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AVOCADO IRRIGATION PRACTICAL OBSERVATIONS IN DETERMINING WATER NEED, IRRIGATION DESIGN AND FREQUENCY SCHEDULING

C J Partridge
Avo Systems Limited, 109 Oliver Road, Tauranga, New Zealand

Summary

While irrigation is felt to be essential for successful avocado production in many countries, it is not a widely adopted practice in New Zealand and very little or no data is available to support the author's contention that lack of irrigation could be a limiting factor. The aim of this paper is to hopefully stimulate some progressive growers to experiment with the concept and at the same time, provide some guidelines as a starting point for local conditions.

Introduction

There are some factors fundamental to the successful cultivation of avocados (Pegg *et al,* 1987).

- soil selection
- using good quality plant material
- irrigation
- management
- fertilisation
- pest and disease control

Provided the prevailing general climatic conditions are conducive to fruit set, it is the successful integration of the above factors which will encourage, maximise and sustain avocado yield in any given orchard. For many years, *Phytophthora* rootrot was the scourge of avocado orchards worldwide and was the most limiting factor for profitable production. The advent of effective control measures (Darvas *et al,* 1987), is now reason for every grower to re-evaluate the factors most limiting on his or her orchard and it is the author's contention that, irrigation management or the lack thereof, could prove to be the next most limiting factor for avocados in New Zealand.

While there is a fair amount of published research on avocado irrigation worldwide, there is a distinct lack of information on irrigation under New Zealand conditions. In fact, the majority of New Zealand growers do not have irrigation systems installed (Cutting,

pers com). By reviewing some research results of other countries and combining this with the author's field experiences, primarily in South Africa, it is hoped that interest will be stimulated amongst local growers and possibly even cause growers with irrigation here and elsewhere, to revisit their systems. It is not within the scope of this paper to extensively review equipment or irrigation engineering, as it is felt that armed with relevant horticultural knowledge, irrigation engineers should be able to design to the tree's requirements.

At this point it should be stressed that the avocado industry in New Zealand is based almost exclusively on the variety 'Hass' and while research elsewhere has been done on other varieties, the main focus of this paper will be on the requirements of the 'Hass' variety.

The avocado tree's requirements

Avocados evolved under warm to cool subtropical rainforest conditions where rain is evenly distributed throughout the year and where they grow on well drained, leached soils. It is generally accepted that water is essential for growth, fruiting and producing marketable sized fruit and that New Zealand is blessed with an abundance of the precious commodity. What should be of interest to growers though, is the distribution of that rain and whether there is sufficient, in normal years, to supply the tree's needs in terms of photosynthetic efficiency, nutrient uptake etc. at the critical times.

Whiley *et* a/.(1988), used phenological growth cycles to identify critical periods for various inputs such as irrigation and nutrition. This excellent work provided a platform for better understanding of avocado tree management but is more directly applicable to Australian and South African conditions where summer rainfall and warmer temperatures are the norm and also, the work was done on the 'Fuerte' cultivar.

More recently, Thorpe *et al.* (1995) reported on tree growth cycles under New Zealand conditions this important work should ideally be reconfirmed since the local grower community has had time to implement better rootrot control practices. Also, rain falls in New Zealand mainly in winter and growing conditions are generally cool. It can therefore be expected that growth cycles will be peculiar to local conditions.

It is well known that the act of flowering and fruitset is in itself, a stressful time for the tree. Any factor, which increases the stress load, will decrease the potential of the tree to maximise its production. It has been estimated that a tree in full flower, increases its surface area for potential water loss through soft flower tissue, by up to 80%. Apart from the avocado's genetic limitations on fruitset, stress will aggravate the already low propensity (as low as only 0.4% of total flowers setting) of the tree to set fruit (Wolstenholme,1985).

Even when the tree manages to set a good crop, it still has to regenerate vegetative growth and roots if it is to stand any chance of fruiting the following season and these processes will be curtailed by any stress. Whiley (1994) in his doctoral thesis, while not referring specifically to irrigation, confirms the necessity of leaf retention and root regeneration for sustained cropping.

Wolstenholme (1989) makes reference to the energy expense to the tree of producing

an oil containing fruit. In New Zealand, many orchards will be carrying fruit from the previous season while flowering and setting for the coming season in any given year, so energy demands can be expected to be high under these conditions.

The growers' and the markets' requirements

Simply put, growers require a sustainable return on their long term investment and have to satisfy the demands of the markets in order to achieve this. The avocado tree's habit of alternate bearing can frustrate both the grower and the market.

Minimising tree stress to try and even out the bearing cycles is one avenue for the grower to follow, but the picture is further complicated by the fact that fruit volume alone will not satisfy the market. Speak to any fruit marketer, and the message is clear: the market increasingly demands the larger sized fruit with good internal and external quality.

