Department of Primary Industries
primefact

Irrigation management of blueberries in Northern NSW

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NSW DPI Agriculture Water Unit

Introduction

The aim of this Primefact is to provide blueberry growers with practical information to ensure that irrigation management is not limiting production, while at the same time attempts to avoid any off-farm environmental impact. It is based on NSW DPI Primefact 827 Irrigation and moisture monitoring in blueberries (2009).

Fundamentals of irrigation

Water stress at critical times when developing a blueberry crop can dramatically affect fruit yield and quality. It is important to avoid water stress, as blueberry plants do not readily show visual signs of water stress. Careful irrigation management is a key factor in achieving good yields and plant performance.

Understanding the basic principles of plant water use

To ensure correct irrigation management in orchards, some basic background information is important. This includes knowledge of plant water requirements, water balances, and soil types, as well as knowing how to recognise any problems associated with under-watering or over-watering.

Water balance

The water balance in plants results from a combination of factors, including weather conditions, the daily rate of crop water use, and the amount of water available for plant uptake.

Know your soil

Soil is the fundamental resource on which your crop production depends. It contains nutrients and stores water, which will be available to plants between rainfall and irrigation events. Soil characteristics, and in particular soil texture, determine the amount of water a soil will store. Knowing your soil and understanding rootzone depth will help you to determine how much water can be held in the rootzone. In general, sandy soils are free draining and tend to hold less moisture than loams or clays. For more information on soil texture see Primefact 1363 Determining soil texture using the ribboning technique.

How much water to apply

The amount of water to apply is defined by the amount of readily available water (RAW) held in the crops rootzone. To determine RAW see Primefact 1362 Determining readily available water to assist with irrigation management.

Given that blueberries are shallow rooted, and the rootzone is likely to be concentrated in a mound (this should be confirmed by soil pit inspection), the RAW is expected to be quite low, usually in the order of 5–8 mm.

A typical drip application rate for a single dripper-line system is 1.8 mm/h (1.6 L drippers at 30 cm spacings, with 3 m rows) and 3.5 mm/h for a double dripper line system (same assumptions with two lines installed).

This means that maximum applications are also quite small compared with other conventionally irrigated horticultural crops. Applications of less than 1 hour per irrigation are common. There is a general trend away from larger drip applications of 2–4 hours in blueberry production in northern NSW.

Avoiding water stress

Blueberries can be a difficult plant to water correctly as they are sensitive to both under and over watering.

Under-watering

Factors that can create conditions where blueberry plants receive too little water are:

- Shallow root systems. Blueberry plants have a relatively shallow root system, with most roots in the top 20–30 cm of the soil surface. This means that relatively frequent irrigations are necessary.
- Mounding. Growing blueberries on mounds makes them susceptible to water stress as the mounds are free draining.
- Little effective rainfall. Plastic covered mounds, especially when newly installed, allow little rainfall penetration.
- Using mulches. Woodchip mulches are difficult to re-wet if allowed to dry out.
- Delivery failure, e.g. blockages in drippers due to inadequate filtration, or poor dripline maintenance and monitoring. See Primefact 1358 Maintaining a drip irrigation system for perennial horticulture
- A trend towards tunnel production, which increases air temperatures and therefore irrigation demand.

These factors make blueberries highly susceptible to water stress, which can result in reduced yields and quality.

Over-watering

Poor understanding of plant water requirements can contribute to over watering. Factors that create conditions where blueberries receive too much water include:

- Shallow root systems. Blueberry plants have a relatively shallow root system, with most roots in the top 20–30 cm of the soil surface. This means that relatively short irrigations are necessary.
- Poorly designed drip irrigation systems can result in water being delivered at a rate greater than the soil's infiltration rate.
- Poor soil moisture monitoring (or no monitoring). Poor monitoring to assess when and how much water to apply can lead to over- and under-watering.

These factors reduce soil aeration, increase the incidence of root diseases such as Phytophthora, and can even result in root death from drowning, all of which will reduce fruit yield and quality.

Importantly, over-watering also leaches fertiliser out of the root zone. This not only wastes fertiliser (adding unnecessarily to production costs), but can also pose a serious environmental hazard, potentially polluting groundwater, rivers, streams and marine environments.

Another factor that can contribute to both under- and over-watering is a poor irrigation system that creates uneven water application. For effective, efficient irrigation management, even water application is necessary.

