WHAT IS HARDENING OFF AND THE USE OF NITROGEN
AS AN AID IN HARDENING OF DOUGLAS FIR SEEDLINGS

by

Homer S Wards Chief Nurseryman
Washington Division of Forestry

What is hardening off?" A precise definition of the term "hardening off" is very elusive, a great deal depending upon the users need for a term to describe the condition of plants at a given time. The term 'hardened" is used synonymously with dormant in describing the condition of plants at the end of a natural growing seasons It is also the term used by greenhousemen who condition their plants for transplanting from greenhouses hotbeds or coldframes during the growing season. Kommel, Rindt, and Munger in their FOREST PLANTING IN THE DOUGLAS FIR REGION haves in the writers opinion the most applicable description cf hardening" of forest planting stocks "The term 'hardening' should be applied to the conditioning of the plants by controllable nursery operations, principally irrigation and fertilization. Plants can go into dormancy with weak, somewhat succulent stems and chlorotic leaves. They can be safely handled and field planted but they are poor survival risks especially on adverse planting sites. Hardening should develop sturdy, woody stems, healthy leaves and buds, and should store an abundance of plant food in the plants to carry them through the winter and to provide them with a good reserve for start of growth the following spring. It is especially important that the plants be well hardened during the last season In the nursery before they are field planted."

In a 1941 Journal of Forestry articles J. C. Kopitke describes the physiological aspects of "hardening" as follows: "The shorter days and cooler nights of autumn initiate a series of changes within the plant which result in its protection from winter injury. In the course of these changes, referred to as 'hardening, starch undergoes hydrolysis and plants accumulate increasing amounts of sugars() The sugars Increase osmotic pressure of plant sap and prevent precipitation of proteins. Cell walls attain greater permeability and the contents of hydrophylic colloids and bound water increase in the tissues."

In a personal correspondences Dr. Youngberg of Oregon State College, Soils

Department, brought out that in accordance to the European literature on the subject it is stated that as "hardening off" progresses the tree will attain a greyish-green color or a yellowish-green color.

In the search for information on the subject, many varied concepts of the physiological factors of "hardening" plants was encountered, one idea being as logical and as well substantiated as the next.

The physiological transformation mentioned by Kopitke might be- readily accepted. The causes of these transformations are subject to conjectures.

There are people who would credit "hardening" of plants entirely to a combination of light, temperatures, and general soil conditions, and then there has been some use made of fertilizer applications to induce prompt "hardening off," potassium salts being the most common and more widely accepted. Kopitke in his experiments *in* Wisconsin determined that up to 300 pounds per acre of potassium salts was beneficial.

At the Caitol Forest Nursery in Washington State nitrogen fertilizers have in some manner aided in the "hardening" of Douglas fir 2-0 seedlings. This is so unusual and contradictory that perhaps a more complete history of the experiments might be justified°

The initial experiment was due more to Chance than actual planning. In April of 1945 some of the 2-0 seed beds had small patches of chlorotic looking seedlings that suggested a nitrogen deficiency. It was decided that perhaps by spot treating with ammonium sulfate early enough in the season that these off-color seedlings would benefit. Due to the complexity of Governmental purchasing the nitrogen arrived August 20. Upon the assumption that the seedlings were lost *anyway* a few of the more chlorotic spots were treated on August 22, 1945. By mid-0ctober the treated trees had changed from a sickly looking yellow to a dark metalic blue-green; the buds were bright, and well formed, the stems were woody, the leaves were healthy, and the trees in general had a very thrifty appearances

This was not the reaction that one would normally receive from a nitrogen fertilizer and our curiosity and interest were such that planned small scale experimental plots mere carried out the following year and ending with the same results of very thrifty appearing seedlings◦ By August, 1948, the procedure had become a standard nursery practice◦ Briefly as it is now carried on the Ammonium Sulfate or Ammonium Nitrate is broadcast on the beds at the rate of 250 pounds per acre. The material is applied dry and is then watered well with the overhead sprinkler system. As mentioned before, this is done in late August and no further irrigation is done during the balance of the season. In all of our experiments check plots were left as controls and the treated seedlings were always superior in appearance of thrift and strength.

