Using Phosphorus Starvation to Regulate Growth

Nutrient deficiency is most often thought of as a problem, but new research shows that withholding phosphorus from some bedding plants can result in a desirable reduction in height.

By Douglas Cox

Non-chemical alternatives to plant growth regulating chemicals have received a great deal of attention in recent years as tighter restrictions have been placed on agricultural chemical use. Some non-chemical methods are very simple, such as avoiding seeding too early and transplanting at the proper time to avoid excessive stretch. For some bedding plants, short or medium height cultivars exist that may be substituted for tall cultivars. Plant growth can also be controlled by manipulating the difference between day and night temperature using the "DIF" method. A more unusual, but practical, way of controlling height is by "mechanical conditioning" of plants by rubbing, brushing or shaking them on a regular basis.

Controlling bedding plant growth (e.g., height, overall size or rate of development) by withholding fertilizer is already being practiced, with varying degrees of success, by many growers. Low fertility is sometimes used to "hold back" bedding plants sown too early or to spread out the transplanting process to match available labor or greenhouse space. Occasionally, low fertility is combined with water stress or low greenhouse temperatures in an effort to control growth. However, general low fertility and water stress are risky strategies that may cause unacceptable reductions in plant quality.

In recent years, low phosphorus, sometimes called "phosphorus starvation," has been promoted as a way of controlling the growth of bedding plants. If carefully managed, a mild to moderate phosphorus (P) deficiency may result in a desirable reduction in growth with no foliar symptoms of P deficiency. In fact, a mild P deficiency actually makes most plants look greener!

Several low analysis P fertilizers (e.g., 20-0-20, 15-0-15 and 20-2-20) are available from commercial greenhouse fertilizer manufacturers and can be used for controlling growth. Unfortunately, there are no recommendations outlining the "phosphorus starvation" technique. A potential problem with this method is too much growth inhibition and/or the appearance of severe deficiency symptoms (e.g., purple coloration) caused by using too little P. Timing of the low P period is also important because, like chemical plant growth regulators, nutrient deficiencies have their greatest effects on plant size early in the crop cycle, during the period of rapid vegetative growth.

Over the past few years, I have been studying the use of low P fertilization as a means of reducing bedding plant growth. I thought this would be easy, but it soon became apparent that causing "phosphorus starvation" was easier said than done when plants supposedly grown with no P turned out as large as those receiving normal levels of P!

FIRST EXPERIMENTS

My first experiments were with 'First Lady' marigold, 'Ultra Red' petunia, and 'Marglobe' tomato grown in 804 tray inserts filled with Fafard 3B. "Control" plants received normal P levels from Peter's 20-10-20 Peat-lite Special (150 ppm N) from crop start to finish.

I tried a number of low P treatments, but the most important was Peter's 20-0-20 Hi-Cal Peat-lite applied the same way as 20-10-20. I reasoned that if any treatment would affect the size of plants, this would be the one because the plants got no P from water-soluble fertilizer during growth. The surprise was that the marigolds and petunias grown with 20-0-20 showed no P deficiency symptoms and grew as tall and were indistinguishable from those fertilized with 20-10-20. Tomato, on the other hand, a plant I knew to be sensitive to P deficiency, behaved the way I expected: plants fertilized with 20-0-20 developed P deficiency symptoms and were shorter than those grown with 20-10-20.

Top: Salvia grown with a normal level of P (left) vs. a low P level (right). Note the darker green of the low P plant. Bottom: 'First Lady' marigold grown with 20-10-20 (left) and 20-0-20 (right). The lack of difference is attributed to the initial P level in the growth medium. (All photos courtesy of Doug Cox.)

Reflection on results from my first experiments led me to believe that the growth medium might be supplying enough P for the marigold and petunia without additional P from water-soluble fertilizer. Fafard 3B, like most commercial soilless mixes, contains no granular superphosphate, but it does contain a NPK "starter charge." It is generally accepted that the starter charge in soilless media is exhausted after two or three weeks and then regular fertilization is required. But, maybe two or three weeks is long enough for plants with a low P requirement to accumulate enough P to maintain six to eight weeks of growth in a small pak.

In more recent experiments, I looked at the effects of growth medium on low P response and how to apply low P fertilizer to control growth. In addition to First Lady marigold, Ultra Red petunia and Marglobe tomato, I also grew 'Bonanza Orange' marigold and 'Flare' salvia in these experiments.