Establishing a good irrigation system

The following features need to be considered when establishing irrigation.

Design and layout

Drip systems can be highly efficient at delivering water – consulting an irrigation professional (preferably a certified irrigation designer early in the design phase) will save time and money in the long term. The hydraulic design of a drip system is fairly complex. In order to achieve the desired uniform water application (dripper discharge variation less than ± 5%) a professional design is necessary. Pressure compensating (PC) driplines are required when slopes are greater than 10%.

Correct design is particularly important on steep slopes so that plants at the bottom of a row are not waterlogged while the plants at the top remain dry. This has been a major problem with drip irrigation on steep slopes around northern NSW, with slopes in many cases exceeding the design capability of dripper systems. Non drain dripline and valve products (such as Netafim DNL) are highly recommended. Professional advice is needed if considering this technology. Maximum run lengths also need attention from a drip performance point of view as well as erosion and runoff control. See Soil and water management practices for blueberry growers in Northern NSW.

Fertigation

Blueberry plants are usually fertilised via the irrigation system with liquid nutrients in a process known as fertigation. Fertigation is compulsory in northern NSW as weed matting does not allow for broadcast application of fertiliser, and high rainfall creates a significant likelihood of leaching large single fertiliser applications. Therefore, small, frequent fertiliser applications through the drip system are recommended.

Single or multiple irrigation lines?

Some growers use a single irrigation line while others use two. Generally, the industry is moving to two driplines (Figure 1) in order to achieve an even growth on both sides of the row, allow shorter irrigation run times (as higher application rates exist), and overcome any minor emitter blockage issues.

If converting from one dripline to two, consult your irrigation designer to determine if your system capacity can handle the extra line.

Dripper spacing will be determined by the plant spacing. Many in-line drippers are spaced at 40 cm, 50 cm or 60 cm. If two irrigation lines are used, try to stagger the emitters so that the zone between the plants is kept evenly moist.

Figure 1: Double irrigation line on woodchip

Growers on steep land should aim to incorporate irrigation supply lines within cross-bank drains as secondary mains. This will divide whole irrigation blocks into smaller units and allow for more uniform water application. Many growers are using pressure reduction devices that fit within the drip line (such as Netafim's DNL). In the design phase, it is far easier and economical to incorporate a secondary main in cross banks to give more even water distribution than putting pressure compensator valves within each of the drip lines.

Applying effective irrigation (phenology)

In northern NSW, the lowest rainfall and the greatest evaporation usually occur from August to December. Therefore, peak water demand for blueberries usually occurs in this period. September to October is generally recognised as the driest period and unfortunately this is often the only time effective irrigation is considered. However, floral initiation for the following season's crop occurs in February and March and inadequate irrigation at this critical time will result in wilting and dieback of tender shoots, and will lead to poor fruit set. Poorly managed irrigation should be viewed as a production limiting practice throughout the whole of the season, not only during periods of water shortage.

Determining when to irrigate

Another essential requirement for efficient irrigation is to irrigate at the right time. Blueberries, as a general rule, require 25–40 mm per week during their growing season. The demand for water is greatest from the time of fruit expansion until harvest. During the final stages of fruit filling, uniform soil moisture levels must also be maintained to stop surges in moisture levels that cause fruit splitting. Monitoring ensures that enough water is applied at critical times. Monitoring water use and water needs in blueberries can be achieved using a combination of soil-based and weather-based monitoring systems.

Soil moisture monitoring tools

The most common types of soil-based monitoring equipment used are tensiometers, gypsum blocks, neutron probes and capacitance probes (such as EnviroSCAN®). The relative advantages and disadvantages of these in relation to blueberry production in northern NSW are shown in Table 1.

Table 1: Comparison of main soil moisture monitoring systems

System	Advantages	Disadvantages
Tensiometers	Relatively inexpensive Easy to install Can be read by growers	Labour intensive to collect data Require regular maintenance Inaccurate at high tensions Can be inaccurate in sandy soils
Gypsum block	Relatively inexpensive Easy to install Can be read by growers	Inaccurate at low tensions Have limited life as gypsum dissolves
Neutron probe	Portable Very accurate	Costly unless consultant engaged Data limited to frequency of consultants visits
Capacitance probe	Continuously logged Very sensitive and responsive to soil moisture	Costly Can require skill and training in interpretation Removal and re-installation can be considered difficult if re-developing mounds every few years

Tensiometers

Tensiometers measure soil tension, which reflects the force at which a plant needs to extract water from the soil. Most models have a vacuum gauge and water reservoir at the top and a porous ceramic tip at the bottom. Tensiometers are filled with water and installed in the ground, with the ceramic tip located within crop rootzones. As the soil dries out, water is drawn out through the ceramic tip, creating a vacuum in the tube which can be read on the gauge. When irrigation or rainfall occurs, water is drawn back into the tube through the ceramic tip, decreasing the vacuum.

