IRRIGATING TOBACCO

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Irrigation is an important component for the production of quality tobacco in Georgia. Rainfall is unpredictable and generally unreliable during the critical growth period. Irrigation is typically used to supplement water needs during periods of rainfall deficit. Too often, water is applied in a haphazard manner with little regard to the water needs of the crop. Research has indicated that underwatering as well as overwatering can significantly reduce both tobacco yield and quality. It is important to apply the water at the proper times and in the appropriate amounts.

Tobacco is generally considered a drought tolerant plant and is much better produced with less than desirable moisture than with excessive soil moisture. The root system is very susceptible to water saturated soil conditions and when adversely affected in this manner yield and quality can be seriously reduced. Under conditions of inadequate soil moisture, tobacco can benefit from timely application of water in amounts to bring the soil moisture level up to or close to field capacity. Over-application of irrigation should be avoided because of the wasteful nature of the use of excessive water and the possibility of negatively affecting yield and quality of the cured leaf by causing damage to the root system or leaching needed nutrients below the root zone and out of reach of the roots.

BENEFITS/RISKS OF IRRIGATION

The benefits of irrigation on tobacco, when needed, are well documented and include improvements in both the physical and chemical nature of the cured leaf. Irrigation may cause plant development to be different from plants grown under moisture stress. Physical and chemical properties of cured leaf may also be changed by irrigation resulting in leaf which is lighter in color, thinner and lower in oils and total alkaloids and total nitrogen than tobacco which has been grown with insufficient moisture. Irrigation increases the sugar content of tobacco leaf and decreases the nicotine content when applied in needed amounts.

Yields are generally expected to increase when irrigation is applied during periods of dry weather. In a series of tests in North Carolina irrigation resulted in 15 percent more yield and 10 percent higher price than for non-irrigated tobacco. Increased yield results from development of a more extensive root system which produces larger leaves, leaves spaced slightly farther apart on the stalk, stalks which grow taller and more harvestable leaves per plant.

Irrigation has also been shown to result in less sucker growth per plant and plants which flower earlier than non-irrigated tobacco. Earlier flowering shortens the period for disease and insect infestations and allows for earlier harvesting of the crop in areas where important such as in Canada where early harvesting may avoid frost injury.

Light irrigation at transplanting time will improve liveability and early growth of new transplants by enabling plants to initiate root growth earlier and by reducing the potential fertilizer injury when weather conditions are extremely dry following transplanting.

Irrigation during later stages of growth reduces the amount of scalding of upper leaves and "firing" of the lower leaves which often occur during dry, hot weather. Faster growth and earlier maturity resulting from timely irrigation may reduce the risk of hail damage and build-up of root diseases, such as black shank, nematodes and insects. Yield and quality losses due to tobacco mosaic virus may be reduced by timely irrigations.

Curability of the tobacco leaf may be improved by increasing the moisture content of the green leaves when harvesting takes place during extremely hot, dry weather.
A number of risks are also associated with irrigation. The possibility of getting an extended rainy period immediately after irrigation is always a risk. Excessive irrigation or rainfall can cause tobacco to ripen faster as a result of nutrient leaching and/or root injury. Contamination of fields with disease organisms in irrigation water which may have received runoff from an infested field should be considered a risk of some impounded water sources. Extensive irrigation late in the harvest stage may mobilize remaining soil nitrogen, allowing it to be taken up by the plant, causing regreening of leaves, and resulting in a lowering of leaf quality.

TOBACCO GROWTH STAGES AND WATER NEEDS

The growth of the tobacco plant, as produced for flue-cured tobacco, may be divided into several stages or phases including; transplant production, transplanting until knee-high, rapid growth, and harvest. Tobacco may benefit from irrigation at all stages of growth if soil conditions are dry and rainfall is inadequate to support the growth of the plant. Leaf quality of tobacco can be significantly affected by irrigation at two stages of growth and development; (i) the rapid growth phase and (ii) harvest. Tobacco may be irrigated any time during the day or night. However, more efficient use of the water may be made by application at night rather than during the hot part of the day. Irrigation in the early morning when possible may help prevent the spread of diseases such as rhizoctonia, blue mold and brown spot.