HOW THE PLANTS WERE GROWN

Seedlings were transplanted to 804 tray inserts filled with Fafard 3B, Metro Mix 360 or a "homemade" 2:1:1 soilless mix about four to

Table 1. Phosphorus and EC levels in growth media at planting, as determined by the SME method.

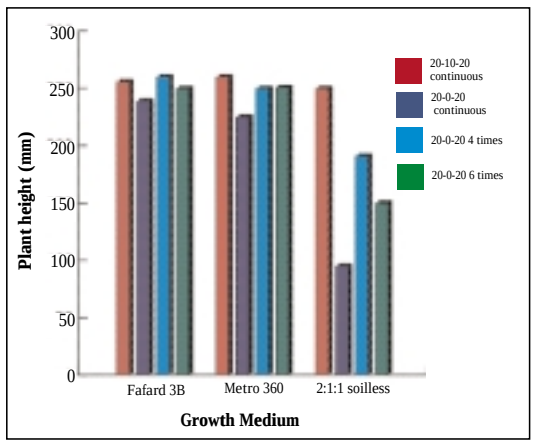
Growth medium	P level (ppm)	EC (ds/m)
Fafard 3B	37	1.85
Metro Mix 360	3	2.58
2:1:1 soilless	5	0.36

six weeks after seeds were sown in 144-cell plug trays. The 2:1:1 mix consisted of sphagnum peat moss, perlite and vermiculite (2:1:1, by volume) to which I added 5 lbs./cu. yd. of dolomitic limestone, but no starter charge or other fertilizer material.

Plants in each growth medium were divided into four groups to receive fertilizer treatments. One group, the control, received 20-10-20 and a second group got a low pH fertilizer, 20-0-20, twice a week from start to finish. A third group got 20-0-20 four times (over 2 weeks) starting at transplanting and then 20-10-20 to finish. The fourth group got 20-0-20 six times (over 3 weeks) and then 20-10-20. The fertilizer rate was 150 ppm N in all treatments.

Seeds were sown in mid-March, and the plants finished in late May. Plant growth measurements, height and shoot fresh weight were taken at the end of the experiment, about five weeks after transplanting.

Fig. 1. Effects of growth medium and phosphorus fertilization on the height of 'Ultra Red' petunia (1 in. = 25.4 mm).



RESULTS

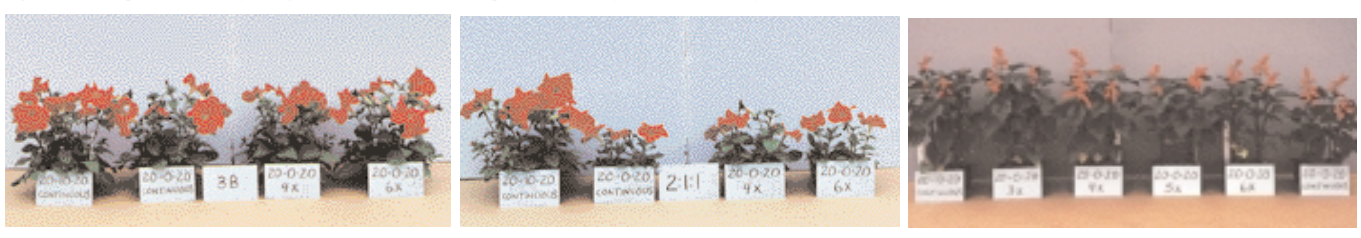
The response of Ultra Red petunia to growth medium and low P treatment was typical for flowering bedding plants. Growth medium had a great influence on how tall the petunias grew in response to P treatment (See Figure 1). In Fafard 3B, P treatment had no effect on plant height. Statistical analysis revealed that even plants receiving 20-0-20, start to finish, were as tall as the plants receiving 20-10-20.

Petunias grown in Metro Mix 360 responded somewhat differently. Plants receiving 20-0-20 continuously were shorter than the control. Plants getting four or six applications of 20-0-20 and then 20-10-20 were as tall as the control.

