PEPPERMINT COMPARATIVE WATER USE USING SSDI AND CENTRE PIVOT IRRIGATION

“SUSTAINABILITY AT THE SOURCE”

Report Prepared for the Upper Murray Agribusiness Group and the Towong Shire Council, for the period September 2007 to January 2008

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INTRODUCTION

The impact of irrigated agriculture on water resources is significant. In Australia, irrigated agriculture uses approximately 75% of consumed water. There is increasing competition between users. The irrigation industry is facing many changes. They will be faced with restrictions, and/ or reductions, in water availability and entitlements. Future growth in irrigation depends on efficiency gains, rather than further use of scarce water resources.

The irrigation sector must be able to use the resources efficiently and effectively. It is these principles, efficiency and effectiveness, that are encompassed by the concept of water use efficiency.

PROJECT AIMS

The project aims to assess the use of subsurface drip irrigation in essential oil production, and to compare water use between centre pivot and subsurface drip irrigation. The aim is to develop strategies for irrigating the essential oil crops, which encompasses the concept of water use efficiency. The crop being grown is peppermint (*Mentha piperita)*.

WHAT IS WATER USE EFFICIENCY?

Water use efficiency is a term commonly used to describe the relationship between water (input) and agriculture production (output). It is obtained by dividing figures with the same units e.g. volume of water used (output) divided by a volume of water supplied (input). Alternatively, the tonnes of produce per mega-litre of water used are often referred to as efficiency, but it is a crop water use index or ratio. Water use efficiency is also often used to express the effectiveness of irrigation water delivery and use. Adding to the confusion in the definition of water use efficiency is the distinction between describing the agronomic performance of the crop (crop water use index) and the engineering aspects of the design and management of the system (irrigation efficiency).

Water use indices are generally a ratio of an agronomic or economic variable to a volumetric or depth measure of the water applied to the rootzone, transpired by the crop or available to the crop. Therefore, the water use index generally measures the productivity or profitability of an irrigation enterprise. The time period considered when calculating an agronomic or economic based water use index is generally over a season or year.

TRIAL DESIGN

A paddock of peppermint is being grown, with a centre pivot as the method of irrigation. This paddock contains 34ha and has been established for two years. At this site soil water is being measured by a G-bug system and also by an Agwise capacitance probe. The G-bug sensors are at 10, 20, 30 and

50 cm depths. The capacitance sensors are at 10, 20, 30, 40, 50, 60, 70, 80 and 100 cm depths. Figure 1 shows the centre pivot irrigated crop on the 7th November 2007.

The subsurface drip irrigation site was established on the 6th October 2006. The peppermint was planted into this 0.5 ha site on the 22nd July 2007. The drip tape has emitters spaced at 50 cm intervals and the rows are spaced at 1 metre apart. Half of the site (nearest to the road) was laid at a depth of 15 cm. The remainder of the area was laid at a depth of 23 cm. The system is designed to apply 4mm/hr. The soil water is being measured by a G-bug which is located in an area of the paddock where the emitters are at a depth of 23 cm. The G-bug sensors are at 10, 20, 30 and 50 cm depths. Figure 2 shows the sub-surface drip irrigation crop on the 7th November 2007.

Figure 1 Centre Pivot irrigated peppermint crop.

Figure 2 Subsurface drip irrigated peppermint crop.

WHY IS IRRIGATION MANAGEMENT IMPORTANT?

1. There is increased competition for water.

2. In many areas there is less water available for irrigation.

3. Increasing costs for water and its application.

4. There are changes in the regulations for water allocation and water use in many irrigation districts.

5. Improved production – by providing optimum soil water levels, this reduces the crops exposure to periods of waterlogging and or drought. In most cases optimal soil water levels will aid crop performance by reducing the incidence of pests and diseases.

6. Economic benefits - through more efficient use of water and energy (applying the right amount of water at the right time). Improved water use efficiency means reducing applications of water not used by the crop or in excess of what the soil can hold, minimising system losses and reducing unnecessary pumping.

