DR. MAHLSTEDE: Buckholz and Agrios had 45 per cent diseased trees on *P. besseyi* One customer sent back some six year old trees to one nursery that were broken at the union. I think our time is up.

MODERATOR NORDINE: Last year we had considerable discussion by a great many speakers in regard to the production of nursery stock or plants in containers. I am sure that a great many members felt that after that they knew all the answers. Fertilization of this material was, of course, stressed, but some way, somehow, someone overlooked the topic of over-fertilization.

We are very happy this morning to have Dr Jim Kelley of the University of Kentucky present this particular topic to you. He has spent a great deal of time and effort on solving some of the problems concerned with the production of nursery stock in cans At this time we present to you Dr. Kelley.

EFFECTS OF OVERFERTILIZATION ON CONTAINER-GROWN PLANTS

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The widespread practice of growing nursery stock in containers has brought about a need for more information in regard to the fertility requirements of woody ornamental plants. Fertilization has always been important in growing quality nursery stock, however, fertilization assumes even greater importance when a plant is grown in a restricted volume of soil such as exists in a container. There are many unanswered questions concerning this type of culture One question that has been of great importance is the fertilization practices necessary for producing quality nursery stock in containers Little is known about the fertility requirements of woody ornamental plants. However, the limited volume of soil that is available for supplying the necessary nutrients of a plant in a container necessitates that for optimum growth, fertilizer be applied to supply the required plant nutrients.

REASON FOR FERTILIZATION

The purpose of fertilization is to provide the plant with a continuous supply and optimum level of plant nutrients for maximum growth of any particular species. Frequent fertilization has aided in providing a constant supply However, information is not available on the optimum levels that should be maintained for woody ornamental plants. Growers are naturally anxious to obtain the maximum growth on a plant whether in a container or in the field. Many times this desire to get rapid growth, particularly on container stock, has led to the application of unusually high amounts of fertilizer. Too much fertilizer, however, can be as bad or even worse than too little. Many times plants are overfertilized, resulting in a reduction in growth instead of more growth.

FERTILIZATION PROGRAMS

Water soluble fertilizers have been most generally used in the fertilization of container stock and a number of fertilization programs using water soluble fertilizers are being used successfully. However, there is considerable variation in frequency of application, rate of application and fertilizer analyses. Some growers use a one-shot application of a dry fertilizer when the soil mix is prepared, and others fertilize as frequently as every 10 days, while still others feed every third irrigation, using a water soluble fertilizer. In some cases a combination of dry and liquid fertilizers are used. The rate of application also varies Less frequent applications generally mean a higher rate and more frequent applications of a very low concentration or amount of fertilizer

The purpose of our work was to obtain more information in regard to the best rate of fertilization for optimum growth and also at what levels growth would be reduced due to overfertilization.

SYMPTOMS OF OVERFERTILIZATION

What are some of the symptoms of overfertilization and what is its overall effect on the plant? The effects of overfertilization are generally (1) reduction in rate of growth, (2) chlorosis or yellowing of the foliage, (3) wilting of foliage, even though the soil may be moist, (4) tip burn and marginal leaf burn, (5) leaf drop, and (6) death of the entire plant. Now, I would like to take these, one by one, and explain a little more in detail the usual symptoms of overfertilization.

The most common and first symptoms of excess levels of fertilizer salts is a reduction in growth. Generally, this goes unnoticed since the plant does not exhibit any unusual characteristics other than a slow rate of growth. If noticed, it often is attributed to some factor other than overfertilization Many times a grower will notice a reduction in growth and believe that fertilizer is lacking, hence, additional fertilizer is applied. Of course, additional fertilizer on a plant that is already overfertilized will simply reduce growth even further.

Another symptom of overfertilization is chlorsis or yellowing of foliage. Many times this is evident when the specific element in excess is potassium. The leaves will simply turn yellow due to iron chlorosis. This can easily be interpreted as an iron deficiency.

Wilting of foliage is a sign of severe overfertilization, and the wilting is due to the high osmotic pressure of the soil solution making it difficult for the roots of the plants to absorb water, even though the soil is moist.

Numerous experiments have demonstrated the close relationship between plant growth and the osmotic pressure of the soil solution. These relationships indicate that it is the total concentration of soluble salt particles in the soil solution rather than their specific chemical nature which is mainly responsible for the inhibitory effects of excess soluble salts on the growth of plants. It is generally accepted that an increase in the osmotic pressure or soluble salt content of the soil solution results in a decrease in water uptake by plant roots Excess soluble salts can also cause adverse effects on the plant other than the reduction in uptake of water.

Tip burns can be due to either excessive nitrogen or potassium and indicates severe overfertilization.

Plants may be reduced in growth of quality because of excess fertilization or an accumulation of soluble salts and without visual evidence that the problem exists. Once visual symptoms appear on a plant, such as chlorosis, wilting of foliage, tip burn, marginal leaf burn, etc, the damage of reduced growth has already occurred. Hence, a grower cannot depend on visual symptoms as a means of diagnosing slight overfertilization.