Careful irrigation scheduling and management, coupled with good nutrition, can improve fruit size in Hass dramatically. Under South African conditions, small Hass fruit size is an ongoing problem (Moore-Gordon *et al,* 1996). It was interesting to the author in the mid 1980's, to observe a situation in Kiepersol in The Eastern Transvaal where a grower interplanted Hass in a banana plantation which was due to be removed over time. The grower in question continued to apply a banana irrigation and fertiliser regime, which was lavish by previous conventional avocado wisdom, resulting in the production of over 15 tons per ha of the largest Hass fruit seen until that time. This sowed the seed that the conventional wisdom based mainly on Fuerte work, was not ideal for Hass and prompted the author to review his advice to growers.

Since then various researchers have confirmed the positive effect of good irrigation practises on fruit size and yield in Hass and van Eyk (1994) reported dramatic yield improvements over two years following a heavy irrigation regime (between field capacity and -40kpa tensiometer reading) with Hass on clonal Duke 7 rootstock.

Moore-Gordon *et al.* (1996) working on a mulching trial, reported an increase of 11.88% in mean fruit mass and 16.7% more fruit over two seasons, when mulching was applied. This was directly attributable to a reduction of plant water stress.

Bower (1984 & 1986) working with Fuerte, reported improved post harvest quality and implicated pre-harvest water stress in predisposing fruit to post harvest quality problems. It is extremely likely that the same principles will apply to Hass.

How much water is required to irrigate avocados?

Soil water holding capacity and prevailing weather conditions will play a major role in water usage, but provided some method of measuring soil moisture is employed, a grower can at least determine <u>when</u> water is needed.

However, it is all very well to have a guideline of irrigate at a tensiometer reading of -40 kpa' for example, but this does not give any idea of how much stored or available water is required over a period of time. In order to try and make a 'guestimate' of what is necessary under New Zealand conditions, it is useful to review some case studies:

- In South Africa, it was long suspected that Hass had different water requirements to Fuerte, the dominant variety. The first inkling that this was true, came in the mid 1980's when a grower in the Levubu area established a block of Hass and Fuerte, both on the same rootstock, at the same time on identical soils and separated only by a road. Using tensiometers, he noticed that those in the Hass block reached the irrigation reading twice as fast as the Fuerte. Unfortunately his actual application rates were never recorded but as a rule of thumb, it is now accepted that Hass requires twice as much water as Fuerte
- Grower A tried to irrigate with microjets according to tensiometers during a very dry period on a 10 year old Hass block on Edranol seedling rootstock. Because bananas also had a priority, he was unable to irrigate optimally when the tensiometers indicated that the soil was dry and therefore irrigated when he could on a bi-weekly basis for 12 hours at a time, from June 1993 to December 1993. During this time no rain fell and the trees went through flowering and fruitset (critical times for water needs). Actual water usage was measured and it was found to be 611712 liters per month (or an average of 153000 liters per week). This resulted in a crop of just under 20 tons per hectare, but more importantly, the grower said he would have irrigated more heavily and more often if he could have
- Grower B has a well managed, mature block (tree canopies nearly covering the total planted surface area) of Hass on clonal Duke 7 irrigated with microjets. Tensiometers were never installed despite much encouragement! Irrigation was applied weekly for a set time of 8 hours at a time and other management inputs were carried out diligently. The orchard had been averaging over 15 tons per ha over four years and water usage was calculated to be in the order of 240 000 liters per ha per month during the critical flowering and fruitset periods. The yields achieved were far above average but in the author's opinion, could have been even better if irrigation was more scientifically scheduled
- Staff at Westfalia Estate in South Africa, have estimated that they try and apply the equivalent of 30-35 mm rainfall per week to the mature producing Hass orchards during flowering and fruit set. If it is assumed that about 65% of the surface area is wetted by their microjet irrigation system, this equates to around 240 000 liters per hectare per week which is similar to the case study above
- Lahav *et al* (1991), reports that 12700 cubic meters of water per ha per year was the minimum required for avocado orchards in Western Galilee, Israel, for desired cropping using under-canopy sprinklers. The introduction of drip and microjet irrigation allowed reductions in water use, but that within the parameters of the trial, every reduction in water applied, resulted in a corresponding yield reduction. Salinity is an additional complicating factor in Israel

Accepting that weather conditions are generally much less harsh in New Zealand over the dry summer months compared to those in South Africa or Israel, plus the fact the soils are generally well drained, a guestimate of water requirements in New Zealand would be: 120-150000 liters per hectare per week <u>on mature orchards, during the critical periods.</u> In making this guess, only careful monitoring of actual requirements and applications over time will prove it right or wrong.

Obviously water requirements will be much less in the early years of an orchard's life. However, most avocados are grown in regions of the world where rain does fall heavily at some time of the year. The trees naturally grow out to colonise new areas during these times and so the rooted area expands when conditions permit. It is therefore very important to design for the mature orchard's requirements. By 'maturity', it is meant that stage when the total planted area is almost fully covered with leaf canopy; this is a function of planting distance and not necessarily tree age. Also, an irrigation system should ideally be designed to cover 65-70% of the canopy surface area with water at orchard maturity so that irrigated water adequately covers the rooted zone.

