TECHNICAL BULLETIN
NO. 158

REPORT ON A STUDY TOUR OF THE IRRIGATED CROP MANAGEMENT SERVICE, LOXTON, SOUTH AUSTRALIA

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NORTHERN TERRITORY

DEPARTMENT OF

PRIMARY INDUSTRY AND FISHERIES

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SUSTAINABLE AGRICULTURE

THE DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES IS COMMITTED TO THE PRINCIPLES AND PRACTICES OF SUSTAINABLE AGRICULTURE

Definition:

Sustainable agriculture is the use of practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities.

Principles:

1. Agricultural productivity is sustained or enhanced over the long term.
2. Adverse impacts on the natural resource base of agricultural and associated ecosystems are ameliorated, minimised or avoided.
3. Harmful residues resulting from the use of chemicals for agriculture are minimised.
4. The nett social benefit (in both dollar and non-dollar terms) derived from agriculture is maximised.
5. Agricultural systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

REPORT ON A STUDY TOUR OF THE IRRIGATED CROP MANAGEMENT SERVICE, LOXTON, SOUTH AUSTRALIA.

YAN DICZBALIS
HORTICULTURIST, IRRIGATION
RESEARCH AND MANAGEMENT
JUNE 1990

HORTICULTURE SECTION
NT DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES
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ACKNOWLEDGMENTS

I wish to thank:

- The NT DPIF for providing the funds for the study tour.
- Mr Trevor Slugget and staff of the I.C.M.S. for their help and encouragement during my stay.
- The SA Department of Agriculture for permission to publish a range of their 'fact sheets' pertinent to Irrigation Management.

CONTENTS

SECTION

SUMMARY

The NT Department of Primary Industry and Fisheries recently appointed a research officer to oversee the research and management of irrigation technology in horticultural crops.

A prerequisite of the position is to determine what irrigation research and management programmes are being undertaken in Australia and how these programmes are being implemented.

One of the premier irrigation management groups of perennial crops is the South Australian Department of Agriculture's Irrigated Crop Management Service (I.C.M.S.).

This technical bulletin contains a report on a study tour to the I.C.M.S. and includes recommendations for the Departments Horticultural Irrigation Research and Management Programme.

RECOMMENDATIONS

1. The NT DPIF Horticultural Irrigation Research and Management group should initiate a programme of soil surveys in conjunction with the CCNT soils division. The programme should initially be of an extensive nature and aim to classify horticultural soils on the basis of readily available water holding capacity.

2. The Horticultural Irrigation Research and Management group should develop an irrigation system field testing capability.

3. The Irrigation Research and Management group should monitor current irrigation practices for both annual and perennial crops.

4. The Irrigation Research and Management group should aim to introduce a commercially orientated scheduling service for both annual and perennial crops.

5. Continued contact between the NT DPIF and S.A. I.C.M.S. should be encouraged. This could be done by encouraging staff to undertake three month sabbatical visits to undertake specific projects. Reciprocal visits should be concurrent so that neither group is short staffed.

6. The Department should use the services of the I.C.M.S. sprinkler testing unit to test sprinklers which are suited to our soil, water and cultural conditions.

INTRODUCTION

The I.C.M.S. (Irrigated Crop Management Service) at Loxton, SA is a semi-commercial group working under the umbrella of the SA Department of Agriculture. The group was initially developed by Messrs Peter Buss and Keith Watson in the early eighties. The group is currently lead by Mr Trevor Slugget (Senior Irrigation Advisor). The group provides a service to Riverland horticulturalists to enable them to efficiently irrigate their crops and reduce salinity and rising water table problems which have been caused by inappropriate irrigation technology in the Riverland area of SA. The main crops in the area are citrus and grape vines, with smaller areas of stone fruits, nuts (almonds and pistachio) and vegetables. The I.C.M.S. is funded by government, research and development grants and a fee for service from participating growers. The group is comprised of four subsections which include Soil Survey, Irrigation System Design, Sprinkler Testing and Irrigation Scheduling. The four subsections work closely together to produce a crop irrigation management plan based on information gleaned by the various sections. The group predominantly provides a service to established farms, however, they also promote the use of surveys prior to the establishment of a new farming enterprise.

SOIL SURVEY SECTION

Leader: Mr Tony Adams

The role of the soil survey section is to define the soil types which exist on the farming unit, so that irrigation management can be based on soil type and the soil water holding capacity.

The first step is to collect readily available information on the farm such as:

- aerial photographs
- topographical and soil-type maps
- information on currently planted trees and vine crops
- irrigation system layout (if applicable)

A detailed soil survey is then carried out on a 50.0 m x 50.0 m grid based on a reference site. On large properties, in excess of 50 ha, the grid size may be increased to 75.0 m x 75.0 m. At each grid site a back hoe pit is dug to a depth of approximately two metres, or down to a restrictive layer e.g. rock, sheet limestone or water table. Within each pit the following parameters are measured:

- depth (cm) of soil strata
- depth (cm) to a restrictive layer
- test for carbonate layers using 1.O N HCl
- colour descriptions of the soil strata using a Munnsel Colour chart
- hand texturing and a soil description of each soil layer
- presence or absence of roots within each strata - in established orchards
- field pH
- geology

If there are sudden changes in soil type or depth between pits, further soil investigations using a hand auger are carried out to define the boundary of the changes.

The information gained from such 'pits' on soil depth, restrictive layers, soil type and rooting zones allow the group to define the area in terms of readily available water (RAW). RAW is defined as the amount (mm) of water per metre between -8kPa (field capacity) and -60 kPa (rough refill point). This data is obtained by combining the field soil strata information with previously obtained laboratory determined soil moisture curves for the various soil types (Fig. 1).

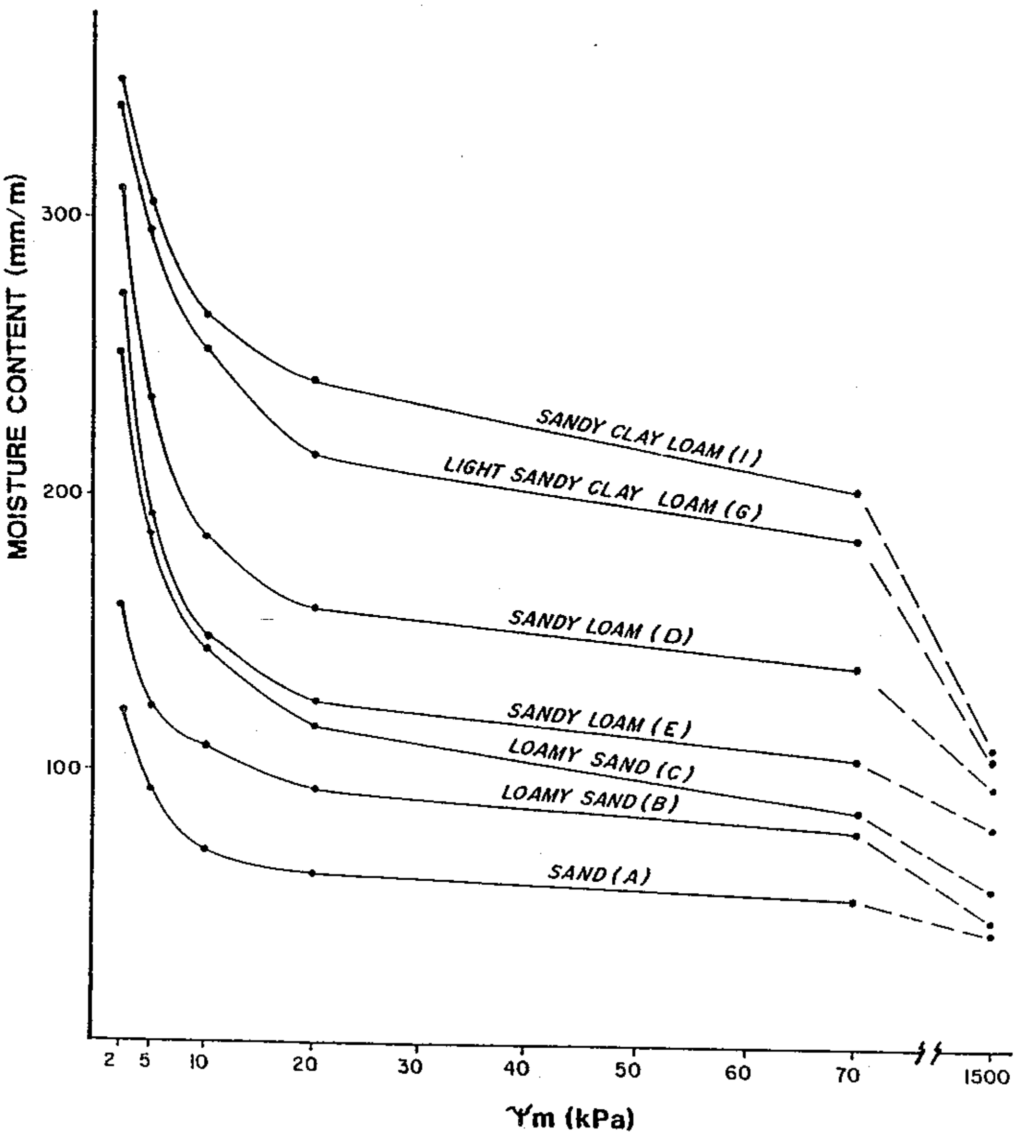

Figure 1. Example of laboratory determined soil moisture curves for various soil types in the Loxton area.

The soil moisture curves were determined by the suction method as defined by Loveday (1974). Moisture percentage at -1500 kPa (defined as the wilting point) is determined by the pressure plate technique. The field observations and calculations of RAW allow plans of the following to be made:

- soil profile description plan
- depth of top soil plan
- drainage hazard plan or depth to impermeable layer
- readily available water plan - an indicator of the soil water storage capacity.

The RAW data is usually expressed in two ways. The first is total top soil RAW which is dependent on soil texture and depth of layers, and the second is rootzone RAW which is dependent on the depth of the rootzone. The latter method of expressing RAW allows irrigation scheduling to be carried out on younger trees which have not fully exploited the soil profile, or on trees which are not able to use water in a soil layer containing fine carbonate material.

The above plans which define the soils, restrictive layers, top soil plan and readily available water are then passed onto the systems design/field testing unit for their advice on irrigation system design or system modification required.

IRRIGATION SYSTEM DESIGN/FIELD TESTING UNIT

Leader: Mr Denis Sparrow

The irrigation system design unit is responsible for the field testing of existing irrigation systems, and the design of new systems prior to installation.

Field testing of existing system involves:

- checking operating pressures at the pump outlet, main line, submains, laterals and sprinkler heads
- sprinkler distribution (can test)
- pump efficiency testing

The system pressure check allows the unit to gain an appreciation of the variation in the system, if any, and the operating pressure at the sprinkler head. Overhead sprinkler operating pressure is measured using a glycerine fitted pressure gauge with pitot tube attachment. The pitot tube is held in the spray stream several mm from the sprinkler orifice. For under-tree microsprinklers the operating pressure is measured using a tee piece with attached gauge coupled directly under the sprinkler head. The field testing unit has found that 40-50% of hand held pressure gauges are inaccurate or incorrectly calibrated. Prior to use they check each gauge against a Buttenberg master-gauge and note the offset. The unit felt that this gauge inaccuracy was a major reason why irrigation systems were not operating at the pressures that they were designed for. It was not unusual to find gauges as much as ±25 kPa off the true pressure, or gauges that had a varying offset throughout their operating range.

The sprinkler distribution or 'can test' is used to determine the uniformity of distribution of the irrigation applied. Uniform distribution of the water is particularly important in the Riverlands due to the high saline properties of the irrigation water. Complete coverage between trees is required to reduce the build up of salts in the dry areas. The principle behind complete coverage is that a uniform application of water over the soil surface will wash the salts down the soil profile thus eliminating any build up of salt in areas which are not thoroughly wetted. Irrigation systems with poor distribution uniformity result in orchards with poor tree health due to a build up of salts in the soil and subsequently in the tree. Although this is not relevant to the top-end of the NT where water quality is very good, it is extremely relevant to the Alice Springs area where salt buildup is perceived to be a problem. The distribution uniformity (DU) is measured using tin cans spaced at regular intervals, (0.5 m - 2.0 m) depending on sprinkler design and distance between the sprinklers. The system is run through a normal irrigation cycle. After completion of the irrigation run, the amount of water collected in the cans is measured and documented.

$$\text{D.U. \%} = \frac{\text{Average of lowest 25\% of readings}}{\text{Average of all readings}} \times 100$$

The recommended range for D.U. is >75% .

The 'can test' data is also used to calculate average precipitation rate.

The third part of the field systems monitoring is pump efficiency. The factors measured are

- power input in kilowatt hours
- head (or pressure) developed in metres, at the inlet and discharge ends
- discharge in litres per second

The above parameters are measured at a number of pump loads which range from near overload to complete shutdown of the mainline gate valve. These measurements allow a comparison between the pump performance curves and present operating performance. Problems such as worn or damaged impeller can be picked up readily.

Irrigation system deficiencies, such as, poor uniformity of pressure, poor sprinkler distribution and poor pump efficiency are noted. These are reported to the grower along with recommendations on how to rectify the problems. Details on the system including sprinkler precipitation rate and D.U. are also forwarded to the irrigation scheduling unit.

The unit also designs systems for new projects. This is done in conjunction with the information provided by the soils survey section on soil RAW patterns through-out the property and the crop type. The property is split into irrigation units; the number of units depending on the RAW differences, crop types, pump and pipe capital cost and operator preference.

The system designs are based on :

- a precipitation rate of 6 mm/hour
- 10-12 hours running time per irrigation unit
- full cover to avoid a build up of salinity

SPRINKLER TESTING

Leader: Murray Harvey

The I.C.M.S. have a specialist sprinkler testing unit or equipment evaluation service. The unit carries out performance tests on irrigation equipment, primarily overhead and under-tree sprinklers.

The work is performed on a fee-for-service basis and the majority of their work is commissioned by sprinkler manufacturers for both prototype sprinklers and commercially released models.

The sprinkler testing involves:

- determining performance characteristics
- measuring pressure/discharge relationships
- measuring distribution uniformities
- measuring distribution under wind (overhead, sprinklers only)

Data from the distribution tests are entered into a specialized sprinkler performance computer package. The package is able to output detailed distribution data on a single sprinkler basis as well as distribution data for an array of sprinklers (Figs. 2, 3 & 4). This information is particularly important where even distribution is required over the total ground area.

The unit has published two booklets of results of sprinkler performance tests. They cover a range of overhead and under-tree sprinklers (ICMS 1987, 1988).

Sprinkler manufacturers are currently not required to have independent testing carried out on their equipment. If the user or intending purchaser demands that independent test data be made available, then manufacturers will be more likely to use the I.C.M.S. sprinkler testing service.

