CIR556

Diagnostic and Monitoring Procedures for Nursery Crops[1]

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Producing container-grown ornamental crops, using available technology, requires intense cultural practices and high levels of management skills. Growers must make decisions based on an accurate assessment of economic considerations as well as environmental, physical, chemical, and biological factors that influence plant growth. Grower experience is invaluable, but even the most experienced grower needs accurate monitoring of the crop environment to make many decisions pertaining to crop culture.

All nurseries should be equipped to make routine measurements of the physical and chemical status of container media such as water-holding capacity, non-capillary pore space, pH, and media solution conductivity. The pH and conductivity measurements are also useful for evaluating irrigation water quality. Nursery operators who grow crops requiring specific light intensities for optimum growth should have a light meter to measure light levels in production areas. Pest identification and examination of plants or plant parts injured by pests or physiological disorders can be greatly assisted by optical aids housed in the nursery laboratory.

GENERAL REQUIREMENTS

The nursery laboratory should be adequately large, with clean, efficient work and storage spaces, reliable instruments, and adequate supplies. The space necessary will depend upon the specific procedures performed routinely. One trained person should be in charge of laboratory operation and maintenance. For small nursery businesses, this person will probably be the owner/operator.

A job description for the laboratory manager or a procedures manual for small nurseries is necessary to ensure consistent procedures and efficient laboratory use. The job description/procedures manual should include general responsibilities, specific tests to be conducted, detailed test procedures, an operations schedule, a record-keeping method, and a system of reporting or using the information generated. Laboratory accomplishments must be evaluated on a consistent basis by the nursery manager, and

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Trade names of suppliers or equipment items mentioned in this publication are used because of known availability. No endorsement of products is intended nor is criticism of unnamed products implied.

laboratory procedures should be changed as necessary. Failure to follow such a rigid format of planning, implementation, and evaluation can result in a wasted investment, even for small nurseries.

Space

Ideally, the laboratory should be located in a special room, but a room with a compatible activity, such as the grower's office, can be satisfactory. The laboratory should be in an air-conditioned area free from heavy dust, excessive humidity, and temperature extremes; these conditions reduce the life expectancy and accuracy of laboratory instruments. An area of 7 to 9 square meters (75 to 97 square feet) is required for nurseries conducting several routine monitoring/diagnostic procedures, and a room with a 3 to 5 ratio of width to length is most efficient.

Counter space should be adequate for the instruments, record books, sample preparation, and cleanup. Four square meters (43 square feet) of counter space and 5 cubic meters (180 cubic feet) of storage space in cabinets and drawers are the minimum required. A water supply and sink with a large trap in the drain pipe are essential for soil test procedures. Cabinets above and/or below the counter should provide sufficient storage space for supplies, reference books, and possibly some small equipment items.

Counter and floor cabinet depths of 56 to 76 cm (22 to 30 inches) and wall cabinets of 30 to 46 cm (12 to 18 inches) are most common. An L-shaped or U-shaped counter is generally more efficient than a long counter, and careful instrument placement will further minimize wasted personnel motion and time (Figure 1). Counters 90 cm (36 inches) high are most comfortable for laboratory activities, but a desk or small counter area at a comfortable sitting height (30 inches, 76 cm) with adequate leg space would be useful in the laboratory.

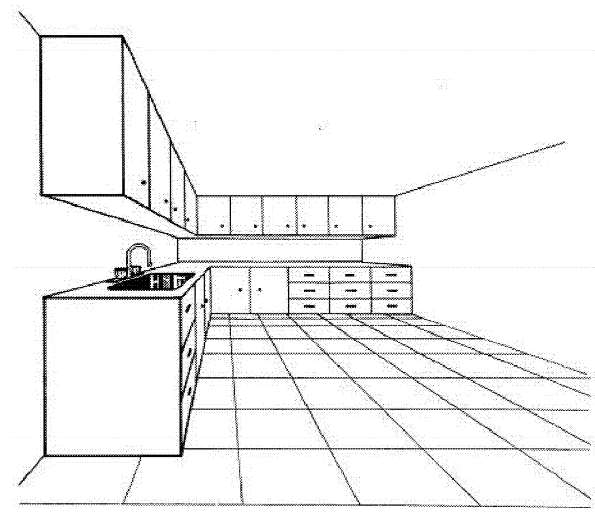

Figure 1. L-shaped counter in laboratory

Supplies

The nursery laboratory must have sufficient glassware and supporting items to make required measurements. These supplies can be purchased from scientific chemical supply companies or nursery supply dealers. Supplies and other small items needed include:

