Irrigating Saskatoon Orchards

Richard G. St-Pierre, Ph.D. (December 2005)

An Introduction To Orchard Water Management

The primary goal of orchard water management is to provide adequate supplies of water to fruit plants with a reasonable investment of time, money and other resources, without creating salinity or waterlogging problems, and without jeopardizing the quality or quantity of the water source. The efficient use of water means using the smallest amount of water to produce the largest harvest in ways that do not cause these problems. Orchard water management includes irrigation, weed control, and drought-avoidance strategies.

Irrigation generally is required for commercial fruit production in Saskatchewan. The Province receives an average of 25-35 cm of water annually, about half of which is considered available to the crop. The water requirements of fruit crops usually are in excess of the water available from precipitation. Soil water reserves are also important to consider. Soil water reserves are based on precipitation received the previous fall, amount of snowfall, amount of snow trapped, and temperatures in late-winter and early-spring during snow melt.

Plant growth, yield and fruit quality are sensitive to water stress. Irrigation is used to increase the total amount of available water, or to adjust the distribution of water to better fit crop requirements. Properly irrigated orchards are less susceptible to cold damage (moist soil stores more heat during the day for release at night). However, weed growth may be stimulated in dry periods by irrigation.

The successful establishment of fruit crops will very largely depend on the supply of water to the young plants during their first two dry seasons. Adequate moisture is essential during the critical stages of leaf expansion, bloom, fruit set and fruit enlargement. When available soil water is reduced, young plants with limited root systems show reduced growth more quickly than do older plants having deeper more extensive root systems. A large, bearing surface and greater yields are the cumulative result of the previous 2 to 5 years of shoot growth and leaf production. Frequent irrigation and shallow or no cultivation encourage roots to grow near the soil surface which is usually more mineral rich. There is a consequent increase in fruit size but too frequent irrigation can decrease flavour and longterm keeping quality.

Most native fruit species, like the saskatoon, will survive under normal moisture conditions without supplemental irrigation, provided that weeds are not allowed to grow. However, irrigation will improve plantation establishment and rapid

growth, appears essential for production at an earlier age, and may be required to maximize fruit yield, depending on natural rainfall. The critical periods for shoot growth, fruit growth and bud development for the following year occur from about mid-May through late-July.

Problems With Over-Irrigation Or Excessive Soil Moisture

Excess water can result in root damage from poor soil aeration and may prevent the uptake of mineral nutrients and water; young plants are especially susceptible to root rot. Proper irrigation is essential for nutrient utilization; excessive irrigation will leach nutrients below root systems and may contribute to pollution of ground water sources. Over-irrigating may increase the incidence of disease, and also may delay the development of winter hardiness, thus increasing the probability of winter damage. Excessive water may reduce yield and contributes to insipid fruit flavour and fruit cracking. Over-irrigation may also leach herbicides below the zone of germinating weed seeds. Ultimately, over-irrigation wastes a grower’s time and money.

Strategies To Conserve Water & Minimize Moisture Stress

The four primary ways by which water is lost from an orchard, and which may contribute to moisture stress, include runoff, deep percolation below the root zone, evaporation, and excess transpiration. Reducing unnecessary losses will help conserve water and reduce the potential for moisture stress, and make more efficient use of available water.

Strategies to prevent water loss include: a) minimizing runoff; b) maximizing the infiltration of rain or irrigation water into the soil by improving soil structure; c) minimizing the loss of water below the root zone by not overwatering; d) increasing the soils's water-holding ability with organic matter; e) minimizing evaporation and excess transpiration by mulching, close spacing of plants, shading, and windbreaks; f) planting native drought-resistant grasses to maximize water absorption and minimize runoff (these also act as passive, dormant mulches during periods of heat and drought); g) pruning consistently and properly (unchecked, excessive growth uses available soil moisture; h) minimizing loss of irrigation water from storage in reservoirs, tanks or other containers by covering or shading the surface to reduce evaporation; i) minimizing the loss of water during distribution by reducing the number of leaks or low spots, and the amount of time the water is exposed to evaporation and to infiltration before reaching the orchard; and j) improving and maintaining water quality by minimizing salts, toxic substances and organisms that cause plant and human diseases.

Planning An Irrigation System For A Saskatoon Orchard - First Steps

Planning an irrigation system is one of the most important steps in establishing a successful saskatoon orchard. Inadequate water supply, or poor water quality, could mean that a grower’s plans for an orchard

are not feasible or in excess of the available water supply. The following information is intended to help growers determine the feasibility of an irrigation project.

