Chairman Webster: Doesn't this have to be worked out by engineers? You have to change the air so many times per cubic content per minute.

Mr. Augenstein: Jim Burns, Regional Engineer, Region 5, handled our problem after the cold storage man told him he realized we were not getting enough air circulation. We have 5 HP unit motors.

Mr. McDaniel: We have big blowers set up in the cooler. Lots of air moves all the time.

Mr. Augenstein: Our blower is one HP with circular-type fans.

Chairman Webster: Air circulation to eliminate mold is very important in any type of storage.

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Chairman Webster introduced Dr. Ernest Wright, Pathologist, Bureau of Plant Industry, Region 6. Dr. Wright presented the following paper on "Microbiological Management of Nursery Soils."

MICROBIOLOGICAL MANAGEMENT OF NURSERY SOIL

by
Dr. Ernest Wright

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The microbiological management of nursery soil is a difficult topic to discuss. At least it is difficult for me to discuss adequately. I will have to plead guilty to having worked on some phases of the problem, but please do not consider me as an authority on the subject. There are a number of reasons for the complexity of the problem. Each nursery site differs in respect to soil management and, furthermore, the same success may be obtained for any one site by several essentially different types of soil management. With considerable temerity I will therefore attempt to discuss the general principles of microbiological management of nursery soil by drawing on a few examples of my own experience.

Let us start with a definition of soil microbiology. We may define it as a study of the microflora and microfauna of the soil and the relation of these organisms to one another. By microflora we mean bacteria, actinomycetes and soil fungi. Under microfauna we have such minute forms of animal life as amoeba, protozoa, nematodes, etc. The microbiological populatinn is heaviest in the upper few inches of the soil. Now what can we say about microbiological management of nursery soils? I am sure that you are all aware that soil is a dynamic, ever changing medium and that it is not static nor can it be held so in spite of ourselves. What then can we do to maintain a desirable balance? We have just heard an excellent paper on the maintenance of soil fertility. Perhaps we should start with how soil fertility affects the microbiological balance of the soil. Here we can start with the statement of an important fact; namely, that an increase in the nitrate-nitrogen level in the soil at the wrong time will increase damping-off losses. Nitrate-nitrogen has a subsequent effect on damping-off by directly affecting the activity of soil micro-organisms. The obvious answer is to maintain a nitrate-nitrogen balance in your nursery soil that is relatively low during the early part of the season, when the seeds are germinating, and gradually increase it as the season advances for the normal development of the seedling crop. This can

be done by regulating the time at which cover crops are turned under or by the correct timing of the application of fertilizers.

As an illustration of the above, I will refer to a series of tests which illustrate particularly well how nitrate-nitrogen levels can be controlled. During the days of the Great Plains Shelterbelt Project, millions of broadleaf seedlings were grown and damping-off losses of certain of the species was quite considerable in some of the nurseries. Standard methods of control, such as acidification and seed dusting, proved unsatisfactory. Soil sterilization was impractical. A method of control was needed that could be easily applied over large acreages. Since these nurseries were all opened at about the same time on agricultural land, it was possible to observe the effect of different preceding crops on damping-off losses. Certain differences were noted in the field and a series of studies was started both in the field as well as in the greenhouse. As these studies advanced, it was found that the carbohydrate-nitrogen ratio following different crops was noticeably affected. Finally it was found that the application of simple carbohydrates to the soil quickly reduced the nitrate-nitrogen level in the soil. The time of application varied, of course, according to the type of soil. Carrying the tests to the field, glucose, a simple sugar, was added to the soil at the time the seed of American elm was sown. The result was a final stand "293%" greater on the glucose treated plots than on the untreated checks. Soil analyses made two weeks after treatment showed that the nitrate-nitrogen level had decreased markedly in the treated plots. The best results were obtained on sandy soil and less striking reduction on loam soils. Nitrogen had to be added later to correct this deficiency and to promote normal tree growth.