7. Reduced environmental impacts – minimising waterlogging leads to reduced nutrient and chemical leaching, less water erosion, reduced potential for the development of salinity and reduces the potential amount of saline groundwater that ends up in rivers and streams.

HOW MUCH WATER SHOULD BE APPLIED AND WHEN (IRRIGATION SCHEDULING)?

When using irrigation scheduling as a management decision making tool, generally the amount of water that should be applied to a crop for any given irrigation depends on:

1. the stage of crop growth

2. the depth of the crops root system, and what is the effective rootzone for the crop. The effective rootzone is the part of a plants rootzone from which the majority of water is drawn, and for most plants is approximately two-thirds of the total rootzone depth.

3. the field capacity of the soil.

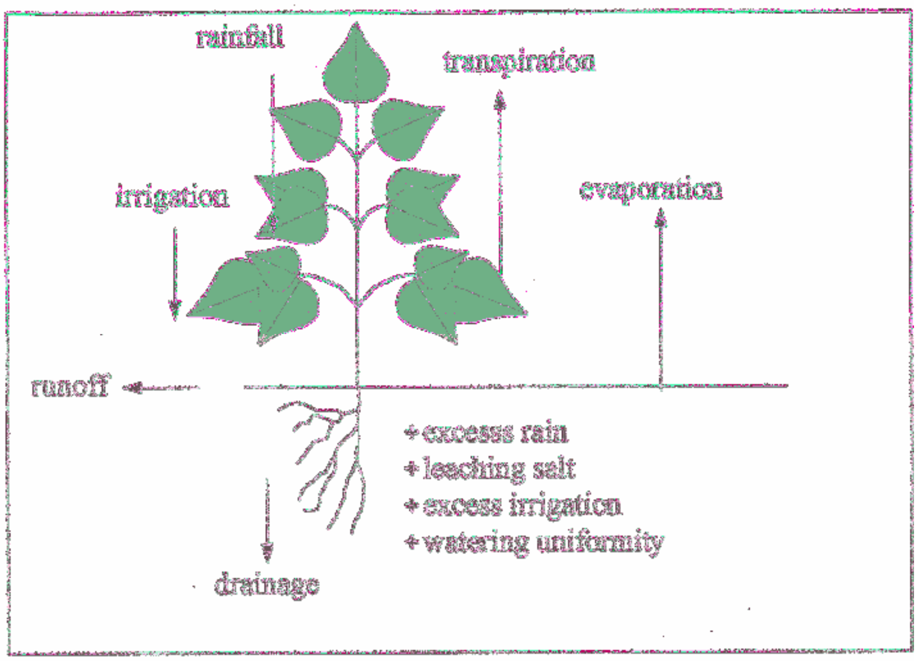
The amount of water applied at any given time should fill the effective rooting zone to field capacity and no more. Nothing is gained from applying more water than is needed to fill the effective rooting zone of the crop.

The time interval between applications depends on:

1. the area of transpiring surface,
2. the rate of transpiration,
3. the rate of evaporation of water from the soil, and
4. the field capacity of the soil.

Irrigation scheduling requires knowledge of the soil-plant-water relationship. The combination of transpiration (crop water use) and evaporation is referred to as evapo-transpiration. Figure 3 shows the factors which influence the soil-plant- water relationship. These factors influence the rate at which water is used or lost. Over-irrigation can cause waterlogging, wastes water with unnecessary pumping and water costs; leaches nutrients and chemicals from the root zone and can produce excess drainage. Under-irrigation stresses plants and reduces plant productivity. It can also result in nutrient deficiencies.

Figure 3: Soil-Plant- Water relationship.