Plant beds require a uniform supply of soil moisture. Germination of tobacco seed is dependent on temperature, light and soil moisture. Although a minimum of moisture is required for germination, adequate soil moisture is required. When plant beds are covered with porous covers, the soil moisture evaporates rapidly and plant beds require multiple light irrigations to insure germination and establishment. When nonporous covers are used at the time of seeding, a single irrigation of 0.25 inch to 0.35 inch after seeding is usually sufficient to meet the needs of the seedlings until temperatures increase to the point that the covers are removed. In moderate climates irrigation with 0.5 inch of water will normally meet the needs of plant beds which have become dry. Withholding irrigation just prior to pulling transplants is used in droughty production areas to harden plants before going to the field and promote root regeneration.

At transplanting a small amount of water (approximately 100 to 200 gal/A) is applied as each plant as it is placed in the soil. This water creates a hospitable environment for new root development and provides good soil contact with existing plant roots.

After transplanting and before severe wilting occurs an application of approximately 0.5 inch of irrigation is recommended to wet the soil slightly deeper than the roots. Irrigation after transplanting is better than before transplanting. Drier soils compact less with the movement of tractors and equipment across the field. Irrigation after transplanting may be the most beneficial water applied during the season. Application of additional water helps settle the soil around the roots of the plants and provides adequate moisture to encourage faster root development. Uniform wetting of the soil following transplanting helps to minimize fertilizer salts injury which is usually worse in soils which start with adequate moisture, but dry after transplanting.

During the early growth stage, from the time of transplant establishment up to the time the tobacco plants are knee-high, approximately four to six weeks after transplanting, water is withheld to create a moderate moisture stress. This moderate stress is considered beneficial to the tobacco plants as deeper root development is encouraged in preparation for the rapid growth phase. Many suggest that this additional root development results in increases in yield and quality of the cured leaf. During the early growth phase irrigation is recommended only during extended drought.

The rapid growth stage occurs from the time the tobacco plants are knee-high to early bloom, approximately from weeks four to six after transplanting. During this time moisture extremely important to the tobacco plant as it is needed to insure good leaf spread and improve yield and quality. Although an
adequate supply of soil moisture is required during the rapid growth phase, water use curves indicate that tobacco should only be irrigated often enough to keep the moisture level sufficiently high to insure rapid growth, not to exceed two inches per week. Excessive irrigation during this critical period may cause damage to the root system. A low tech approach to determine the need for irrigation is to look at the plants for signs of wilting before eleven o’clock a.m. or if the soil appears ashy in color and void of all moisture.

During harvest, irrigation is not generally required. Water loss from the plant is reduced as it approaches maturity compared to the rapid growth phase. The need for water for cell expansion decreases as leaves reach their full size and as the ripening process changes the color from green to yellow in flue-cured tobacco. Leaf cuticle and waxes increase with maturity further reducing the rate of transpiration. The transpiring surface of flue-cured tobacco is continually being reduced by individual harvests. Slight moisture stress may be beneficial by helping to reduce the severity of brown spot and slow down the harvest rate.

In extreme drought conditions irrigation during the harvest stage will increase the maturity rate of tobacco, improve curability of the leaf by allowing better yellowing, and reduce burning of leaf margins which lowers leaf quality and indicates an imbalance of chemical components.

Tobacco may ripen faster after heavy rains or heavy irrigation because (i.) part of the nitrogen is leached from the root zone, (ii) water damage occurs to the root system, or (iii.) because of physiological reactions within the leaf made favorable by higher moisture content.