It is believed that the application of the sugar to the soil accelerated the growth of the soil micro-organisms resulting in a rapid consumption of the nitrogen present in the soil, hence the decrease in damping-off losses. Similar results can be obtained by the application of straw, green manure, etc. to the soil, but the matter of correct timing becomes more difficult. Just how such applications will work for coniferous crops is not known, nor would I advocate the use of sugar except on a trial basis. In such cases I would suggest applying about 1¼ pounds of cane sugar per 100 sq. ft. of seedbed at time of sowing.

Now let us take a different approach to biological control. Suppose that we could have a soil free of all micro-organisms, especially the parasites, but containing all the elements for good plant growth. This has been the aim of agriculturists for many years and in some instances has been attended by singular success. Among the early attempts along this line was soil sterilization by steam. Obviously this is not practical on a large scale, nor is it always desirable. Other methods of sterilization, such as formaldehyde fumigation or injection of chloropicrin gas are used. The latter has given excellent results for many truck crops. My own experience in the use of chloropicrin gas has been confined to coniferous nurseries. Let me cite you one series of tests that boomeranged.

In a ponderosa pine nursery having a sandy soil, chloropicrin was applied on a trial basis. This nursery was suffering heavy losses from late root-rot of 1-0 stock. At the end of the first growing season, the seedlings in the chloropicrin treated plots were more numerous and showed much better color and vigor than those in the untreated areas; moreover, the losses from root-rot were practically eliminated. But alas, by the middle of the second growing season, the seedlings in the

chloropicrin treated beds were definitely off-color and were only about one-half the size of those growing in the untreated check plots. A careful examination of the roots of the pine seedlings growing in the chloropicrin treated beds showed that they mostly lacked mycorrhizae. The chloropicrin had done an excellent job of killing the parasite fungi in the soil, but it had also killed the beneficial mycorrhizae. Towards the end of the second year, the mycorrhizae began moving in from adjacent untreated areas and the seedlings in the treated plots improved in color and growth. Hence we have here an example of controlling the soil microorganisms to such an extent that it was detrimental to the seedling crop. When growing stock for only one year on chloropicrin treated soil, the problem more or less takes care of itself in that when the plants are transplanted to new areas, they probably pick up their mycorrhizal associations quite readily.

Let us now discuss briefly soil acidification. To begin with, most conifers grow best in an acid medium. Conversely, damping-off fungi are most virulent above pH 5.0. Hence acidity below 5.0 favors the host and at the same time is unfavorable to the parasites. Therefore, here we have a combination of macrobiological and microbiological control.

With these few examples, I hope that it is clear that the microbiological management of nursery soils is a very important part of the nurseryman's job. In fact, a successful nurseryman is essentially a practical soil microbiologist, whether he likes it or not.

Mr. Lemmon: What were the proportions of sugar application that you gave?

Dr. Wright: We put it on at the rate of one gram per lineal foot. The beds run in narrow plots.

Chairman Webster: What form of simple sugar?

Dr. Wright: Commercial sucrose, Cane sugar. We applied glucose because it was in the experimental state. Simple sugar would be the thing. You can put it on broadcast. We used the sugar as it does not shift the PH.

Mr. Lemmon: I have another question. Does sugar send it on the acid side?

Dr. Wright: You probably would have to have a combination of treatments. That is why it is not practical on a nursery. This year, small plots are being tried out.

Chairman Webster: Could you use sugar by diluting it with sand or soil before application, so that it will not cake the soil?

Dr. Wright: Yes, that would be a way to do it. It was found to be more successful in a sandy soil. I would like to hear what results you have if you try it. The sugar is put on before you sow the seed. Confine it to coniferous trees.

Chairman Webster: How much of a problem is damping-off in your nursery?

Mr. Wells: I have a little of the Fusarium type. We have tried this sugar on a small scale. It seemed to have no effect. The damping-off hits about the first of August. Just have not been able to get anything to prevent it. Seedlings are about three inches high by then.

Dr. Wright: This was the purpose of chloropicrin, to control that type of damping-off. On sugar pine we had light damping-off. We applied mercury and it seemed to help some, but you could get a soil sterile and at the same time put in the micro organism.

Chairman Webster: Mr. Wells, does this take large areas?

Mr. Wells: No, just trees here and there; 15 percent of it. The very tip will wither and turn over and die. The needles turn brown.