A high vacuum reading on the gauge indicates that the soil is dry, and a low reading shows that the soil is moist. Tensiometers are useful in estimating when irrigation is necessary.

For information on tensiometers see Primefact 1359 Tensiometer tips.

Gypsum blocks

Gypsum blocks also measure soil water tension, which is determined by electrodes embedded in a gypsum block installed in the rootzone. They are placed in the soil at depths and positions similar to those recommended for tensiometers. Connecting cables run from the electrodes to the soil surface. The gypsum is porous and takes on the soil–water characteristics of the soil. To obtain readings, a portable handheld meter or logger is connected to the blocks. The meter reads the level of resistance of a small electric current passed through the electrodes – the more water in the soil and block, the lower the resistance to a current. The meter then converts this reading to tension.

Gypsum blocks are measured either directly with a portable meter or remotely by a sophisticated irrigation controller linked to a computer. New display methods have recently made gypsum blocks popular with horticultural crops (such as the G-dot in Figure 2).

Figure 2 – G-dot meter

Neutron probe

In Australia researchers or irrigation consultants who provide soil moisture monitoring services at a fee for service generally use the neutron probe.

Aluminium access tubes are installed in representative soil and crop type combinations across the property. Often more than one tube is located at a monitoring site. Soil moisture is estimated by lowering the neutron source to the required depth within the access tubes. The radiation source releases fast neutrons, which are slowed by colliding with hydrogen atoms in the soil. The main source of hydrogen atoms in soil is water. The count of slow neutrons detected by the probe is calibrated with soil water content. Soil water content can then be converted into millimetres of water to help managers make informed decisions on when and how much to irrigate. Some neutron probes are programmable, which means that soil water content and plant available water can be displayed directly on the screen. Otherwise, soil water data can be interpreted using a hand-held calculator, entered into spreadsheets or downloaded via USB or cable connection into a commercial software package for interpretation and irrigation scheduling advice.

Figure 3 EnviroSCAN showing electronic sensors at various depths

Capacitance probe (EnviroSCAN®)

These systems use capacitance sensors located within access tubes (generally PVC or ABS) installed at representative sites and depths for the duration of the irrigation season. Sensors use electrical capacitance to measure soil moisture, with a high frequency electrical field around each sensor passing through the access tube into the soil. Sensors are commonly spaced at depth intervals of 100 mm within the access tube, and are generally adjusted to suit the rooting depth of the crop (Figure 3).

For more information on capacitance probes see Primefact 1365 Using capacitance probes for irrigation scheduling.

Suitability of soil moisture monitoring tools to blueberry production in northern NSW

As blueberries in northern NSW are generally drip irrigated at very frequent intervals (often 1–4 times per day in summer), continuously logged sensors, which are quick to respond to changes in soil moisture, are the most suitable method of soil moisture monitoring. This generally limits the selection to continuously logged capacitance probes such as EnviroSCAN. If readings are readily available digitally or through ‘cloud’ technology, the ability to use this information becomes even more powerful.

Soil moisture monitoring tools that are read manually (such as the tensiometer and gypsum block) can only provide a general indication of soil moisture as these tools provide data only when readings are taken. During busy periods, it is well recognised that manually-read tools are read less often, and therefore the ability to monitor soil moisture levels accurately and effectively is reduced. Limited information is obtained if these types of tools (including a neutron probe) are read twice per week (which is acceptable for conventionally irrigated horticultural crops), but seven or more irrigation events occur over the same period. No water use trend or pattern can be obtained in this situation.

Some tensiometers and gypsum blocks can be continuously logged, which can overcome this problem. The issue to consider then, is are these sensors sufficiently responsive to provide an indication of wetting and drying data when irrigation events occur daily, or multiple times per day. For some soil moisture monitoring tools, this might not be the case and the best system for individual situations needs to be decided.