Drowning is perhaps more likely to damage tobacco than most other crops. Drowning results from damage to roots by water saturation of soils in the root zone. The potential for drowning can be reduced by planting flue-cured tobacco on well-drained soils and on high, wide, row ridges to enhance drainage and raise the root system up above the saturated soils. Younger tobacco (12th leaf stage) is more susceptible to drowning than tobacco at a later growth stage (17th leaf stage). Wilting after conditions of excess soil moisture is a direct result of lack of water being transported to the shoot. Under anaerobic conditions roots are injured primarily by lack of oxygen. Water uptake by dead roots is only 40 percent of healthy roots.

DETERMINING WHEN TO IRRIGATE

Immediately after transplanting tobacco should be irrigated with about one half inch of water. This helps to settle the soil around the roots and provides moisture to stimulate fast root development. After the stand is established and until tobacco is two feet high, irrigate only after an extended dry period. It is generally accepted that slightly dry soil during this period helps to stimulate deeper root development, which benefits the plant during the later rapid growth stage. Moisture levels should be maintained near field capacity during the rapid growth stage (two feet high to early bloom). Leaf expansion and internode elongation are often severely restricted if adequate water is not available during this period. During the harvest period, irrigate tobacco only during extreme drought. The plant requires less water as it approaches maturity; however, adequate water is required for proper maturing and curability.

The need for irrigation can often be determined by simply observing the appearance of the crop and soil. If tobacco shows signs of wilting before eleven o’clock or if the soil appears ashy in color and void of all moisture, irrigation may be beneficial to the crop. Tobacco produced in areas typically dry during the production season can be irrigated based on a balance sheet approach which tracks plant water use and moisture application.
Water-Holding Capacity

The water-holding capacity of soil is extremely important to determining the need for irrigation. Pore spaces between soil particles are either large or small. The free moisture in the small pore spaces is held by capillary forces. Water is removed from large pore spaces by gravity. Coarse textured soils (sand) have larger pores. Fine textured soils (clay or silt) have smaller pores. Soils are saturated when the pores are completely filled. Soils are at field capacity when water ceases to drain from them by gravity. Drainage from saturation to field capacity for most soils used for tobacco usually requires two to three days. Sandy soils require less time for drainage than clay soils.

Tobacco plants can utilize both the water which drains from the soil by gravity and that which is held against gravity by the soil particles. Some moisture is held so tightly by the soil particles that it is unavailable to plants. Wilting point is reached when soil moisture is depleted to only that which is unavailable to the plants. Tobacco utilizes the moisture which is held against the forces of gravity, but is available to the plants.

Tobacco roots pull moisture mainly from the top 8 to 12 inches of soil. A majority of the flue-cured tobacco is grown on loamy sand or sandy loam soils with an available water-holding capacity between 0.7 to 1.5 inches of water in the root zone.

Water Loss and Use.

Water loss occurs from the soil through the process of evaporation. Water loss from the plant results from transpiration, moisture loss as vapor through plant leaves. The combined effect of these two processes is termed evapotranspiration. In Georgia evapotranspiration varies from 0.1 to 0.25 inches per day. Tobacco usually requires an average of one inch per week of water for good growth.

DETERMINING HOW MUCH WATER TO APPLY

For maximum yields, adequate soil moisture should be maintained in the top two feet of soil. Most tobacco producing soils hold about one inch of available water per foot of depth (specific information on soil water holding capacity can be obtained from SCS Soil Surveys.) In a two foot root zone this soil would hold about two inches of available water at field capacity. Highest yields are maintained when available moisture remains above 50 percent of field capacity. Therefore, the allowable depletion before irrigation would be only one inch. The required irrigation amount to replenish the field would be one inch plus losses due to evaporation and non-uniform distribution. The standard practice is to add 25% for losses, therefore the required irrigation amount is 1.25 inches. This amount will be less for sandier soils, more for loamier soils. The peak water use for tobacco is about 0.25 inch per day and occurs at about 8 weeks after transplanting (see Figure 1). During this period the soil in the previous example would require irrigation every four days. Water consumption earlier and later in the season will be considerably less and therefore irrigation will be less frequent.