An Overview Of Irrigation Requirements And Strategies

It is important to accurately determine the water requirements of the mature orchard prior to planting in order to ensure that the irrigation system can provide enough water during critical periods when rainfall is inadequate. Water consumption in a mature saskatoon orchard is approximately 1acre-foot per season (equivalent to 12 inches of rainfall, or 275,000 gallons of water). The range of water consumption for a mature saskatoon orchard is estimated to vary from less than 225,000 to over 400,000 gallons/ acre/season, depending on amount of rainfall, daily temperatures, soil type, and length of growing season. Growers frequently underestimate the water requirements of their orchard, or assume rainfall will provide all that is required. As a result, reduced transplant survival, slow orchard establishment, and reduced growth and yields often occur. Years with lower than average precipitation could leave growers who don't realistically anticipate their irrigation needs caught without water during critical times such as during fruit development or during the period of flower bud initiation, which is essential to the next season's fruit crop. Water stress during other parts of the season can also lead to diseases such as *Cytospora* canker. Many growers feel that 3 to 5 heavy irrigations per season are adequate for a healthy crop. This strategy would only be effective if consistent and sufficient rainfall occured between irrigations. Trickle irrigation systems in particular are designed to provide a small volume of water on a frequent schedule in order to meet the water requirements of the crop. As a rule, in order to achieve the most favourable conditions for plant growth and yield in a fruit crop, plants should not be subjected to prolonged or severe water stress. However, under certain circumstances it may be beneficial to provide some water stress during specific periods to improve fruit flavour, increase sugar content, or to reduce plant growth.

Steps Required To Develop An Irrigation System

The first step in undertaking an irrigation project is to contact Sask Water. Any irrigation project larger than 2.5 acres requires at least some involvement with Sask Water. During the initial consultation, the grower will be provided with some general information on the irrigation development process, irrigation system options, and available water source(s). Assuming that the project is large enough to require further Sask Water involvement, a Request for Technical Assistance application form will be sent to the grower. For an irrigation project to be feasible, the recharge rate of the water source must exceed the water demands of the crop. With overhead sprinkler irrigation, additional water may be needed to flush the site every second season in order to prevent salt build-up in the soil.

The PFRA should also be contacted

when planning a dugout. Financial assistance may be available to help with construction costs, and the local PFRA office should be able to assist with grant applications. The PFRA will consult with Sask Water on projects that involve dugout construction for irrigation purposes. Considering the water use of saskatoons, it is unlikely that an average-sized dugout could be relied upon to irrigate more than 3 acres of mature bushes. Unless the water recharge rate of the dugout is roughly equivalent to the water used, then a dugout cannot be sustained over the long term.

To qualify for technical assistance from Sask Water, there must be a minimum of 12 acre inches of available water from the potential water source 7 out of every 10 years, and the irrigated area must be at least 2.5 acres. The initial cost for technical assistance is approximately $275.00, which includes the application fee, a water quality test, a preliminary water supply study, a soil assessment, and a site inspection by a representative from Sask Water. During the site inspection, the results of the water supply study and the soil assessment will be discussed with the client. A water sample to be analyzed for quality will be collected during the initial site visit. The quality of the water sample will help determine the suitability of the water source for irrigation purposes. Irrigation system options, including system components and pumping requirements, an overview of irrigation system design, and a preliminary cost estimate, also will be provided during the on-site consultation. Detailed irrigation design plans are included with this initial cost, and will be provided if the client decides to proceed with the project.

Orchards larger than 10 acres in size require an Irrigation Certificate from Sask Water. To obtain an Irrigation Certificate, extensive soil salinity testing is conducted across the site at two soil depths with specialized equipment. As well, numerous soil samples are collected and analyzed for soil texture, electrical conductivity, sodium adsorption ratio, pH, and the concentration of major ions. The data are collated, and detailed elevation and salinity maps are created. These maps are used to classify the site in terms of suitability for irrigation and are used to determine whether an Irrigation Certificate will be granted. The cost of this testing is approximately $1,400.00.

Once all the requirements for the project are met, then a permit for Approval to Construct Works will be provided by the Water Resource Office and construction of the project can begin. Subsequently, to obtain an Approval to Operate permit, the system should meet the minimum engineering design specifications outlined in the preliminary plan.

More information on the irrigation development process can be obtained from Sask Water, Irrigation & Agricultural Serivices Division, 410 Saskatchewan Avenue West, Box 1000, Outlook, SK, S0L 2N0; Phone (306) 867-5500; Fax (306) 867-9868.