SOIL TYPE (TEXTURE) HAS AN IMPACT ON SOIL WATER AND IRRIGATION SCHEDULING

Soil consists of soil particles, air spaces, water, and humus and living organisms. Some water is held firmly to the soil particles (adsorbed water) and some is held in the pores between the soil particles (capillary water). Plant roots use the capillary water from the largest pore spaces first. As the water is used from the soil, it becomes increasingly difficult for the plant roots to remove the remaining water. A point is reached when the plant roots cannot extract the remaining (adsorbed) water from the soil. Soil water tension is how tightly the soil holds its water and how much effort a plant has to exert to extract water from soil. The G-bug system being used in this project measures this soil water tension.

The amount of water held and the quantity available varies with soil type. Having an understanding of the water holding capacity of your soil can be helpful in planning irrigation and may help to improve efficiency, regardless of the type of irrigation equipment being used to deliver the water. Therefore it is useful to know how much water the different soil types in paddocks will hold.

Soil texture determines how much water is available to the plant. Soil texture describes the relative amounts of sand, silt (loam) and clay. Within the textural groups sand particles are the largest in size, silt is medium and clay the smallest.

Soil structure also impacts on the amount of water available to a plant. Soil structure impacts on the bulk density of the soil, which is the weight of soil in a given volume. Bulk density is an indication of the quantity of pore spaces and therefore influences the amount of water that can be held in the soil. Good soil structure for any given soil type can potentially hold more water than a poorly structured soil of the same type.

TERMINOLOGY

1. Saturation or Full Point - This is when all the pore spaces are full of water. This is immediately after rainfall or irrigation before drainage occurs.
2. Field Capacity - This is when the gravitational water has drained away. Depending on the soil type, this takes approximately 12 to 48 hours. This is the maximum amount of water the soil can store for crop use.
3. Refill point - This is when the soil water is not easily extracted by the plant. Refill point is when you should irrigate. Refill points may be varied to suit different crops and stages of growth of a particular crop.
4. Wilting Point - This is when plants are unable to extract soil water. They will wilt, but do not recover when water is applied. If soil dries to this level, plant growth and yield will be severely reduced.
5. Readily Available Water - This is the amount of water stored in the soil, which can be easily extracted and used by plants. It is expressed as mm of water per depth of soil.

IRRIGATING PEPPERMINT FOR ESSENTIAL OIL PRODUCTION

Peppermint production is particularly sensitive to water availability. The management of an irrigated peppermint crop requires that a number of factors be carefully considered to obtain high yields and quality oil. These include:

1. In general, peppermint is a relatively shallow rooted crop.
2. Peppermint has a medium to high water requirement. The total requirement can be as much as 5 to 6 ML per season. The potential crop water use varies with seasonal weather conditions. During the peak growing period crop transpiration can be as high as 6+ mm per day.
3. Peppermint has relatively low salt tolerance.
4. At present most peppermint grown in Australia for essential oil production is watered by travelling irrigators, centre pivots and linear move irrigators.

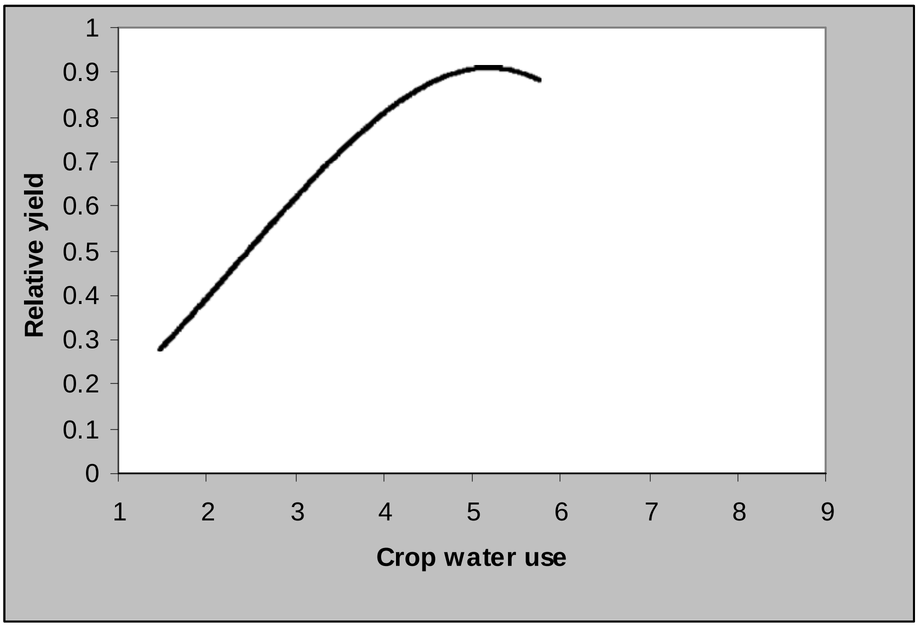
To maximise yield and quality of peppermint oil, irrigation should occur when 35% of the available water in the crops rootzone has been depleted. Generally this rootzone is in the 300 to 400 mm depth range. Inadequate water reduces the oil yield of peppermint, as will excess irrigation.