It must be acknowledged that no explanations of how or why can be offered, and it may be a little trite, "but the proof of the pudding is in the eating."

DISCUSSION:

hardened as to their storagability Don't you think those two things should follow the work you have done before you make any decision as to whether we should follow that program?

MR. WARD: To be frank the more I go into it the more uncertain I an that it is the right procedure. I used nitrogen at the wrong time of year and am offering it for what it is worth.

COMMENT: The experiment at the Geneva Nursery in New York had no response to direct application of fertilizer. Maybe if we had our nursery soils in the correct balance at seeding time there would be no need for later applications.

MR. WARD: It might have a bearing on the ability of the trees to produce roots. We have noticed that trees with a high nitrogen content in the top spoil in storage more readily than trees that don't have it. That might not apply to trees that are treated as late in the year as you fertilized them.

QUESTION: What is the relation of the nursery soil to the field soil?

MR. WARD: I wouldn't have any idea.

QUESTION: What is the comparison in frost damage?

MR. WARD: I did this nitrogen application on two-year old stock. When applied the buds were beginning to form. However, in the bed of 1-0 I had in experimental stock it delayed frost damage. I got my frost damage in February on the controlled bed. By spring there was no difference. They had equalized°

MR. YOUNGBERG: What happens to that stock after it is planted in the fields that is important. Unless you take the stock out in the cutover we don't have a leg to stand on.

MR. WARDS We had 30% of the stock that went out to the field. Eight per cent was lost to causes other than rodents.

MR. YOUNGBERG: That is the point I would like to bring out. A lot of work has been done in the stock aid it might appear differently but it acts differently in the field. It may look the same morphologically but physiologically it acts differently in the field.

MR. WARM It has been used more or less over the whole nursery some eight years. Our nursery is standard. We have eight beds to a unit and I save every eighth bed as check.

MR. YOUNGBERG: You still, haven't checked the two treatments against each other (in the field)?

MR. WARD: Not side by side.

MR. DEFFENBACHER: Last summer we treated some Sitka spruce with ammonium sulphate. Sitka spruce that had been stored; at the same time that had not been fertilized. They were in good shape but those that had been were all last. My experience was with Sitka spruce and it was sad.

MR. WARD: My experiments have all been with Douglas fir.

MR. McDANIEL: Did you check your soil moisture before you applied your ammonium sulphate?

MR. DEFFENBACHER: No.

MR. McDANIEL: That was in late August?

MR. DEFFENBACHER: Yes.

MR. McDANIEL: We understand that ammonium. sulphate is more of a stimulant.

MR. DEFFENBACHER: Yes.

MR. McDANIEL: How much water did you put on?

MR. DEFFENBACHER: A good 2.5 hours with the overhead.

MR. McDANIEL: Your pressure throws about a one-quarter inch?

MR. DEFFENBACHER: Yes.

MR. McDANIEL: Comparatively dry hard nursery soil?

MR. DEFFENBACHER: **Yes.**

MR. McDANIEL: You didn't try to water any heavier? What would have happened if we had run into a warm August rain?

MR. DEFFENBACHER *if* we had an inch or inch and a half we would have had a breaking of buds.

MR. HAROLD ENGSTROM: There is nothing new under the sun. In 1939 I visited the Savannah nursery. 1 was surprised to find he was supplying liquid fertilizer over the whole nursery. **He** had determined through trial and error that fertilizer late in the season after the buds were set gave the trees more strength and could withstand the transplanting process. He was using it as standard procedure. Following thatp in 1946,9 we had a small nursery where we had 1-0 ponderosa pine seedlings. In August, after the trees wee fairly dormant I applied fairly heavily ammonium phosphate to theme I couldn't follow up the following year. The men reported the trees planted as 1-0 stock gave outstanding performance. Ammonium phosphate on stock to be winter stored will give a problem. Necessary research hasn't been carried on on a statistical basis

Mr. Dircksen was called upon to discuss the Oakdale Nursery program. Mr. Dircksen in turn requested Mr. Corson to tell about it.