Maximum water requirements during critical periods, implies that this demand will only occur for a relatively short period of the growing season as cooler weather or rainfall will reduce irrigation demand at other times; in effect, a case of not always needing the capacity, but needing it badly during key events in the trees production cycle. In New Zealand, this will probably be at times from late September to February, corresponding to the flowering and fruit set period.

Irrigation systems

Apart from gentle rain, there is no perfect irrigation system although designers are getting close to it. Some, like high volume, dragline or floppy sprinkler systems used in South Africa are very good from a water distribution point of view, but wasteful in the early years and can be labour intensive to operate. Others, like drip irrigation are suitable initially but end up not being able to distribute the water adequately and are prone to blockages; in the author's opinion drippers are not recommended for avocados at all. Micro-jet irrigation systems provide a compromise, can be expensive, but together with the floppy sprinkler system would appear to be most suited to local conditions.

It is felt that the ideal system would have the following characteristics:

- Capable of delivering water to a limited area under each tree when young to reduce water wastage initially
- Capable of increasing the wetted area to take into account tree growth and cover 60-70% of the canopy area at orchard maturity. In the design of the system, sufficient pressure and pipe delivery must be designed for, as the system has to expand
- Not be prone to blockages
- Should be capable of delivering 60 liters of water per hour per emitter or more ie. be capable of high delivery rates
- Should be designed such that the cycle time between irrigations does not have to exceed one week. On well-drained soils, stress conditions can develop rapidly especially during periods of hot weather
- Be designed such that different cultivars, age groups, or blocks on different soil types, are capable of being irrigated as separate entities. This is important as water requirements can differ

Managing and scheduling irrigation

An orchard's water requirements can vary considerably over a short period of time. Calendar irrigation scheduling can not take into account the often subtle changes in soil moisture status and additionally, the avocado does not thrive under poorly aerated soil conditions (Wolstenholme, undated), so a drying cycle is required; this can only be achieved by using some form of soil moisture measuring device.

There are some sophisticated scheduling devices on the market, unfortunately often at prices too sophisticated for the average grower and the following are some examples of what is available:

- Evaporation pan
- Tensiometers
- Neutron probes
- Enviroscan

While it is not the intention to provide a list of pros and cons of each device it is this authors assumption, that tensiometers would be the choice of the average grower. This is because despite some shortcomings, they have proved their reliability in the field, have been tested under experimental conditions, are relatively inexpensive and are easy to install and maintain. Their drawbacks should be mentioned as well however and these are:

- They measure moisture in a very limited soil area and so careful site selection is necessary
- They require discipline on behalf of the grower to read and service regularly

At a minimum, two tensiometers should be installed per irrigation block; a 30cm and a 60cm tensiometer with the shallow to indicate cycle frequency and the deep one cycle duration. It is also very important that they be installed within the area wetted by the irrigation system, of a representative tree in the block, on the dripline of the warmest side of the tree.

The pro and cons of mulching are reviewed in an article by Wolstenholme *et al* (1996). It would appear however, that researchers and orchard managers are overlooking a possibility of fine tuning irrigation needs even further: avocado roots thrive in well aerated soil conditions and mulching encourages root development in the mulch and at the soil/mulch interface. Thereafter these roots are often ignored from an irrigation point of view. This author would argue that there would be benefit in installing 15cm tensiometers wherever mulching has been applied to monitor the moisture conditions in this zone, where some of the healthiest roots will be found.

In the light of research results and personal observations, it is felt that if using tensiometers, irrigation should commence at a reading of-40kpa on clays and volcanic soils in New Zealand and -30kpa on sandy soils. Although a slight stress period may be thought to be beneficial under some circumstances in other countries, the fact that two crops are generally hanging on the trees at any one time, is probably stressful enough.

Irrigation and fertilisation

Fertiliser cannot be effectively utilised by the tree in the absence of available soil moisture. Having an irrigation system therefore allows the grower to be more certain that the fertiliser inputs are effective at the desired times. This is of especial note under New Zealand conditions where a lot of essential fertiliser is required during the summer growing period when rainfall is erratic.

Over-irrigation

Avocado roots are intolerant of prolonged periods of poorly aerated or waterlogged conditions. Additionally, *Phytophthora* rootrot is encouraged by such conditions. It has been observed that young trees especially, can be over-irrigated while their roots are confined in a fairly small soil area and so, growers should take care to manage irrigation especially carefully during the first year of establishment.

Where to from here for New Zealand avocado growers?

If you already have irrigation installed, reading this paper will hopefully give you some useful information on how to re-examine your system and its management.

If you are unsure of whether irrigation is required or not, before committing a substantial capital outlay to an irrigation system, you could purchase some tensiometers to monitor the soil moisture conditions in your orchard over a period of a full season. Whatever the results, they will be interesting and will be a very useful aid to determine whether you should be considering installing an irrigation system.

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