Dr. Wright: That is very typical of several nurseries.

Mr. McDaniel: It was said to be a fungus.

Dr. Wright: A common thing, but it has attracted very little attention. We find very little in literature on this. This is particularly bad because of the cost and loss here and there in the nurseries.

Mr. McDermitt: At the nursery at Nisqually the roots look all right, but the tops will be dead. We have good control by use of chloropicrin gas. We did not have the loss in the treated beds that we had in the untreated.

Dr. Wright: It may involve the other seedlings. You have to control it before seeding. This seems to hit in stock that is not quite as dense. The denser the growth, the less you have of it.

Mr. Wells: We used side boards on the beds. We have very little of it. Temperature becomes a factor.

Dr. Wright: Fusarium operates with higher temperature.

Mr. Wells: We tried formate as a dust, but it did no good. We also treated the seed.

Dr. Wright: It may be different on other soils.

Mr. Landquist: Apparently this mycorrhiza is important to seed growth. We had an experience with sugar pine. It was small and stunted. We were told that there are different kinds of mycorrhiza. We put duff on sugar pine beds and got mycorrhiza. On the Ponderosa pine beds it was loaded with mycorrhiza, but the sugar pine was not.

Dr. Wright: One crop will have mycorrhiza and one will not, because the soil characteristics are not the same. The application of the duff on the soil seems to be most effective. I imagine you want it in at the time the seed is sown. Apply it early as you can get it on.

Mr. Haddock: How much could you apply? Could you use the water extract?

Dr. Wright: No, I do not believe this would do.

Mr. Landquist: The humus in the soil is very important.

Dr. Wright: If I remember the figure, one of two nurseries reported fairly good results by using two bushels of humus to about 100 sq. ft. of bed.

Mr. Landquist: I was thinking that you introduce mycorrhiza by transplanting, but you have to know the right species.

Dr. Wright: You can introduce the mycorrhiza to the nursery soil, but you may also introduce the fusarium parasite if you take duff; however, it is safer than taking it from another nursery.

Mr. McDaniel: How long is it going to be before application of commercial fertilizers is safe? It is highly potent stuff. We burned the nitrogen out of the soil. They are adding some every year and burning up the soil.

Dr. Wright: It would vary according to the type of soil.

Dr. Wheeting: That goes back to what we talked about earlier. We need the nitrogen. If you have fertilizer or organic matter and add commercial nitrogen to increase the rate of decomposition; that is what you mean by burning out.

Mr. McDaniel: We are not putting too much humus into the soil. If you can't find free humus, then we have to resort to commercial fertilizer and burn up the soil.

Dr. Wheeting: Over the years, a continuous treatment of nitrogen salts would reduce the fertility of the soil. Along with it would be the loss in favorable physical condition. We want granulation and the intake of water. I like to look upon the nitrate treatments as a means of getting humus back along with the organic matter. Make additions to hurry them and then keep them up. Hang on to nitrogen rather than just putting in so many pounds. What we are trying to do is keep nitrogen that will enable us to keep more humus in the soil. If we can keep that in mind, we won't burn the soil.

Mr. Augenstein: What will some of these potashes do to the mycorrhiza? Destroy it?

Dr. Wright: I don't think it will unless you overloaded it. Phosphorus and soil ammonium have influence on the development of mycorrhiza. Mycorrhiza on coniferous seedlings are beneficial because they allow water absorption by the roots.

Mr. Stubbs: Can seed be treated to control damping-off?

Dr. Wright: I have seen some effect, but it does not give complete control. Conifer seed will germinate and come right out of the soil. It is doubtful whether seed treatment is enough to be justified.

Mr. Stubbs: You don't think you gain anything by treating your seed. Conditions have some influence. Where you have a greenhouse where you have fairly good control, it is different than treating seed in nursery seed beds.

Mr. McDermitt: We have tried semesan. We did not get any results.

Mr. McDaniel: We have some luck with phygon.

Mr. Augenstein: Phygon is a by-product of American Rubber Company. Phygon is the latest.

Dr. Wright: You can readily see there is plenty of room for experimentation. I recommend trying out new things on a small scale.

