Chairman Webster: Thank you, Jim, for your excellent contribution on weed control measures. Our next topic is devoted to nursery irrigation and will be presented by Walter Engstrom.

NURSERY IRRIGATION
by
Walter Engstrom

Irrigation in its broadest sense includes all of the problems of collecting, storage, delivery, and application of water to the land to promote growth. In order to fully understand the science of irrigation and to make the best use of water, we must first know the functions of water and its relationship to the soil and plant reactions. While the main object of irrigation is to keep plants growing, water is a much greater influence than any other factor upon the form and structure of a plant. Water is important to the plant in many ways. It is a component part of protoplasm and, with carbon dioxide, is essential in the manufacture of plant food. It constitutes the greater percentage of the weight of the plant. All plant food must be in solution before it can be utilized by the plant. Water is this great solvent. It serves as a medium of transport of food materials; keeps cells turgid, a condition essential to normal functioning of the plant, and last but not least, it tends to prevent excessive heating from the soil, air, and chemical reactions taking place in the plant. The greatest sources of danger which a plant has to meet are insufficient absorption and excessive transpiration. To combat this situation, many plant species will in their fight for existence tend to make certain internal and external changes when the optimum moisture range is decreased; some such changes being increased osmotic pressures, thickened cell walls and protective coverings, and changes in amounts of the various plant tissues. External changes will be more easily discernable in a dwarfing of the plant, shortened needle growth, and off color which is a condition we wish to avoid.

Forms of Soil Water

Because of its great importance, it is necessary to be familiar with the various forms or kinds of water as all soil waters are not available to the plant.

There are primarily three forms of soil water and these are briefly described as follows:

(1) Hygroscopic water, or water that is held by the soil after capillary water has been removed; mostly held as very thin films on soil particles, especially colloids. Sometimes also term given to moisture that is absorbed by a dry soil from the atmosphere.

(2) Capillary water is water that is held as liquid films around soil particles after excess water has been removed by gravity; that is, it resists further gravitational pull. Is sometimes broken down to upper and lower capillary range, the upper where capillary water is abundant and the lower where movement of water slows down.

(3) Hydrostatic water is water that moves downward by gravitational force and drains away. Also known as gravitational or free water.

It is with the capillary water that we are most concerned, as hygroscopic water is unavailable to the plant, due to the fact that the attraction for water to the soil particles increases as the film grows thinner, until water cannot be furnished rapidly enough to insure normal functioning of the plant. Likewise, hydrostatic water is available only briefly as it passes on through the root zone. The amount of available water will, of course, vary in different soils and is determined by several factors. Most important of these are soil texture, or size of soil particles, the arrangement of these particles known as soil structure and the amount of organic matter. The effect of each is as follows:

(1) Soil Texture. Since water is held in a thin film upon the surface of the soil particles, running together and forming drops or masses only in a saturated soil, the amount of water retained necessarily increases with an increase of water holding surface, and the finer the particles the greater the surface. Likewise, the movement of water in all directions is dependent on the size of these particles and the upward movement or capillary action being increased while the downward movement by gravity decreases in proportion to the fineness of the particles encountered. This can be readily noted in clay or silt loams and coarse sandy soils when in contact with a water table, the former being quite moist while the latter is dry.

(2) Soil Structure. The effect of structure on water retaining power is evident by the fact that a soil in good tilth will hold more water than a hard, compact one. Clay soils will hold water more tenaciously and retard or prevent its movement even to the extent of becoming water logged and preventing the normal flow of air in the soil.

(3) Organic Matter. Organic matter affects the water content directly, as to quantity and quality, by holding water in large amounts in a sponge-like fashion. It also has an indirect effect on soil structure as it tends to loosely cement sand particles together, thereby decreasing percolation.

Our concern is the amounts of water necessary and when to apply. These are, of course, individual problems and are dependent on type of soils, kinds of stock grown and climatic conditions. This must be ascertained for each nursery site, but the basic principles are the same. We must first determine the water-holding capacity of our individual soils, the plant requirements, and the various factors that influence the withdrawal of moisture from the soil, such as temperatures, humidities, and wind action as it affects evaporation. Of these, the one most apt to give us trouble is the amount of water needed for normal plant functioning and the point at which such normal functioning ceases due to lack of moisture. Unfortunately, little is known about the latter, which we know as the wilting coefficient, and much study and research are needed along this line.

