Mr. Chapin: (cont'd) by the time those were planted in Pullman; so we tried one other thing. We took a lot out of storage and baled them as we normally would. First we weighed them out and baled them as we normally would and then held them for the same length of time which it would have taken to go to Pullman. Then we re-weighed that stock and at the same time weighed stock directly out of the storage box. I can't quote you the figures, but there was a definite difference in weight of that material and the stock that had been baled for a week. We got very much poorer survival than we did on that taken directly out of storage, so I think there is a correlation between the weight loss or dessication and survival that could be worked out. We have already got to the point that unfortunately it won't be the same for each species.

Mr. Lanquist: What species were they?

Mr. Chapin: We used Ponderosa pine and Douglas-fir. We have worked with Norway spruce and it seems to be the best, that is, it is easier to store and the best survival of the coniferous species.

Chairman Webster: Thanks very much, Frosty. Our next topic is going to be handled by Dr. Ernie Wright on the "Effect of Mycorrhizae on Growth and Survival of Ponderosa Pine and Other Species."

Dr. Wright: After we get through here with this little paper which is going to be very short, we have some slides to show. They illustrate some of the points and Jim Augenstein has kindly brought over the roots of White Pine and Engelmann spruce which I believe have some mycorrhizae showing.

MYCORRHIZAE AND THE GROWTH AND SURVIVAL OF PONDEROSA PINE

by
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We have already discussed the importance of seed source in relation to the growth and subsequent survival of plantations. Now using the same seed source let us consider the importance of mycorrhizae on growth and survival of planting stock.

First perhaps we might attempt to define what a mycorrhiza is. A simple definition that has been offered is that a mycorrhiza is a fungus root. A more complete description might be that it is an association of two different living components forming a morphological organ on the roots of various plants. Actually one of the components is a fungus whose hyphae penetrate the cells of the root tips of a host plant and forms a mantel-like growth or net over the root tips. Some investigators regard this relationship as beneficial and symbiotic in character while others maintain that the fungus is in reality a parasite on the host plant. We are concerned with the effect of the mycorrhizae on the host plant and the forester is particularly interested since there are several reports which strongly demonstrate that mycorrhizal plants show a higher percentage of survival on adverse field planting sites. Since the object of the nurseryman is to grow the best possible stock, his interest in mycorrhizae is likewise understandable. It is this particular phase of the subject which will be briefly discussed here. We need not concern ourselves with the different types of mycorrhizae but rather let us confine our discussion to the external or ectotrophic mycorrhizae.

The function of mycorrhizae is pretty well demonstrated to enhance the absorption of nutrients and subsequently soil moisture into the roots of plants. Just what nutrient is most important is still a disputed subject in which the Doctors appear to disagree.

In reviewing the literature on mycorrhizae, we find in many instances that the records on survival of mycorrhizal as compared to non-mycorrhizal stock in field plantings, leave much to be desired. Very little data show, for example, the comparative sizes of the plants. In fact, data are seldom given; generally only statements. For western conifers the records are even more meager.

In making a comparison of field plantings of mycorrhizal and non-mycorrhizal stock, it seems to me that we should first of all take the caliper and size of the respective seedlings into consideration. If we have seedlings that are twice the caliper of other seedlings, both having a well balanced root to shoot ratio, would we not be justified in expecting a higher percentage of survival for the larger stock even though mycorrhizae were largely absent from the root systems? Since mycorrhizal stock is frequently larger than non-mycorrhizal seedlings of the same age, are we, therefore, measuring the effect of mycorrhizae or the effect of seedling caliper or both. This question may appear academic; however, it is a very practical one since by manipulating soil nutrients, pH and control of pathogens we should be able to produce stock of suitable size without special attention to mycorrhizae. The satisfactory development of mycorrhizae on seedlings as grown in the nursery is recognized as an easier and a more simple way of producing stock of suitable size for field planting. Let us, therefore, consider some of the preliminary results of tests that the Division of Forest Pathology now has in progress.