- Thermometer
- Vacuum aspirator
- Filtering flask
- Buchner funnels (1 to 4)
- Glass beakers (250 to 500 mL)
- Filter paper (to fit Buchner funnel)
- Rubber or neoprene hose (to fit aspirator and funnel)
- Distilled or deionized water
- pH buffer solutions of pH 10.0, 7.0, and 4.0
- Squeeze water bottle
- Glassware drying rack
- Laboratory grade soap (such as Alconox)
- Glass stirring rods
- Buckets or pans
- Masking tape
- Graduated cylinders (50 to 100 mL)

- Nonabrasive tissue
- Soil sampling tool

INSTRUMENTS AND MEASUREMENT PROCEDURES

Electrical Conductivity

A solubridge, or conductivity meter, with a conductivity cell is needed to measure electrical conductivity in media and irrigation water. Conductivity meters measure the electrical conductivity of solutions, and dissolved salts increase the conductivity. Most fertilizers are salts, and because the media concentration of salts is related to electrical conductivity, this can be used as an indicator of the need for additional fertilizer or for the removal of excessive salts from the media.

Some fertilizer carriers are not salts, such as urea, and do not affect the electrical conductivity of solutions. However, for guiding fertilization management and monitoring the effects of irrigating with saline water in container-grown plants, conductivity measurements are most useful when taken frequently enough to detect trends and dramatic changes.

The Beckman Solubridge (Model SDB-15) with a conductivity cell (Model CEL-VS2) and Myron L Agri-Meter are commonly used in the nursery industry. They cost approximately $200, whereas more sophisticated conductivity meters and cells cost between $300 and $800. Suppliers of conductivity meters include:

Capitol Agricultural Service and Supply Co.
P.O. Box 3508
Montgomery, AL 36193

E. C. Geiger
Box 285
Harleysville, PA 19438

A. H. Hummert Seed Company
2746 Chouteau Avenue
St. Louis, MO 63103

Fisher Scientific
7464 Chancellor Drive
Orlando, FL 32809

Baxter Healthcare Corporation
1430 Waukegon Road
McGraw Park, IL 60085-6787

Excessive salts cause injury to root systems, ultimately restricting water and nutrient uptake. This results in wilting and leaf tip and margin burn of new or recently matured leaves. Leaf chlorosis and nutrient deficiency symptoms can indicate a non-functional root system. Periodic testing is important, as moderate to high salts levels may not be expressed by visible symptoms, although growth is reduced. Excessive concentrations of salts can result from medium components, irrigation frequency and duration, water source, and/or fertilizer materials and application methods. Heavy rainfall can also leach nutrients from the container medium. Media for long-term crops should be tested at least monthly, but weekly sampling during the summer may be necessary to track fluctuations in electrical conductivity. Knowledge of conductivity fluctuations helps nursery operators optimize fertilization rate and application frequency.

Collection and Sample Preparation

Collection of representative medium samples is necessary for accurate conductivity determinations. Salts may accumulate in specific locations in media due to water movement patterns and fertilization methods. Therefore, one isolated sample may not give an accurate representation of the conductivity or nutrient status of the growth medium as a whole.

Several methods are used to obtain liquid extracts from container media needed for electrical conductivity, pH, and other nutritional parameter determinations. The optional methods available to nursery operators include the 2:1 dilution procedure, saturated paste, and the Virginia Tech extraction procedure (also referred to as the pour-through method).

The 2:1 and the saturated paste procedures require removing media from the container. With a soil probe or narrow trowel collect 15 to 20 sample cores from containers of a representative bed or area, and blend the samples together into one uniform sample. The upper layer of container media cores may be disturbed and should be discarded. Save about 250 mL (1/2 pint) of the total sample for testing. Additional details for sampling are given in Container Media Test Information Form 2674, available from the county extension office.

Mix two volumes of distilled water with one volume of media for the 2:1 dilution procedure, and allow the mixture to sit for 2 to 6 hours. Time is not crucial, but must be consistent for all samples and sampling times. Maintain accuracy and consistency with each sample when using the 2:1 method.

The saturated paste procedure involves saturating a 200 mL (0.8 cups) volume of container medium with distilled water. Slowly add distilled water while stirring until the medium surface is shiny, but no free water moves across it when the beaker is tilted. For best equilibration of salts, allow the saturated sample to sit for 2 to 6 hours. Extract the medium solution by vacuum filtering the saturated medium (Figure 2).

