Analyze Now or Pay Later: A Role for Testing in the Business of Plant Propagation

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It is amazing how much money is spent needlessly due to the lack of testing. The reasons for not testing are as many and varied as the people who give them. They include "I have no problems," "It costs too much," "I know my business" or "my land," "Testing doesn't work," or "If I wait to test I'll lose too much profit."

Testing services provide information used to make more accurate, less risky management decisions that justify the cost. The point of testing is to prevent problems, to make better business decisions. There are things that can not be known about land, media, or water without some type of testing. Testing services **DO** work. They are based on sound research and years of experience. Some, who don't take the time to test, realize losses not profits. Testing uses a sample of a population to learn something about a population, instead of using the whole population to learn as many people do.

Several examples of problems created due to the lack of testing will be presented. Not all are from the plant propagation industry, but all illustrate a point. Several testing methods will be discussed. Some you can perform easily, while others require specialized personnel or equipment. The testing discussed addresses routine decisions in horticulture. How much nitrogen is needed? Is a particular soil mix suitable? Does the water have too much salt? All are questions that affect the bottom line.

How much do you think is spent on back-support belts. You see them everywhere: delivery people, back rooms of restaurants, and the grocery store. Safety is good business, prevents losses, and makes money. Worker compensation insurance rates should be lower if employees use these belts. Our insurance carrier did not agree. They checked testing results. The belts are no help and may give lifters a false sense of security leading them to bend the back instead of the knees. A lot of money was spent without testing and for no gain.

A Southern California color grower used color plants worth several million dollars to test a new source of sawdust for his growing medium. All were lost, a very expensive test. The grower's new supplier, my client, called to have a third party test the product. Soil mixes made with new and old sawdusts as well as redwood bark were tested. Five species of plants were grown in three media in replicated greenhouse trials. All mixes produced healthy plants of each species; however, growth was not equal. Water-holding properties of the media differed and all were irrigated based upon properties of the media made with the new sawdust. The grower's old media produced inferior plants. Some did not survive. Photographs presented in court provided convincing evidence that the problem resulted from the grower's management, or lack of testing.

Symptoms on plants grown by a propagator of California natives ranged from deficient through normal to toxic. Tissue and media analyses indicated a wide range of nutrient contents. Some plants received far too much while others received little or no fertilizer. Obvious variability of the blended fertilizer product used in the media was detected by visual observation. Blended dry fertilizers made from ingredients having different particle size distributions will separate during handling. That happened in this case. Each bag had a different combination of ingredients. The problem is easily prevented by testing fertilizer ingredients and selecting only those that are compatible.

During the mid-sixties, fertilizer manufacturers changed the particle size distribution of some products. A blender of dry fertilizers, not the one mentioned above, performed an expensive test. The fertilizer components separated as the bin above the bagger was filled and unmixed more as material flowed from the bin into bags causing the grade in individual bags to vary greatly. The California Department of Food and Agriculture found that the firm failed to meet label guarantees and was proceeding to prosecute. State's evidence was discarded when their sampling methods were tested and it was shown that the sampling device used to draw samples was biased. An ingredient and product testing program was put in place resulting in decreased deficiencies. It was this experience that helped with quick diagnosis of the problem at the native plant nursery.

Why test? To make money of course. To obtain information used to make more accurate, less risky management decisions. To check on the quality of a supply or a product. The problem in each example could have been predicted and prevented with a few dollars worth of testing. There are things we do not and can not know without some form of testing. No one can see nitrate in water or water-holding capacity of a soil mix. Tests for these types of things do work. They are based upon sound research and experience.

What should be tested? Anything new, anything unpredictable, and things that change over time or space. While all the examples involved post-decision problems, most of our testing is performed before routine decisions about nutrient, salinity, soil, and irrigation management are made. No examples of pre-decision testing were given because profitable routine decisions don't result in such graphic examples.

Pittenger (1986), evaluated 15 potting soils available in California stores and found that six had less than desirable physical properties and seven had one or more undesirable chemical properties. His concern was that sufficient information was not available on the label for a customer to make a decision. Similar concern by the Australian Institute of Horticulture and the CSIRO Division of Soils led to an Australian Standard (Council for Standards Australia, 1989) for potting mixes. The standards include test methods as well as definitions of properties. Clearly there are differences between products that are worth knowing about, in advance.