SOURCE OF SOLUBLE SALTS AND PREVENTION OF OVERFERTILIZATION

What methods can be used in guarding against overfertilization? The best method of preventing overfertilization is to use a good fertilization program, combined with periodic soil tests for the major elements and a soil test for total soluble salts. The soluble salt test is a very simple one that can be easily made with an instrument known as a solubridge. This instrument is used to determine the total soluble salts or fertilizer salts which exists in the soil, by measuring the electrical conductivity of the soil solution. If a soil, is low in fertilizer salts, the electrical conductivity will also be low, and as the salt level increases, the conductivity of the soil will increase. The most common measure of electrical conductivity in regard to the soil in mhos per centimeter X 10^{-5}. The Model RD-15 solubridge read directly in mhos X 10^{-5}. Generally, it has been found with most soils for florist crops, readings between 50 and 150, using a 1 to 2 soil: water extract, are satisfactory for most crops.

It is important to remember that all inorganic fertilizers are soluble salts. These soluble fertilizer salts are essential for plant growth but when present in the soil in excessive amounts they are harmful to plant growth, primarily because of the high osmotic pressure in the soil solution

FACTORS AFFECTING FERTILITY REQUIREMENTS

As might be expected, plants differ in their fertility requirements. The fertility requirements of ornamental plants appear to depend on (1) the degree of establishment, (2) the plant species, and (3) age of the plant.

Our work has shown that the age of the plant is important in determining its response to rate of fertilization. Young, unestablished plants are generally not able to withstand high levels of soluble salts in the soil. We have found that in general container-stock should be grown the first two or three months, or until established, at slightly lower levels of fertility than usual, and once the plant is established the fertility levels should be raised to the recommended levels.

Our studies have been primarily with five plants: *Pyracantha coccinea* Lalandi, *Ilex crenata rotundifolia, Euonymus alatus compacta, Magnolia soulangeana,* and *Abies concolor* Our first finding was that these five plants did not equally tolerate high levels of fertility. We have rated them as most tolerant, on down to the least tolerant. We found that *Pyracantha coccinea* Lalandi was the most tolerant to high

fertility levels: *Ilex crenata rotundifolia* was next in order, *Euonymus alatus compacta* followed third; and *Magnolia soulangeana* was fourth, the least tolerant of high fertility was *Abies concolor*. Plants that had been in the can for at least one year appeared to tolerate higher levels of fertilization than during their first year in a container. Fertilization requirements also appeared to be higher the second year.

FERTILIZER TREATMENTS

In the work I am reporting on, we used seven rates of fertilization in order to determine at which level the most satisfactory growth occurred, and also at which level growth began to be reduced due to excess fertilization The levels of nitrogen and potassium were varied Superphosphate was added to the soil mix at the time of mixing and no additional phosphate fertilizers were applied. The treatments used were: no fertilization, .68 pounds of 20-0-20, 1.36 pounds of 20-0-20, and 2.72 pounds of 20-0-20 (Table 1.) The other three treatments were at the same rates — .68 pounds, 1 36 pounds, and 2 72 pounds o fa 20-0-10 instead of the 20-0-20. We were interested in whether the potassium should be equal to or less than the amount of nitrogen. The response of the plants was determined on the basis of total inches of new growth per plant, the average growth per lateral, and the average number of laterals that were produced by each plant.

BEST TREATMENTS AND TOXIC LEVELS

Of the treatments used, we found that in general the 1.36 pounds of either a 20-0-20 or a 20-0-10 gave the best results. When we went as high as the 2 72 pounds of either a 20-0-20 or 20-0-10, there was a reduction not only in total growth but growth per lateral, and also average number of laterals per plant. Also, at the higher rate there was a greater mortality of plants. Of course, we had some mortality of plants in all treatments during the growing season, but at the higher levels of nutrition the plant mortality was considerably higher.

To be more specific in regard to *Pyracantha coccinea* Lalandi, our best growth for this plant occurred when we used .68 pounds of 20-0-10

Table 1.—Effect of fertilization rates on growth of four species of woody plants in one gallon containers.
(All measurements in inches)

Pounds of fertilizer/100 gal water, 1 pt /plant every 10 days	Pyracantha coccinea Lalandi	Ilex crenata rotundifolia		Euonymus alatus compacta		Magnolia soulangeana	
	1st yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
No fertilizer	49 2	31 7	48 6	20 5	52 1	13 3	15 3
68 lbs 20-0-20	71 0	68 8	216 3	33 4	88 2	29 1	41 9
1 36 lbs 20-0-20	57 9	58 1	245 7	33 3	75 1	27 5	48 4
2 72 lbs 20-0-20	59 6	46 9	267 6	36 5	46 5	21 6	44 1
68 lbs 20-0-10	69 8	55 4	197 1	35 7	93 2	27 0	43 1
1 36 lbs 20-0-10	60 9	53 3	245 2	38 4	94 9	27 8	43 4
2 72 lbs. 20-0-10	63 9	48 9	249 8	38 0	74 2	28 4	42 1
L S D 5% level	N S	7 8	31.0	6 1	15 8	5 2	13 0
L.S D 1% level	N S	10 4	442 0	8 2	21 3	7 0	17 9