To begin with, my recent interest in mycorrhizae came about indirectly. In an attempt to control a virulent Fusarium root-rot of Ponderosa pine seedlings, chloropicrin was used to sterilize the soil of the seed bed. Thus a control of the disease was accomplished, but soil sterilization eventually defeated our purpose by adversely influencing the quality of the stock. Using the same source of seed, we found that at the end of the first year the Ponderosa pine stock growing in the treated soil appeared greener and larger than the check seedlings. However, soon after the start of the second growing season, the stock in the sterilized seed beds began to fall off in growth and by the end of the second growing season it was noticeably stunted and chlorotic. Examination of the respective root systems showed that the roots of the seedlings growing in the chloropicrin treated soil lacked mycorrhizae while the seedlings in the untreated check beds contained abundant mycorrhizae and were healthy, robust plants. It was apparent that it was essential to determine the difference in survival between non-mycorrhizal stock after transplanting to the field. But first let us consider the difference in the size and weight of the stock.

The 1-0 Ponderosa pine stock grown in the chloropicrin treated soil had considerably heavier root systems (by weight) than those seedlings grown in the check beds. However, the spread of the root system was considerably less for the former. The development of the top growth was about the same. On a root to shoot basis, the seedlings of the chloropicrin treated soil had a 5 - 4 ratio while those in the untreated beds had a 2 - 3 ratio.

However, when the 2-0 stock was measured, the seedlings from the chloropicrin treated soil had the roots and tops weighing only about one-third as much as those from the check beds and the spread of the roots was also only about one-third that of the stock from the untreated soil. On a root to shoot basis, the

seedlings from the chloropicrin treated soil had a ratio of 1 - 1 while those from the check soil had a 1 - 2 ratio.

The average caliper of the 1-0 stock was about the same for the seedlings grown in chloropicrin treated soil as for those grown in the check beds. However, for the 2-0 stock the caliper was only about one-half as much for the seedlings grown in the treated soil.

The 1-0 stock was not transplanted into the field. The 2-0 seedlings from the chloropicrin treated and untreated soil, however, were followed in field transplanting plots. The transplanting was done by regular field crews at the same time that all stock was planted.

Three sites were selected for the plots and the survival was as follows:

for fall survival.

Field survival of 2-0 Ponderosa pine stock

Burned-over areas

From chloropicrin treated soil		From untreated soil	
No mycorrhizae		Abundant mycorrhizae	
Percent survival		Percent survival	
Planting #1	84	97	Good site
2	28	97	Fair site
3	62	83	Poor site

We were unable to get readings for plantations 2 and 3 the next spring because of deer damage during the winter. However, for plantation #1 on the good site, the survival for the non-mycorrhizal seedlings was 65.0 percent and for the mycorrhizal stock 84.4 percent.

The measurement of height showed an average of 2.5 inches for the 2-0 non-mycorrhizal stock and 4.8 inches for the mycorrhizal stock.

Tests are now under way to determine the difference in survival between mycorrhizal and non-mycorrhizal seedlings of the same size at planting time. Preliminary counts indicate that a higher percentage of seedlings with mycorrhizae are surviving than for the non-mycorrhizal stock, but the differences are less striking than shown above.

At this point it appears that 2-0 Ponderosa pine seedlings with mycorrhizae develop better and larger than non-mycorrhizal stock and that the mycorrhizal stock also survives better in field plantings. The tentative conclusion, therefore, is that mycorrhizae are beneficial and not parasitic on Ponderosa pine seedlings under the tests described. For other species, such as Douglas-fir, observational evidence indicates that mycorrhizae are equally important. Tests are now under way to gether more concrete evidence.

Dr. Wright: That concludes my paper, with the exception of these slides which I want to show you. They will illustrate better the differences in size by far than I can explain to you at this time.

Mr. Youngberg: Ernie, do you suppose the fact that those differences in the size of the seedlings in your chloropicrin bed at the end of two years might possibly be due to the fact there were mycorrhizae present in the non-treated bed and that they had a better nutrient set-up and made better growth the second year?

Dr. Wright: That is possible. In discussing this with the chloropicrin people, they have showed in various agricultural grass they get a stimulation of growth in chloropicrin treated soil over non-chloropicrin treated soils, due to the killing of various fungus, flora, and fauna of the soil and release of various nutrients temporarily into the soil. Still you can have growth on your treated soils where you don't have it on your untreated soils. Mycorrhizae, of course, were abundant in this soil, which I should have mentioned there.