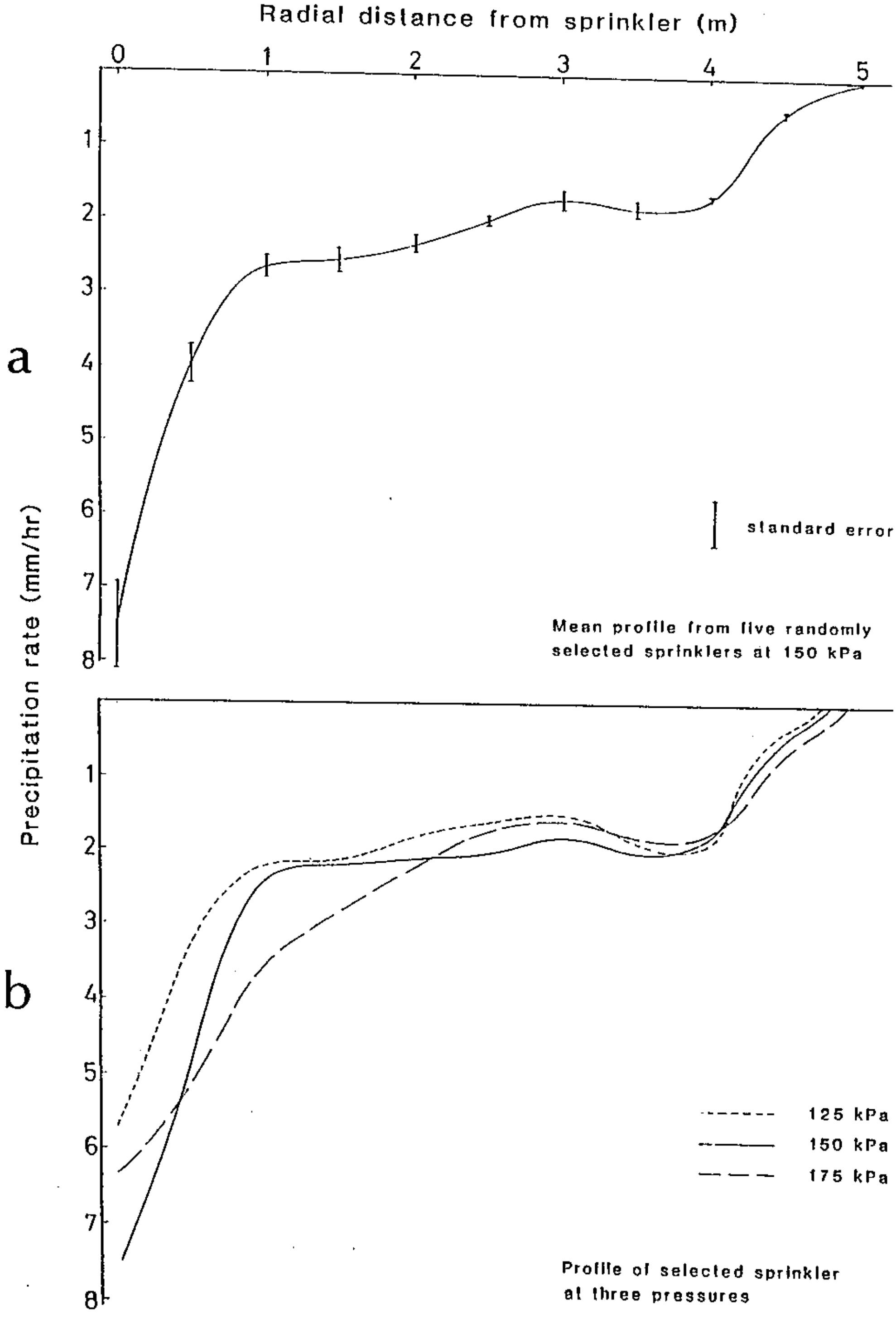

Figure 2. Single sprinkler distribution data at standard operating pressure (a) and a range of operating pressures (b)

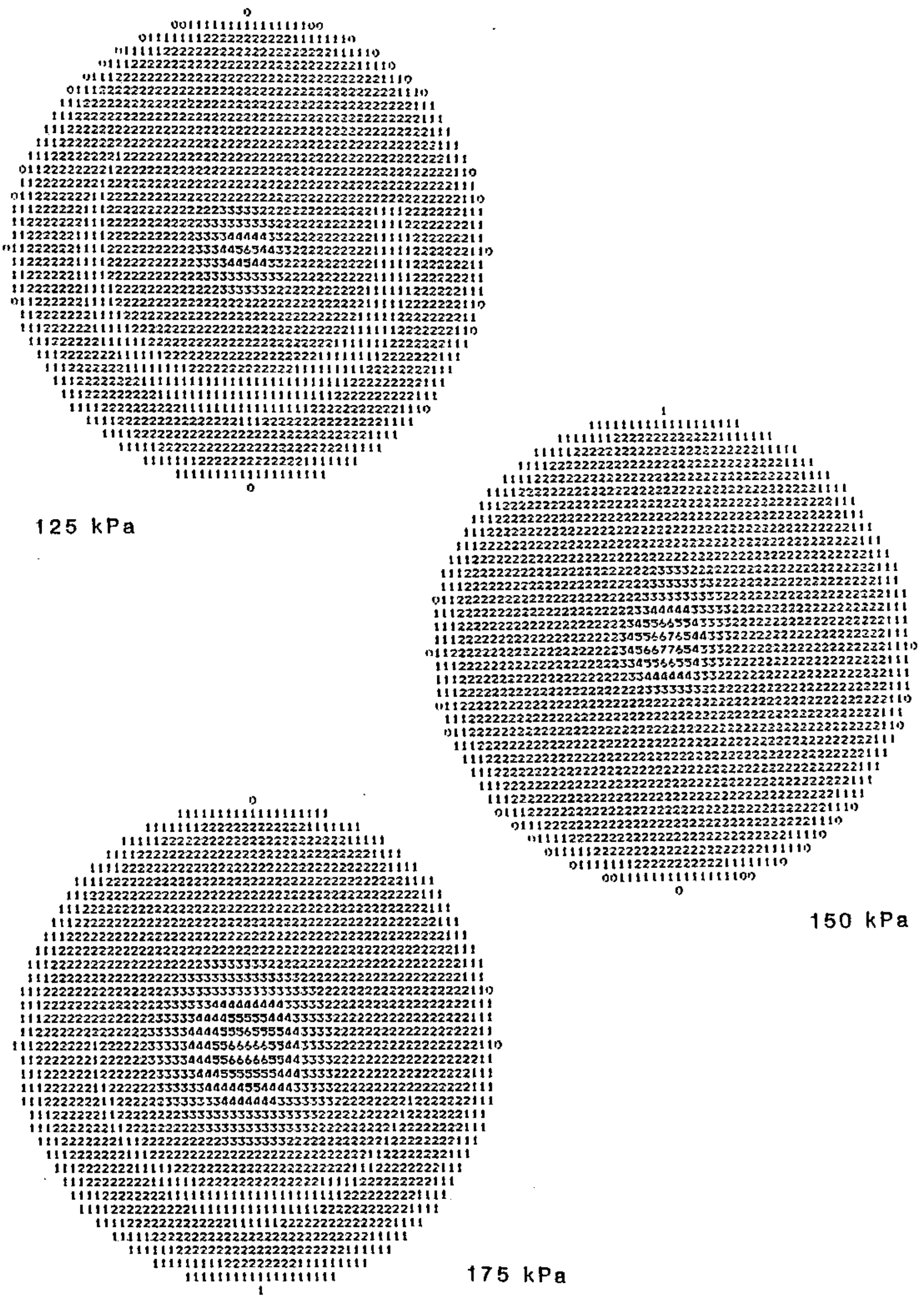

Figure 3. Sprinkler distribution pattern at three operating pressures. Numbers denote mm/hour.

AUSTRALIAN IRRIGATION EQUIPMENT TESTING FACILITY 5003

DISTRIBUTION PATTERN OF SPRINKLERS

MICRO SPRINKLER 150kPa
NEW SPRINKLER

```
          0      DISCHARGE    (L/h):   236   TEST TYPE      :  4 - RADIALS
DATE: 11/ 9/86   NOZZLE HEIGHT(m):    0.18   TEST SITE/NO.  :  ENCLOSED ( 385)
TIME:            STREAM HEIGHT(m):    0.78   TESTED BY      :  M HARVEY
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    ssmf98754433333333333345556666666667766665543344333333333333444clss
    ssskca8644333333333333455566666666677666655433443333333333445hsss
    #                                                                  #
    0        1        2        3        4        5        6        7
    sprinklers  7.32 m  apart

    coefficient of uniformity  :  69.3%                # = sprinkler
    distribution of uniformity :  66.2%
    design precipitation rate  :   4.4 mm/hr
```

Figure 4. Sprinkler distribution pattern between an array of four sprinklers.

IRRIGATION SCHEDULING

Leader - Mr Scott Norton

The irrigation scheduling unit offers a neutron probe computer based service to growers to help them determine how much water should be applied to crops to match the soil water holding capacity and maintain crop health and productivity. The group aims to reduce water wastage due to excessive irrigation and reduce the build up of salts in the root environment. These two requirements conflict because a reduction in salt levels is managed by promoting drainage through the root-soil profile, however, the drainage cycles are managed in such a way as not to add excessive amounts of water to the water table.

Prior to going into the field the farm is divided into irrigation units or shifts based on soil readily available water capacity, crop type, irrigation system potential, topography and farmer preference. Monitoring is carried out on selective units depending on the number of units the growers is prepared to pay to have monitored, the diversity of crop and soil types and the age of the plantings. Typically, site numbers vary from one to ten with the bulk of properties having 2 - 3 monitoring sites. Information from one site is often extrapolated to other irrigation units which are not monitored.

The I.C.M.S. charges $1000 per site per year plus a $200 installation fee. Each site consists of 3 access tubes. This charge covers the following:

- 75 monitoring visits
- three soil salinity samples @ 25,50,75 and 100 cm
- sprinkler distribution test
- leaf or petiole analysis three times per year
- installation of a testwell to monitor the water table
- site calibration of probe versus volumetric soil water
- soil water information and irrigation recommendations after each monitoring visit relayed to grower via telephone or facsimile
- collection of information on growers cultural practices
- six irrigation advisor-grower visits

Information on the height of the water table as determined by the test well installed at the monitoring site allows the scheduling group to confirm the drainage information collected by the probe. If upward movements in the water table do not match the probe estimates of drainage this may indicate that the increased water-table height is due to drainage from a neighbouring property. This sort of information has been used to control the irrigation practices of growers who are over-watering and causing problems on neighbouring properties.

Site Selection

Three tubes are installed at each site, as indicated in Fig. 5.

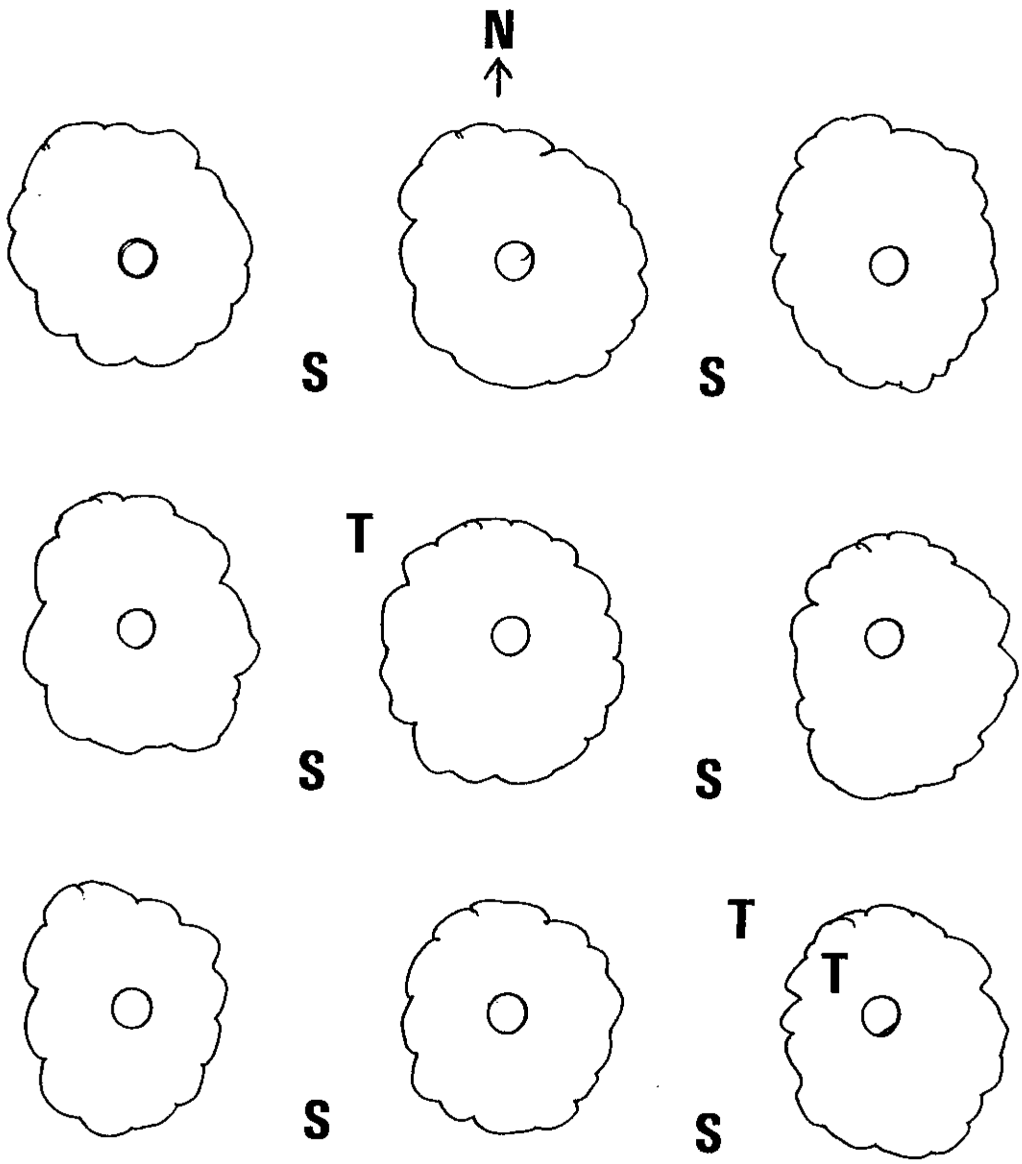

Figure 5. Access tube location in an orchard monitoring site. S = sprinkler, T = access tube.

The I.C.M.S. team have determined that the above location of access tubes enables them to calculate a mean soil moisture, from the three tubes, as well as check sprinkler distribution or evenness of wetting. I am not able to concur with this and believe that if the aim of the three tubes is to determine a mean soil moisture reading then the tubes should be in the same positions relative to the sprinkler and tree, on three different trees and three different sprinkler laterals. Having two sites on the same tree and lateral could adversely bias the readings if there is a problem with that lateral.

The scheduling team uses the following guidelines to select an access tube site, these include:

- select average size healthy trees
- position the tube on the NW aspect of the tree
- avoid area subjected to irrigation runoff
- avoid old soil pit or disturbed sites
- avoid positioning a tube in an irrigation shadow area
- avoid areas which have major changes in topography
- know the distribution pattern of your sprinkler and avoid overly wet or dry areas
- don't position the tube in the vicinity of buried lateral or submain lines
- avoid farm traffic lanes
- avoid the drip ring area

In vine crops, which are mainly irrigated by overhead sprinklers, the tubes are placed along the row, approximately 60cm from the butt, in such a way that the 3 tubes are affected by different sections of the overhead sprinkler distribution pattern.

Tube Installation and Removal

The method of tube installation developed by the I.C.M.S. is worth noting as it allows for rapid installation of tubes combined with accuracy of installation.

A standard 50.0 mm aluminium tube with wall thickness of 1.6mm is used for the neutron probe access tubes. Tube length is 1.5 m. The length is designed to allow 10.0 cm to remain above the ground. The last probe reading is taken at 120.0 cm.

The method of installation is designed to eliminate a space between the soil surface in the core and the outer surface of the tube. A hole, 45mm in diameter and 1.4 m in depth is augured out using a 50.0 cm continuous flight auger attached to 1.0 m of 45.0 mm shaft driven by a petrol motor. The hole is augured out in increments of 30 cm to 40 cm to avoid compaction of the sides. The aluminium access tube is then driven into the hole with a rubber coated sledge hammer. A metal anvil fitted into the top of the access tube protects the aluminium tube from direct blows from the hammer (Fig. 6).