Weather-based monitoring methods

Weather-based monitoring models that use evapotranspiration are a useful tool for blueberry growers to increase awareness of when crop demands are high. However, this type of monitoring is not as useful as an accurate soil moisture monitoring tool, particularly as managers become more precise with their irrigation management.

Weather-based methods of scheduling irrigation rely on growers obtaining readings of evapotranspiration (Eto) from a weather station, adjusting these readings with a crop coefficient (Kc) specific for a crop type and growth stage, and then estimating the amount of water that remains available in the root zone (RAW) of the crop.

Crop coefficients for blueberry plants have not yet been determined under Australian conditions but values in Table 2 are a close approximations based on USA data (Haman et al. 1997).

Designing an irrigation schedule

There are two steps in climate based scheduling.

Step 1. Determine the amount of water held in the root zone (RAW) of a blueberry plant to calculate how much to irrigate.

The RAW stored within the effective root zone can be calculated by determining each soil texture type and measuring the thickness of each layer, and then multiplying the thickness by the appropriate RAW value. In most cases, there will be only one soil type in a mound, but it is worth checking to make sure. See Primefact 1362 Determining readily available water to assist with irrigation management.

Let's assume a RAW of 8 mm. This means that 8 mm of water is readily available in the soil for the plant's use. Once this 8 mm of water has been used, then irrigation is required to refill the plant's effective root zone. Climate-based scheduling is then used to estimate when this 8 mm is used by the crop.

Step 2. Use crop coefficients to adjust daily evapotranspiration to estimate daily water use.

Crop coefficient (Kc)

A crop coefficient is a value that represents the ratio of plant water usage at a particular stage of growth, compared with evapotranspiration. When multiplied by daily evapotranspiration figures, an estimate of daily water use is obtained (mm/day).

Evapotranspiration (Eto)

To estimate how much water is lost from the crop evapotranspiration, data from a weather station can be used. Evapotranspiration data represent daily water use of a healthy, uniform, actively growing crop completely covering the ground (e.g. grass, lucerne). These figures can be obtained from the Bureau of Meteorology website for various locations around Australia.

Like most horticultural crops, blueberry canopies do not completely cover the ground. The Eto must be adjusted to the area represented by the canopy size (Kc).

For example, the Kc in January is 0.7. If the Eto on a particular day in January is 5.8 mm, estimated plant water usage is:

0.7×5.8 mm = 4.1 mm

Crop coefficients in the Florida region of USA vary from 0.3 in winter to 0.7 in summer for mature 'Sharpe Blue' plants (Haman et al. 1997). No research has been done to determine how crop coefficient figures vary for variety, plant and row spacing, or the effect of weed matting in Australia. All these issues mean that climate-based scheduling for high value blueberry crops in northern NSW should be used as an estimate and general guide only.

Table 2: Estimating water usage for blueberries

Month	Crop coefficient	Long term daily Eto at Alstonville, NSW	Average daily water requirement (mm/d)
January	0.7	5.8	4.1
February	0.7	5.0	3.5
March	0.5	4.3	2.1
April	0.5	3.5	1.7
May	0.3	2.7	0.8
June	0.3	2.5	0.8
July	0.3	2.7	0.8
August	0.5	3.5	1.7
September	0.7	4.6	3.2
October	0.7	5.0	3.5
November	0.7	5.5	3.9
December	0.7	6.1	4.3

Putting all the steps together

Once the maximum irrigation to apply (RAW) and the plant water use have been calculated you can then estimate how frequently the orchard or block will need to be irrigated. Since pour soil has a RAW of 8.0 mm, we have moisture reserves of only two days in January. This information can provide the basis of an irrigation schedule.

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Haman D, Prichard RT, Smajstrla, AG, Zazueta FS & Lyrene PM. 1997. Evapotranspiration and crop coefficients for young blueberries in Florida. Applied engineering in agriculture 13(2):209–216.

More information

Primefact 1358. Maintaining a drip irrigation system for perennial horticulture

Primefact 1359. Tensiometer tips

Primefact 1362. Determining readily available water to assist with irrigation management

Primefact 1363. Determining soil texture using the ribboning technique

Primefact 1364 Irrigation scheduling principles for horticultural crops

Primefact 1365. Using capacitance probes for irrigation scheduling

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