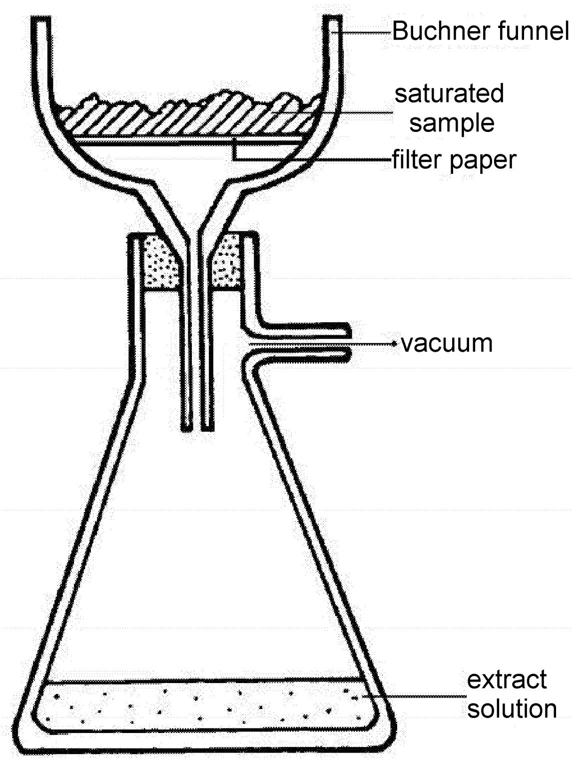

Figure 3. Vacuum filtering the saturated medium to extract the medium solution.

The Virginia Tech extraction procedure consists of watering a container plant and allowing time for drainage (2 hours to overnight) in order for the salts level in the medium to reach equilibrium. After this equilibration period, the container must be elevated above a collection container so that leachate or extract is not contaminated with debris or salts on the perimeter of the container (Figure 3). The bottom or sides of the container should not be wiped before collecting leachate.

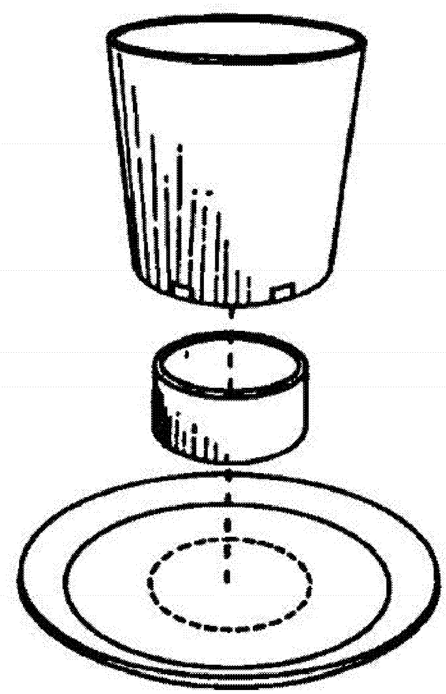

Figure 4. In the Virginia Tech extraction procedure, the container must be elevated so as not to contaminate the leachate.

Apply distilled water (in a circular motion) to the growth medium surface to yield 30 to 50 mL of leachate from the container. Leachate should be collected from 5 to 10 containers per production bed or area to obtain an average value that is representative of the growth medium nutritional status. This method of leachate collection allows for quick determinations of extract or leachate electrical conductivity, pH, or elemental concentrations.

Irrigation water conductivity can be measured directly with a meter, and the parts per million of soluble salts calculated. Interpretation of meter readings and parts per million of soluble salts in irrigation water is given in Table 1 . Injected fertilizers will increase the electrical conductivity of irrigation water. Irrigation water electrical conductivity, pH, and elemental concentrations should be monitored periodically. Water samples for elemental concentration determinations may be sent by the county extension office to the University of Florida Extension Soil Testing Laboratory, or samples can be sent to a commercial laboratory.

Table 1. Interpretation of soluble salts level in irrigation waters for ornamental crops.

Meter Readings mhos x 10^{-3}/cm or dS/m*	Total Soluble Salts (ppm)	Rating
0 - 0.25	0 - 175	Excellent
0.25 - 0.7	175 - 490	Good
0.7 - 1.4	490 - 980	Fair
> 1.4	> 980	Poor
Adapted from: Waters, W.E., J. NeSmith, C.M. Geraldson and S.S. Woltz, 1972. *The interpretation of soluble salts tests and soil analysis by different procedures*. Bradenton AREC Memo Report GC-1972-4.		
*dS/m = decisiemens per meter		

Measurement and Interpretation

The conductivity meter is calibrated with a 0.01 normal potassium chloride (KCl) solution or with a test solution supplied by the manufacturer. A 0.01 normal KCl solution has an electrical conductivity of 1.4 mmhos/cm. Units for most meters used in the nursery industry are mmhos/cm (mhos/cm x 10^{-3}). However, for some meters, the units are mhos/cm x 10^{-5}. Therefore, the electrical conductivity of the calibration solution using meters with these scales would be 1.4 mhos x 10^{-3} and 140 mhos x 10^{-5}, respectively. See the instruction manual if calibration is necessary.

