TRICKLE IRRIGATION FOR SEED ORCHARDS

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Abstract.--Trickle irrigation systems are currently being established in operational seed orchards. Advantages of trickle are efficient water use, improved plant response, logistical improvements in orchard operations, and economies in system design, cost and maintenance. Potential problems of trickle include sensitivity to clogging, salinity buildup, and moisture distribution. Early operation of International Paper Company trickle systems is promising.

Moisture is a critical facet of seed production (Gallegos 1977, Lamb et al. 1973, Shoulders 1973, Wenger 1957). Irrigation has been shown to be a successful orchard practice. It can improve survival and growth of young grafts (Long et al. 1974); improve crown size and resulting cone production (Davey 1975); and can be used to manipulate the timing of water stress resulting in increased female strobili production (Dewers and Moehring 1970).

These advantages of irrigation have convinced International Paper Company to utilize this technique in its advanced generation seed orchards. Rigorous selection of these orchard sites will allow effective use of water stress to induce female strobili after the initial years of utilizing irrigation to produce large cone bearing surfaces (crowns) on the trees. Use of irrigation and other intensive orchard management techniques allows fewer orchard locations, reduced operating costs, and economies of scale that are essential to a large orchard program. Additionally, the reduced orchard acreage allows for effective management of orchard operations over the long term.

Trickle irrigation was judged better than sprinkler irrigation to meet the orchard requirements of International Paper Company's first advanced generation location - Bellamy II. The water at this location (Marianna, Florida) contained enough calcium that long-term irrigation would raise the soil pH above acceptable levels. This effect has been noticed in a Florida irrigation trial (Schultz et al. 1975). The reduced usage and localized placement of irrigation water with a trickle system would help overcome this problem. Additionally, the lower costs of establishing and maintaining a trickle system made it attractive when compared to sprinkler irrigation.

Over 150,000 acres are currently under trickly irrigation in the United States and over 800,000 acres worldwide (Shoji 1977). The first U.S. trickle irrigation system in an operational seed orchard was established by the Texas Forest Service in 1975. Trickle irrigation systems are now in operation in approximately 200 seed orchard acres in the southeast, which includes three International Paper Company seed orchards. More acreage will be irrigated with these kinds of systems in the near future.

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DESCRIPTION OF TRICKLE IRRIGATION

Trickle irrigation can be defined as the supply to plants of filtered water through a low pressure piping system in an exact predetermined pattern that eliminates water spraying or running down furrows and that delivers only a few gallons of water/hour/"emitter." In the soil under each emitter is a "turnip" of moisture (Figure 1) that can be utilized by the tree. The size and shape of the "turnip" is determined by the soil characteristics and the rate and duration of water application. The application of water is on a daily or alternate day basis with trickle irrigation. This frequent irrigation keeps soil moisture tension at low levels when compared to the less frequent water application typical in other systems (Figure 2).