Mr. Corson said, Several years ago we were looking for a nursery site with sandy loam. Transplants of 1-0 seedlings were brought down from Mt. Shasta. The growing season was rot long enough there. It is only seven or eight months. The result has been all that anyone could hope fore The survival has been very good. The last year we tried to raise trees from seed put in seed beds. They have been working out as good as you. can find anywhere. This particular site grows sane pretty good sugar pine. We have never been able to grow it in California before. It always froze. This last spring the stock was so developed we decided to try it in the field.

"The Bureau of Land Management requested one hundred thousand seedlings. We asked them to try at least one-half of sugar pine as 1-0 stock. We didn't make any guarantee. So far we don't know the results.

"There is no particular difference in the location of the nursery at Oakdale than any other nursery throughout the country. The soil is quite sandy and it takes quite a little water to keep the trees going. Otherwise conditions are no different than in any other nursery other than we have a long growing season."

DISCUSSION

MR. ADAMS: How about soil temperatures. Doesn't it get pretty warm?

MR. CORSON: Just what you would expect - 100 to 105 in summer time surface temperature.

QUESTION: Haw did you shade?

MR. CORSON: Found it isn't necessary on transplants. Didn't use shade on nursery stock. 'de did find by putting a little shade on the seedling stock it had a little better coloring on foliage ad cut down on the watering. This year we are giving one-half shade on seed beds.

MR. ENGSTROM Have you grown 1-0 seedlings and transplanted them there and what is the size?

MR. CORSON: The first production of that went out this spring.

MR. ENGSTROM: Were they bigger than the ones that were moved from Mt. Shasta?

MR. CORSON: No difference in the size.

MR. ENGSTROM The 1-0 stock there is much bigger than Mt. Shasta.

MR. CORSON: You could expect that, Eight to nine months there as compared to five at Shasta."

QUESTION: According to the reports from the Forest last years there isn't any great difference in the cost of planting.

MR. CORSON: There would be a difference in the cost of shipping.

QUESTIONS Back in the shelter belt we found the larger the stock the better the survival,, but where the limit is we don't know.

MR. CORSON: We don't know either. That has been our experience also. I might throw this in. The planting on the Modoc: I don't know whether most of you are acquainted with the east side type in California. We had to hold some stock in the nursery because of a financial situation and produced it as 2-l. Most of the stock on the burn was 1-1. Took 2-l stock on the extreme east side of the burn there there is practically no soil at all - practically a lava outcrop and planted in May which is late. They were planted two years ago and they have about 80% survival which is something we have never had in that area before.

QUESTION: Did you plant in wet cycle or dry cycle?

MR. CORSON: Normal type of season. Practically no rain after planting was made. That is the thing that was so surprising to everybody.

MR. McDANIELS: You took it from Oakdale?

MR. CORSON No. Mt. Shasta..

MR. McDANIELS: You haven't planted the Oakdale stock there?

MR. CORSON: No. We have kept the Oakdale stock to the Central Sierra.

MR. McDANIELS: We have a problem in Oregon of raising 2-O ponderosa pine and some transplant stock in valley nurseries where the temperature is mild and then planting in eastern Oregon to see if they **will** compare with the eastern Oregon nursery plantings°

MR. McDANIELS: On your potato field nursery was the **soil** checked by the plant pathologists?

MR. CORSON: Yes. Dr. Wagner checked for pathological features that are detrimental, and for pie It has a high pH. In putting in seed beds we have to use sulphur to lower the pH. Use sulphur 400 pounds to the acre but treat the seed beds after sowing with sulphuric acid about 1/8 ounce to the square foot.

Mr. Lanquist introduced Messrs . Dircksen and Allen of the Oakdale Nursery.

Mr. Gilbert Shubert sho d motion **pictures** of operations at both the Oakdale and Mt. Shasta Nurseries. It was noted that more women laborers are being employed in the nurseries because they are faster workers, more interested in the work and much more efficient than mend