The calibration solution must be at the same temperature as the samples of extract. Rinse the electrode with distilled water and blot dry. Immerse the electrode in the extract and record the reading. Remove the electrode, rinse with distilled water, and store immersed in distilled water. In order for comparisons to be made from sample to sample and from samples taken at different times, consistency in taking measurements is very important.

Interpretations are given in Table 2. Ranges given correspond to most ornamental plants; however, adjustments must be made for plants known to be salt sensitive. For example, azaleas are salt sensitive, and the optimal conductivity level is about one-half that of nonsensitive plants. Values in Table 2 are based on the saturated paste procedure, but are also used for interpreting the Virginia Tech procedure. Values for the 2:1 procedure are not given, but are about one-half those of the saturated paste values (except for pH, which is the same). Additional details for these extraction procedures are given in Video Tape 217, available from the county extension office.

pH Measurement

A pH meter is used to measure acidic or alkaline reactions of media solutions or irrigation water. It measures the negative log of the hydrogen ion activity. A pH meter can be purchased for $100 to $900, depending upon the accuracy and options desired. A meter with accuracy of ± 0.1 pH and repeatability of ± 0.05 pH is generally adequate for a nursery laboratory. Models that are AC powered and/or battery powered are available. Take care to evaluate a pH meter on accuracy and durability because there are meters on the market not suited for commercial use.

Some manufacturers or distributers of popular pH meters include Cole-Parmer Instrument, Fisher Scientific, and Orion Research. Meters may be purchased from manufacturers, nursery equipment suppliers, or laboratory supply companies such as those listed previously.

Proper care and storage of meters and electrodes will ensure long life. Electrodes of routinely used meters should be inserted into distilled or deionized water and the meter switched to "stand-by" or "off" when not in use.

A pH meter is calibrated with buffer solutions of pH 10.0, 7.0, and 4.0. Buffers can be purchased from companies that supply pH meters. Place the electrode in the pH 7.0 buffer and allow time for equilibration. (Pour the buffer solution into a small beaker. Do not insert the electrode directly into the stock buffer solution.) Then use the meter calibration dial to

Table 2. Interpretation of container medium test.*

	Rating Category				
Analysis	Low	Acceptable	Optimum	High	Very high
pH	< 5.0	5.0 to 5.5	5.5 to 5.8	5.8 to 6.5	> 6.5
Electrical conductivity, dS/m	< 0.7	0.7 to 1.0	0.7 to 1.0	1.0 to 1.5	> 3.0
Nitrate-N, mg/L	< 40	40 to 80	80 to 100	100 to 200	> 200
Phosphorus, mg/L	< 3	3 to 8	8 to 12	12 to 18	> 18
Potassium, mg/L	< 10	10 to 20	20 to 40	40 to 80	> 80
Calcium, mg/L	< 10	10 to 20	20 to 40	40 to 100	> 100
Magnesium, mg/L	< 10	10 to 15	15 to 20	20 to 60	> 60

*Plants of the Ericaceae family (e.g. azaleas) and salt-sensitive plants require only one half the electrical conductivity amounts and can tolerate only one half the levels of nutrients (NO_3-N, P, K, Ca, and Mg) shown in this table.

adjust the meter to 7.0. Remove electrodes from the buffer and wash thoroughly with distilled water (a squeeze bottle with a spout works well) and blot dry with a nonabrasive tissue.

Place electrodes in the pH 4.0 buffer and adjust the meter reading using the slope/temperature dial after equilibrium has been reached. The calibration dial should not be moved during this step. Read the pH 7.0 buffer again after washing the electrode and if no — or only slight — adjustment is necessary the meter is calibrated. The electrodes can be placed in the pH 10 buffer to check the calibration. If more adjustment is required, repeat the entire procedure.

Meters for determining pH differ in accuracy, and some may not calibrate exactly with the pH 7.0 and 4.0 buffers. Wide variations can be caused by meter malfunction or contaminated buffer solutions. After the electrodes have been washed and blotted again, the meter is ready for use. Insert the electrodes in the extract obtained by one of the methods described in the previous section, and a stable reading should be obtained within 1 to 2 minutes. Remove the electrode, wash with distilled water, blot, and store in a small sample of buffer. Consistency is important, because it allows the nursery operator to compare pH readings over a period of time.