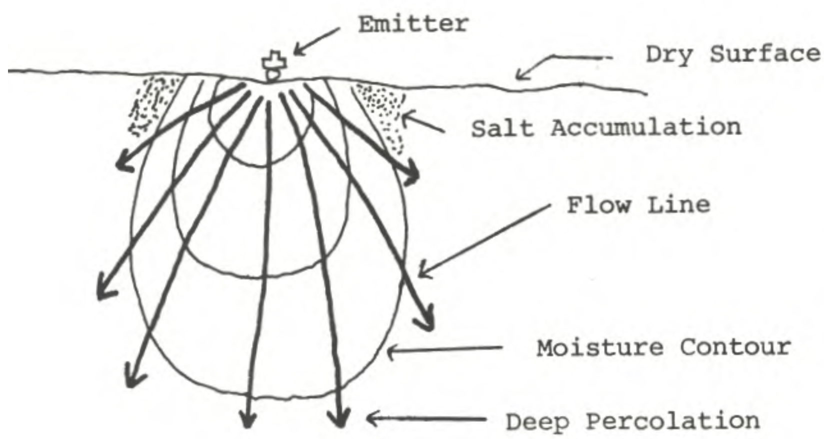

Figure 1
"Turnip" of Moisture

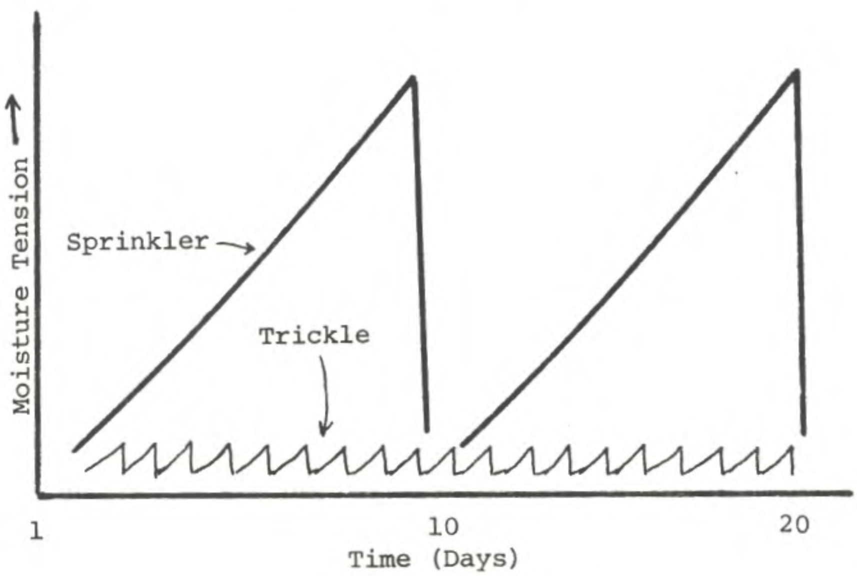

Figure 2
Moisture Tension
Sprinkler vs. Trickle

Trickle irrigation gives only partial ground coverage. For widely spaced tree crops a 20% to 30% coverage is necessary for adequate moisture availability. Table 1 illustrates the coverage that can be obtained with various emitter patterns and soil types (Karmeli and Keller 1975).

Table 1 -- Percentage of Soil Wetted

Spacing between laterals (feet)	Soil Texture: Course	Medium	Fine
5	53	80	100
10	26	40	53
15	18	26	36
20	14	20	27

Emitters are located along a lateral to form a continuous wetted soil mass

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Emitters. The component about which centers the designing of a trickle system is the emitter. This device is attached to the lateral lines and feeds the water to the soil at flows ranging from 0.5 to 4 gph (gallons per hour). A suitable emitter for an irrigation system should (1) have a uniform and constant water discharge rate, (2) have a large flow cross-section to reduce clogging, and (3) be inexpensive and compact. Many and varied emitters are currently manufactured and each has certain characteristics which affect the design of the system. Emitters can be classified into three types - long path, tortuous path and nozzle - based on the construction of the chamber through which the water flows. Additionally, emitters can be self-flushing and can be designed to compensate for pressure variations in the water supply. The water flow through the emitters can be classified as laminar, partially. turbulent, or turbulent. The emitter type, the associated water flow, along with specific construction of the emitter, all affect its overall suitability for a given irrigation application. Careful consideration should be given to emitter selection, particularly to their susceptibility to clogging.

Filtration. Filter requirements are determined by the quality of the water source and the requirements of the particular emitter. Screens of various mesh size are the most common filtration device. Graded gravel and sand filters with back-flushing capabilities can also be used. If large quantities of very fine sand are to be removed, a vortex separator is very efficient. A vortex separator will not remove organic debris and requires another filter (such as a screen), if this is a problem. Settling ponds are an efficient means of removing very large quantities of sand and silt. Filtration of the mineral and organic particles from the water entering the system is of prime importance to the continued serviceability of a trickle system. A trickle system should receive 100% filtered water or no water at all.

Chemical Injection. An irrigation system offers the possibility of applying various chemicals through the system. Many different kinds of equipment are available for these applications. Fertilizers can be applied through a trickle system. Phosphorous is not recommended for application through a trickle system due to problems with its solubility in water, its likelihood of precipitating and clogging emitters, and its immobility in soil. Nitrogen fertilizers generally work well in trickle applications. Anhydrous ammonia and aqua-ammonia generally don't work well due to volatilization of gaseous ammonia and precipitation of soluable calcium and magnesium that may be in the water. Potassium oxide works well in trickle systems. Caution should be used in supplying trace elements through a trickle system due to the low quantities needed, possible reaction with salts in the water and the possibility of excess levels being toxic.

Chlorine (5-10 ppm) can be injected into the trickle system to combat algae growth.

Acid can be injected into the system to remove bicarbonate buildup.

Herbicides can be injected to control weed growth around emitters. Other chemicals may be suitable for irrigation application. Any unfamiliar compound being injected into an irrigation system should first be tested for compatibility with system materials.

Cleaning. Fine sand, silt, and clay tend to settle out in the slow flow at the ends of submains and laterals. Valves or capped ports should be placed at the end of each lateral and along submains to allow the periodic flushing of fine particles from the system.

Hydraulic Design. Careful attention must be paid to producing uniform water pressures in the irrigation system (Kenworthy 1974). An elevation map of the irrigation area should be made prior to installation, although this is not always necessary. Use of pressure regulators, frictional characteristics of pipe, and pressure changes due to elevation, are all important aspects of designing a system that has constant pressure characteristics. Use of pressure compensating emitters simplifies the hydraulic design of a system. Consultation with a knowledgeable trickle irrigation engineer regarding hydraulic design is time and money well spent.

Metering and Monitoring. Keeping account of the amounts of water pumped into various areas is an important control in a trickle system. Due to the discontinuous, visually subtle, nature of trickle irrigation, water applications according to the "look" of an area is very imprecise. Use of moisture-tension measuring devices for the trees and/or soil is a requirement for development of an enlightened irrigation regime.