The oil yield of peppermint is determined by the number of leaves, not the size of the leaves, retained in the canopy. Getting the irrigation scheduling right has a large impact on the canopy management. Moisture stress in peppermint is associated with lower oil yields and higher menthofuran levels, which affects the quality of the oil. Indications are that moderate levels of moisture stress early in the season may improve yield because moisture stress produces smaller leaves, which are more likely to be retained by the plant. Shading in the canopy influences lower leaf fall or retention. Work is continuing on the impact and timing of some controlled moisture deficit period.

Over watering can also result in reduced oil yield. Excess water can cause waterlogging, increase the risk of developing root diseases, increase the amount of leaf drop (as a result of shading), and leach nutrients to below the rootzone. The high humidity that can result in a canopy from over watering also affects the quality of peppermint oil, by increasing menthofuran levels, especially during the summer heat.

Figure 4 indicates the relative oil yield from peppermint as a function of crop water use. The crop water use figures on the y-axis below are only indicative numbers, not absolute figures. This is to show the general trend of increasing oil yield with increased crop water. The yield is maximised at a particular water level and water applied in excess of this point may actually result in the relative oil yield falling.

Figure 4 indicates the relative yield of peppermint oil as a function of crop water use.



RESULTS

The centre pivot paddock was harvested in January 2008. The crop yielded approximately 80 kg/ha of oil. The plan is to manage the crop and get a second cut from this area in late March or early April.

The pivot peppermint was kept well watered for most of the growing season (and at times maybe too well watered). The crop was very lush and had a very dense canopy. By the time of the first harvest much of the lower leaf had fallen. The top two graphs, Figure 5 and 6 below are from the pivot paddock. The first is the Agwise capacitance probe and the second is the G-bug. On the G-bug graph the increase in root pressure (larger kPa) relates to the harvest period, prior to irrigation starting again.

The subsurface drip irrigated crop faced some establishment issues. The decision was made to not harvest this area, but to mow it and wait for regrowth. A decision to harvest or not at the time of the second cut in the pivot paddock will be made. No yield data is available for comparison. At times the kPa readings in the SSDI crop were very high, greater than would be ideal to maximise oil production, and way past the recommended refill point of 35% of field capacity for peppermint. See Figure 7 below.

The benefits of using subsurface drip irrigation are well documented for many other situations. This technique for irrigating peppermint is a relatively new one. The potential for efficiently using water is great, in a relatively high water use crop. There is potential benefit from a reduction in disease levels. The crop in the SSDI trial area has established and will be able to be compared with the pivot watered crop during the coming season.

Figure 5: Agwise capacitance graph representing the 9 individual sensors. Data is delivered by telemetry and can be downloaded as often as desired.