The greatest low P response occurred in the 2:1:1 soilless mix with no starter charge. Application of 20-0-20 continuously, four or six times, all resulted in much shorter plants than the control. Petunias were too short and flower number was reduced when 20-0-20 was applied continuously or with six applications. Four applications (2 weeks) of 20-0-20 resulted in desirable height reduction with no adverse effect on flowering. First Lady marigold, Bonanza Orange marigold and Flare salvia had about the same response to growth medium and low P treatment as Ultra Red petunia. However, in the case of First Lady marigold and Flare salvia, six applications of 20-0-20 resulted in a greater and more desirable level of growth control than four applications.

Generally, regardless of plant species, fresh weight and plant height

Left: 'Ultra Red' petunia growing in Fafard 3B. Center: 'Ultra Red' petunia in 2:1:1 growth medium. Right: 'Flare' salvia in 2:1:1 growth medium.



were affected in the same way by low P treatments. However, sometimes differences in growth between treatments were revealed by fresh weight determinations even though height was not affected and other differences in size were not visually apparent. For example, First Lady marigold plants grown in Fafard 3B and fertilized with 20-0-20, start to finish, weighed less than the control plants even though there were no differences between the two treatments in height or appearance. Perhaps if the plants were grown longer, low P effects on height and appearance might have appeared.

ROLE OF GROWTH MEDIUM

The growth medium appears to be important in the response of bedding plants to low P for growth control, and I believe it is due to the nutrient starter charge. I made a soil test at planting, which is helpful in understanding the differences between the three mixes (See Table 1). Fafard 3B (where most plants were least responsive to low P) has a much higher P level to start than Metro Mix 360 and the 2:1:1 soilless mix.

Metro Mix 360 and the 2:1:1 soilless mix have similar P levels, but overall, Metro Mix 360 was more fertile to start as it had a higher electrical conductivity (EC) level. Plants were less responsive to low P in Metro Mix than 2:1:1 mix. Perhaps the starter charge in Metro Mix may provide a consistent level of P for longer than two weeks. The exact nature of the charge cannot be determined because it is a proprietary charge. Also, a soil test made at planting cannot explain the different influences on P level or predict how long it will be adequate to support the plants. The importance of the starter charge in crop nutrition and the overall P requirement of bedding plants needs more study.

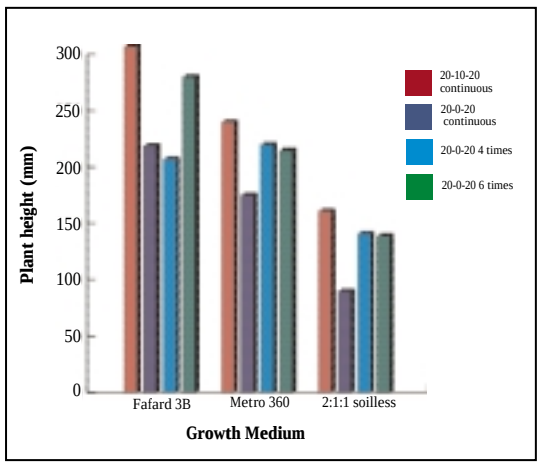


Fig. 2. Effects of growth medium and phosphorus fertilization on the height of 'Marglobe' tomato (1 in = 25.4 mm).

RECOMMENDATIONS TO GROWERS

I recommend that a grower wishing to try this method of bedding plant growth control use a low P soilless growth medium, preferably custom blended or homemade. The mix should contain 1 lb./cu. yd. of potassium nitrate as a starter charge. Do not use a starter charge containing P! Tomatoes in paks appear to be quite sensitive to low P during greenhouse production. For this reason, with tomatoes, I recommend using a commercial soilless mix, such as Fafard 3B, containing a significant fertilizer starter charge rather than a specially prepared low P mix.

Begin fertilizing twice a week right after transplanting with 20-0-20 for two to three weeks and then finish with a NPK fertilizer like 20-10-20 or 15-16-17. Rates should be 150-200 ppm N, or the bedding plant rate normally in use. For crops sown and transplanted in late winter or very early spring, the low P fertilization period may have to be longer. If fertilization with 20-0-20 is extended beyond three weeks from transplanting, carefully monitor crop progress to prevent too much growth reduction, a delay in flower development or P deficiency symptoms. Plants must receive fertilizer at least twice a week throughout the crop season. This will result in desirable height reduction and no P or other nutrient deficiency symptoms.

Continuous fertilization with 20-0-20, or other fertilizer supplying no P, is not recommended because it will probably result in too-short plants and/or the development of severe P deficiency symptoms.

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