Water Salinity Guidelines For Saskatoon Orchards

A knowledge of water quality is important to proper water management. Water quality tests should include measures

of electrical conductivity (EC), pH, iron, sulfides, and total dissolved solids (TDS). Surface water should be rated in terms of colour and particulate matter in suspension. Water quality is associated with organic and inorganic materials suspended or dissolved in the water, and the presence of algae and/or bacteria.

Two-thirds of the groundwater in Saskatchewan has sodium or salinity levels greater than recommended for use. Adequate testing of water quality is essential prior to any commitment to irrigation.

Measuring Water Salinity

The symptoms of excessive salinity may first be noticed on young plants where growth and survival may be substantially reduced. Symptoms on older plants include drying or `burning' of leaves beginning at the leaf tips and moving along edges. The leaves also may abscise prematurely. Salt injury may be reduced by irrigating more frequently, and by irrigating when conditions are least conducive to evaporation (in the early morning, for example).

The amount of salt leaving the root zone through drainage should equal the amount brought in through irrigation and rainfall. To prevent salt buildup, it is important that there be enough extra water applied at regular intervals to wash out the salt, and adequate drainage to carry water away from the root zone. With an increase in soil salinity, plant roots extract water less easily from the soil solution. This situation is more critical under hot and dry conditions. A high soil salinity can also result in toxic concentrations of ions because they can accumulate in leaves. This is especially true of chloride ions.

Levels of salinity are usually expressed in terms of the ability of water to conduct electricity (electrical conductivity; EC). The better water conducts electricity, the saltier it is, and the more that crop production will be reduced. Conductivity is measured by special instruments in units of millimhos/centimeter (mmhos/cm), or deciSiemens/meter (dS/m); 1 dS/m = 1 mmhos/cm (equivalent to 640 ppm salt).

Salt content can also be expressed in terms of milligrams of dissolved solids per liter of water (simply measured by completely evaporating a liter of water in a container protected from dust); the result is a measure of total dissolved solids (TDS) in milligrams per liter of water, and expressed as parts per million (ppm). A TDS of 0 - 500 ppm is acceptable for all crops. Water with a TDS of greater than 500 ppm may present a clogging hazard, especially if drip irrigation is used. Water with a TDS of 800-1000 ppm can cause salt burn symptoms if overhead sprinkler irrigation is applied infrequently for long periods. Water sources with a TDS of greater than 800 ppm should be considered unsuitable for irrigation.

Irrigation Requirements Of Saskatoons

When irrigating a saskatoon orchard, a grower may ask a number of questions. Why irrigate at all? How frequently should irrigation be applied? How much water is

ideal? The goal of using irrigation should be to achieve a balance among total yield, fruit quality, and year-to-year reliability of the crop. Irrigating properly will help maximize an orchard's profit over the long term.

Factors Affecting Water Use

The water requirements of saskatoons vary with plant age, row spacing, soil type, soil texture, and climatic conditions such as temperature, daylength, relative humidity, and wind. The type of irrigation system used also will have an impact on how water is applied to an orchard. The scheduling of irrigation in an orchard irrigated by overhead sprinklers is different than with a trickle irrigation system. These differences are inherent in the system's design since the water application rate for each system is quite different. Trickle irrigation systems are designed to frequently provide small volumes of water to a limited amount of soil. Sprinkler systems deposit water to the entire area occupied by the crop on a more intermittent schedule, where the soil is allowed to dry out more between each irrigation cycle.

Soil texture has an impact on water-holding capacity and availability of water. Water drains quickly from sandy (course) textured soils, which is good for aeration, but the water-holding capacity is low and water stress can occur rapidly. Course soils require more frequent irrigation scheduling than other soil textures. Heavy clay (fine) textured soils have a high water-holding capacity but also have greater amounts of hygroscopic water. These characteristics make it difficult to maintain a balance between waterlogging and too dry a soil. Clay soils should never be allowed to dry out since large cracks can form in the soil structure and these can damage crop plant root systems. Loam (medium) textured soils drain reasonably quickly, have a high water-holding capacity, and a large amount of available water, making it relatively easy to manage the soil water balance.

Rooting depth is also a major factor in determining the need for irrigation. A restricted rooting depth increases the need for irrigation.

The wet zone created underneath a trickle emitter is relatively small when compared to the entire soil surface that is wetted by sprinkler irrigation systems. For trickle-irrigated crops, it is more effective to have the majority of the root system in the volume of soil wetted by the trickle emitters. Plants grown on well-drained, sandy soils may have feeder roots extending 2 m or more into the soil. However, these roots won't help the plant when the soil becomes very dry, if most of the root system is outside of the soil volume wetted by the trickle emitters.