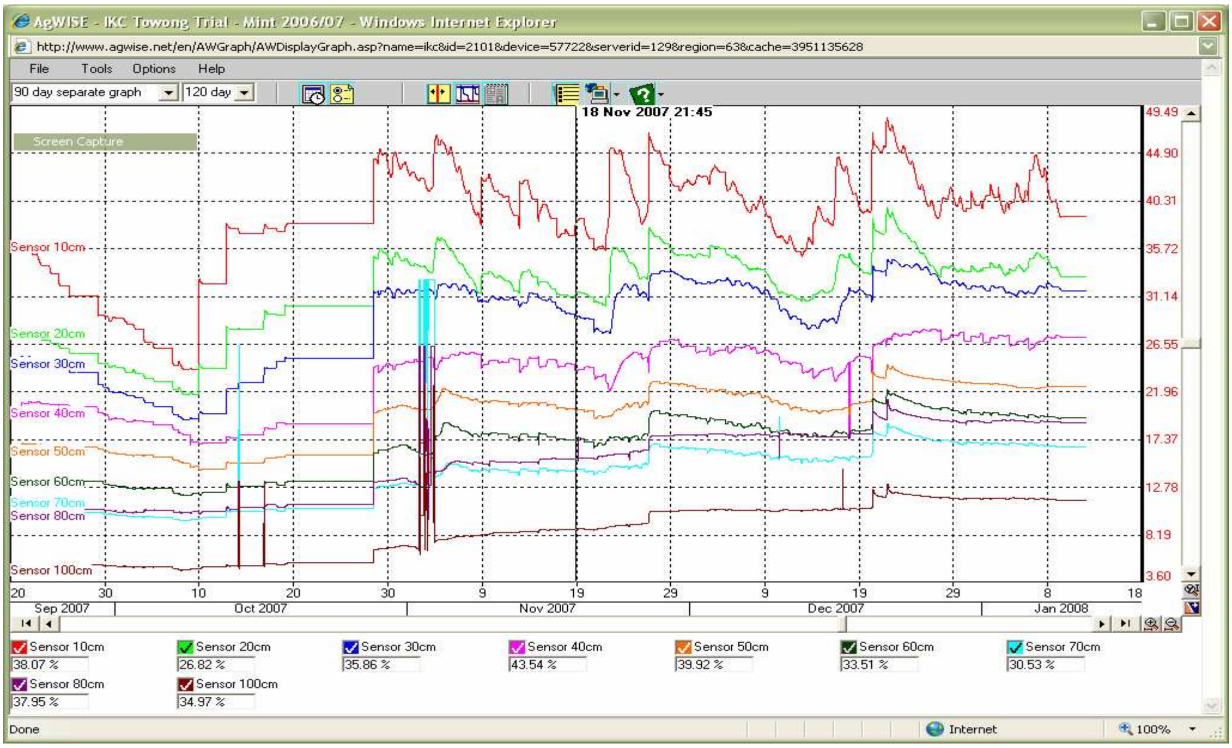


Figure 6: G-bug data for the centre pivot paddock. This is downloaded by the project officer and emailed regularly to the grower.