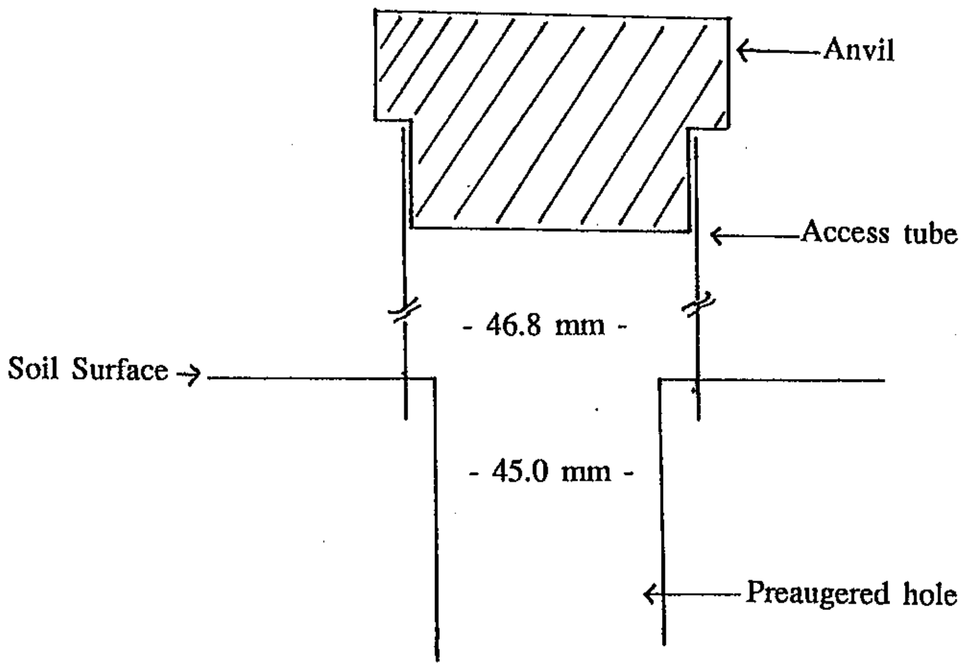

Figure 6. Diagramic representation of access tube installation.

Once the access tube is installed to the required depth the anvil is removed. The soil accumulated at the bottom of the tube, due to the cutting action of the larger diameter access tube on the small diameter auger hole, is removed using a short flight hand driven auger. Care is taken at this stage not to remove too much soil at one time as the soil may compact, between the auger and the inner surface of the tube thereby causing the tube to be lifted at the same time. After removal of the soil the tube is fitted with a pre-made silicon rubber bung to seal the bottom of the tube. This prevents water entry into the tube from a water table. The bung is inserted using a 25.0 mm pipe with 37.5mm joiner at the end fitted with a hard rubber bung containing a hyperdermic needle. The silicon bung is fitted on the needle so that the needle protrudes from the other side. This arrangements allows the air to escape from the access tube as the tight fitting silicon bung is fitted (Fig. 7).

After inserting the bung, the top of the tube is covered with a tight fitting plastic cup to prevent entry of water. During tube installation care must be taken to avoid compaction of the site around the tube as this will alter the bulk density around the tube and therefore readings obtained near the soil surface will no longer be representative of the surrounding orchard site.

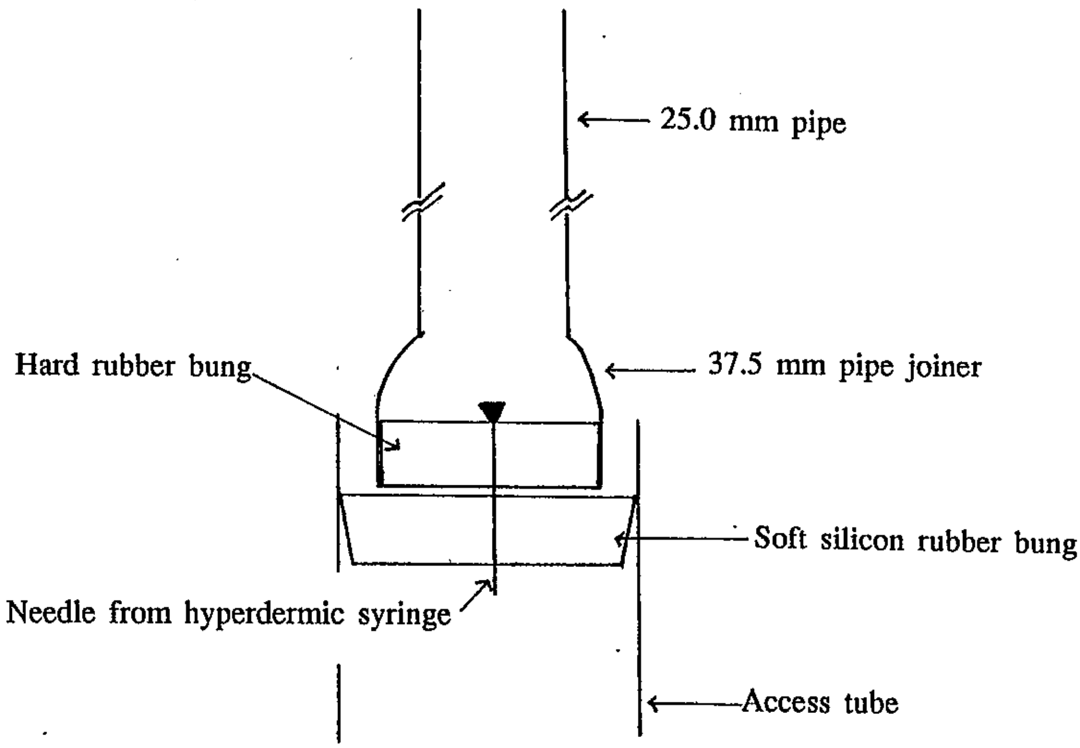

Figure 7. Diagrammatic representation of silicon rubber bung installer.

Tubes are removed using an endless chain block hung from a sturdy four legged tower. The tower is approximately 2.0 m high. The lifting chain is attached to the access tube via a bolt which passes through the tube and the end chain link.

Site Calibration

Prior to taking readings a standard count is made in an access tube installed in a 200 l drum of water. This procedure allows the operator to check that the probe and the probe electronics are functioning normally. At Loxton the standard count is measured every morning prior to taking field readings.

Calibrating the probe counts or count ratio (i.e. site reading/background count) against volumetric moisture (g/cm^3) involves a number of steps. The calibration equation is dependent on a number of factors, including soil type and bulk density. The ICMS team have built up a file of calibration equations for the soil types they have encountered. Despite this, at each new site the probe is calibrated against volumetric soil moisture (g/cm^3) as determined by gravimetric moisture (g/g) and bulk density (g/cm^3) for the range of depth they monitor (10,20,30,40,50,60,80,100,120 cm). The calibrations determined at the new site are compared with those from other sites which have a similar range of soil textures in there profile. Further fine tuning of the calibration equations may occur by applying a known amount of precipitation through irrigation and adjusting the equation accordingly.

The following steps are made to compute a calibration equation for each site:

1. Install a neutron probe access tube near the monitoring site when soil moisture is high (near field capacity).

2. Record the probe readings at selected depths.

3. Use bulk density sampling equipment to sample for gravimetric moisture and bulk density at selected reading depths. Two samples per tube per depth within 20 cm of the access tube.

4. Weigh fresh samples and record wet weight (g)

5. Oven-dry samples for 24 hours @ 105°C.

6. Weigh samples and record dry weight (g)

7. Calculate gravimetric moisture (g H_2o/g of dry soil)

$$= \frac{\text{soil wet weight (g) - soil dry weight (g)}}{\text{Soil dry weight (g)}}$$

8. Calculate Bulk Density (g/cm^3) of sample

$$= \frac{\text{soil dry weight (g)}}{\text{volume of sample (cm}^3\text{)}}$$

9. Calculate volumetric soil moisture (g/cm^3)

$$= \text{Gravimetric moisture (g/g) x Bulk Density (g/cm}^3\text{)}$$

10. Calculate mean volumetric soil moisture for each depth from the two samples.

11. Repeat above when soil is dry (near estimated refill point). For a more accurate calibration the above procedure should be carried out three or four times as the soil dries out, so that there are a number of soil moisture levels at which probe readings are taken.

12. Calculate a linear regression between the probe C/R (count ratio) readings (y - axis) and volumetric soil moisture (x-axis)

13. Compare regression lines for each depth and combine those that are statistically similar.

14. Test accuracy of equation by applying a known amount of precipitation by irrigation. If necessary fine tune the calibration equation to account for the water added.

At the calibration site a hole is hand augured and the soil hand textured, this enables the site calibration to be compared with calibrations for similar soil profiles.

Scheduling Theory

The aim of irrigation scheduling is to supply the water requirements of the crop so as to maximise yield and quality while maintaining water use efficiency. The scheduling team have a good estimate of the readily available water capacity of the soil profile from the soil pit survey. This capacity needs to be refined for scheduling purposes, hence the soil full point (drained upper limit) and refill point (soil water level at which plant water use declines) need to be defined (Fig. 8). This is done by monitoring the site for approximately three months and calculating the change in total soil water storage over a specified depth, with time in relation to present irrigation practices and rainfall. Gradually the monitoring personnel build up a feel for what is happening to the soil water and refill and full points are determined.

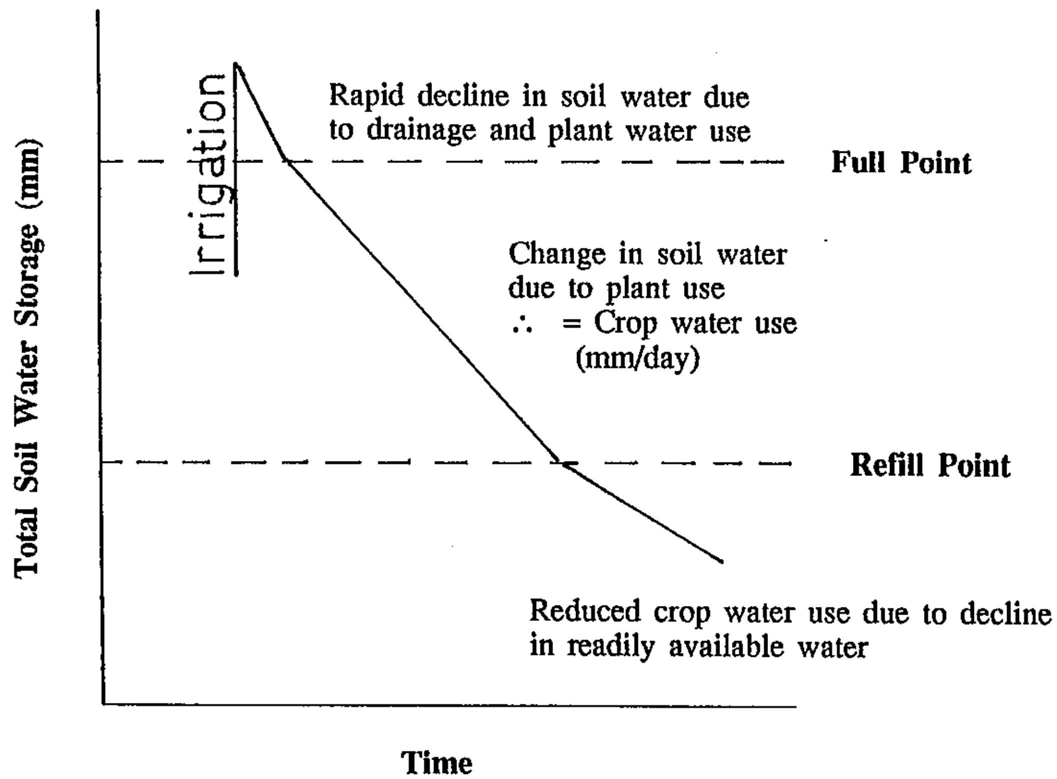

Figure 8. Representation of total soil water against time.

The refill point is not necessarily static, it changes with crop, season or plant phenological stage. During the plant's dormant periods the refill point would be much lower than that required when the plant is actively growing eg. fruit set and filling. The I.C.M.S. scheduling group emphasised that in any new scheduling situation (e.g. new crop) three to four months is required to determine the full and refill points with accuracy. Crop water use (mm/day) as determined from the graph of total soil water with time are compared with crop water use figures as determined by evaporation data and crop factor information. Although the process appears to be lengthy the long term benefits for orchard crops are that, once an irrigation schedule has been determined over several seasons, the grower is able to irrigate with confidence knowing that he is maximising water use efficiency and minimising the environmental degradation and economic cost which can occur with incorrect irrigation practices.

Conclusion

The use of soil moisture measuring devices such as the neutron probe and tensiometer are only a part of managing crop irrigation effectively. The I.C.M.S. has developed in such a way that it incorporates the necessary disciplines (soil survey, irrigation system testing, sprinkler testing and irrigation scheduling) required to make effective decisions about irrigation management. The I.C.M.S. has the added flexibility in that the various disciplines can work separately from each other and also work together. Having the various disciplines within one body make for effective co-operation between groups. The people who have most to gain are the irrigated crop farmers of the area who have access to a fully co-ordinated irrigated crop management service.

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3. Loveday, J. (1974). Ed. "Methods for analysis of irrigated soils". Technical Communication No. 54 of the Commonwealth Bureau of Soils, C.A.B.

APPENDIX

South Australian Department of Agriculture
'fact sheets' relevant to irrigation management.

FS	38/86	Evaluating your fruit property
FS	39/86	Understanding Riverland soils
FS	40/86	Evaluating sprinkler systems
FS	41/86	Monitoring soil water
FS	42/86	Tensiometers - preparation and installation
FS	44/86	Interpreting tensiometer and testwell readings

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Evaluating your fruit property

By Officers of the Irrigated Crop Management Service, Loxton Research Centre

Fruitgrowing should be about making money. Every fruitgrower should aim to make money by growing healthy, high yielding plants that produce quality fruit.

You will be able to improve the health and production of your plantings by looking at your crops and soil, measuring and recording what is happening on your property, analysing your records and seeking advice if necessary.

There are five key steps in this process:

- Record your management practices.
- Inspect the plantings and record what you see
- Collect and record information about the soils, plants and fruit quality
- Analyse the information you collect
- Seek assistance as necessary.

Record management practices

Record your management practices as you complete each job. You can compare them from year to year. You should record:

- Spray program including the date of spraying and time of day, areas sprayed, type of chemical, quantity used, and the weather conditions.
- Fertiliser program including the date of application, areas covered, type of fertiliser and amount used.
- Pruning and hedging times.
- Irrigation program including the date, area irrigated, and amount of water applied at each irrigation. Rainfall should also be recorded.
- Production including yield and harvest period for each patch, percent packout, fruit size, and fruit quality.
- Gross returns and production costs for each patch. The gross return is the price you receive for your fruit. The production costs include the cost of fertiliser, water, electricity, herbicide, wages for pickers, pruning, fuel and so on.

Record also overhead costs which include council rates, loan repayments, bank charges and insurance.

Inspect the plantings

Regularly inspect your plantings so that you can control problems before they get out of hand. Don't just drive through the property, but walk slowly through each patch, stopping to look at the plants in detail.

Resist the temptation to walk down the same rows. Vary the route through the patch and make sure you look closely at the problem areas. At the same time, look at the areas you think are healthy: you may be surprised at what you find.

Make a note in your diary or notebook of important observations and any problems that are evident. These notes will be a reminder of the state of your property and will help you make comparisons from year to year. Some things you observe will indicate a management problem and by recording them you will have a reminder to prevent the problem occurring again.

Make regular checks of the following points.

Plantings

- Weak growth;
- vigour of new growth;
- wilting;
- leaf colour;
- pests and diseases;
- abnormal growth;
- frost, hail, wind, and sun damage;
- leaf burn and leaf drop.

Crop yield and quality

- Amount and extent of flowering;

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AGDEX 560

 ISSN 0725-3516

FS 38/86

- fruit set;
- fruit drop;
- fruit sizing;
- external fruit quality;
- internal fruit quality.

If you are really keen, take a ride in a plane, preferably in autumn, and inspect your property from the air. Look for uneven growth patterns, patches of weak growth and unevenly watered areas.

To get a permanent record of the appearance of the property, buy an aerial colour photograph from the Department of Lands at Berri. Aerial photos are taken every two years in the Riverland, so it is always possible to get an up-to-date picture of your block.

Irrigation and drainage

Check that your irrigation system is operating efficiently. (See fact sheet 40/86 *Evaluating sprinkler systems*).

If drains are installed, make sure they are not blocked.