Generally, plants grow best in a medium having a pH of 5.5 to 6.5, since pH influences availability of nutrients in the medium solution. The pH range of 5.0 to 6.5 provides a compromise range for greatest availability of the maximum number of essential elements. If pH is higher than desired, sulfur can be added to lower the pH, but this must be done carefully since sulfur burns roots at relatively low concentrations. A pH lower than desired can be corrected with the incorporation of dolomitic limestone. The formulation and particle size of the lime determine its reaction rate. Dolomitic and agricultural limestone react over a period of several weeks to several months, and should be mixed with media for best results. The smaller the particle size, the faster the reaction. Media pH should be measured before potting to determine appropriate rates of amendments, and routine pH (at least monthly) determinations are advised.

POTTING MEDIA REQUIREMENTS

A good potting medium must anchor plants and provide adequate nutrients, water, and air. Roots without adequate air will grow poorly or die, regardless of how good other factors may be.

Aeration and Water-Holding Capacity

Growers who experiment with media need to be able to check water-holding capacity and aeration of each medium. Several published lists give the water-holding capacities and air space of various growing media. Such charts are useful; however, there are many situations they do not and cannot cover. Due to significant effects of the container (i.e. depth, total volume, configuration), these determinations should be made with the specific container(s) used for the crop. A simple procedure can be used for this that costs little except time. Materials needed are a measuring cup, masking tape, a pencil, the containers to be used, a bucket or pan, and a few containers for water.

Measurement Procedures

Air space of a medium is the total volume of pores filled with air after irrigation and drainage. The water-holding capacity is the percent of the total volume of the medium that is filled with water after irrigation and drainage. When a medium is saturated and allowed to drain, air replaces the volume of water drained. Measuring the drainage water then gives a quick measurement of drainable pore space or air space. Steps in the procedures for determining air space and water-holding capacity are given below. If a measurement of air space alone is desired, there is no need to determine the volume of water required to saturate the dry medium in step 3.

1. Measure the container volume. Secure tape on the container drainage holes and fill with water to within approximately 1/2 inch (13 mm) of the brim. Mark this line with a pencil. Carefully measure the volume of water by pouring it into a measuring cup. This volume of water is the container volume to be occupied by the medium.

2. Dry the container inside. **Do not** remove the tape. Fill the container with dry medium to the "fill line," marked in Step 1, using packing procedures as when potting a plant.

3. Using a measuring cup, slowly add water to the container and keep track of the volume of water used. Wet the medium until it is saturated (a thin film of free water is present on the surface). Some dry media such as peat moss or pine bark are difficult to wet. If a wetting agent is used in production, then use a wetting agent at this time at the recommended rate. Add small amounts of water periodically as necessary to ensure complete saturation. The volume of water used to saturate the medium is the total pore space of the medium.

4. Loosen the tape on one drainage hole and discard water that drains from the medium. This initial drainage helps settle the medium as it would in production.

5. Cover the drainage hole and resaturate the medium with water. Adding water along only one side of the container will minimize air pockets.

6. Place the container in a pan or bucket large enough to collect all drainage water. Elevate the container above the pan for complete drainage. Remove the tape from the holes and collect the water drained during a 2-hour period.

7. Measure the volume of water drained from the container. Use the smallest units on the measuring cup (millimeters, ounces, or teaspoons).

8. Calculate the water-holding capacity and the percent air space by the formula in Equation 1.

9. It is advisable to take 3 to 5 container/medium samples through the procedures at the same time and average the calculated parameters.

$$\text{\% air space} = \frac{\text{volume of drained water (step 7)}}{\text{container volume (step 1)}} \times 100$$

$$\text{water holding capacity} = \frac{\text{(total pore space (step 3) - volume of drained water (step 7) x 100}}{\text{container volume (step 1)}}$$

Equation 1.

Interpreting the Measurements

These procedures allow the evaluation of the percent air space and water-holding capacity of particular media in the particular containers chosen for the crop. Media with predominantly small pores (small particles) tend to retain more water, and consequently have less aeration, than a medium having large pores (large particles). The ratio of various media components and component particle sizes must be adjusted to the specific container, plant requirements, and other production practices of individual growers.

Air space requirements for most greenhouse crops range from 10 to 20 percent, with most bedding plant media containing only 5 to 10 percent air space after drainage. Water-holding capacities for these media should be 40 to 50 percent. Epiphytic orchids, ferns, bromeliads, and other moisture-sensitive plants require more than 35 percent air space. Some woody ornamentals grown outdoors may require media with

25 percent air space to provide adequate drainage during the rainy season in Florida. The water-holding capacity of media in these production systems should be 30 to 40 percent.