It cannot be determined entirely by the soil type as some plants can absorb more moisture from a given soil than others. On the other hand, some investigators have concluded that species differ very little as to water content when permanent wilting takes place, and that the big difference lies in the distribution and extent of the root system, the theory being that an extensively branched root system with an abundance of root hairs will contact a larger soil surface than a small root system and would reduce the moisture content of the soil to a minimum before wilting. The exact permanent wilting point is difficult to determine and should not be confused with temporary wilting from which a plant will recover. It is, however, I believe, the approach to the temporary wilting point or the slowing up of water intake that we should be most concerned with as, even though the plant will recover, it has definitely suffered through the slowing up of cell and plant food formation. The more often this takes place, of course, the more detrimental will be its effects.

From the determined soil capacity and wilting point, the amounts and period to apply water can be calculated, but it is fully realized that time and man-power and probably the means are not usually available to make such determinations.

Consequently, we must resort to more rapid methods and even then no hard-and-fast rules can be laid down, as proper watering is so intimately related to changes in local weather conditions. A day-to-day or more often check on the soil moisture in the beds is necessary. Through long experience it is possible to determine conditions by feel and ocular observations. We all, no doubt, have our pet methods which all lead to the same conclusions. Furthermore, we know that countless millions of trees have been raised and successful plantations have been established with few failures, so our deductions have not been too far amiss.

In my own case, I make use of a soil auger to determine depth of moisture and amounts by adherence of the soil particles to each other when squeezed into a mass, as well as color of top soil. For fast work, a stiff metal pin similar to a surveyor's pin may be used, inserting it into the seed bed which in most soils will readily establish depth to the dry area. Various other methods through the use of absorption cups, systematically placed containers for weight determinations, and indicator plants have been experimented with, but I know of none in use today which might indicate that such methods are again too complex or unnecessary. My practice is to make sure of a moist sub-stratum at all times and keeping the soil moist in the seed zone during the period of germination, allowing a gradual drying out of this zone as root growth progresses, making sure that sufficient water is applied each time to reach the existing moisture zone. In other words, to allow no dry layer or stratum to form. By the latter part of August, irrigations are made less frequently to gradually build up resistance in the plant to withstand winter conditions, or readying the stock for field planting which we term the hardening off of the stock. If climatic conditions are such that natural precipitation cannot be expected, irrigation water must be applied so as to insure the soil going into the winter in a moist condition to take care of the natural respiration of the plant.

We might briefly touch on the uses and misuses of water other than the mere use of keeping plants growing in a normal healthy condition.

The use of too much water is an error that is not too hard to commit. Very often, because the water is there for use and the common feeling being that too much is better than not enough. This is without a doubt true to certain limitations, but it may have a detrimental effect other than on the plant in lessening or eliminating the air content of the soil which is essential for proper growth. This is, of course, more serious on the heavier soils and those underlaid with hardpan. Uncontrolled irrigation may also be detrimental in the leaching out of reach of the plant roots, plant nutrients or salts by too heavy watering, as well as the building up of concentrations of salts by too little watering. The use of water, too, is made in the combatting of certain diseases, such as damping off, which, if in progress, may be lessened by the drying off of the soil. Lastly, but still quite a factor, is the economical angle as watering, as well as water, is an expensive activity at best and should be considered as one of the limiting items in its use.

I have not mentioned the mechanics of applying water, as I believe our individual nursery layouts and distribution facilities are substantially the same. I would, however, before closing like to give a short resume of the Bend Nursery Project.

Heretofore, practically all nursery stock for field planting on National Forest lands has been grown at our Wind River Nursery at Carson, Washington, where climatic conditions are very far removed from those found in eastern Washington and Oregon. At that nursery, where the annual precipitation is around 80 inches with 120 inches not uncommon, one can well imagine the difficulty of establishing a successful planting when stock from such a location is out-planted in areas where annual precipitation is but 13 inches, such as we have in the vicinity of Bend. The Bend Nursery was established to grow stock for such areas of light rainfall, and it is our hope to be able to develop a more or less tailor-made tree, which will be able to withstand severe drought conditions. The nursery, when completed, will comprise approximately fifty acres under an overhead water system, commonly known as the Skinner system, with a considerable area adjacent that could be used for transplant stock, if necessary. Such area would have to be irrigated by the open furrow method or by use of movable sprinkling lines. Our irrigation system may differ from others only in method of supply. Water for irrigation purposes in the area is supplied through several Irrigation Companies and the water is tied to the land. This was one of the factors that established the location of the Bend Nursery as the use of the water is allocated by priorities based on the time of incorporation. The headgate of our supply is located better than a mile from the nursery and prior to our acquiring the land, water was brought to the site through an open ditch. Because of the nature of the country, water losses in the ditches are so great we constructed a 12-inch pipeline and by-passed the ditch. The water is brought from the headgate through this line by gravity to a three-compartment reservoir where it passes through a series of screens and thence pumped into the nursery system. The use of this type of water originally caused some concern, due to the large amounts of debris, scum, and weed seed that it carried which would tend to plug up spray nozzles and reinfest the area with weed growth. Our filters are constructed of a fine mesh screen, known as "Fourdenier screen," and we find most, if not all, foreign matter is eliminated and a minimum of nozzle plugging is experienced.