Root system

Dig holes in each patch and check the health of the root system, looking especially for problems with root rotting and nematodes.

Soil

Dig holes and check soil moisture and depth to the water table (if you have one). See fact sheet 41/86 *Monitoring soil water.*

Collect and record measurements

Almost all management decisions must take into account measurements taken on your property. It is vital to collect and properly record this information.

Measurements include:

- Annual leaf analysis which measures the nutrient and salinity levels of your crop. Leaf analysis kits are simple to use and readily available.
- Soil salinity, periodically determined from samples of soil sent to a laboratory.
- Fruit size, total soluble solids, brix/acid ratio and any other factor important for fruit production and quality.
- Water available to your plants, measured with tensiometers.
- Depth to water table, measured with testwells.

Some of these measurements should be made on a regular basis. Others need to be made when relevant. It may be necessary for you to seek specialist help in determining this.

Analyse the information

A simple way to analyse records is to graph them. Some useful graphs can be prepared from:

Leaf analysis results

By graphing nutrient results from the same patch, the levels of each nutrient can be compared from year to year. Trends that you can see in the graph allow you to compare the effect of fertiliser applications over any given period. In the same way, graphs of sodium and chloride levels can show the effect of irrigation on each patch and can be used to identify both irrigation system and management problems.

Comparing your values with known standards will tell you if they are too high or too low. It is also useful to compare values with those of other growers in the district. Figure 1 shows a graph of leaf analysis values plotted from year to year.

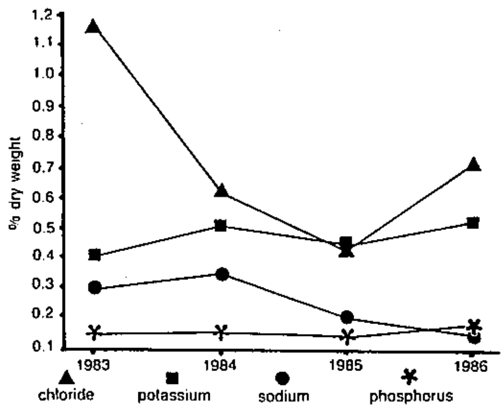

Figure 1: Plotted leaf analysis results from year to year in Valencia.

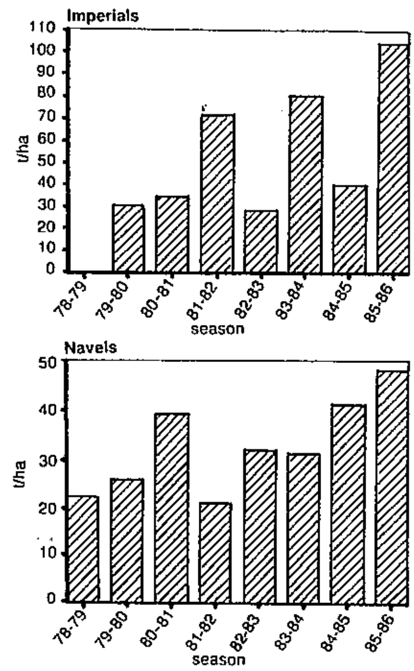

Figure 2: Yields for different patches of citrus from 1978-79 to 1985-86

Yield results

Graph the yields for each patch. The observations you recorded when inspecting your property and the measurements you record at harvest will help to explain the trends. The bar graph shown in figure 2 is a good method of graphing yields.

Soil moisture and water table levels

Graph your tensiometer and testwell readings as shown in the fact sheet 44/86 *Interpreting tensiometer and testwell readings*. Graphing these readings helps you decide when to irrigate and how much water to apply.

Profitability

Determine the gross margin for each of your plantings using the gross returns and production costs. Figure 3 is an example of a gross margin calculation for a single hectare of valencias.
Figure 4 is a bar graph showing gross margins for a common mix of crops on Riverland properties, which enables you to compare the performance of different plantings. For information on how to determine the profitability of your plantings, refer to the Department of Agriculture's Regional Economist, or your accountant.

Seek assistance

Where a problem is found or if you require better performance from your plantings, seek assistance. There are many sources of information and advice for fruitgrowers in the Riverland. Don't rely only on neighbours for advice on your property — seek specific technical advice. The Department of Agriculture has district advisers serving all areas in the Riverland, and they are a good first contact. Specialist advisers and research officers may be needed to solve some problems. The action required will depend on the problem. A sample of plant or soil may be all that is needed to assess the problem in some situations.

Don't be afraid to ask for advice if you need it.

Advice is also available from

- Engineering and Water Supply Department's Irrigator Advisory Service;
- private consultants;
- packing shed and winery field representatives;
- fertiliser and chemical company field representatives;
- irrigation suppliers.

Remember also that by keeping records of your management practices, observations and measurements, you will make the job of advisers and specialists much easier when they are needed to help you solve your problems.

Keep up to date with current technical information. The Agricultural Bureau is an excellent source of information through guest speakers and field days. As well, it fosters informal sharing of experiences with other growers.

It is also important to stay informed by reading information provided by wineries, packers, grower organisations, fertiliser and chemical companies, your local newspaper, and in publications from the Department of Agriculture.

Figure 3: Worksheet setting out gross returns, production costs and gross margins for a 1 ha patch of valencias

Region: Riverland   Crop: Valencias   Area: 1 ha
Irrigation: sprinkler   Planting spacing: 250 trees/ha

Gross return			$
t/ha 40	@	$125.00/t	5 000.00
less grower levy		$1.56/t	62.40
TOTAL GROSS RETURN			4 937.60
Production costs			
Pest and nutrient sprays			
Urea (2 appl) 21 kg/ha	@	$394.00/t	16.55
Summer oil 80 L/ha	@	$1.13/L	90.40
Z-M (2 appl) 7 kg/ha	@	$1.35/kg	18.90
Copper oxychloride 7 kg/ha	@	$2.75/kg	19.25
Fertilisers			
Superphosphate 625 kg.ha	@	$162.00/t	101.25
Urea 400 kg/ha	@	$394.00/t	157.60
Cover crop 7 kg/ha	@	$2.00	14.00
Irrigation			
Water 13 000 kL/ha	@	3.49c/kL	453.70
Power	@	2.50c/kL	325.00
Herbicides			
Roundup 2 L/ha	@	$19.21/L	38.42
Bromacil 0.6 kg/ha	@	$38.00/kg	22.80
Diuron 3.5 L/ha	@	$4.40/L	15.40
Other costs			
Picking	@	$25.25/t	1 010.00
Loading	@	$0.00	0.00
Freight	@	$7.00/t	280.00
Fuel 10 hours	@	$1.80/h	18.00
TOTAL PRODUCTION COST			2 581.27
GROSS MARGIN			2 356.33

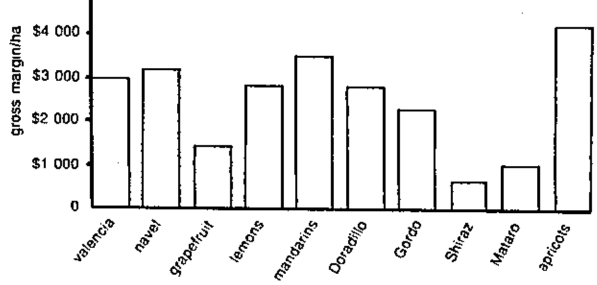

Figure 4: Gross margins for each patch of planting on a property

Summary

Monitor the state of your property by following the five steps listed above.

Record your management practices, regularly inspect your plantings, collect and record measurements, and analyse your records. This may sound tedious, but it will help you to assess the state of your property and ensure that your plantings are healthy, high yielding and profitable. If problems occur and you need help, these records will make solving the problem much easier.

Other fact sheets in this series prepared by the Irrigated Crop Management Services, Loxton Research Centre, are:

39/86 *Understanding Riverland soils*
40/86 *Evaluating sprinkler systems*
41/86 *Monitoring soil water*
42/86 *Tensiometers—preparation and installation*
43/86 *Installation of testwells*
44/86 *Interpreting tensiometer and testwell readings*

For information and advice about irrigation management on your property, contact your District Office or the Irrigated Crop Management Services, Loxton Research Centre, Box 411, Loxton 5333; telephone (085) 84 7315.

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Understanding Riverland soils

By Officers of the Irrigated Crop Management Service, Loxton Research Centre

In the Riverland, where the water needs of crops are met almost entirely by irrigation, it is the soil that must store this water and supply it to the plants.

To make life difficult for the irrigator, Riverland soils are extremely varied. The wide range of textures and the variation in soil depth cause large variations in water storage. Understanding these soils is the basis of good irrigation management.

A cross section of the Murray Valley (figure 1) gives a general picture of soil types within the river valley, and above the valley in the area known as the Mallee Highland.

Soils within the river valley were formed when fine clay and silt particles were deposited over the flood plain by the River Murray. These soils are loams and clays which grow mainly vines, stonefruits, pomefruits, and vegetables.

Above the valley, the soil types are known as mallee soils, consisting of wind blown sands which overlie layers of lime and clay. The landscape is characterised by depressions, rises and sandhills formed by wind and water erosion.

The position in the landscape determines a soil's depth and texture and its best use. For example, vines are commonly grown on the depressions while citrus is more common on the rises and sandhills.

Many of the important decisions in irrigated horticulture require an understanding of the soil. Examples are the choice of crop and irrigation system, and irrigation scheduling. This fact sheet provides the background to understanding Riverland soils by describing basic soil characteristics.

Texture of the soil

Soil texture depends on the proportions of sand, silt, clay and organic matter present in the soil. Table 1 shows the percentage of these in typical Riverland soils.

Sand particles are much larger than clay particles and therefore sandy soils feel coarse compared with clay soils, which feel smooth when wet. The soils of the Riverland generally increase in clay percentage with depth, and therefore the textures can change from sands to loams or from loams to clay loams down the soil profile. As an example figure 2 shows the texture layers in two typical Mallee soils.

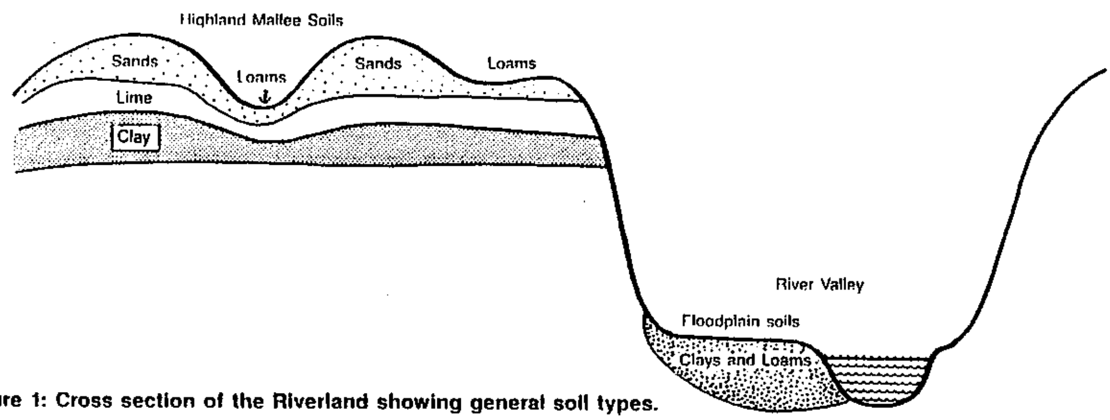

Figure 1: Cross section of the Riverland showing general soil types.

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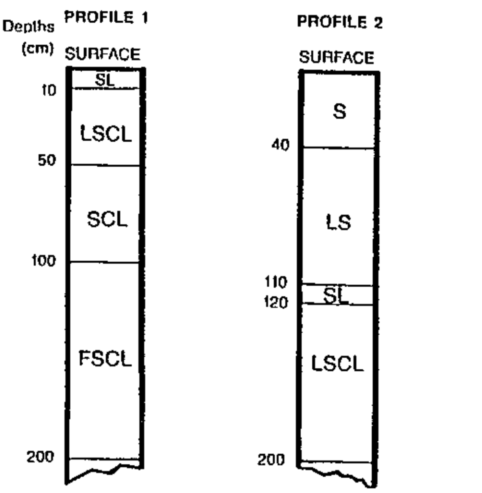
AGDEX 560

 ISSN 0725-3516

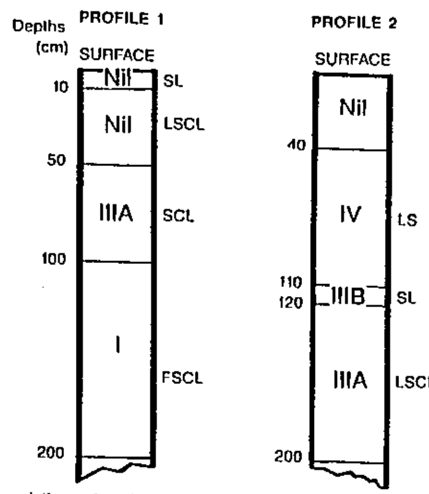
Table 1: Composition of sand, silt and clay particles in typical Riverland Soils.

Texture	Clay (%)	Composition Silt (%)	Sand (%)	Location
Sand	4	2	94	Mallee highland
Loamy sand	9	2	89	Mallee highland
Sandy loam	15	8	77	Mallee highland
Light sandy clay loam	17	11	72	Mallee highland
Sandy clay loam	23	15	62	Mallee highland and River valley
Fine sandy clay loam	30	14	56	Mallee highland and River valley
Light clay	32	14	53	River valley
Medium clay	37	15	48	River valley



S = Sand, LS = Loamy sand, SL = Sandy loam, LSCL = Light sandy clay loam, SCL = Sandy clay loam, FSCL = Fine sandy clay loam.

Figure 2: Soil texture layers in two typical mallee soils.



Note: Descriptions of each lime layer classification are given in Table 2.

Figure 3: Lime layers in two typical mallee soils.

Table 2: Summary of lime classes

Class	Description
I	Fine lime in a clayey soil. Class I lime becomes soft and plastic with irrigation, resulting in poor drainage which leads to waterlogging. Root growth is poor
II	Sheet or boulder limestone. Drainage is excellent except where limestone occurs as a solid sheet. Root growth is excellent if Class II is in boulder form.
III	Layers of this type are characterised by a distinct colour change between the topsoil and the lime layer. There are three types:
IIIA	Compact mixture of fine and rubbly lime and loamy soil. The rubble consists of small stones less than a centimetre in diameter. Drainage through Class IIIA is fair but root growth is poor or nil.
IIIB	As for IIIA except that the rubble consists of stones up to 10 cm in diameter. Drainage through Class IIIB is good and root growth fair to poor.
IIIC	As for IIIA except that rubble consists of stones up to 30 cm in diameter. Drainage through Class IIIC is good and root growth is fair.
IV	A weak accumulation of fine lime in a sandy soil. Drainage and root growth are good

Between the sand, silt and clay particles are small pores filled with water and air. When the soil is irrigated, water moves down through the soil filling most of the pores. Between irrigations, water is extracted from the pores within the soil by the plant's root system.

Soils within the river valley are generally clayey. Drainage qualities vary, depending on the amount of clay in the soil: the higher the clay content, the poorer the drainage. For example, heavy river-flat soils do not drain well and the rootzone is shallow.

Mallee soils generally have sandy surface textures with better infiltration and drainage qualities. Changes in the landscape from sandy rises and sandy clay loam depressions result in these soils' being more variable in depth and texture over short distances. In addition, many surface soils in the Mallee Highland are shallow.

The rootzone

The rootzone of a crop is simply the depth to which roots penetrate. More importantly, the effective rootzone is the depth over which roots extract most of the water available to the plant. Hence it is the effective rootzone depth that should largely determine the depth required at an irrigation.

The effective rootzone depth can be restricted by the presence of shallow lime layers and clay layers.

Lime layers

Lime layers occur in all mallee soils. A lime layer restricts root growth because of the high concentration of free lime. Table 2 describes the four different classes of lime layer and how each class affects root growth and drainage.

The classes are established according to the texture of the soil material in the layer, and the size of the lime fragments. As an example, figure 3 shows the position of lime layer classes in two typical mallee soils. Figure 4 shows how these same lime classes affect root growth.