What do we need to know? Several physical and chemical properties of growth media are of primary importance in the production of container-grown plants. A soil mix must be light-weight, have a high water-holding capacity, and have adequate aeration when at container capacity. Container capacity is the maximum amount of water a mix will contain when in equilibrium with gravity. Salt content, including salt contributed by fertilizers, must not be so high as to restrict growth and nutrient content must be sufficient to support growth. Physical and chemical analyses as well as bioassays may be involved.

Water quality can have a big impact on productivity. It must have low total salt content as well as low concentrations of toxic elements such as chloride or boron. Nitrate content of water can be a plus. Some constituents precipitate upon evaporation or react with some fertilizers to form insoluble materials and plug emitters. Many growers are required to recycle water presenting a new set of risks. As water is consumed by plants, salts become more concentrated and drain water analysis will help determine at what point it must be discarded.

What can you do? A simple bioassay is easy to plan and execute. For example, a new medium ingredient could be tested in an existing production facility along side the medium it is to replace. The new mix in labeled pots can be randomly placed in normal production. If there is no detectable difference the new mix will be safe to use. If the new mix produces better plants, the new mix may justify a higher price. If the new mix does not do as well, it may need different management or perhaps it should be rejected. Such a test requires little more than normal production equipment and pots or labels so the test mix can be distinguished from normal production.

Such a bioassay integrates all the parameters of a mix that affect plant growth. A key is good planning if results are to be meaningful. Replication and randomization are critical. There is normal variation. No two things or places are exactly alike. Variation occurs. Replication, randomization and statistical evaluation will help prevent interpreting normal differences as though they were differences due to what was being tested.

To evaluate some physical properties on your own, all that is required is a balance or scale and a drying oven. In addition, you will need several pots and one or more small buckets or other water-tight containers large enough to contain a pot, all from your inventory. The procedure that follows will provide total porosity, container capacity, air-filled porosity at container capacity, and bulk density.

1) Determine and record the tare weight of each pot.

2) Determine and record the tare weight of each water-tight container.

3) Fill a tared pot with medium to be tested.

4) Tap the pot on the bench several times to settle the mix.

5) Saturate the material by slowly wetting the mix from the bottom so that air will not be entrapped and structure of the medium is not changed. Leave the medium just barely submerged for 24 h.

6) Quickly transfer the pot to a tared water-tight container to retain the water which will drain rapidly from large pores. Weigh and record the weight.

7) Set the pot aside for 24 h to allow the mix to drain to container capacity.

8) Weigh the pot and record the weight.

9) Place the pot in a drying oven and dry.

10) Weigh the dry material and record the weight.

11) Record or mark the distance from the top of the pot to the top of the dry soil mix.

12) Empty, clean, dry, and line the pot with a plastic bag.

13) Weigh and record the weight of the pot and bag.

14) Fill the lined pot with water to the level determined in step 11.

15) Determine and record the weight of the pot and water.

Calculations are as follows:

$$B = (d - t)/(w - l)$$

Where B is bulk density in g/ml, d is the weight of the dry mix from step 10, t is the tare weight of the pot from step 1, w is the weight of water and lined pot from step 15, and l is the tare weight of the lined pot from step 13.

$$P = (s - c - d)100/(w-l)$$

Where P is porosity as % v/v, s is the weight of the saturated mix from step 6, c is the weight of the tared water-tight container from step 2, d is the weight of the dry mix from step 10, w is the weight of water and lined pot from step 15, and l is the tare weight of the lined pot from step 13.

$$C = (f - d)100/(w-l)$$

Where C is container capacity as % v/v, f is the weight of the drained mix from step 8, d is the weight of the dry mix from step 10, w is the weight of water and lined pot from step 15, and l is the tare weight of the lined pot from step 13.

$$A = P - C$$

Where A is air-filled pores at container capacity in % v/v, P is porosity, and C is container capacity.

This procedure is rough and quick. To more accurately predict conditions that will occur in production, fill the pots and water them three times per week over a 3-week period so the material will settle to the density that would occur in production. After the final watering, allow the mix to drain for 48 h, then resume with step 5.

Excessive moisture is the most critical value. Factors other than aeration play a role in plant health so no exact guideline can be given. It is generally accepted that there should be more than 10% v/v air-filled pores at container capacity. General guidelines are as follows:

Bulk density	0.5-0.8 g/ml
Porosity	80% v/v
Container capacity	60% v/v
Air-filled pores at container capacity	10-20% v/v

More precise determination of water-release characteristics involves placing the medium on a ceramic pressure plate or other low-tension plate connected to a manometer. The manometer allows determination of soil moisture contents at various tensions which is a reflection of pore size distribution. According to De Boodt and Verdonck (1972), ideal media should have porosity of 85%, easily available water-holding capacity of 20% to 30% and water-buffering capacity of 4% to 10%. Easily available water is released between tensions of 10 and 40 cm of water and water-buffering capacity between 40 and 100 cm. It is generally accepted that plants recover little water at tensions above 100 cm.

