WESTERN

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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

OATS

SECTION 1

PLANNING AND PADDOCK PREPARATION

PADDOCK SELECTION | PADDOCK ROTATION AND HISTORY | BENEFITS OF CROP AS A ROTATION CROP | DISADVANTAGES OF CROP AS A ROTATION CROP | FALLOW WEED CONTROL | FALLOW CHEMICAL PLANT-BACK EFFECTS | SEEDBED REQUIREMENTS | SOIL MOISTURE | YIELD AND TARGETS | DISEASE STATUS OF PADDOCK | INSECT STATUS OF PADDOCK

SECTION 1

Planning/Paddock preparation

More information

GRDC - Crop Variety Guides

Growing winter crops profitably demands higher production per unit area while aiming to maintain a low cost per unit of production. This can only be achieved by increasing grain yields by adopting new or improved technology. The aim is not only higher total production, but also greater productivity from the resources invested in crop production, along with overall sustainability of the farm business.

Paddock selection and rotation combined with using disease-resistant varieties are the best actions to minimise disease. See the National Variety Trial website at www.nvtonline.com.au. [1]

1.1 Paddock selection

Keys to good establishment:

- Use plump good quality seed from paddocks with a good fertiliser history, uniform in size, not cracked or broken, stored in dark cool dry conditions (not more than one year old) and free from pests and disease.
- Seed should have a high percentage germination, free from weed seeds and inert rubbish.
- Good soil-seed contact and 'sufficient' soil moisture for quick germination is ideal but not always possible.
- No weeds should be present during sowing.

1.1.1 Paddock preparation

Cultural practices from paddock preparation to seeding rate and sowing date help promote plant establishment and survival. In Western Australia, with its unpredictable and erratic rainfall combined with poor soils, cultural practices are essential to help maximise oat production.

Legume-based pasture and crops provide more nitrogen (N), which increases grain yield and protein. Lower levels of applied N are needed following a good legume rotation.

It is important to control grasses prior to the oat crop using pasture manipulation or spray-topping in the previous pasture. Control in the preceding canola crop or grain legume is essential to reduce root disease and allow early sowing.

Customers of the export hay market require that hay be free of contamination. Paddock preparation is a major part of management for export hay and requires:

- removing old crop residues (chain/rake or burning);
- removing obstructions such as sticks, tree branches, stones, carcasses and wire; and
- rolling paddocks to effectively reduce contamination and risk of machinery damage.

[1] NSW DPI District Agronomists (2008) Wheat growth and development. PROCROP Series, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

Profit depends on choosing the most suitable variety for each paddock and matching this to the paddock's limitations, such as available moisture, diseases and nutrient status.

The newer varieties do have a significant yield advantage so variety selection is a major part as well as disease resistance and milling quality.

Profitable yields largely result from good management.

Agronomist's view

For no-till systems before seeding, standard paddock preparation protocols, such as knocking down the weeds, should be followed. [2]

1.2 Paddock rotation and history

Growers need to plant oats into a paddock that is very clean for grass weeds due to the very limited options for grass control in the crop, in particular for wild oats, brome grass and barley grass.

Crop sequencing is a key part of a long-term farming systems approach to tackling weed, disease and moisture challenges in the northern grains region. In Western Australia, growers are finding that early-sown oats are quick to form a canopy and outcompete weeds such as low levels of ryegrass. Sowing early is proving to be an effective weed control strategy on clean paddocks providing improved yields and less weed seedset.

1.2.1 Soil pH/liming

Oats are relatively tolerant of acid soil, being more tolerant than wheat, barley or canola.

Growth will be adversely affected when soil pH is below 4.8. [3]

The signs of soil acidity are more subtle than the clearly visible symptoms of salinity and soil erosion. Cereal growers may predict that their soil is acidic when acid sensitive crops fail to establish, or crop production is lower than expected, particularly in dry years. Regularly testing top soil and sub soil pH levels is critical for all cropping enterprises.

Where soils are at risk of becoming acidic the future impact of soil acidity can be reduced, but not eliminated, by slowing the rate of acidification.

This can be achieved by:

- minimising leaching of nitrate N;
- using less acidifying fertilisers;
- reducing the effect of removal of product; and
- preventing erosion of the surface soil.