Clay layers

Mallee soils are often underlain by a clay layer, known as the Blanchetown Clay, which restricts free drainage of water. Excess irrigation water collects on top of the layer, which is often several metres thick, producing a perched water table. This perched water table may rise into the root system of the plant, reducing crop health and yield. A class 1 lime layer in the soil profile is a good indication that Blanchetown Clay underlies the property.

In summary, the depth of the rootzone depends on the depth of topsoil above the clay and lime layers. Where these layers are shallow, the effective rootzone will be restricted and drainage problems are likely to occur. It is important to check your soils to determine the depth of the rootzone. Knowing this will allow you to determine the amount of water the soil can hold and make available to the plant.

Water available to the plant

How much water to apply has been asked many times by growers uncertain whether they are applying too much, or too little. When soil is irrigated, water is stored in the soil pores. The amount of water that can be easily extracted is called the 'available water'. This amount is determined by the depth of the effective rootzone and the texture of the soil layers in the rootzone. Table 3 shows the amount of water available to the plant per metre depth, for various soil textures found in the Riverland.

The amount of available water is also the amount of water required to fill the soil when the crop is due for irrigation.

In figure 4 the available water has been calculated for two rootzones. Soil profile 1 has a lime layer at 50 cm which restricts root growth to this depth. Soil profile 2 has a rootzone of 120 cm and therefore has a higher available water content. Deeper and less frequent irrigations would be appropriate for this soil.

Table 3: Water available to the crop in typical Riverland soils.

Texture	Available water (Millimetres per metre depth of soil)
Sand	30-50
Loamy sand	50-60
Sandy loam	60-65
Light sandy clay loam	Approx. 65
Sandy clay loam	65-70
Fine sandy clay loam	Approx. 65
Light clay	Approx. 60
Medium - heavy clay	Approx. 40

There are several ways to monitor the amount of water available to the crop, and each method helps the grower to decide when to irrigate next, and how much to apply. These methods are discussed in the fact sheets 41/86 *Monitoring soil water*, and 44/86 *Interpreting tensiometer and testwell readings*.

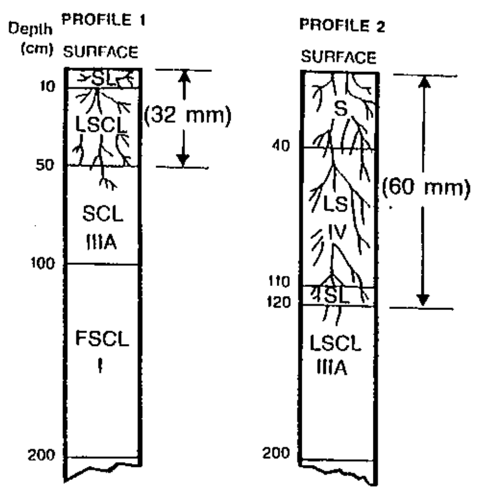


Figure 4: The amount of water (mm) available to the plant in two typical mallee soils.

Other soil characteristics

Soil pH

Soil pH measurements are taken to determine the acidity or alkalinity of the soil. Where the pH is less than 7, the soil is acidic and where it is greater than 7, it is alkaline. Soil pH should be taken into account when considering which crops to plant on your property.

Fine lime in surface soils increases the pH and as a result reduces the availability of nutrients such as iron, manganese, zinc and copper. Lime-induced chlorosis is very common in the Riverland owing to the high fine lime content.

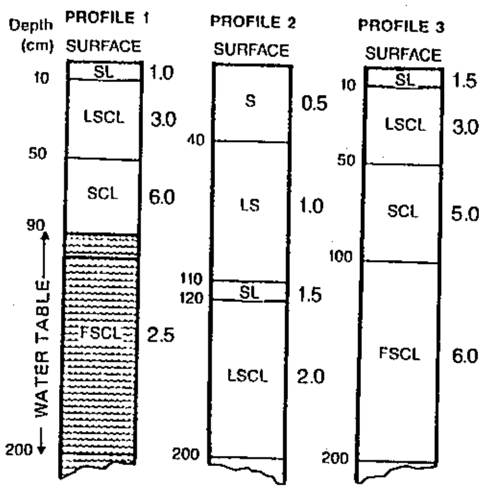
Soil salinity

Millions of years ago the land through which the River Murray now flows was a vast sea and the natural salt from the sea remains in the soil. Hence soils that have never been irrigated can be high in salinity.

However in irrigated areas, high salinity is usually an indication of poor irrigation management. Rising water tables produced by over-irrigation can bring salts dissolved in the ground water up into the plant rootzone, adversely affecting the crop health and yield. On the other hand, under-irrigation leads to high soil salinity owing to inadequate leaching of salts from the plant's rootzone.

Uneven distribution of water can lead to high soil salinity as salt accumulates in the under-watered areas. These areas are not leached when you irrigate your property.

Profile 1 in figure 5 shows the salinity values in a soil profile where over-irrigation has brought salt up into the rootzone from a shallow water table. Profile 2 shows the



Soil salinity in milliSiemens per centimetre (mS/cm)

Soil salinity standards for horticultural crops

mS/cm	Assessment
0-1.5	Low salinity
1.5-3.0	Some yield loss — most crops
>3.0	Severe effects — high crop losses

Figure 5: Soil salinity in three typical mallee soils.

salinity values in a profile that has been adequately leached. Profile 3 shows the effect of under-irrigation, which has failed to adequately leach the rootzone.

Soil surveys

In the Riverland, soils can change texture and depth over very short distances. There can be a big variation in soil types on a single property. It is important to dig holes over your property to see what soils you have, their depth, the type of impermeable layers, and the depths of the root system of your plantings.

The Department of Agriculture offers a Land Use Service which carries out soil surveys. This involves digging holes on a grid over the property at a spacing that varies from 50 m to 100 m in order to see where the soil changes occur. The holes can be dug by power auger or backhoe to a depth of about two metres. The backhoe is the preferred method since it allows the layers of soil to be clearly seen. At each pit, the following information is recorded:

- depth of effective rootzone
- depth and texture of each soil layer
- depth and type of lime layer
- depth to Blanchetown Clay, if present
- field pH of each layer
- fine lime content (its reaction to diluted hydrochloric acid)
- soil salinity.

The depth of the rootzone and the soil texture are recorded on a plan of the property. Figure 6 shows the soil map for a property with three different soils. These three areas need to be irrigated differently.

Information obtained from the soil survey is used to determine the amount of water to apply at an irrigation.

A soil map produced from the survey will allow the grower to select a suitable crop for horticultural development. It will assist in planning any replanting programs and help in the design of irrigation systems. Maps showing the amount of water the soil can store for the crop's use will help growers to determine how much water to apply to their soils.

Summary

Understanding your soil is essential. It will ensure healthier crops with greater yields and save you money through more efficient water use. Do you know your soils well enough to make the right management decisions?

Other fact sheets in this series prepared by the Irrigated Crop Management Services, Loxton Research Centre, are:

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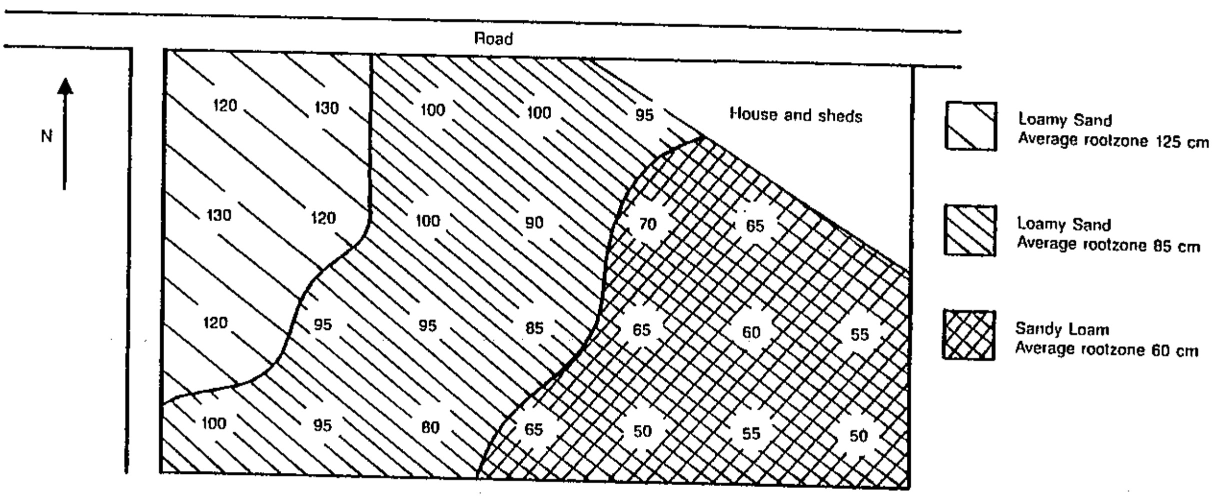

Figure 6: A soils map of a mature citrus planting showing surface soil textures and depth of the rootzone.

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Evaluating sprinkler systems

By Officers of the Irrigated Crop Management Services, Loxton Research Centre

Horticultural crops in the Riverland need water. Natural rainfall is insufficient so an irrigation system is needed on every property. To get the best results from an irrigation system you need to understand it and periodically check its efficiency.

Many types of irrigation systems are being used in the Riverland, but this fact sheet describes how to evaluate sprinkler systems, since they are the most common system. Sprinklers water more than 65 per cent of horticultural plantings in the region.

There are three essential things you should know about your system.

- What depth of water does it apply?
- Does the depth of water vary from sprinkler to sprinkler, and if so, by how much?
- Do the sprinklers spread the water evenly?

Serious problems have occurred on many properties because growers have not known to what depth or how evenly the water is being applied. A good system applies the required amount of water, evenly.

To evaluate your system, a few measurements must be taken on the property, under actual working conditions. It is important to test both old and new systems: new ones because they should be operating to design specifications; old ones because their efficiency deteriorates with use.

There are many reasons why a new or an old system performs poorly. The problem is not always obvious until it is too late and the plantings have declined.

Here is how to go about evaluating your sprinkler system:

- Collect all the equipment required for the tests.
- Measure the sprinkler pressures and pressure variation across the property.
- Check the nozzle sizes used.
- Measure the depth of water applied.
- Determine the pump performance.
- Check for wear in sprinklers.
- Measure the sprinkler's distribution pattern.

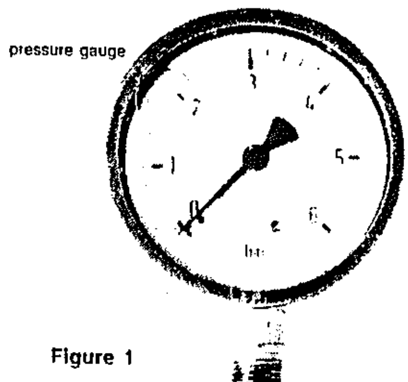

Figure 1

Figure 2

This is what you'll need:

- A current irrigation design of your property.
- A good quality, accurate pressure gauge with a range of 0-400 kiloPascals (kPa) (see figure 1).
- A pilot tube for taking pressures of over-canopy sprinklers and large low-level sprinklers (see figure 2).
- A threaded tee piece and fittings for taking pressures of small low level sprinklers (see figure 3).
- Three to four metres of flexible plastic tubing to measure outputs. The tubing should be of a size which will allow it to fit over the sprinkler nozzles.

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 ISSN 0725-3516

- A bucket or drum large enough to collect the flow from a sprinkler for 30 seconds.
- A watch that measures in seconds.
- A large metric measuring jug.
- A small measuring cylinder or rain gauge.
- At least 30 tin cans with a minimum height of 100 mm, to measure the distribution of sprinklers. Reject cans may be available from Containers Ltd, Berri.
- A tape measure 30 to 50 m long.

Measuring sprinkler pressure and pressure variation

Variation in the depth of water being put on to your block is mainly caused by variation in sprinkler pressures.

If the system is working properly, the valves will be adjusted so that the average pressure over the whole unit is as close as possible to the design pressure stated on the irrigation plan. None of the sprinklers should be operating at more than 10 per cent above or 10 per cent below this average pressure.

When checking pressures, the first step is to adjust any sub-main or internal valves to the pressure shown on the irrigation plan. This should be done at the start of each irrigation season by carefully adjusting each valve several times until steady, correct pressure is achieved.

The second step is to measure the operating pressure of at least 10 sprinklers spread across each irrigation unit. This must include the sprinklers nearest the valve, at the start and ends of laterals, and at points of high and low elevation.

The irrigation unit should be operating under normal conditions when this is done.

How to check pressures

Over-canopy and large low-level sprinklers

Attach the pitot tube to the gauge and then position it as shown in figure 4, with the end of the tube held into the water stream, about 3 mm away from the nozzle. The reading may fluctuate, but the correct reading will be the highest registered on the gauge with the pitot tube in this position. Don't worry if you get soaked at the first attempt: staying dry comes with practice.

Small low-level sprinklers

Attach the threaded tee piece to the gauge. Then select a sprinkler and choke off the water by crimping back the connector tube. Remove the sprinkler and replace it with the tee piece, finally screwing the sprinkler on top of the assembly. Release the connector tube and record the pressure.

From the reading taken at 10 or more sprinklers, calculate the average pressure by adding all the pressures together, and dividing them by the number of sprinklers used in the test. The result should be close to the sprinkler pressure stated on the irrigation plan. If the variation is greater than 10 per cent above or below this, try to reduce it by adjusting any internal valves installed in the system. If the variation cannot be reduced to within the ten per cent tolerance level, discuss the problem with an irrigation designer.

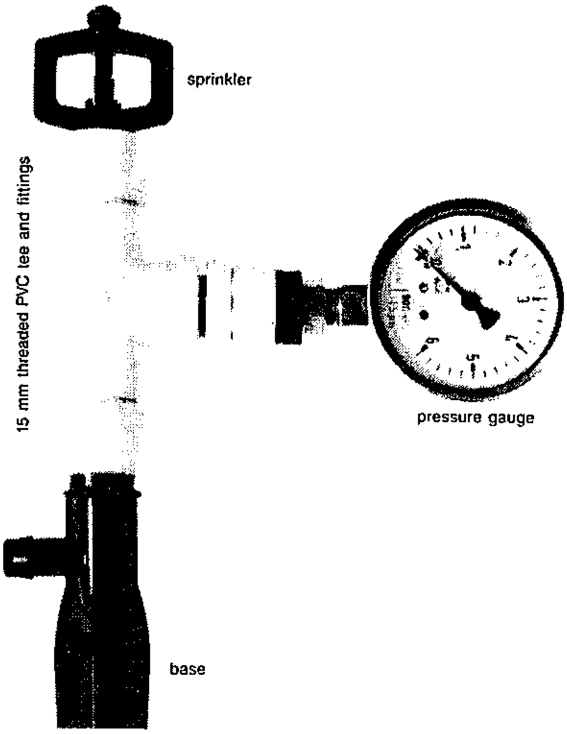

Figure 3

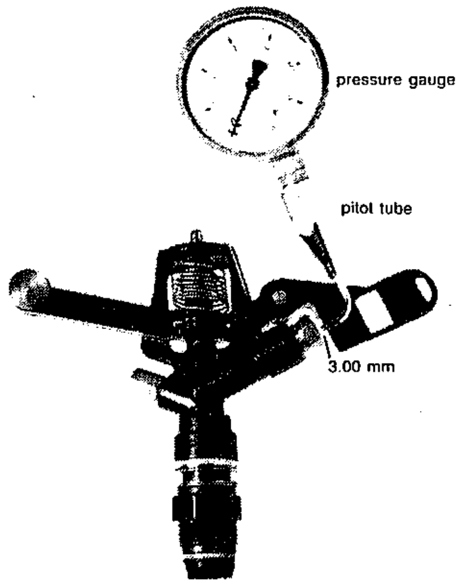

Figure 4

Check nozzle size

Sprinklers should have the nozzle size stated on the irrigation plan to ensure an even depth of water is applied across the irrigation unit. It is usual for nozzle sizes to be uniform throughout, although sometimes the size varies to satisfy differences in pressure or spacing. Study the irrigation plan carefully and check the nozzle sizes across the unit. Most nozzles are marked with their size in millimetres, fractions of an inch or, in the case of plastic nozzles, by color coding.

