Crop modelling and AQUAMAN

Irrigation scheduling

Irrigation scheduling using neutron probes, tensiometers or the book-keeping approach of ‘Watershed’ can help growers make better irrigation decisions. These methods can be used for irrigation scheduling for all crops, not just peanuts. However, in peanut crops there is a specific need to maintain moist soil in the podding zone.

Growers who have internet access can use the DPI&F’s in-season web-based irrigation scheduling module (AQUAMAN) for peanuts. Using this decision support package, growers can develop optimum irrigation schedules using a crop modelling approach. Some growers who have tested AQUAMAN said that it recommended irrigation 1 to 2 days earlier than they otherwise would have done.

AQUAMAN automatically adjusts the amount of irrigation the crop needs, depending on the stage of crop growth and the soil type. The grower collects daily maximum and minimum temperatures from the soil (5 cm depth) and air, as well as rainfall and irrigation levels. They enter this information into the model via the internet every day or two. The model then creates an irrigation report and sends it back to the grower by email. Figure 2 shows an example of a typical report output from AQUAMAN.
I found the AQUAMAN program very helpful. It told me when I needed to irrigate, perhaps two days before I would have originally, and I think that led to a much better crop this last year.

Noel Johnson (Farmer)

**Figure 2.** Daily water use print-out from the peanut model AQUAMAN. Irrigation should be sufficient to keep the red graph line above the grey line.
**Growth stages**

There are four phases in a peanut crop when water availability is critical in determining yield:

- germination and establishment
- early vegetative stage
- flowering, pegging and pod development
- during podfill

Figure 3 shows the approximate water demand by peanuts through the crop cycle. The crop stages such as emergence (E), floral initiation (FI), flowering (F), grainfill (GF), end grainfill (EG) and maturation (M) are indicated on the top of the chart for a 1900 degree days requiring crop.

During the emergence phase the crop needs soil water for imbibing and emergence, so soil needs to have sufficient moisture, but it does not necessarily use all the available water and much is either lost as evaporation or is used for later crop growth. In the later stages when crop cover is nearly complete water demand is higher and the crop uses most of the available soil water, with very little loss to evaporation.

The importance of water in these different phases is shown by the effect of water stress or drought during these periods (Table 2). DPI&F’s irrigation scheduler, AQUAMAN, automatically accounts for the differential water use during these various growth stages. Moisture sensing devices such as tensiometers can also complement AQUAMAN.

**Figure 3.** Peanut crop water demand
Table 2. The effect of water stress on peanut crops at different stages of crop development

<table>
<thead>
<tr>
<th>No moisture period (days after planting)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no drought</td>
<td>4700</td>
</tr>
<tr>
<td>20 – 50</td>
<td>4000</td>
</tr>
<tr>
<td>50 – 80</td>
<td>3400</td>
</tr>
<tr>
<td>80 – 110</td>
<td>3700</td>
</tr>
<tr>
<td>110 – 140</td>
<td>4600</td>
</tr>
</tbody>
</table>

Source: Kvien, C.S. University of Georgia, USA.

An even application of irrigation water is critical for achieving even maturity and the greatest yield. Near infra-red (NIR) imaging reveals patchy crop growth due to uneven water application (Figure 4).
Germination and establishment

Establish the crop with a pre-plant irrigation to fill the soil profile.

Irrigation is a way to ensure fast, even germination and establishment. If seeds remain in dry soil for several days, germination and seedling vigour may decrease and rhyzobia survival may be reduced.

In general, it is best to plant into moisture rather than irrigate soon after planting to ‘water up’. Watering after planting cools the soil by at least 2 to 3°C and may delay emergence and pre-dispose the seedling to disease, particularly for early plantings in cooler environments.

Provided the soil is well above the minimum of 18°C (and preferably 20°C), irrigation should not create emergence problems. In some areas of north and central Queensland, however, the cooling effect of irrigation may be an advantage when planting into very hot soils. A light irrigation can also help seedling emergence through a crusted soil surface.

On sandy soils, peanut seed can take up pre-plant herbicides, such as trifluralin, when planted dry and then lightly irrigated. This has the potential to cause the seed to die.

I used tensiometers to help me with watering. I didn’t water too much, but I made sure I watered enough to give me a good crop – seven-plus tonnes to the hectare is a pretty good crop.

Peter Russo (Farmer)
Early vegetative phase

Slight water deficits just before flowering can mean more even flowering and pod set, resulting in a more uniform crop to harvest.

Peanut roots can grow up to 3 cm per day and may reach a depth of 100 cm after 40 to 50 days. However, the depth at which roots extract soil water only increases at 1 to 2 cm per day. In effect, the roots can grow faster than their ability to extract soil water.

From emergence to early flowering (about 30 to 40 days after planting), peanuts are not very sensitive to slight water deficits. Slight water deficits at this stage will increase rooting depth and lead to more synchronised flowering and podding. Pre-flowering ‘stress’ irrigation has caused yield increases of 13 to 19 per cent compared to crops grown using a full irrigation regime.

Water use at this pre-flowering stage can deplete the soil down to about 40 per cent of plant-available water. The plant will be under moderate crop water stress at this stage. A very rough guide is to irrigate when the plants shows the first signs of wilting.

Do not allow plants to wilt severely, as this level of stress in high yielding situations is too great and may adversely affect final yield.

