to less successful growers. However, lack of precise knowledge of plant inputs, poor data collection and methodology limit the establishment of accurate predictive models.

The long range benefits of plant modeling. We need to think in terms of propagating and producing plants not just with today's technology but with new systems coming in the next 20 years. It may well be in the next 25 to 30 years that a sizeable portion of retail nursery items will be produced under specialized warehouse conditions where environmental controls are manipulated. Tissue culture and accelerated growth techniques (AGT) of light, fertility, CO_2, and water manipulation are examples of such controlled conditions.

Growers must become more receptive to computer usage in the quantification of data to make better managerial and production decisions. As our ability to take more accurate environmental and plant data improves, the use of more precise models to make management decisions will enable us to be more productive and efficient nursery producers.

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PLANT MODELING — PRACTICAL APPLICATIONS

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A "model" is another term for a set of equations that describe the system in question. Their purpose is to help make decisions. These models can be very simple or complicated and are simply an organized expression of knowedge about the interacting factors in a given system. Models may cover very broad areas or deal with only very specific situations. Vrecenak and Harrington (1) attempted to model the transpiration of trees in urban areas. They concluded that modeling held promise of aiding in urban plant management but noted that

more accurate input information for the model was required.

An example of a very broad model would be one describing the demand for large container-grown trees in succeeding years. The model might consist of the following equation:

$$D = C + L + S + / - A + / - P + / - W - O$$

D = demand for container-grown trees in general

C = construction starts in your geographic sales area

L = local attitudes for tree planting

S = sales effort/promotion

A = alternative tree-production practices

P = price

W = weather conditions

O = other nurseries' reactions to anticipated demand

Construction starts are easy to obtain from city or county records. Local attitudes towards tree planting are more difficult to obtain. However, a good example of an influencing factor is the "Oklahoma City Beautiful" program, which is having a positive influence on the number of trees being planted.

Sales effort and promotion of container-grown trees is dependent on personnel and, to some degree, the quality of the product. Adding a good salesperson in an active geographic area may have a great influence on sales. Or splitting a sales region if the current sales person is unable to make contact with all the possible customers could have the same effect.

Alternative tree-production practices such as conventional field production and B & B or tree spade digging practices will remain. However, if winter and spring rains frequently limit harvest and sale of trees, field-grown and geographic conditions limit summer digging/handling of trees grown/dug with these methods, then container production would be a plus. For example, late spring and summer planting of B & B or spade-dug trees in the mid-Atlantic states is not as risky as it is in the prairie corridor of Texas, Oklahoma and Kansas.

Price is always a factor to consider, especially relative to demand the various alternative production/handling methods. In general, the cost of producing sizable trees in large containers is more expensive than field production. Because of the greater production cost and the large up-front capital investment required, estimates of future demand must be as accurate as possible.

Weather conditions could be separated into many segments or grouped as I have done here. In general, I am treating weather conditions as a broad area including summer-heat

stress and overwintering stress relative to the wholesale producer, the landscape contractor or retail garden center. Wind and the problem of keeping container-grown trees upright is another weather variable. Weather conditions in northern states could be a substantial negative factor due to the cost of overwintering an above-ground container. On the other hand, in areas of Florida and the southeastern states weather conditions might be a minor negative factor.

The reaction of other nurseries to the anticipated demand must also be considered. If many wholesale nurseries in your geographic sales area are also expanding their production of container-grown trees, a larger negative factor should be included.

To take the example further, place some hypothetical numbers in the equation. Construction starts are projected to be up 10% in two years when the crop of container-grown trees you are considering will be ready for sale. The sales effort/promotion is to be increased 25%. There are no current or anticipated changes in attitudes relative to the geographic sales area. Alternative tree production is up — but only about 5%. The price of the final product will be up about 15%, but alternative production will be up a similar amount so, proportionally, consider no change. Weather conditions have been consistently hurting alternative (conventional field) production of trees. Add a 10% advantage to container-grown trees. Other nurseries are generally increasing their production of large container-grown trees as well, so adjust your estimate down by 15%.

You end up with the following equation:

Demand for container grown trees = + 10% + 0 + 25% − 5% − 0 + 10% − 15%. Thus, anticipated demand will be up by 25%. If your nursery sold 11,253 trees in containers 10 gal. or larger last year, you should consider producing 25% more for sale in two years, or 11,253 + 2813 = about 14,066.

One could argue that by simply taking sales figures for several years past, then projecting into the future, a similar value would be reached. Projecting from current and past sales does provide useful information. However, it does not take into consideration the assortment of present and future factors that can be incorporated into a model.

.Consider a second example that deals with a much more specific situation. The calcium and magnesium requirements of plants grown in soilless mixes in containers appears to be quite specific. However, there are several factors involved: 1) the amount of calcium and magnesium in the components of the mix; 2) amount of calcium and magnesium in the water

supply; and 3) the length of time the crop requires to reach salable size. Since dolomite is used almost universally as the supplemental source of calcium and magnesium, set up a model as follows:

$$\text{Approx. 60 ppm calcium is needed for plant growth} - \frac{\text{ppm Ca in mix}}{\text{number months of crop}} - \frac{\text{ppm Ca in water}}{\text{supply}} = \frac{X}{7.5}$$

One lb. of dolomite will supply approximately 7.5 ppm calcium in a container growth medium. Therefore, if the equation for a specific nursery mix and water is

$$60 - \frac{150}{7} - 40 = 1 \text{ ppm needed, or essentially no dolomite.}$$

On the other hand, if another nursery has only 8 ppm Ca in the water supply and is using the same growth medium the equation would be:

$$60 - \frac{150}{7} - 8 = \frac{31 \text{ ppm needed}}{7.5} = \text{Approximate 4.1 lbs. of dolomite}$$

The same procedure could be done for the magnesium, which appears to be approximately ½ of the calcium requirement.

These figures are rough approximations at this time. However, with additional experimentation and data the equation can be adjusted and refined for greater accuracy. Remember, the equation is simply an organized expression of knowledge about the interacting factors in a given system. The equation should also be an effective tool in preventing oversights of factors when considering adjustments in cultural practices.

Use of models in various aspects of the nursery industry is new but holds promise of becoming another useful tool, especially when incorporated into computer systems.

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