Unmarked nozzles with round openings can have their size checked by carefully inserting the shank of an unused steel drill bit into the nozzle. The bit with a snug fit indicates the nozzle size. This method can also be used to check for nozzle wear. A sloppily fitting drill bit of the same size as that stamped on the nozzle indicates substantial wear, and the nozzle should be replaced.

Measuring the depth of water applied

The depth of water applied is simply the amount of water that would be collected in a rain gauge placed at the soil surface during irrigation.

Two factors affect the depth of water applied during irrigation:

- The volume of water used (litres or kilolitres)
- The area being irrigated (square metres or hectares)

To irrigate efficiently, you must know what depth of water your sprinkler system is applying. This will ensure enough water is applied and will minimise the amount lost to drainage.

Two simple steps are used to measure the depth of water being applied. First, record the meter reading (usually in kilolitres) at the start and finish of the irrigation. Subtracting the reading at the start from the reading at the finish will give you the kilolitres used. Then look at your irrigation plan to find out the area that was irrigated. This is how you find out the depth of water applied:

$$\frac{\text{kL reading at finish} - \text{kL reading at start}}{\text{Area irrigated (hectares)} \times 10} = \text{depth in millimetres (mm)}$$

The second step uses the discharge of an individual sprinkler and the area over which it applies the water. Using the manufacturer's performance chart, read off the discharge for the combination of nozzle size and pressure.Then work out the area being irrigated by each sprinkler. This is done by measuring the distance between rows of sprinklers, and the distance between sprinklers down the row. Figure 5 gives an example in vines, and figure 6 in citrus. The spacings will be on your irrigation plan, but check them on the block with a long tape measure.Here's how to work out the depth applied:

$$\frac{\text{discharge in litres per hour}}{\text{distance between sprinklers along row (metres)} \times \text{distance between rows of sprinklers (metres)}} = \text{depth in mm}$$

That gives you depth applied in one hour; to calculate the total depth of water applied in an irrigation, multiply the depth an hour by the number of hours the system operated.

Compare the depths determined by the two steps, as they can be used to check each other. Several factors can cause differences, such as an incorrect estimate of the area irrigated, an inaccurate meter, and incorrect measurement of sprinkler spacing

Since nozzles are affected by wear, it's essential to periodically measure discharge and compare this with the manufacturer's performance chart. Do so by collecting the discharge from a sprinkler in a bucket for 30 seconds. In the case of small low-level sprinklers, hold back the arm or spinner and direct the stream into the bucket for the 30 seconds. With large sprinklers, place the end of three to four metres of plastic tubing over the nozzle, and direct the stream into a bucket for 30 seconds. Where the sprinkler has a rear nozzle, repeat the test on the second nozzle to determine the total discharge.

Measure the water collected in litres, using a measuring jug. To determine the discharge in litres an hour use the calculation:

Litres collected in 30 seconds x 120 = litres an hour.

Repeat the test on at least 10 sprinklers across the irrigation unit. The discharge measured over your block should be compared with the manufacturer's specifications. If yours are more than about 15 per cent higher, it is likely that substantial nozzle wear has occurred, and you should consult your supplier about nozzle replacement.

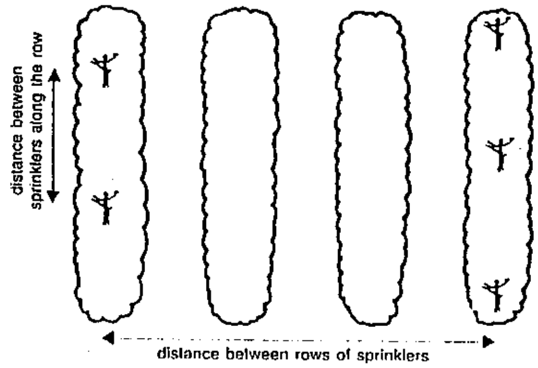

Figure 5: Row and sprinkler spacing in vines

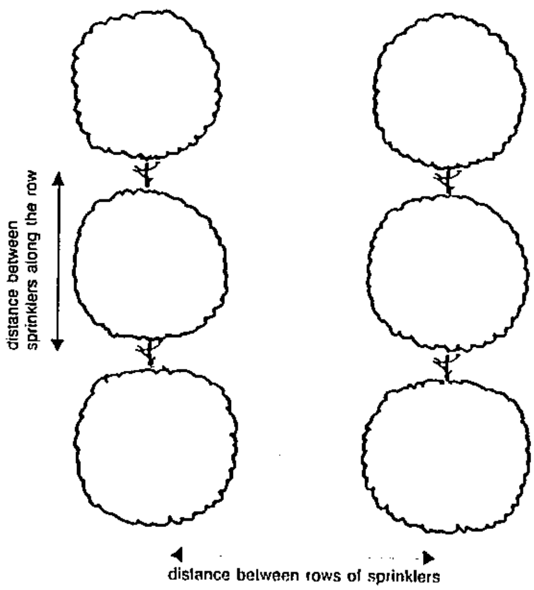

Figure 6: Row and sprinkler spacing in citrus

Measuring pump performance

Pumps and motors also wear out with use. Most growers accept this as fact but do little about it until the unit fails. Many irrigators are unaware of how well the pump set is performing, the real operating pressure or the efficiency

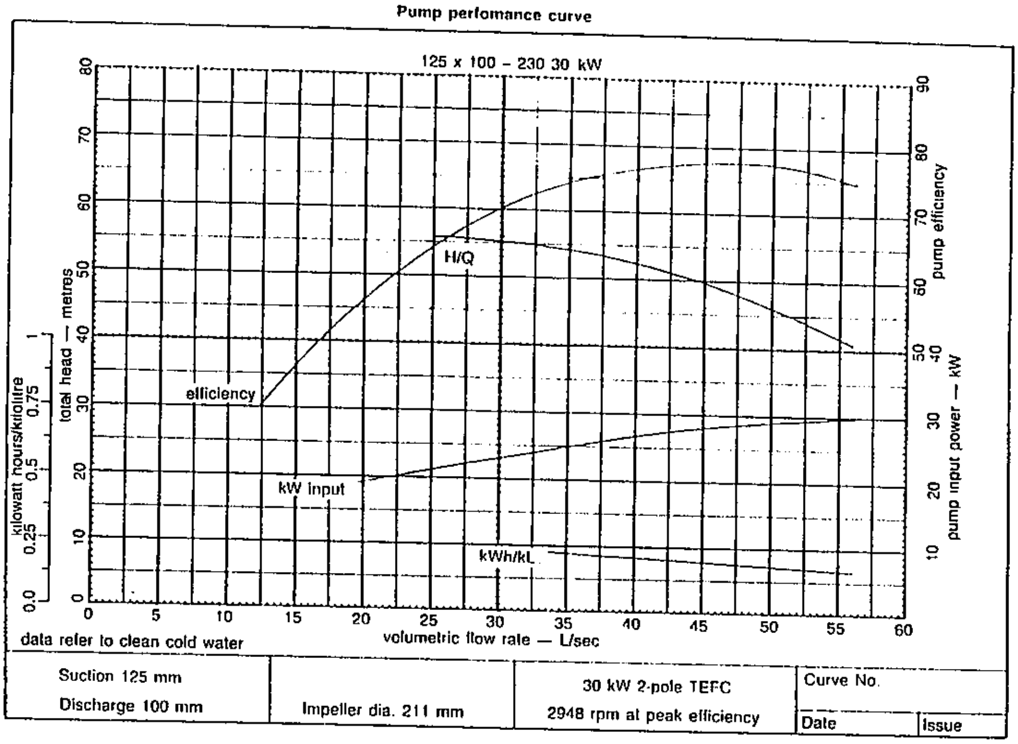

Figure 7: Pump performance curve

of pumping. Nor do they have a chart of the pump curve to show at what flow the optimum efficiency of the pump set is obtained (see figure 7). A measurement of pump performance is a job for qualified, experienced personnel such as local qualified dealers or consultants. This, and corrective action where necessary, are essential parts of evaluating your sprinkler system.

Measuring sprinkler wear

Watch your sprinklers during an irrigation to see if they are working properly. Look for:

- excessive leakage of water around the sprinklers;
- 'dumping' water around the sprinklers;
- uneven rotation (seen as 'fluttering' in small sprinklers);
- loss of throw, leading to dry or underwatered areas;
- sprinkler parts distorted by the sun, for example, the bridge of microsprinklers;
- sprinklers not working, or stopping during an irrigation.

During winter, dismantle some sprinklers and check for wear of parts. This includes wear of the spindle, spinner and nozzles of microsprinklers, and the base, connector tube, seals, washers, springs, arms, spindles and nozzles of larger undertree and overcanopy sprinklers. Replacement of worn sprinklers and parts during winter will prevent problems arising from sprinkler failure during the irrigation season. It will prevent a decline in plant health caused by poor sprinkler performance.

Calculating sprinkler distribution

If the sprinklers distribute the water unevenly, some areas will receive too little water and others too much.

Underwatered areas will be inadequately leached and salty, and in the overwatered areas large amounts of water will be wasted. If you attempt to remedy this problem by applying more water, the extra amount is likely to create drainage problems.

You can check the evenness of distribution by simply placing a grid pattern of empty tin cans between sprinklers. At least 30 cans of the same size should be used. Ensure the cans are upright, and not under low hanging foliage. The can layout will depend on the type of crop, and the type of sprinkler system installed. Figure 8 shows several can layouts for various crops.

For low level sprinklers, the cans should be dug into the ground with about 25 mm showing above the surface. This will ensure that the cans are below the throw of the sprinker.

Sketch a plan showing the position of the cans in relation to the sprinklers and trees or vines. Turn the sprinklers on and operate them normally for at least two hours, but preferably for a full irrigation. Record the direction and strength of the wind during the test.

After the sprinklers have been turned off, measure the contents of each can using a measuring cylinder or rain gauge and record the amount on the sketch plan.

Repeat the test to determine the evenness of the distribution over a range of wind conditions. As well, carry out the test at several locations in the irrigation unit.

Now for some simple sums to find out how evenly the sprinklers distributed the water.

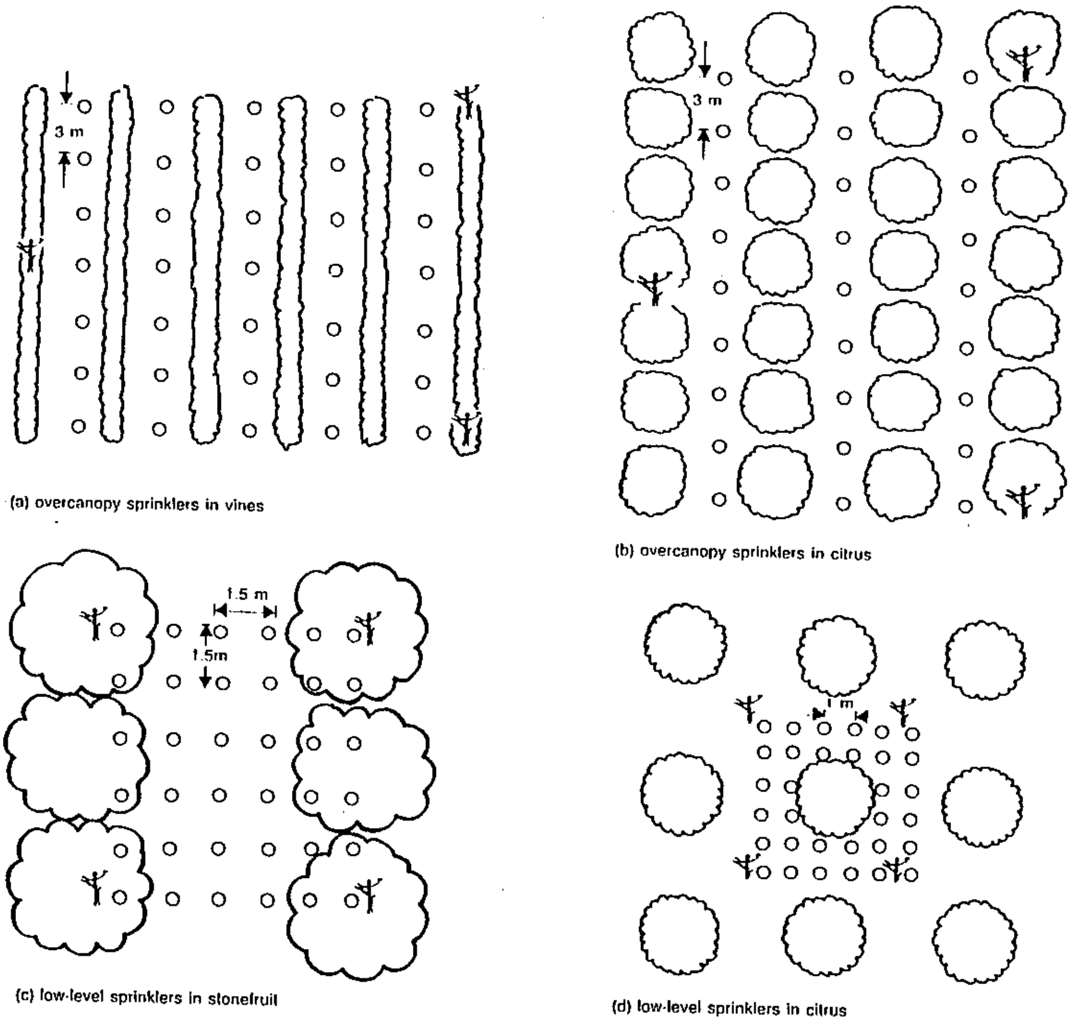

Figure 8: Examples of can layouts; cans spaced so that about 30 are used for each test.

How to calculate distribution uniformity

From the sketch plan, firstly average the contents of the cans by dividing the total amount of water by the number of cans. Then circle the lowest amount, the next lowest, and so on, until you have circled a quarter of the values on the plan.

The next step is to average this 'lowest quarter' of the readings. Distribution uniformity as a percentage (DU%) is calculated by dividing the low quarter average by the average of all the readings, and multiplying by 100. So:

$$\frac{\text{Low quarter average}}{\text{Average of all readings}} \times 100 = \text{DU\%}$$

A DU equal to or greater than 75 per cent indicates acceptable uniformity, while values less than 67 per cent indicate that the sprinkler distribution is non-uniform.

Where faults are found in the irrigation system, the necessary changes should be worked out with your irrigation designer.

The Department of Agriculture provides a service that assists growers in the investigation, selection, and management of irrigation systems. This service can be obtained by contacting your district horticultural adviser.

After evaluating your sprinkler system, and correcting any faults, you can irrigate knowing how much water you are applying and that you are applying it efficiently. This will save you water and money and help you grow better crops.

Other fact sheets in this series prepared by the Irrigated Crop Management Services, Loxton Research Centre, are:

38/86 *Evaluating your fruit property*
39/86 *Understanding Riverland soils*
41/86 *Monitoring soil water*
42/86 *Tensiometers—preparation and installation*
43/86 *Installation of testwells*
44/86 *Interpreting tensiometer and testwell readings*

For information and advice about irrigation management on your property, contact your District Office or the Irrigated Crop Management Services, Loxton Research Centre, Box 411, Loxton 5333; telephone (085) 84 7315.

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Reproduced below is 'fact sheet' No. 41/86
of Department of Agriculture, South Australia

Monitoring soil water

By Officers of the Irrigated Crop Management Service, Loxton Research Centre

Why monitor soil water?

The purpose of irrigation is to add water to the soil to provide the moisture essential for plant growth. The end result should be optimum yield and fruit quality.

To decide when to irrigate and how much water to apply, you must monitor the amount of water in the soil. Without monitoring, it is easy to over or under-water soils.