MEASURING LIGHT INTENSITY

Growers of ornamental plants, particularly foliage and flowering plants, must be able to regulate the light intensity received by crops if maximum plant growth and acceptable quality are to be achieved. Some nursery operators think they can visually estimate light intensity in areas where shade-grown crops are located and adjust shade levels based on previous experience. Unfortunately, such judgments and manipulations are frequently not accurate, and substantial reductions in crop growth and quality are sustained. Proper measurement and regulation of light intensity can be done only through use of an appropriate light meter. Since some nursery operators maintain plants in commercial, institutional, or residential buildings, a meter should be sensitive to light levels of 50-foot candles (ft-c) or less. Nursery production light levels in greenhouses and shadehouses will vary dramatically, depending on geographic location, season, time of day, type and condition of structure cover, and weather. A meter that can measure up to 10,000 ft-c is desirable.

The best type of light meter for practicing horticulturists is an incident light meter that reads directly in ft-c or lux units. An incident meter is pointed with the light-sensing cell toward the light source as opposed to many photographic light meters of the reflectance type that must be pointed toward the subject to measure reflected light. A few incident-type meters used primarily for studio work have conversion scales or factors for conversion to ft-c or lux units. Techniques described for using cameras with built-in meters to determine light intensity should not be used, because they are awkward and less accurate than incident meters. Table 3 lists several sources of incident light meters that can be used in nurseries, greenhouses, and indoors.

Table 3 is on page 12.

PHOTOGRAPHIC RECORDS

Some nursery operators keep complete records of crop production procedures, including pests and other problems encountered. Record usefulness can be enhanced with photographs that can be referred to after a problem or situation has passed. Usually color slide film (35 mm) or color print film is preferred, since many problem symptoms involve plant color change.

If the nursery operator plans to give illustrated talks at trade meetings or have illustrated seminars for employees, transparency film (slide film) is probably best. Color prints can be made from slides if prints are also needed. Negative color film would be the cheapest route if only color prints are desired, and would result in higher quality color prints.

Proper camera selection will depend upon nursery needs, photographer expertise and equipment money available. A 35 mm, single-lens reflex camera provides maximum flexibility. A camera equipped with some type of macro-lens can be focused very close to small plants or plant parts without the addition of extension tubes, bellows, or portrait lenses. The 110 or disk film format is adequate if only general snapshots are desired and the need for ultra closeups is not anticipated. Once a camera and accessories have been selected, the equipment can be purchased from a local camera store or discount mail order supplier listed in most photography magazines. Camera equipment should be stored in a clean, cool, dry environment, and a protective case is desirable if the camera is to be transported routinely.

OPTICAL AIDS

Damage resulting from physiological disorders, mechanical damage, or damage from pests is often obvious to the unaided eye, and no further inspection is necessary to diagnose the cause. Injury symptoms or pests on aerial portions of the plant or the root system that are difficult to see must be magnified to be studied.

A hand lens of approximately 10 to 20 power is useful in diagnosing many plant problems (Figure 5). A binocular microscope with 20- to 80-power magnification should prove useful if additional magnification is required frequently (Figure 6). A small, high-intensity lamp is useful for illumination of

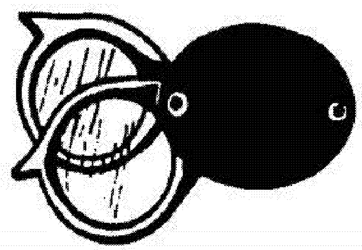

Figure 5. Simple hand lens (10 to 20 X)

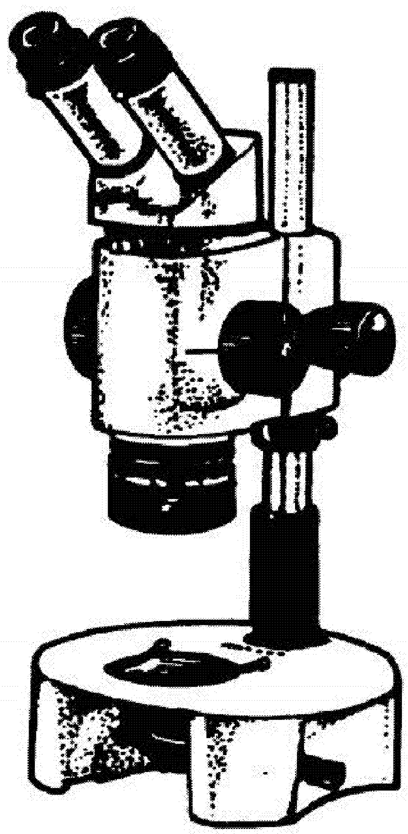

Figure 6. Binocular microscope (20 to 80 X)

plant specimens when using a hand lens or low power microscope.