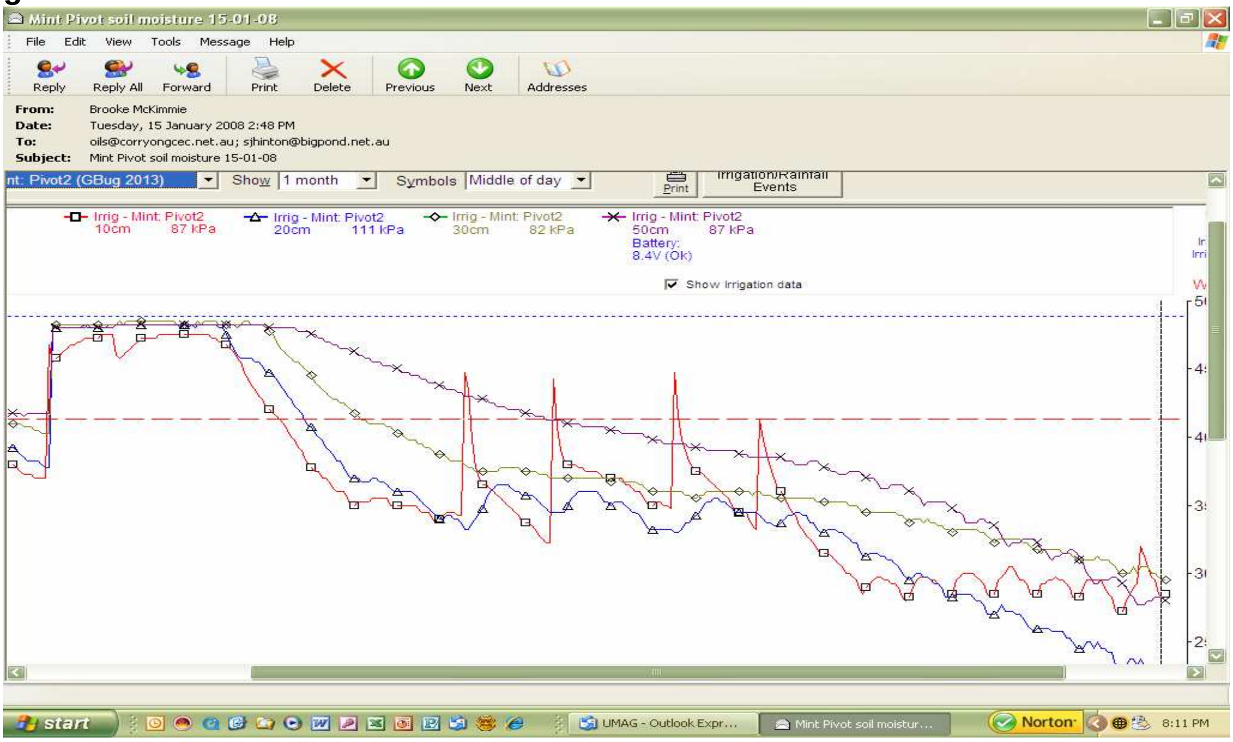
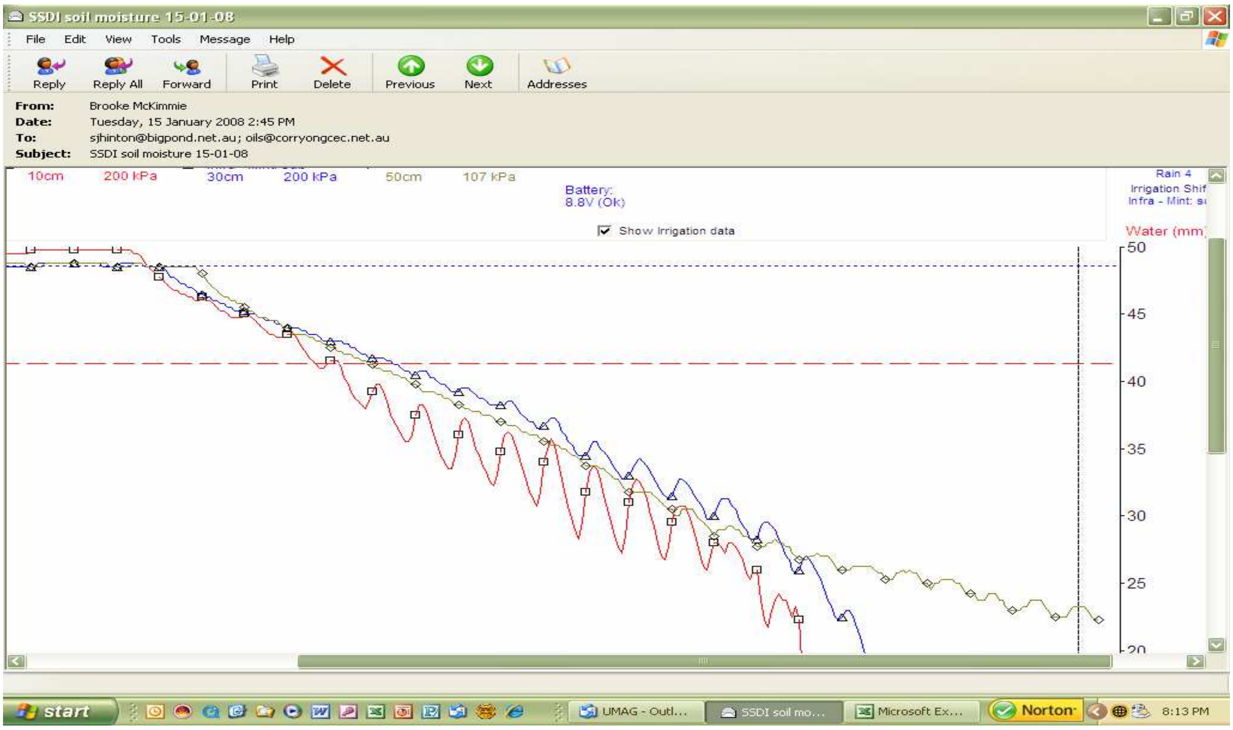