Over-watering is applying too much water at irrigation, or watering too often, causing soils to become over wet. This results in a range of problems for both plants and soil, including poor aeration, a higher incidence of root diseases, dieback, and lime induced chlorosis. Water tables can also occur, bringing dissolved salts into the rootzone. Over-watering also leaches fertilizers out of the rootzone, which causes crop production and quality to suffer.

Under-watering occurs when irrigations are spaced too far apart or when insufficient water is applied at irrigation. It stresses plants, increases salinity uptake, and makes plants more susceptible to disease. A decline in crop production and quality will result.

Clearly, soils need the **right amount** of water at the **right time**.

How to monitor soil water

It is impossible to know how much water is in the soil just by kicking the surface or feeling the surface soil. There are however, some practical alternatives.

A simple method is to regularly dig holes to one metre with an auger or shovel and to feel the soil as it comes out of the hole. With practice, this will help you decide whether the last irrigation wet the entire rootzone, and when to irrigate next. Using this method, the holes should be dug 2 to 3 days after an irrigation and then 2 to 3 days before the next.

Dig several holes across the planting to allow for soil variability, and record your findings in a note book. Using this information, you can gain an appreciation of the different soils and rootzones that exist on the property, and how these vary in their irrigation requirement.

Other methods of monitoring soil moisture involve using tensiometers and testwells. Tensiometers indicate how much water is available to your plants. Testwells measure the rise and fall of the water table, and can be used to ensure that enough water was applied to leach salts from the rootzone. Tensiometer and testwell preparation, installation and the interpretation of the readings, are described in the following fact sheets:

42/86 *Tensiometers—preparation and installation*
43/86 *Installation of testwells*
44/86 *Interpretating tensiometer and testwell readings.*

Monitoring soil water is an essential part of the irrigation management of Riverland horticultural properties. A range of methods are available to be used alone or preferably in combination.

Other fact sheets in this series prepared by the Irrigated Crop Management Service, Loxton Research Centre, are:

38/86 *Evaluating your fruit property*
39/86 *Understanding Riverland soils*
40/86 *Evaluating sprinkler systems*

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For further information write to or call at any office of the Department of Agriculture
Telephone inquiries: 227 3020, 227 3038.

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Reproduced below is 'fact sheet' No. 42/86
of Department of Agriculture, South Australia

Tensiometers—preparation and installation

By officers of the Irrigated Crop Management Services, Loxton Research Centre

A tensiometer is an instrument placed in the rootzone of a crop which indicates the availability of water to that crop.

It behaves like an artificial plant root and consists of a tube with a porous ceramic pot at one end and a gauge at the other. The tube between the gauge and the pot is filled with water and sealed with a cap (figure 1).

Tensiometers are used in groups, with two or three instruments installed at different depths making up a 'station'. At each station the tensiometers are installed at the top, middle and bottom of the rootzone. For vines and tree crops in the Riverland, this is commonly at about 30, 60 and 90 cm respectively. For vegetable crops tensiometers are commonly installed at 30 and 45 cm.

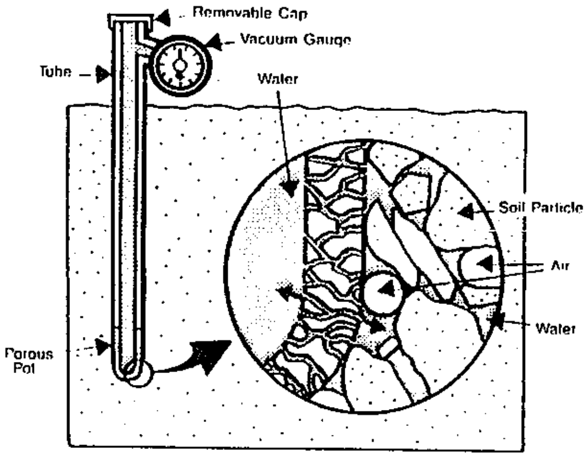

Figure 1: Tensiometer.

How does it work?

Water moves freely in and out of the porous pot. As the soil dries the water moves from the pot into the soil, creating a vacuum in the tube which is registered on the gauge. The drier the soil becomes, the higher the reading on the gauge and the more difficult it is for the plant to extract water from the soil. After an irrigation water moves back into the pot and the gauge reading falls.

Hence, tensiometer readings follow the same general pattern. They are low after an irrigation, reading between 6 and 10 centibars. As the plant removes water from the soil, the readings will rise. As the next irrigation approaches, the readings rise at a faster rate. Immediately before an irrigation, the tensiometer in the active root zone will read between 25 and 50 centibars, depending upon the soil type and crop. After irrigation, the readings will fall and the cycle will be repeated.

Preparing for installation

When tensiometers are purchased it is necessary to prepare them for installation. Unprepared tensiometers will not give true readings. The preparation may need to be adapted slightly depending on the brand. The method shown here is for the Irrometer™ brand of tensiometer.

- Remove the cap and rubber stopper. Fill the tensiometer tube and reservoir with **rainwater** and put the tensiometer in a bucket of rainwater for two to three days with the cap left off.
- Prepare some water for final filling of the tensiometer. Boil some rainwater **for several minutes** to drive off air in the water. Store this boiled water in a hot water bottle, adding algacide, and ensure that all air is expelled from the bottle when you seal it.
- After the tensiometer has soaked for two or three days, empty it and replace the pot in the rainwater to prevent it drying out. Now refill the tensiometer with water from the hot water bottle.
- With the suction pump that is supplied with the service kit, pump the tensiometer up to approximately 70 centibars and tap it to release any air bubbles trapped in the instrument. Carefully release the

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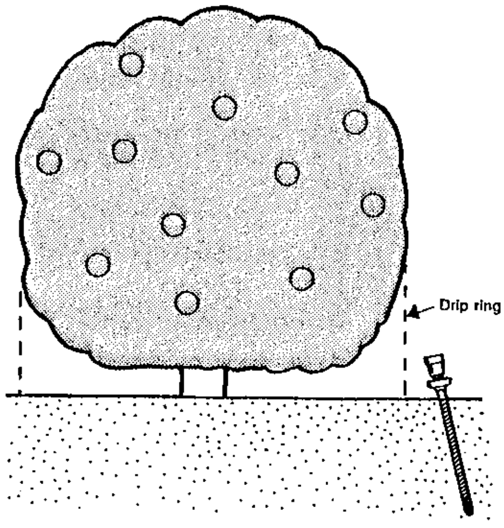
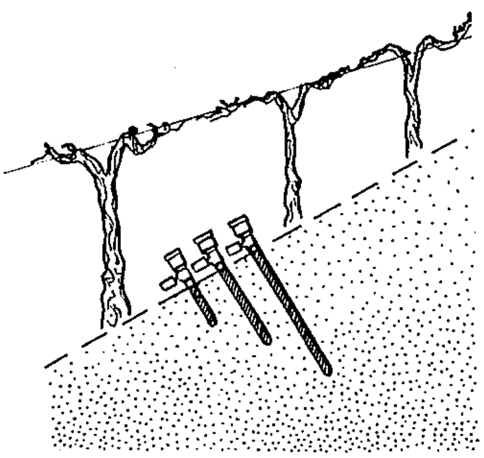
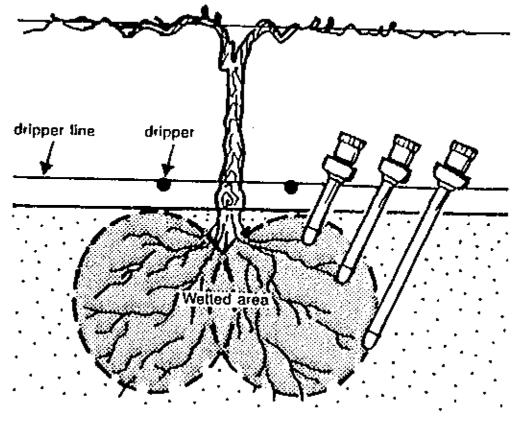


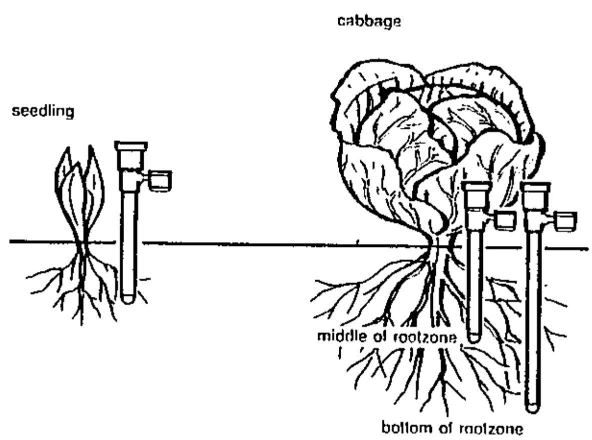
(a) Citrus sprinkler irrigated: just outside the drip ring



(b) Vines sprinkler irrigated: in the butt line



(c) Vines dripper irrigated: next to a dripper, in the wetted area



(d) Shallow-rooted vegetables, dripper irrigated

Figure 2: Where to position tensiometers.

vacuum pump and replace the cap by tightening it until the rubber is sealed, and then turn the cap a further quarter turn **only**.

- Place the tensiometer in a bucket of saturated coarse sand and take it to the installation site.

Where to install

If a tensiometer is to give useful information about the availability of water in the soil, it is essential to put it in a suitable position and to install it properly.

Use the following guide to select the right site.

- Determine the greatest area of similar soil for the crop. It may be necessary for you to have a soil survey made of the property to identify the various soil types (see fact sheet 39/86 *Understanding Riverland soils*).
- Select an area where the plants have average vigour. A second station should be placed elsewhere in the planting as a check.
- Choose a spot to install the station (figure 2). For **citrus** the tensiometer stations should be placed just **outside the drip ring** of the tree canopy, and on the **northern side** of the tree. For **vines** the tensiometer stations should be between two vines in the butt line. In sprinkler irrigated vines the tensiometers should be angled out into the row, and in dripper irrigated vines they should be placed within the wetted zone. For shallow-rooted vegetable crops the tensiometer station should be placed in the active root zone of the plant. When the crop is young, one shallow tensiometer is adequate; as the plant grows place a deeper tensiometer at the bottom of the rootzone.
- Ensure that the positions selected receive an **average water application**. It will be necessary for you to check the operating pressures, water output, and water distribution of sprinklers in order to choose the best possible sites (see fact sheet 40/86 *Evaluating sprinkler systems*).

Equipment needed for installation

Obtain the following items to ensure the tensiometers are installed correctly.

- Sets of Irrometers (or equivalent) to give measurements at the top, middle and bottom of the rootzone (usually 30, 60 and 90 cm).
- A service kit that includes a hand vacuum pump and instruction booklet.
- Boiled rainwater.
- A suitable bucket filled with saturated coarse sand to stand tensiometers in.
- A 75 mm hand auger.
- Torch.
- A coring tool made from a one-metre length of 13 mm (half-inch) water pipe with a 45 mm outside diameter washer welded on to one end. A piece of curtain rod is welded below the washer (figure 3).
- A small cover for the tensiometers, such as a piece of sisalation, folded and stapled to make a neat fitting sleeve.
- A white painted post to mark the position of the station, so that tractor operators and pickers can see it.

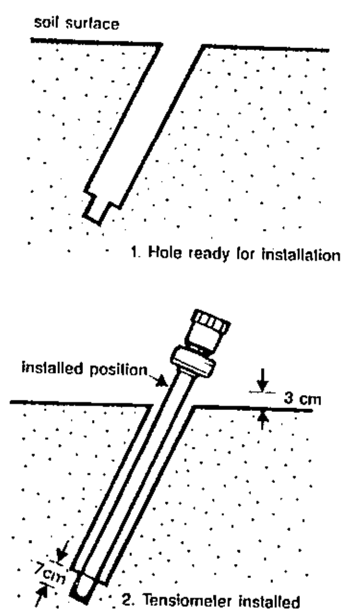


Figure 4

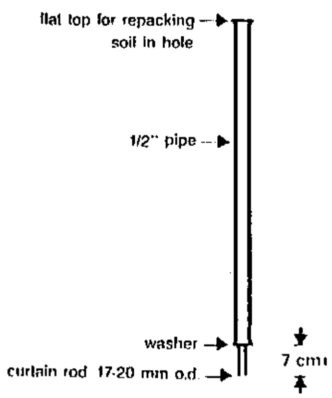


Figure 3: Coring Tool.

Installation

Installation is best done when the soil is moist, preferably two or three days after irrigation.

Using a 75 mm auger, start digging at a slight angle, laying out the soil in the order it was removed on to a bag or plastic sheet. Keep checking the depth by placing the tensiometer in the hole: stop digging when there is about 10 cm between the bottom of the gauge and the soil surface.

Having augered to the required depth, carefully insert the coring tool into the hole, centre it, and then hammer it down a further 7 cm. Remove the coring tool containing the soil core.

Place the pot of the tensiometer in the mouth of the cored hole (use a torch to check the position if necessary). Force the pot into the hole by pushing directly down on the cap. Do not wobble or rotate the tensiometer shaft and do not push on the gauge. When the pot of the tensiometer is properly positioned there must be at least 3 cm between the bottom of the gauge and the soil surface. If there is less than 3 cm or if the tensiometer can be easily rotated, the installation should be started again in a fresh hole.

When you are satisfied with positioning the pot, place a small amount of water into the bottom of the hole and allow it to soak in. This helps the pot to make contact with the soil.

Start replacing the soil around the tensiometer using material from the bottom of the hole. Every few handfuls, tap down the soil with the flat top of the coring tool (see figure 3) or some other suitable tool. Continue repacking to the surface, finishing with the topsoil to ensure that the original order of soil layers is maintained.

Remove the cap and with the hand vacuum pump apply a suction of 70 to 80 centibars on the gauge for at least 15 to 20 seconds while tapping the side of the tensiometer. This removes air bubbles trapped in the instrument.

Slowly release the lip of the vacuum pump and replace the cap and stopper. Screw the cap down until the rubber stopper just touches the base of the reservoir, then apply another quarter of a turn.

Protect the gauges with a small cover, such as a folded and stapled piece of Sisalation. Do not use large covers as these will interfere with the water stream from low level sprinklers.

Install the white marker post near the tensiometers so that the site is clearly visible.

Maintenance

Under normal use, air bubbles form in the water column just below the stopper, resulting in incorrect gauge readings. To remove them, service tensiometers about every two weeks in summer and every month in winter.

- Remove the cap and stopper by holding the reservoir and gauge in one hand and unscrewing the cap with the other. This procedure prevents the tensiometer from rotating in the soil.
- Top up the water reservoir with boiled rainwater that has cooled in the hot water bottle.
- Remove air bubbles with the hand vacuum pump by applying and holding the suction at 70 to 80 centibars on the gauge for at least 15 to 20 seconds while tapping the side of the tensiometer.
- Slowly release the tip of the vacuum pump. Before replacing the cap check that its rubber stopper has not become flattened or perished. If so, replace it. Then replace the cap.

Summary

A tensiometer is a valuable tool to aid irrigation management on your property. With proper use, it will benefit not only your plantings, but your pocket. Initially, buy several sets of three, and see the benefits and cost savings, and then install further sets in each soil type on your property. This will ensure overall watering efficiency, better plant health, and increased crop yield.

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44/86 *Interpreting tensiometer and testwell readings*

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Reproduced below is 'fact sheet' No. 44/86
of Department of Agriculture, South Australia

Interpreting tensiometer and testwell readings

By Officers of the Irrigated Crop Management Service, Loxton Research Centre

A tensiometer measures how hard the root system of a plant must work to extract water for its needs. It directly measures the 'soil matric potential', which is the physical force that the root system must overcome to free the water from the grip of the soil particles.

All tensiometers read in centibars (cb). One hundred centibars equals one bar. The higher the reading on the gauge, for example 40 cb, the harder it is for the plant to extract water from the soil. The lower the reading, for example 10 cb, the easier it is for the plant to extract water from the soil.