Often soil moisture sensing devices are used to schedule irrigations. Examples of such devices are tensiometers and resistance blocks. Generally, two of these are installed at different depths, one near the middle of the root zone and one near the bottom. Typically, one will be installed 8 to 10 inches deep and the other 16 to 20 inches deep. The shallow devices are used to determine when to irrigate and the deeper ones are used to insure that adequate water is maintained near the bottom of the root zone (see Figure 2). A minimum of two to three sensing locations should be maintained in each field. When using tensiometers, readings should be maintained between 5 and 30 centibars during the rapid growth stage. Readings below 5 indicate that the soil is too wet and above 30 too dry. During earlier and later growth stages higher readings are acceptable. Tensiometers are an accurate means of measuring soil moisture, but they do have one drawback. If the soil is allowed to dry out to the point where the tensiometer readings go
Some farmers prefer using electric resistance blocks such as gypsum blocks or Watermark™ sensors. These are generally not quite as accurate as tensiometers but they do not require regular servicing. As a general rule you should read and record soil moisture readings at least three times per week and irrigate accordingly.

Excessive water will leach some fertilizer nutrients below the root zone and may result in lower yield and quality of the crop. Repeated light irrigation of dry soils will encourage growth of roots near the soil surface. A shallow root system makes the crop more susceptible to injury from dry and hot weather than expected with a normal root system. During the rapid growth stage it is recommended to withhold irrigation until about 40 percent of the available soil water is left and then irrigate to field capacity. More sandy soils need more frequent and lighter of irrigation and heavier soils need less frequent and heavier irrigation.

Infiltration Rate of Soils

The infiltration rate of most soils used for the production of tobacco in the southeastern United States varies from 3 inches per hour for coarse textured soils to as little as 0.5 inch or less per hour for the sandy clay loams. Infiltration rate is influenced by; compactness of soil, soil structure, organic content, presence of plant material on the surface and quantity of water already in the soil.

When water is applied faster than it can soak into the soil, it runs out the end of the row. This is wasteful of water and energy and reduces the accuracy of the estimate of water entering the soil. Infiltration is reduced as tobacco becomes larger, causing water to be shed toward the middle of the rows. The danger of runoff is greater as the tobacco plant grows.

Irrigation Scheduling

Appearance of the crop and soil can be a good indication of the need for irrigation. Look at the plants for signs of wilting before eleven o’clock or if the soil appears ashy in color.

A water balance sheet may be used to track plant water use and account for added water. Tensiometers will not accurately read low moisture levels in sandy loam soils at which tobacco can survive very well. Moisture blocks which measure electrical resistance appear much more useful for measuring soil moisture in these coarse soils. For best results scheduling should be based on the combined use of production experience, crop observation, a water balance sheet and moisture blocks.

WATER QUALITY

Various water sources may be used to irrigate tobacco. Among these water sources are; surface water supplies such as impounded ponds and streams, ground water supplies such as wells, wells plus holding ponds and municipal water systems.

Disease

In most cases the water available for irrigation would be completely suitable for use on tobacco. However, there are a number of instances when the available water are not suitable for irrigation. A number of diseases may be spread by contaminated irrigation water. Disease organisms such as black shank and Granville wilt may be spread to uninfested fields by contaminated water, especially from streams and ponds receiving drainage from infested fields. Additionally, diseases such as black shank which normally infect plants through plant roots, where resistance resides, may directly infect plants through the leaves and stems following irrigation. Additionally, brown spot sometimes appears worse following irrigation.
However, simply the application of irrigation could provide a suitable environment for infection by brown spot.

Salts in Irrigation Water

Chlorine is the element of primary concern when irrigating tobacco. Particular attention should be given to the Cl content of irrigation water if the water source at any stage of growth should happen to be a municipal water source which has been treated with Cl. No more than $30 \text{ kg} \text{ ha}^{-1}$ should be applied to tobacco from all sources. Most surface water sources in Georgia contain 4-10 mg Cl L$^{-1}$. Thus 2.5 cm of irrigation water would deliver 126 grams of Cl for each mg L$^{-1}$ determined to be in the irrigation water.