Level of Automation. Due to the non-visual nature of irrigation through a trickle system, an automatic shut-off should be built into the pump controls. A system that approaches complete automation is possible. The complexity of these systems and their susceptibility to malfunctions argue against a high level of automation. Some level of automation is usually desirable, although a manual system will have fewer breakdowns and the personnel operating the system are likely to quickly discover malfunctions, due to the attention required to operate the system.

PROS AND CONS OF TRICKLE

Advantages. Trickle irrigation has several advantages over conventional irrigation. One is that water use can be reduced by third to half when compared to other systems. Well or reservoir capacity can therefore be considerably decreased. In areas of chronic irrigation water shortage, this can be a considerable advantage. Where water quality is poor, this reduced usage can delay or prevent buildup of undesirable chemicals.

Plant response can be improved by constant low soil moisture tension, elimination of chemical buildup in the soil, and minimizing the beneficial effects of irrigation to competing vegetation.

Logistical improvements are made in orchard operations. The portion of the soil always kept free of irrigation allows unimpeded vehicle operation. A trickle system can be completely underground, thus avoiding any obstructions to orchard traffic. Fertilization is both labor and fertilizer efficient.

Finally, trickle irrigation systems are relatively inexpensive to install, maintain, and operate. Trickle is not adversely affected by the wind, as a sprinkler is.

Disadvantages. When compared with other systems, the major disadvangate of trickle is its sensitivity to clogging the small emitter passageways. Trickle irrigation wets only a portion of the soil volume, and the distribution and coverage of the water must be sufficient to prevent significant moisture stress. In areas where salt buildup can be a problem, trickle systems will buildup a salt accumulation at the fringe of the wet soil mass. A light rain could cause movement of these high salt concentrations into the zone of greatest root activity and damage the trees. This problem can be minimized by operating the system during these rains to leach the salt down through the soil profile. If rainfall is less than ten inches per year, other types of irrigation may be necessary to remove accumulated salts. Due to the thin walls of the tubing commonly used in trickle systems, animal damage can be a problem. Rodents sharpening their teeth or looking for water will cause leaks. Penetration of the emitters through discharge ports by roots can occur.

INTERNATIONAL PAPER COMPANY INSTALLATIONS

Bellamy II. International Paper Company's initial trickle installation is near Marianna, Florida. The size of the installation is 90 acres. A 30 h.p., three-phase electric motor pumps 450 gpm from the Chipola River irrigating 30 acres at a time. Automatic shutoff is provided by a timer. A single manual-flushing 70 mesh screen filters the water, in addition to a large mesh screen on the suction line. Water meter, backflow preventing valves, pressure relief valve and a priming line are included in the pump group. Three different injection points are located on the PVC mainline. The Bermad water-powered injector pump can be used at any of the locations. Eight pressure regulators and gate valves are located between mains and submains. The buried 1/2" PVC lateral can be individually cut off by a gate valve. Flushing of the laterals and submains is possible. Rainbird EM-TB2 emitters are used throughout and provide a 7.5' x 20' spacing. This system has been operational for a year.

Nacogdoches. Another system is approaching completion near Nacogdoches, Texas. This 32-acre orchard is irrigated 16 acres at a time on alternating rows. A double parallel, PVC mainline bisects the sloping orchard and allows for uniform pressures with only a single pressure regulator. A single access point for the Bermad water powered injector is provided. A 7.5 h.p., single-phase electric motor pumps 130 gpm from a settling pond on Black Creek. Automatic shutoff is provided by a timer. Side by side Bermad 150 mesh self-flushing filters, check valves, and water meter complete the pump group. The buried 1"

PE lateral lines can be individually shut off and flushed. Rainbird EM-TB2 emitters are used and form a 7.5' x 30' grid with 2.5 gpm applied through each point. Trees are on a 30' x 30' spacing. A pocket goipher barrier has been placed around the orchard to eliminate damage to the system.

Woodville. A two hectare trickle system has been established near Woodville, Texas. The domestic water well slowly fills a 5000 gallon plastic lined reservoir. A 3 h.p. gasoline motor pumps 40 gpm from the reservoir irrigating the entire two hectares. Automatic shutoff is provided by the motor running empty of fuel. A single back-flow preventing regulator, preceded by a self-flushing 200 mesh filter, controls water pressure entering the PVC submains. A single access point for the water powered injector is provided. The flow of individual laterals is controlled by gate valves. Sixteen different emitter types are installed in this orchard to evaluate their operational reliability. These include the Chapin Micro-dippers; the Dole emitter; Rainbird EM-TB2, EM-TA2, and EM 1010; Spot SRVE, and MRVE; subterrain ST1, ST2, and STF1; Dewline red, and white; Submatic; D.I.I.; and Ein Tal. A flushing capability for the half inch PE laterals and the spacing if 5' x 6' meters. Emitter spacing is variable. The system became operational in 1978.

SUMMARY

Although operational experience is limited, the current trickle systems operate well and no major problems (such as emitter clogging) have developed. Due to the low cost of installation and operation, and favorable initial results, IP plans to install additional trickle irrigation acreage in 1980.

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