Most of the water in the soil available for plant growth occurs as a thin film on the soil particles or as droplets within the soil pores. The amount of water held in the pores one to two days after an irrigation is known as field capacity. At field capacity, tensiometer readings can range from 6 cb to 10 cb for sandy soils, and 10 cb or more for the heavy textured soils. Readings less than field capacity indicate that the soil is saturated.

Because Riverland soils vary widely, (see fact sheet 39/86 *Understanding Riverland soils*) a tensiometer reading between 30 cb (in light textured soils) and 60 cb (in heavy textured soils) tells you that it is time to irrigate. High tensiometer readings such as these indicate that the soil moisture has been depleted to a level where the crop is stressed, and needs water.

Testwells are used to measure the depth from the soil surface to a water table. Where present, water tables generally rise after an irrigation showing that water has drained down to an impermeable layer below the rootzone. Water tables fall as the groundwater slowly percolates either through or along the top of the impermeable layer, or is extracted by the plant's root system.

When to take readings

Ideally, tensiometer readings should be taken at the same time, in the early morning. Tensiometers must be read just before an irrigation and one or two days after the irrigation. In addition, read the tensiometers as necessary between irrigations to assist in deciding the timing of the next irrigation.

In spring, summer and autumn, crop water use is relatively high and the soil profile dries out more quickly. During these seasons take tensiometer readings more often. For example, for sprinkler irrigated citrus in sandy soils, readings should be taken two to three days each week. For vines on loamy soils, readings taken once a week are usually enough. During winter, tensiometers installed in deciduous crops can be read monthly since water is not used by these crops.

Testwells should be read just before and one to two days after an irrigation. For convenience, read them at the same time as the tensiometers.

How to record the readings

Tensiometer and testwell readings should be entered in a notebook or diary together with rainfall and irrigation amounts and dates.

It is important to identify the location of tensiometer and testwell stations by recording a valve or site number, the depth of the tensiometer being read and the date and time when the readings are taken.

It is essential to plot tensiometer and testwell readings on a piece of graph paper. A graph will provide a better picture of the changes of soil moisture and water table levels.

For further information write to or call at any office of the Department of Agriculture. AGDEX 560
Telephone inquiries: 227 3020, 227 3038.

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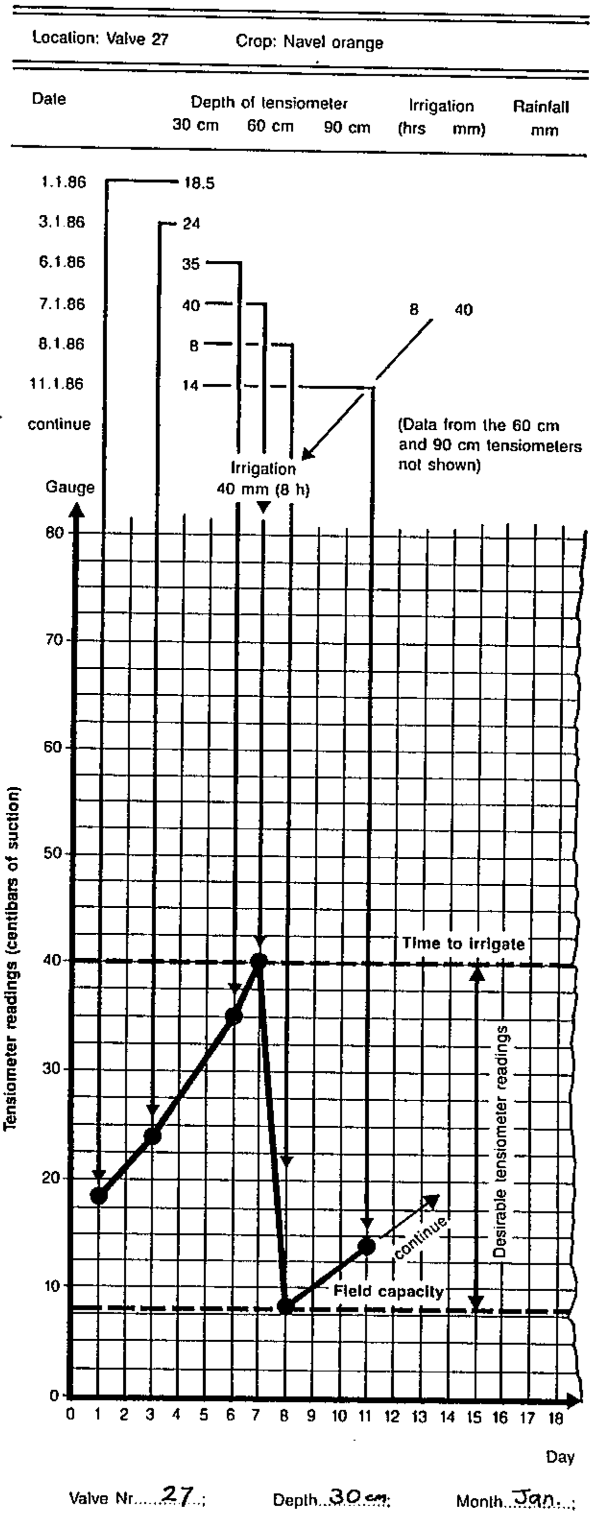

Figure 1: Notebook and graph of tensiometer records

Tensiometer records

An example of how to use your notebook records to plot tensiometer readings on a graph is given in figure 1. The vertical scale of the graph represents the range of tensiometer readings from 0 cb to 80 cb. The horizontal scale represents time in days.

Each point plotted in figure 1 is the tensiometer reading for a particular day. Follow the line starting from the value on the table to the graph paper. Joining the points on the graph with a full line makes clear the changing trend in soil moisture.

The date of each irrigation or rainfall should be recorded with an arrow above the graph. The time in hours and the amount of water applied during each irrigation, or the amount of rainfall should be recorded above the arrow. The area between the two broken black lines represents the area of desirable tensiometer readings. Irrigating to keep the readings between these lines will maintain the plants in an unstressed or minimal stress condition.

Testwell records

Testwell readings should be plotted in a similar fashion (figure 2). The vertical scale represents the depth of the water table in metres from the ground surface. The horizontal scale represents time in days.

The thick black line represents the depth of the rootzone, and water tables should be kept well below this level at all times.

Interpreting the readings

The graphs in figure 3 show typical changes in tensiometer and testwell readings. A tensiometer station normally consists of three tensiometers, but for easier interpretation the readings from only two have been plotted in figure 3 (*see page 4*).

The following interpretations were made on the changes in the readings occurring below the circled numbers displayed in the graphs. Look at the graph and the circled number first, then read the comment for each number.

Comment 1

Tensiometer readings were increasing and the water table was falling right up to when the 10-hour (65 mm) irrigation started. Note how quickly the tensiometer readings fell when water reached the porous pot of both the deep and the shallow tensiometers. This indicates that the entire rootzone was wetted.

The testwell graph shows that the water table rose only slightly after the irrigation, therefore the irrigation was adequate, and not excessive.

Comment 2

A 10-hour irrigation was applied, which was completely unnecessary as tensiometer readings were still low, indicating that topsoil and subsoil were wet enough for the plant to obtain water. The water table rose into the rootzone as a result of the deeper soil becoming saturated.

Where over-irrigations like this occur frequently, the water table will remain in or near the rootzone and the soil above it will stay permanently wet. This will cause poor

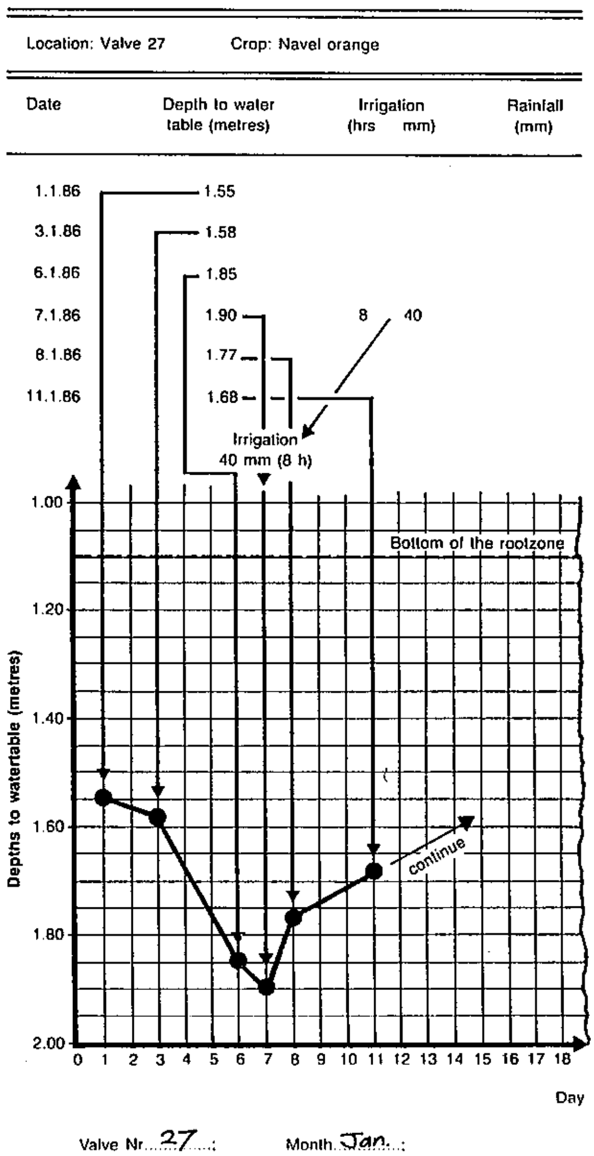

Figure 2: Notebook and graph of testwell records

root aeration, and bring salts from the water table into the rootzone. Apart from unnecessary wastage of water, crop yields and quality will ultimately decline.

Comment 3

Rainfall at this time slowed the rate of increase in tensiometer readings and delayed the need for irrigation. The water table had started to fall since the last irrigation, but the rain delayed this decline as well.

Comment 4

The readings of the shallow tensiometer began to increase rapidly and a short (five-hour) irrigation was applied to re-wet the upper rootzone but not the deeper rootzone, which was still wet enough. The irrigation did not penetrate deep into the rootzone, and the water did not reach the deep tensiometer, so its readings continued to rise. As no water was added to the water table, it continued to fall.

Comment 5

The readings of the shallow and the deep tensiometers had increased indicating that an irrigation was required to wet the entire rootzone. A 10-hour irrigation was necessary to re-wet the entire rootzone.

Immediately after the irrigation both tensiometer readings fell and the water table rose slightly, indicating that the irrigation was adequate, but not excessive.

Comment 6

By observing the slope of the line produced by joining the plotted tensiometer readings, and referring to earlier irrigation cycles, it is quite easy to project ahead (see dotted lines) the number of days before the next irrigation is required.

Of course, hot weather or a sudden rainfall will alter the projected trend, and in this case, the decision when to irrigate will have to be based on further tensiometer readings.

Points to remember

- The tensiometer whose readings rise the most rapidly (usually the shallow one) will determine when the next irrigation is due.
- The deepest tensiometer helps to determine the correct depth of irrigation.
- Don't change your irrigation practice drastically. Monitor the readings for a period; dig holes with a shovel or a 100 mm auger, and follow your irrigation through the soil until you gain confidence in the tensiometer readings. This may take several irrigation cycles.
- It is not possible to set out instructions of when to irrigate for all crops, soils, methods of irrigation and climatic conditions. However, by plotting your tensiometer and testwell readings and keeping them within the desirable range (figure 3) you will gain confidence in using these instruments and be able to decide when to irrigate and how much water to apply.

If you have any questions about using tensiometers or testwells, please contact your district horticultural adviser, who can arrange specialist help from the Irrigation Scheduling Services at the Loxton Research Centre.

Other fact sheets in this series prepared by the Irrigated Crop Management Services, Loxton Research Centre, are:

38/86 *Evaluating your fruit property*
39/86 *Understanding Riverland soils*
40/86 *Evaluating sprinkler systems*
41/86 *Monitoring soil water*
42/86 *Tensiometers—preparation and installation*
43/86 *Installation of testwells*

For information and advice about irrigation management on your property, contact your District Office or the Irrigated Crop Management Services, Loxton Research Centre, Box 411, Loxton 5333; telephone (085) 84 7315.

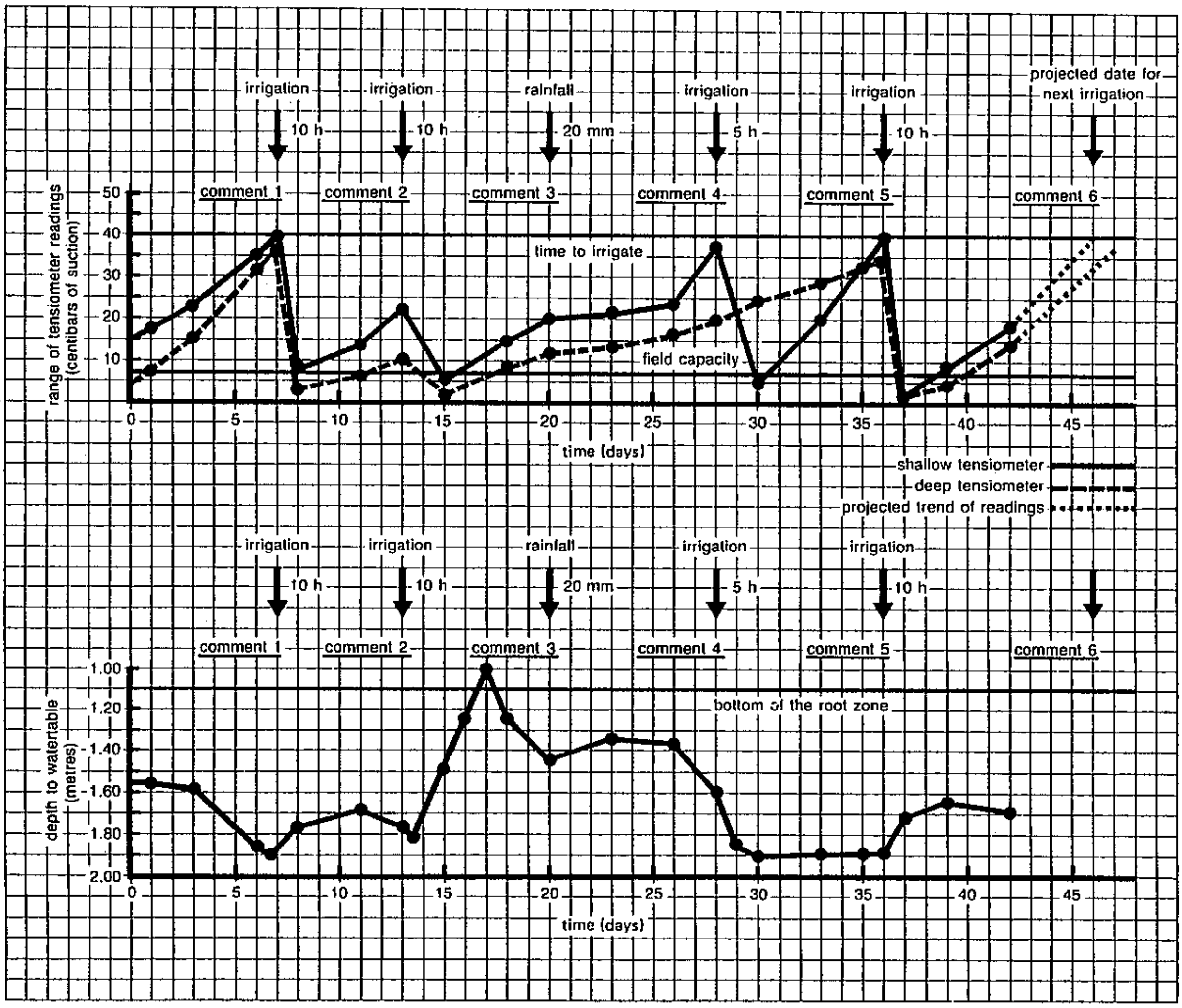

Figure 3: Plotting tensiometer and testwell readings (see 'Interpreting the readings', on pages 2 and 3)

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