Manure lagoon liquid is not considered suitable for irrigation of tobacco due to both the excessive chlorine content, as well as the excessive nitrogen content of the liquid. Nitrogen content of liquid lagoon waste varies widely.

OTHER PRODUCTION PRACTICES IN RELATION TO IRRIGATION

Choose practices which will give the best results under good growing conditions. Variety selection, plant population and topping height should be selected to produce high quality leaf which is desirable to the buyers. Manage irrigation properly and do not irrigate excessively. There is no justification for changing production practices just because irrigation is to be used if only enough water is used to keep the crop in good condition.

Additional N and K may be needed with excessive irrigation or precipitation following irrigation. In studies in Virginia, irrigation depressed yields at lower and higher rates of N. Medium rates of irrigation and N interacted to increase yields. Excessive irrigation or rainfall may cause leaching of soil N below the root zone. Ripening may begin before maturation has been completed.

Some growers apply extra N at the last cultivation as insurance against leaching in wet weather which may occur during the rapid growth phase. When expected precipitation does not occur, more irrigation is required to leach extra N and maintain leaf quality. This is not an environmentally or economically sound practice.

IRRIGATION EQUIPMENT

A variety of irrigation systems are available and are used for overhead irrigation of tobacco and other crops. Gun sprinkler systems may be solid set, portable pipe sections or self propelled traveling systems. Center pivot systems can cover large primarily circular areas with a minimum of physical requirements by the operator. Complete coverage of irregular shaped fields by center pivot systems presents some problems. Self-propelled lateral move sprinkler systems have some distinct advantages in that they are able to cover rectangular shaped fields. Lateral systems require multiple risers along the lateral move path.

A variety of pumps are available which may be run by LP gas, diesel fuel or electric. Pumps may be installed permanently or they may remain portable.

DRIP IRRIGATION

Drip irrigation is another system for delivering irrigation water to tobacco. Drip irrigation is termed so because of the slow application of water delivered to plants under low pressure through emitters spaced uniformly along the length of plastic tubing. Drip irrigation can be an efficient use of water as this system has been reported to reduce water use by 30 to 50 percent.
Components of a drip irrigation system include; a water source, pump, filters, main line, water meter, check valve, low pressure drain, vacuum breaker, pressure reducer, manifold, injection pump for adding fertilizer, sub mains and drip tube with emitters.

Drip irrigation may be used with or without plastic mulch to cover the row bed into which the tobacco is planted. With plastic mulch, no cultivation is necessary and no application of chemicals or fertilizer is possible except through the irrigation water and the drip system. Without plastic mulch, conventional cultivation and fertilization is still possible. The minimal pump operating pressure for the system is a distinct advantage. Water is delivered through the drip tubing at 10 to 15 psi. A water supply which is clean with regard to micro flora growth and chemical contaminants is required. Contaminated water sources can clog filters and emitters.

Benefits of utilizing the drip system for irrigating tobacco include; efficient use of water, the possibility of injecting fertilizer through the system either to supplement or replace the normal dry fertilizer program, possible increases in the quality of the lowest plant leaves without splashing sand on these leaves, and a reduced potential for soil erosion from surface water runoff on rolling terrain.

Problems presented by drip irrigation include; expense of installing the needed wells and system components, a tendency to over irrigate causing leaching of fertilizer nutrients, a requirement for increased management ability and an understanding of the pumping and delivery system, and disposal of plastic mulch and drip tubing.

In the U.S. application of soil fumigant and plastic mulch with drip tube increases the cost of production by as much as $600.00 per acre. Permanent installation of needed wells, pumps, filters and supply lines can add as much as $1500.00 per acre to the expense of installing a drip system.
Fig. 1 Moisture Use by Tobacco (Harrison and Whitty, 1971)

Fig. 2. Proper Use of Tensiometers