Mr. McDermitt: We have tried everything that has been suggested and at the beginning we lost a lot of seedlings by damping-off, but in late years we have lost very little. I don't believe an application of chloropicrin has a good effect. It retards the growth of mycorrhiza. An application of it every three years or so would be beneficial. A person can go to extremes.

Mr. Landquist: I remember many years ago that somebody wrote a paper on mycorrhiza. I believe he said that if you don't have mycorrhiza formation on the roots that the soil will not release the phosphate and make it available for the plants.

Dr. Wright: That is one of the theories. Mycorrhiza does increase the available phosphate.

Dr. Wheeting: Dr. McArdle did some work with mycorrhiza.

Mr. Isaac: He was not too enthusiastic when he got through.

Mr. Haddock: Definite increase in absorption in mycorrhiza increases respiration, but we have been unable to prove it.

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Chairman Webster introduced Mr. Vincent Bousquet, Forester, Vail-McDonald Tree Farm, Weyerhaeuser Timber Company. Mr. Bousquet gave a talk on "What Are the Tree Farmers' Specifications for Planting Stock?" He did not submit a paper for recording in the minutes.

Mr. Bousquet: The Nisqually 2-0 stock is more acceptable tree than it was several years ago. We have been getting good 2-0 stock as we have a heavy planting program in the next eight to ten years. We took so much care in handling and have excellent specifications, but did not get a good plantation. At the end of three years, we have about 88 to 90 percent survival. Good seed not always gets good seedlings. Choose an area where the seed is coming from. Tree farmers for two or three years have been short of trees. I am in the market for trees, but there is always a shortage. We want trees and we are trying to cooperate with the nursery managers. We might see a shortage of man power, if things get any worse than they are. We are hiring high school students. I would like to say in conclusion that these meetings are very fine, and I would like to look in on them occasionally. Hope you have more of them.

Chairman Webster: I would like to answer your request for trees, if you will give me your order for two years from now. More and more tree farmers want trees. In raising two-year-old stock it is a difficult problem to anticipate what the demand will be two years in advance.

Mr. McDermitt: If you will guarantee good seed, I will guarantee good trees.

Mr. Levin: I concur with Vince Bousquet and restate that fact, that we do want perfect trees. We will utilize a good average tree. We have a little committee connected with the Nisqually nursery to determine future needs. We tell Mac the type of trees we like to get. We decide what we want and that is what we have been getting. It has helped Mac and has helped us. We have been getting good survival since culling. Growth has increased considerably. The proper time of year to plant, is important. If cold storage is found practical, we can lift in the fall and store them. This will let us do our planting in the spring. We have found over a period of years that our survival has increased from 15 to 20 percent where we were planting during December, January and February.

Chairman Webster: Are you planting 1-0 or 2-0 stock?

Mr. Levin: Both. 1-0 in heavy fern. Our plantings in open brush have been 2-0. We are going to try out a change-over to 2-0 for the open brush type plantations by using 1-0 for heavy fern areas.

Chairman Webster: What is survival in fall and spring planting?

Mr. Levin: We put in our 2-0 earlier. We tried 2-0 in April and May. It was a little late. If you plant your 2-0 in February or March, you get sufficient rain to tighten up the ground. 2-0 survives as well or better. 1-0 is surviving better in the dense fern stands. The reason for the 1-0 surviving in the heavy fern and salal is that the fern will fall over and break it off. 1-0 stock from four to eight inches builds itself up and by the time it hits the fern, it will push its way through.

Chairman Webster: Our bracken fern grows five to six feet high in places and very dense. The minute we get our first frost the tops die and begin to mat down. It is a good cover for seedlings if it is not too dense. If too dense it is difficult to secure good seedling survival.

Mr. Bousquet: In areas where we expect poor survival we plant up to 1000 seedlings per acre. It is a good deal when you go over it the first time. Cost is about $21 per acre.

Mr. Bjorklund: Cost should run around $5 per thousand at the nursery.

Mr. Brown: What field spacing is used?

Mr. Levin: Eight feet between rows; six feet between trees. One thousand trees per acre on 1-0 stock or slightly over.