to each 100 gallons of water, applying 1 pint every 10 days throughout the growing season. With *Magnolia soulangeana* we found that the 1.36 pounds of 20-0-20 gave the best growth At levels above approximately 1½ pounds of fertilizer per 100 gallons of water there was a definite reduction in growth. *Euonymus alatus* responded most satisfactorily to a low level of fertilization and also a 2 to 1 nitrogen-potassium ratio. The 68 pounds of 20-0-10 gave the best growth response on *Euonymus alatus compacta* At levels higher than this there was a significant reduction in total growth and in average number of laterals per plant *Ilex crenata rotundifolia* likewise responded best to moderate levels of fertilization with the .68 pound rate of 20-0-20 giving the best growth the first growing season, and the 2 72 pound rate of 20-0-20 the best growth the second growing season.

SOIL NITROGEN AND POTASSIUM

The fertilization program was combined with an intensive program of determination of soil nitrogen and potassium. Results indicate that the soil nitrates should not be allowed to go higher than 100 parts per million on a soil basis, and soil potassium should not go beyond 300 parts per million. As far as safe levels of fertilization are concerned, it appears that for most plants in containers fertilization rates should be between one and two pounds of a 20-0-20 or 20-0-10 per 100 gallons of water and applied approximately 1 pint per plant every 10 days This rate in general gave the most satisfactoy results with nitrate levels being maintained near 100 parts per million and potassium levels near 300 parts per million on a soil basis.

It also appears based on the solubridge test that soluble salt readings greater than 75 to 100 may result in a reduction in growth of many woody ornamental plants, particularly the more salt sensitive species. More work is needed before definite recommendations can be made in regard to soluble salt levels

SUMMARY

In summarizing, I would like to say that overfertilization of woody ornamental can result in a reduction of growth, chlorosis, severe stunting or death. The symptoms of slight or moderate overfertilization is a reduction in growth with no unusual leaf characteristics More severe overfertilization can cause such symptoms as chlorosis or yellowing of the foliage, wilting of the foliage, burning of the tips and margins of the leaf and even death of the plant. Severe overfertilization is probably not too common. Slight overfertilization is believed to be rather common The best method of preventing overfertilization is to use a sound fertilization program combined with periodic soil testing for nitrogen and potassium as well as testing for soluble salts by using a solu-bridge. Soil nitrates should be maintained at not over 100 parts per million and soil potassium levels should not be greater than 300 parts per million on a soil basis. Tentative results indicate that the solu-bridge reading of a 1:2 soil. water extract should be between 50 and 125 for the woody plants studied. In the work being reported, these levels were most nearly maintained by fertilizing with a dilute fertilizer

solution containing 1 5 to 2 pounds of 20-0-10 or a 20-0-20 water soluble fertilizer per 100 gallons of water and applying 1 pint per gallon container every 10 days throughout the growing season

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MODERATOR NORDINE: If we were to open the floor to questions it would be easy to devote the rest of the forenoon to questions. Dr. Kelley will be here on Friday night for the question box session. I feel sure that a great many of you will want to question him at a great length concerning this very, very interesting topic With your permission we'll hold the questions until Friday evening.

The Program Chairman has a great deal of latitude for the selection of his speaker and many times he selects something of a personal nature. Now I am quite sure that you all know the question that Martin brings up every single year at the question box, that is, the dropping of the needles on taxus. He has never been able to get an answer to this problem and I suspect that he brought in the next speaker for that particular purpose. However, I do know, too, that we will all benefit from this next particular topic.

Nearly 30 years ago Richard White, who is now Executive Vice President of the American Association of Nurserymen, made a statement to the former Plant Propagators Society that nurserymen will attribute the death of plants in propagating cases and in the beds to everything under the sun but to plant diseases. Many of us have become acquainted with this important statement in recent years So with this in mind we are very, very happy to introduce the next speaker He is Dr Spencer Davis of Rutgers University where he is Extension Specialist in plant diseases. In other words, he devotes full time to answering questions on plant disease problems With that, Dr. Davis!

DR. SPENCER H. DAVIS (Rutgers University, New Brunswick, New Jersey): Thank you, Sir and Gentlemen.

Apparently Dick White was a good reformer in New Jersey because he got all our nurserymen to think that nothing happens to a plant other than a disease. I wish many of our nurserymen had been here for the first two papers. I think it would have relieved our burden a lot. Incompatibility answers half of our problems and over-fertilization answers the other half.

DISEASES IN PROPAGATING BEDS

SPENCER H. DAVIS
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I realize that each nursery has its own particular problems If you talk ten minutes about somebody's problems it is not of too much interest to the person who has a different type of problem confronting him.. We are going to talk therefore, a little bit about the general diseases found in propagating beds. We are also going to think about what happens to many of these cuttings after they become plants. You