Salinity and nutrient content of media play an important role. D. D. Warncke (1979) discussed use of the saturated media extract (SME) for evaluating chemical properties of media for container-grown plants. A large sample of media is saturated with gentle mixing. Saturated medium is equilibrated for 2 h followed by determination of pH and vacuum extraction of the soil solution. Nutrients and electrical conductivity are determined on the extract. Interpretative guidelines proposed by Warncke are presented in Table 1. Nutrient balance can be estimated using results from the SME method.

Table 1. General guidelines for greenhouse soil testing nutrient levels and their interpretation (Warncke, 1979).

Soil test	Low	Acceptable	Optimum	High	Very High
pH	5.5	5.5-5.9	6.0-6.4	7.0	7.5
Soluble Salts					
mmhos	0-0.74	0.75-1.99	2.0-3.49	3.5-5.0	5.0+
Nitrate-N ppm	0-39	40-99	100-179	180-280	280+
Phosphorus ppm	0-3	4-7	8-13	14-19	20+
Potassium ppm	0-59	60-149	150-249	250-350	350+
Calcium	0-79	80-199	200-349	350-500	500+
Magnesium	0-29	30-59	60-99	100-149	150+

Table 2. Guidelines for interpretation of water quality for irrigation (Ayers and Westcot, 1985).

		Degree of restriction on use		
Potential problem	Units	None	Slight to moderate	Severe
Salinity				
EC_w	dS/m	<0.7	0.7-3.0	>3.0
Infiltration				
SAR = 0-3 and EC_w =		>0.7	0.7-0.2	<0.2
SAR = 3-6 =		>1.2	1.2-0.3	<0.3
SAR = 6-12 =		>1.9	1.9-0.5	<0.5
SAR = 12-20 =		>2.9	2.9-1.3	<1.3
SAR = 20-40 =		>5.0	5.0-2.9	<2.9
Specific ion toxicity				
Sodium (Na)				
Surface irrigation	SAR	<3	3-9	>9
Sprinkler irrigation	me/l	<3	>3	
Chloride (Cl)				
Surface irrigation	me/l	<4	4-10	>10
Sprinkler irrigation	me/l	<3	>3	
Boron (B)	mg/l	<0.7	0.7-3.0	>3.0
Miscellaneous effects				
Nitrogen (NO_3-N)	mg/l	<5	5-30	>30
Bicarbonate (HCO_3)	me/l	<1.5	1.5-8.5	>8.5
pH Normal range 6.5-8.4				

Exact interpretation depends upon other factors such as nutrient source, species being grown, and the type of growth desired. Use of slow-release fertilizer will yield lower salt and nutrient concentrations, yet will be adequate. Luxuriant, rapid-growing natives, are not desired for re-vegetation so lower nutrient values may be acceptable.

Water quality is one of the most important tests to be performed by anyone in irrigation horticulture. Water quality and how it is managed determines the salinity of the growing media. Gone is the time when salinity could be offset by using a little more water and discarding the drain water. We are expected to use water more efficiently by recycling the drain water. In addition, the folks downstream don't want what we leave in our discarded drain water.

Increased salt content as expressed by electrical conductivity has the effect of reducing water-holding capacity. Sodium will reduce infiltration rates of many soils. Chloride, boron, lithium, and other constituents are toxic to some species. Bicarbonate will cause unsightly residue on foliage when applied through overhead sprinklers or misters. Table 2 contains general interpretative guidelines. Interpretation varies greatly depending upon leaching fraction, species grown, and other factors (For more detail see Ayers and Westcot, 1985). Iron, manganese, and other constituents, on their own or in combination with some fertilizers can cause emitter plugging.

Whether or not you do the testing or contract for it depends upon four factors. First is the value of your time or the time of your employee. Management and technical personnel in production organizations earn more managing production than by testing. Second, people who test on a routine basis are usually more efficient at testing just as production people are more efficient at production. Third, there are times when more precision or care in the test is required than production people may be able to provide. Fourth, some testing requires more equipment than is available in the normal production facility.

The important thing is that adequate information is available for decisions. Testing can provide useful information, information that facilitates more accurate, less risky, and more profitable decisions.

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