Mr. Augenstein: The reason for finding mycorrhizae in some soils and not others is due to the character of the soil and the lack of aeration?

Dr. Wright: Well, that is a kind of moot question, I guess, Jim. Apparently mycorrhizae do develop under some conditions much more rapidly, much more frequently than they do under others. Just what those conditions are is yet undetermined and it seems under adverse conditions, or under tough planting sites, very frequently you have mycorrhizae development on the area better than you do where the soil has a good supply of nutrients.

Mr. Augenstein: Doc Waters in Missoula has trouble raising conifers, mostly pines and fir. He can raise spruce pretty good, but he brought some seedlings, Ponderosa pine seedlings, out to our nursery where we have an abundance of mycorrhizae and there was none on his seedlings and very few hair roots. We planted them, and at the end of the first growing season, they were just covered with mycorrhizae and a lot of hair roots. He also took some of ours to Missoula and planted them, and it soon was all gone. The hair roots had sloughed off and the mycorrhizae was gone. He tried to take some of our soil to encourage mycorrhizae, but by the time he got his experiments set up, the strip houses moved in and took over that area so he wasn't able to find out whether it would stay there by mixing our soil with native soil.

Dr. Wright: That is one of the very perplexing problems. You might say if you have a nursery that has a limited supply of mycorrhizae, why not introduce it to the nursery. Well, of course it has been done to a considerable extent by the use of certain duff brought from the forest and applied to the seed beds, but in other cases where it has been tried on the soil, it doesn't stay there. It just fades away. What the microflora, the biochemical and other relationships are that bring that about, I don't know, but sometimes you just don't seem to be able to introduce it.

Mr. Nagle: Have you made any observations yet as to how long it takes mycorrhizae fungi to be re-established in your soil?

Dr. Wright: To be re-established? No, I don't know that. I do know that in Ponderosa pine and in Douglas-fir you get a fair showing of mycorrhizae on the seedlings by the end of the first year, but you don't get very much development in mid-season of the first year as far as the plant is concerned. The second year it will really show up.

Mr. Nagle: You didn't make any effort to innoculate?

Dr. Wright: No effort to innoculate, just took it from natural conditions and went on from there.

Mr. Lanquist: Well, seeing I got my citizenship papers from Mike here, you know the Swedes are very interested in the study of mycorrhizae, and I waded through a whole bunch of recent literature that has been done on mycorrhizae studies. Now, the funny thing about that, they fully agree with you in a way, that mycorrhizae does not develop in soils that are productive because the plants do not need it; so that is a good statement, and it is comforting too, you know, because you don't have to bother.

Now you can introduce mycorrhizae in your nursery in one season, like you say, because we tried it. We tried to grow sugar pine and we couldn't do it. Well, we grew the sugar pine but the roots were very poor, so we went out and collected some duff under a sugar pine stand. We dug down a little bit and took it up and we put the duff on the seed beds and planted our sugar pine, and we got a good crop of mycorrhizae on our sugar pine and consequently a good growth. In fact, it was so good we got in a kind of a fix one time there. We had promised to ship a few thousand sugar pine to a place and we forgot all about it somehow, so I said to a fellow working with me, "By golly, we got to do something." He said, "What about those one-year-old seedlings we got? Maybe we can do that." So we dug them and took a look at them and shipped them down there, and we got a letter back saying, "Those were really nice two-year-old sugar pine seedlings."

Mr. Bjorklund: I was wondering about what Karl said on Scandinavians. I have asked quite a few of them who have toured through our nursery about the problem of hemlock, and quite frequently they say you have to have the right type of mycorrhizae. Hemlock required certain types. And they usually spiel off several names that I haven't heard of, but they say quite often in their nurseries they will go out under hemlock forests and bring some of the duff in with the idea of innoculating their nursery soils with certain mycorrhizae. They claim that way they can get adequate growth the first year, so their seedling is large enough to withstand the winter and also any frost heaving. Now, I don't know; I was wondering if anybody over here had tried that idea?

Dr. Wright: I think that is a proper way to go at it, particularly since mycorrhizae are extremely difficult to culture artificially in culture medium. If you could do that, then you could introduce -- if mycorrhizae would grow on wheat or rye and introduce it into your seed bed, you would have a fine situation, but unfortunately it is very difficult to get them in culture. They are extremely temperamental. The best thing is to take the duff from under the forest of the species you have to grow and introduce it on the seed bed.

