson@ncsu.edu.