Some hand magnifiers come equipped with battery-powered light sources, which are handy when portability and relatively low magnification are needed. A headband mounted magnifier may be preferred in some situations where many specimens are examined under field conditions, because it gives the observer the use of both hands while working (Figure 7). A partial listing of some optical aids and their sources is provided in Table 4.

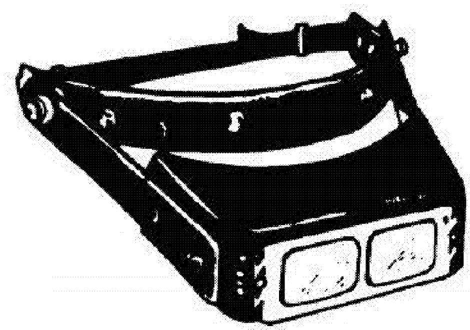

Figure 7. Headband mounted binocular magnifier

Table 4. A partial list of sources of optical aids

Table 4. A partial list of sources of optical aids for plant problem diagnosis.				
	Type of optical aid			
Distributor	1	2	3	4
Office supply stores	X	X		
Laboratory supply firm including:				
Fisher Scientific7464 Chancellor DrivePO Box 13430Orlando, FL 32809	X			X
Baxter Scientific Products1900 NW 97th AvenueMiami, FL 33172	X			X
Biological supply firms including:				
Carolina Biological Supply Co.Burlington, NC 27215	X			X
Forestry supply firms including:				
Forestry Suppliers, Inc.205 West Rankin StreetPO Box 8397Jackson, MS 39284	X	X	X	X
1) Binocular microscope (20 to 80 x)				
2) Headband mounted binocular magnifier				
3) Self illuminating hand magnifier				
4) Simple hand lens (10 to 20 x)				

PLANT PROBLEM REFERRALS

Many of the day-to-day plant diagnostic activities can be accomplished using the procedures and/or equipment described in this publication. Occasionally, more complex testing procedures or highly specialized professional advice from your county extension office or a professional consultant is needed to avoid economic losses. The following procedures may be followed for referral of several categories of nursery plant problems. Each diagnostic service has its own sample information form and instructions for sample collection and offers its own interpretation based upon the procedures used. Maximum benefit from the time and effort invested in samples can only be realized when the instructions for the specific test are followed and the form is completed with as much detail as requested. Professionals at your county extension office can assist with more details on sample collection and preparation and interpreting the results of diagnostic tests.

SUSPECTED DISEASE PROBLEMS

Pathogen identification requires highly trained personnel, specialized isolation and culturing techniques, and a compound light microscope with a magnification range of 100 to 1000 power. Unless a nursery is large enough to have a plant pathologist, required optical equipment, and related supplies for pathogen detection, plant tissue suspected of harboring unidentified pathogens should be sent to a diagnostic laboratory. Samples can be sent through your county extension office to the Florida Extension Plant Disease Clinic, Plant Pathology Department, Building 78, University of Florida, Gainesville, FL 32611. Each sample must be submitted with a completed "Plant Disease Diagnostic Form" (IFAS Form 2901), which can be obtained from your county extension office along with additional instructions for sample collection and handling. Diagnostic results from the clinic are transmitted to the local county extension office by electronic mail, and this information is then passed on to the nursery operator.

SUSPECTED INSECT AND MITE DAMAGE

Submit suspected and unidentifiable pest or plant samples showing pest damage to your county extension office. They have the required forms, vials, and mailers for sending samples to the Extension Entomologist, Entomology Department, University of Florida, Gainesville, FL 32611. Results of the diagnosis are sent to the county extension office from which the nursery operator is informed.

Insect identification can also be obtained through the Division of Plant Industries (DPI) of the Florida Department of Agriculture and Consumer Services. A DPI inspector is assigned to periodically inspect your nursery plants.

SUSPECTED PARASITIC NEMATODE PROBLEMS

Nursery operators should request one or more "Nematode Sample Kits" from their county extension office. Each kit contains instructions for sampling, a data sheet, a sample box, and a mailer. Boxed samples are then sent by the nursery operator, with a $8.00 payment per sample, to: Nematode Assay Laboratory, Building 78, IFAS, University of Florida, Gainesville, FL 32611-0611. Assay results are mailed directly to the nursery operator. A copy of these results is also sent to the county extension office.

WEED SAMPLE IDENTIFICATION

Unidentified weed samples can be taken to the county extension office where they will be sent with a "Request for Plant Information Form" (IFAS form 3100/4-92) to the Herbarium, 209 Rolfs Hall, IFAS, University of Florida, Gainesville, FL 32611-0322. Identification information will be returned to the county extension office by mail.