Mr. Levin: It will cost a few dollars more, but it will eliminate replanting.

Mr. Haddock: Would that show off in better grade of lumber?

Mr. Chapin: We have had about the same results from 1-0 as 2-0. It was not practical to put out two grades of stock. We prefer the 2-0.

Chairman Webster: What kind of beds?

Mr. Chapin: Broadcast bed and grade is taken care of by the 30 to 35 density. By rigid control of the water, the two-year's we are able to hold back the height. Anything over twelve inches is too tall.

Chairman Webster: In doing that you get a well hardened-off tree.

Mr. McWilliams: What is the cost difference between 1-0 and 2-0 stock?

Mr. Bjorklund: Only about $1. Little or no watering is required the second year and little additional cost in lifting, packing, and materials.

Chairman Webster: Our cost will run a little over that.

Mr. Stubbs: About the density. In beds where density is pretty low, you are going to have height, but you will get good survival on difficult sites.

Chairman Webster: You can always get the density you want in the beds.

Mr. Chapin: The weeding cost does not go up because you are getting better shaped trees with no crowding out. On the thinning the cost is a little but with a density of only about 50 per square foot, it is rather a small operation. The added cost is added space. We have run comparisons. A small density is practical - running 99 and in some cases 100 percent. No grading problem at all. Grading is done in the beds.

Chairman Webster: We hold to 2-0 stock, five to six inches high. One foot is too big from a standpoint of planting.

Mr. Augenstein: Culling out some of the small stock in the nursery is expensive. I visited a nursery and they do away with these trees. You can't throw trees away because they cost so much to raise. We have run a number of tests on this. We send small trees out to the planting job. We don't go by caliper. A big tree with a good root is not as good as a small tree with a good root. A small tree on a good site will grow as well on a poor site. If you cull out using a caliper, what is going to happen to the cost?

Mr. Bousquet: We have to pay more for trees, if the results warrant it. We pay the rate laid out in the contract $1.60 per hour for tree planters.

Mr. Levin: We are paying $1.50.

Mr. Isaac: Last year a number of foreigners went through here. They take the attitude that trees are like pigs - take out the runts. If trees are graded, you will get some small trees. It pays to throw out 10 to 25 percent of the stock in nursery grading because there are that many runts in normal stock. Those small trees will grow, but if you have to raise them and protect them, you had better plant a few less trees and get better ones. I have tried to get some planting stock standard for the S.A.F. planting committee and have had a hard time. I have measured fir 2-0 stock and started at six-inch tops, and eight to ten-inch roots. There may be seedlings in beds that are smaller than that and still be good trees.

Chairman Webster: What did you decide about caliper?

Mr. Isaac: I do not want to talk about it. You want the seedling that will stand up. 4/32 is good 2-0 seedlings. If it were small, I would not hesitate to plant it. If you get a tough planting site, 2-0 seedlings are probably the best. If you get a good site, you want a good seedling instead of a sick one.

Mr. Rindt: 1-0 stock does not develop well on an unfavorable site. If you are going to put it on a site with mild climate and other favorable conditions, 1-0 stock may do. A fair climate has something to do with the way you use 1-0 or 2-0 stock.

Mr. Bjorklund: Depends on the years. Some years are much tougher than others.

Mr. Isaac: Nobody wants to talk about hemlock. After I consider it more carefully, one needs an umbrella over it on a hot, sunny day.

Mr. Landquist: When we first started our nursery at Shasta, we figured if we had a good root and good top it was a good tree. We sent our stock out that way. Now the experiment station has decided and we have proved that trees must have a certain stem diameter. So I am the only one who is grading by stem diameters. If I was going to plant the trees, I would take the trees that look suitable to me regardless of stem diameter.

Chairman Webster: I do not think that stock should be graded on stem diameter. However, stem diameter should be considered within certain limits along with top root ratio and other factors.

Mr. Adams: The survival is supposed to be best on the larger diameter stock.

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Chairman Webster introduced Mr. James W. Augenstein, Chief Nurseryman, Savanac Nursery, U.S. Forest Service, Region 1, Haugen, Montana. Mr. Augenstein presented the following paper on "Weed Control."