Mr. Long: I was wondering if Dr. Wright had any knowledge of the effect of chlorodine on the mycorrhizae?

Dr. Wright: No, I have not.

Mr. Long: I am using it for control of strawberry weevil and I just wondered what effect it might have.

Dr. Wright: I haven't had the opportunity to do that. I do know some of those things have only a slightly detrimental effect. Mycorrhizae are very temperamental; sometimes they kill out very easily and sometimes you wonder how they survive. But I have no information on Chlorodine.

Now, Mike, to ease my conscience here, I might say something about the effect of mycorrhizae on some of the other species very briefly. First, I had better qualify by saying I don't have any complete tests on them, but I do have information that the relationship appears to be holding about the same for Douglas-fir, although my data -- I wouldn't want even to quote it now -- is very limited, but for Douglas fir I think mycorrhizae, on tough sites and on burns in particular, and that brings up another story that is very significant. For example, on severe burn, you may have a fairly sterile site immediately after the burn. Maybe you had mycorrhizae in the soil in the beginning, but maybe you don't have a sufficient supply at the time, and if your seedlings don't have mycorrhizae when you put them on that burn, that is maybe one of the factors in the seedlings dying on a wholesale basis. However, if you have the mycorrhizae on the seedling when you introduce it, I see no reason why it shouldn't survive under normal conditions, so I think the mycorrhizae would hold about the same as for Ponderosa pine, but I have some tests I hope I can bring up next time on that.

(The meeting then adjourned to see slides, etc.)

Chairman Webster: Gentlemen, we are running behind schedule just a little, but I am sure we will be able to pick up our time as we go on. I have a couple of pictures furnished by Tom Wells, showing what they consider as good mycorrhizae on one side and poor on the other. They both look pretty good to me, but we will pass these pictures around for you to look at as we go into the next subject.

Mr. McWilliams: Mike, just as a matter of interest, we keep a pictorial record of our stock each year, and that is just a sample. In each nursery, every year, we take pictures of our average planting stock, and it is not chosen by the nursery superintendent -- it is chosen out of the planting stock.

Chairman Webster: Our next subject, gentlemen, is the "Latest Developments in Weed Control," to be handled by Karl Lanquist. Karl is the Chief Nurseryman of the Mt. Shasta Nursery.

Mr. Lanquist: Well, you know, when I first came over here to this nursery, I thought maybe I knew something on this subject, but then looking over the area at this nursery, I don't feel quite as competent to put this weed control program over, because I couldn't see any weeds out here, although it might be they have been picking weeds for a month before we got here. We will never know about that.

HOT WAR ON WEEDS

by

Karl B. Lanquist

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The top few inches of the earth's crust is a veritable storehouse of weed seeds. Farmers of California spend more than fifty million dollars a year to fight the weeds, but even on lands that have been in rotation for 10 years there may be 3,000 weed seeds in each square foot of soil.

Science has come to the aid of the farmers with many chemicals and machine weapons for fighting the weeds. We have selective chemicals which will kill the broadleaved species, and those that will kill grass and leave the broadleaved weeds.

Oil sprays and other sprays can give a weedfree soil, but strangely enough, we cannot make up our minds whether it is best to grow the weeds and turn them under or kill all vegetation with oils. The problems to be weighed are water penetration and what is best for the soil and the crop.

We have learned to plant some of our crops in close rows, thus shading out many weeds.

We have been forced to seek every possible labor-saving source in order to compete with the rapidly rising cost of production. New chemicals used in controlling weeds, particularly the pre-emergence sprays, plus improved mechanization, have decreased labor costs about 66 percent in the last few years. Pre-emergence sprays have saved a tremendous amount of hand labor and have helped to reduce costs. We should not forget that practical crop rotation and cultivation of fallow areas are good practical weapons for weed control which are frequently overlooked.

The progress we have made in American agriculture through the use of chemicals is being threatened by fanatics who claim that chemical fertilizers and weed sprays poison the soil and leave spray residue on fruits and vegetables that are a menace to public health.