PLANT TISSUE SAMPLES

Since the Florida Cooperative Extension Service does not offer a leaf nutrient analysis service, it would be advisable to work with a commercial laboratory with staff who have experience with nursery crops. A list of commercial laboratories in

Florida that routinely perform tissue analyses can be obtained from your county extension office. Laboratories with experience and expertise in procedures and the associated interpretation with nursery crops should be selected.

CONTAINER MEDIA SAMPLES

If more information about the chemical status of a potting medium than soluble salts and pH is needed, sampling procedures and submission form (IFAS form 2674) can be obtained from your county extension office. Samples may be submitted through the county extension office or mailed directly to the Extension Soil Testing Laboratory at the address provided on the sample submission form. The "Container Media Test" includes the determination of pH, electrical conductivity, $N0_3$-N, P, K, Ca, and Mg for a cost of $6.00 per sample. Reports of potting media tests are sent to the county extension office and to the nursery operator by return mail.

IRRIGATION WATER SAMPLES

The Extension Soil Testing Laboratory also conducts analyses of water for pH, electrical conductivity, Ca, Mg, Na, Fe, and Cl. Water samples should be submitted to your county extension office or mailed directly to the laboratory with a payment of $7.00 per sample. Samples should be sent to the Extension Soil Testing Laboratory with a completed IFAS Form 2673-A, and the results of the test will be sent to the nursery operator and the county extension office by return mail. This test does not determine if the water is safe for human consumption. Bacteriological tests are available from the county health department.

GAS TESTING

The nursery atmosphere influences crop growth, as does media fertility level, water quality, and other factors. Few nurseries monitor air quality or modify atmospheric parameters other than temperature and/or humidity.

Crop damage has been reported when industrial firms release air pollutants, such as sulfur dioxide or hydrogen fluoride, that drift over crops and other vegetation. This type of damage is difficult to diagnose, as it occurs infrequently and lasts for a relatively short period of time.

Heating units in greenhouses occasionally burn improperly due to poor maintenance, and produce one or more by-products, including ethylene and/or sulfur dioxide, which can injure plants. Concentrations of gases suspected of causing plant damage within a nursery can be tested with one or more gas testing devices.

Mine Safety Appliances Company, Pittsburgh, PA, 15208 manufactures a gas testing kit that can be used to test for more than 100 different gases, vapors and mists, with the appropriate glass sampling tube, filter, and reagent kit. Most gaseous pollutants encountered under greenhouse conditions require only a glass detector tube designed for the specific gas being investigated. Periodic characterization of gases in greenhouse atmospheres is recommended if forced air heating units are used. Ideally, heaters should be on and greenhouse ventilators, or fan louvers, closed for approximately 20 to 30 minutes before drawing a sample with a gas testing device.

TEMPERATURE AND HUMIDITY RECORDERS

Temperature and humidity recorders inform greenhouse managers of fluctuations in these conditions over time. This information allows the manager to make necessary adjustments in climate control to optimize crop growth while minimizing energy costs. Interactions between temperature and humidity are extremely important, especially when critically cold temperatures threaten crop plants.

Such environmental sensors and recorders are usually positioned in the greenhouse, but chart paper, calibration equipment and procedures, and file storage for recorded data should be stored in the nursery laboratory. Instruments can be purchased that record both humidity and temperature or just one of these parameters. Instrument sophistication ranges from simple chart recorders to electronic micro-processors that record the parameters at multiple stations and may even automatically adjust environmental control equipment.

Table 3. Selected incident light meters for use by ornamental horticulturists.

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		Areas where meters can be used*				
Meter and model	Light intensity sensitivity range (ft-c)**	Outdoors in Florida	Greenhouse and shadehouse	Building interior	Relative cost	Name and address of manufacturer or national distributor
General Electric(Model 214)	0 - 10,000	Winter only	+	+	Low	General Electric Co.Nela ParkCleveland, OH 44112
Gossen(Luna-Pro)	0 - 32,000 (conversion scale)	+	+	+	Intermediate	Berkeley Marketing Co.P. O. Box 1060Woodside, NY 11377
Gossen(Panlux)	0 - 12,000	Fall and winter only	+	+	High	Berkeley Marketing Co.Gossen DivisionP. O. Box 1060Woodside, NY 11377
Sekonic(Model L-398)	0 - 1, 250	-	Heavily shaded greenhouse only	+	Intermediate	Copal Corp. of America58-24 Queens Blvd.Woodside, NY 11377
Spectra(Candela)	0 - 30,000	+	+	+	Intermediate	Photo Research1000 No. HoliwoodBurbank, CA 91505

*+ = OK for use in indicated area; - = not for use in indicated area

**Foot-candles x 10.76 = lux.