Too much stress will also cause the peanut plant to shed its nitrogen fixing nodules. The plant will take time to recover after the next irrigation before it can fix more nitrogen.

Trickle irrigation is beneficial because we can get the water on when we want it, we are using less water because we are not watering the interspace – only watering where the peanuts are actually growing and the pumping costs are a lot less than overhead irrigation.

Don Halpin (Farmer)
When drought stress is removed, the plant hormone cytokinin is released, stimulating flowering. A yield increase comes from a more synchronised flowering phase and, therefore, a more evenly mature crop at harvest. If the profile of a deep soil is filled at planting then flowering may start after only one or two irrigations.

Extended early season droughts delay flowering and so extend the time to maturity.

Too much water during early vegetative growth can cause an excessive bush size and a shallower root system. Large bushes often have more disease problems and become water stressed sooner than bushes with deeper root systems.

**Flowering, pegging and pod development**

As flowering commences (about 35 to 65 days after planting), give a full irrigation to try to fill the soil profile. Then aim to keep the topsoil moist for the next 40 to 50 days.

Peanuts flower in response to high levels of available soil moisture. In crops of Virginia and runner types, flowering starts about 40 days after planting and pod development is complete by day 90. Spanish types begin flowering about 40 days after planting and pod development is complete by around day 75.

Water use during flowering, pegging and pod development is 5 to 12 mm per day, depending on evaporation at the crop location. The peanut plant will use water from a depth of 90 cm or more.
Very low humidity causes high transpiration rates and so increases the crop’s demand for water from the soil. This stress can severely reduce flowering and pod set. Having adequate moisture during the critical 50 to 90 days after planting increases yield and promotes even pod set, early maturity and good quality pods.

On the other hand, high humidity within the crop canopy increases the risk of fungal diseases such as leaf spot and sclerotinia.

Water applied during this development phase is used more efficiently than water applied later in the crop cycle. If the water supply is limited, use it during this growth period rather than ‘saving it’ for later.

Water stress during flowering, pegging and pod set often causes fewer pods to develop and so reduces potential yield. Water stress can cause a yield reduction of 15 to 40 per cent compared to the yield of a well-watered crop. During this phase, plant-available water should not drop below 60 per cent.

Keep the soil in the pegging zone (top 20 to 70 mm) moist. Pegs will not penetrate a hot, dry or hardsetting soil and embryos in the tips of pegs will fail to develop into pods in dry soil. Keep the pegging zone moist, even if adequate moisture is available deep in the profile. Once the canopy closes, the soil in the pegging zone dries out relatively slowly.

The effect of dry soil in the pegging zone is seen in this example: a dry podding zone for a Florunner crop caused a 13 per cent

The AQUAMAN program and weather station gives us some idea of when to start and stop watering. I can monitor the crop a bit better than just digging a hole with a shovel.

Tony Chapman (Farmer)
reduction (61 to 48%) in the number of pegs which developed into full pods. Seed yield was reduced by 27 per cent compared to well-watered plants.

Moisture in the pegging zone during pod addition and development allows calcium and boron uptake by the developing pod. In dry soil there are often ‘pops’ (fully formed shells with no kernels inside), more one-seeded pods and seed with lower calcium content.

Water stress during flowering and pegging often results in ‘flushes’ of flowers and pods when water becomes available from either rain or irrigation. Two or more flushes of pods can occur, making it difficult to decide when to harvest because the pods from each flush may mature 10 to 20 days apart. This usually results in a lower overall yield and quality compared with an evenly matured crop. This effect is not as prevalent in Spanish types.

**Podfill**

Irrigate to provide just enough water to avoid crop stress in the podfill stage.

After about 30 days of adequate moisture in the pegging zone, the pods can continue development in a drier soil, provided the plant has adequate moisture in the lower root zone. Allow the plants to use moisture down to 50 per cent of plant-available water in this stage.

Less irrigation is required during the last 30 to 40 days. A late season drought can be less detrimental than during the pod setting

---

*I think the crop modelling has real value for growers, mainly in identifying any yield gap. That is, the models can tell you the theoretical yield for a particular paddock, year and set of rainfall and the radiation data so a grower can really know what yield to expect from the paddock. If he is getting much less commercially than the model suggests then he knows that he has missed out on a lot of yield.*

Graeme Wright (DPI&F)
period, but do not stress the crop if it can be avoided. Nutrients and other resources stored in the vegetative part of the plant transfer to the developing pods in this stage. The crop’s demand for moisture usually declines close to harvest, resulting in lower crop water use.

Too much water during podfill can increase the incidence of leaf, stem and pod diseases, cause pod deterioration and lead to uneven maturity.

Adequate moisture during podfilling will reduce the risk of the aflatoxin-producing fungus, *Aspergillus flavus*, invading pods.

*Information contained in this publication is provided as general advice only. For application to specific circumstances, please seek professional advice. The Department of Primary Industries and Fisheries, Queensland has taken all reasonable steps to ensure the information in this publication is accurate at the time of publication. Readers should ensure that they make appropriate enquiries to determine whether new information is available on the particular subject matter.*

© The State of Queensland, Department of Primary Industries and Fisheries (2007). Address enquiries to copyright@dpi.qld.gov.au or phone 61 7 3404 6999.