Orchards consume and lose water daily. This consumption and loss consists of water used by the fruit plants (transpiration), and water evaporated from the soil surface (evaporation). During hot, dry summer days in Saskatchewan, peak evapotransporation rates vary between 5.6 and 7.1 mm (0.22 - 0.28 inches) per day.

To keep pace with this loss, a trickle irrigation system should be designed to provide approximately 40 - 70 litres per

minute per hectare (5 - 7 US gallons per minute per acre), otherwise there will not be enough hours in the day to keep up with water use during periods of peak demand.

Growers often comment that they start their trickle irrigation when the fruit crop starts to develop but the system can't seem to keep up with water demands. This is because the system was not designed to apply water on an intermittent schedule. Typical trickle irrigation scheduling requires that irrigation be applied to maintain soil moisture around 75% of field capacity. If the soil is allowed to dry out much beyond this point, and crop water use increases, then it may be impossible for a trickle system to meet the water demands of the orchard.

One study looking at water use in saskatoon orchards found that saskatoon plants growing in an orchard environment use significant amounts of water from the row alleys outside the wet zone of the trickle irrigation system. The same study also showed that under certain conditions it may be difficult for the irrigation system to keep up with the water demands of the plants. Once soil reserves are low and summer heat intensifies, it's often impossible to replace the water needed to maintain a good moisture reserve. For this reason it was recommended that irrigation begin before inter-row areas dry out. These observation and conclusions are not surprising considering the design parameters of trickle irrigation systems.

In order to achieve optimal conditions for growth and yield in a fruit crop, plants should not be subjected to prolonged or severe water stress. It may be beneficial to create a slight water stress during specific periods to increase fruit sugar content, thereby improving fruit flavour, or to reduce plant growth.

Young plants are particularly vulnerable due to their small and shallow root systems. Water stress can severely affect root growth and survival in young plants. Attempting very long irrigation periods with a trickle irrigation system on an intermittent schedule will increase the risk of waterlogged soil conditions and could cause significant root damage.

Rainfall, high relative humidity, low air temperature, and light winds all reduce the amount of irrigation required. Although trickle irrigation systems are intended to operate more frequently than other types of irrigation, it is possible to provide too much water to the crop, especially in fine textured soils. Excessive moisture, especially early in the season, may cause waterlogged conditions and limit soil aeration, thus preventing normal root growth.
Water-logged soil, especially early in the season, can kill fruit plants. Excessive moisture will encourage root-rot organisms, and excessive moisture in any soil, but particularly in sandy soils, will leach out nutrients.

Irrigation Guidelines For Saskatoon Orchards

Research has shown that a mature saskatoon orchard will use approximately 250 - 350 mm (10 - 14 inches) of water per season, depending on environmental conditions.

Newly-established saskatoon bushes require only small volumes of water, but should never be allowed to dry out. During the first year, plants generally require about 1 - 2 litres (0.25 - 0.50 US gallons) of water per plant per day during warm dry weather. Water use in the orchard will increase yearly in proportion to plant size. In the absence of rainfall, 16 - 24 litres (4 - 6 US gallons) of water per plant per day will be required in a mature orchard. Trickle irrigation systems are designed to provide small volumes of water on a frequent schedule, typically every 1 to 3 days in the absence of adequate rainfall. These amounts may be met by rainfall but it is important to monitor soil moisture so that plants are not stressed.

Electronic soil moisture senors and tensiometers provide the most accurate guide to water requirements in a trickle-irrigated orchard. It is best to maintain soil moisture levels between 20 and 30 centibars in medium- textured soils, and between 40 and 50 centibars in fine-textured soils. Soil moisture levels in sandy (course) textured soil should be maintained in the 15 - 20 centibar range. In course soils, tensiometers capable of measuring low water tension must be used. Electronic soil moisture sensors such as Watermark™ sensors are not accurate in the soil moisture range needed for course soils.

The use of soil moisture sensors or tensionmeters will allow growers to adjust more easily to differing soil types and amounts of rainfall.

Growers may reduce irrigation during August and September to slow plant growth and to allow proper hardening-off. To accomplish this, it is not necessary to induce significant water stress. When temperatures cool off in September, water use will decline dramatically. However, it is still important to continue irrigating as needed until and following leaf-fall to prevent dehydration over the winter, and perhaps to increase resistance to *Cytospora* canker.