It is realized that while much of the foregoing statement is highly theoretical, it is nevertheless scientifically provable and sound and will serve as a good basis on which to make our determinations of individual needs and applications.

Augenstein: What is the advantage of overhead irrigation over furrow irrigation? We use furrow on transplant stock and overhead on seed beds. We get better roots on furrow irrigation than we get with the overhead system.

Chairman Webster: How can you irrigate uniformly with the furrow method?

Augenstein: I think soil type would enter in there. Our soil is adapted to furrow. We run 25 to 30 minutes through 500' beds. Our paths are cultivated and it takes time for the water to run to the end of the bed. I am in favor of irrigating seedlings stock by furrow. We find that overhead irrigation tends to develop roots close to the surface.

Chairman Webster: Our root pruning encourages deeper lateral root development and we have experienced no problem in the development of the shallow lateral roots with overhead irrigation.

Chapin: I would think your soil type would be the limiting factor. I am sure we could not get proper irrigation through our soil in Bellingham with furrow irrigation.

Lanquist: We had a chance to try out furrow irrigation on heavy soil. We used it on transplants. I believe the seedlings were superior when we used overhead irrigation as we could control the water better. When we used furrow irrigation, spots would get water soaked and other spots were dry.

Chairman Webster: Does anyone have any experience in controlling soil temperature by the use of irrigation in lieu of shade frames?

McDaniel: We control the temperature, bringing it down with water. We bring the temperature down by application of one watering period since the top soil has highest temperature during the heat of the day.

Chairman Webster: The theory used to be that we do our irrigating early in the day. Is this necessary, or can it be done during the heat of the day?

Lanquist: One time we had trouble raising white pine. The ground seemed to form heat lesions. Someone hit on the idea of cooling the soil by sprinkling to control surface soil temperature. Soil temperature as high as 120°. Sprinkling solved our problem.

Rindt: Lake State Experiment Station ran experiments on that subject. It was believed that we had to water in the cool of the day, thinking that cold water on a hot day would injure the plants. This seems not to be true. I have watered when air temperature was 107 and soil temperature 125 in the heat of the day on 1-0 and 2-0 stock with no harmful effect.

Chapin: We use overhead sprinkling in lieu of shading and have not shaded for 10 years. We are raising spruce, pine, fir and have had no trouble in 10 years.

Deffenbacher: We have done away with shade frames.

Chairman Webster: Do you watch your soil temperatures at each application?

McDermitt: I have lost trees by letting the soil temperature get too high before applying water.

Chairman Webster: Thank you, Walter, for a job well done. The subject was very interesting and I believe that from the discussion some of us picked up a few pointers that will save our employers considerable money. Our next topic is Stock Distribution - Lifting and Grading, and will be presented by Norman Bjorklund and Earl McDermitt of the Nisqually Nursery, the only industry nursery represented here today.

STOCK DISTRIBUTION - LIFTING AND GRADING

by

Norman Bjorklund and Earl McDermitt

Since inception of the Nisqually Nursery in 1941 by the West Coast Lumbermen's Association to provide planting stock for reforestation of idle private forest lands, lifting and grading methods have been developed from experience and through experimentation to handle a seedling crop which now averages six to eight million trees per year. Practices being used currently will be changed as needed.

Lifting

Lifting operations generally start at the Nursery about the fifteenth of November and continue until the first part of April. By November 15th the trees are in a dormant condition and have hardened off to the extent that they can be handled without appreciable damage. By early April, spring growth is beginning and further lifting is stopped. Lifting operations are coordinated with packing orders on a week to week basis, as the storage facilities at the Nursery are