Figure 7: G-Bug data for the SSDI trial area. This is downloaded by the project officer and emailed regularly to the grower.



EVALUATION

The grower has been using the telemetry graphs to monitor where they are at with their irrigation management. The data from the g-bugs has also been monitored. The real time data from the telemetry system has been very useful and is a very good tool to aid in irrigation management decisions.

The coming year should provide data that will allow for an effective comparison of the two types of irrigation systems in peppermint oil production.

RECOMMENDATIONS FOR 2008

We now have enough data from the capacitance probes to establish full and refill points for the soil type were the logger is located. This will then provide easier interpretation of the data for the grower using the system. We can also define a second summed graph that shows the summed water for the effective rootzone of the crop, not the total over all the sensors. Irrigation application should only fill the effective rootzone back to field capacity.

It would be beneficial to collect figures on the volume of water applied to the paddocks with each irrigation or rainfall. This then allows some degree of fine tuning for the interpretation of the right quantity of water to apply to the paddock and the timing of the application. It also will allow for an assessment of the crop water use index between the two systems. This can be completed by a meter on the SSDI system to measure what quantities of water are applied to the crop. To monitor water applied or rainfall in the pivot paddock a rain gauge can be used, but would require some diligence to record the data. Alternatively there are available relatively inexpensive self-emptying rain cup gauges that can store 9 days of data. This means that someone would need to visit the paddock every 9 days to record the data into a recording sheet. The best option would be to get the grower to record this information.

By collecting data on the amount of water applied through both systems (pivot and SSDI) we can then undertake a simple economic analysis (financial and resources used) on the productivity from each system. By accurately recording the resources (water) that are used to achieve the given output we can do some valid comparisons. This information would then allow accurate gross margins to be developed for the different essential oil production systems.

It may be useful to install a G-bug sensor into the SSDI trial area in the area where the emitters are at 15 cm. This would give data of the water movement through the soil profile. As SSDI has not been widely used in peppermint production the biggest issue is what is the best depth for the emitter to be placed at to maximise the crops oil production? Another option is to install a couple of continuously logging Green light- Red light capacitance instruments in this area (these can be provided on loan for the duration of the season).

I recommend that we do some comparative sampling in the crop during the growing season. Useful measurements that can help correlate with the yield data are canopy measurements such as height, node number, internode spacing, lateral leaf numbers and counts of any leaf fall in the lower parts of the canopy. Assessments of plant health may also be indicative of benefits or not, from the different systems. Assessment of rooting depth and the development of the root system under SSDI would be beneficial. This could be undertaken when site visits occur.