Application of lime sand or finely crushed limestone is the only practical way to neutralise soil acidity. Lime is most effective if sufficient is applied to raise the pHCa to 5.5 and it is well incorporated into the soil. Where acidity occurs deeper than the cultivation layer, the lime will only begin to neutralise subsurface soil acidity if the pH of the surface soil is maintained above 5.5. [4]

2 DAFWA (2014) Oats: seeding and establishment, https://www.agric.wa.gov.au/oats/oats-seeding-and-establishment

3 Pacific Seeds (2006/07) Pacific Seeds Yearbook 2006/2007 - Oats Agronomy Guide, https://www.pacificseeds.com.au/images/stories/winter_forage/information/yearbookoatsagronomy2006.pdf

4 B Upjohn, G Fenton, M Conyers (2005) Soil acidity and liming. Agfact AC. 19. 3rd edition. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/167209/soil-acidity-liming.pdf

1.3 Benefits of crop as a rotation crop

- Early sowing options – helps spread out the work load at a busy time.
- Long coleoptile length – enables deeper sowing when moisture is not close to the surface.
- Dual purpose – grain or hay can be grazed.
- Frost mitigation – sow into more frost prone paddocks as oats are estimated to be 4°C more tolerant to frost at flowering than wheat. [5]
- More tolerant to waterlogging than wheat, barley or canola.
- Can be cut for hay or harvested for grain.
- Provides a disease break for other cereals.
- Highly competitive crop canopy that competes well with weeds when sown early.

1.4 Disadvantages of crop as a rotation crop

- Limited option in grass weed control.
- A smaller range of in-crop broadleaf weed control chemicals.
- Still a cereal, so offers little disease break to diseases such as Crown Rot, CCN, Take All.
- Some varieties can shed pre harvest (usually less risky than barley).
- Less drought tolerant than other cereals.
- Volatility in grain prices.
- Highly susceptible to dry finishes.

1.5 Fallow weed control

Uncontrolled heavy weed growth during the summer fallow period can reduce the yield of the subsequent crop by:

- robbing subsequent crops of available soil N
- decreasing the amount of stored soil moisture
- reducing crop emergence due to the physical and/or chemical (allelopathic) interference at seeding time

More information

DAFWA - Weeds

Controlling summer weeds early will conserve valuable soil N and moisture for use by the crop during the following season. A Western Australian (WA) grower at Salmon Gums can demonstrate an average farm crop yield increase of 400 kg/ha following adoption of consistent summer weed control.

A study by the Cooperative Research Centre (CRC) for Australian Weed Management found that summer weeds can lock away large amounts of N in the weedy biomass, rendering it unavailable for crop growth. Weed burdens of 2.5 t/ha can cause a net loss of available soil N, and burdens of more than 3 t/ha can reduce subsequent wheat yields by as much as 40%.

Another GRDC-funded study in South Australia found that the major impact of summer weeds was on soil moisture. Complete weed control increased available soil moisture at one site by over 11 mm. The CRC study also found that as weed biomass increased, water losses increased. However, the magnitude of the water loss and its importance to the subsequent grain yields varied from site to site.

Summer weeds can also impede crop emergence. Moderate to heavy uncontrolled weed growth can result in reduced crop emergence in minimum tillage systems due to

5 T Bray (2014) Irrigated milling oats set to roll. IREC Farmers' Newsletter – Large Area No. 190: Autumn 2014, http://irec.org.au/farmer_f/pdf_190/Milling-oat-opportunities-for-irrigators.pdf

the impenetrable stover layer left on the soil surface. Wireweed for example, has long tough and wiry stems which can get caught in the tines at seeding.

Weeds that are 'allelopathic' release toxic substances directly from plant's roots, or during the decomposition of their residue. These toxic substances can inhibit the subsequent germination of the crop. In the CRC study, allelopathic weeds (such as caltrop) reduced subsequent wheat emergence by as much as 25% due to the chemicals that were exuded from the roots.

Effective weed control can reduce weed numbers in subsequent years and run down the seedbank. Uncontrolled weeds contribute massively to the soil seed bank, increasing control costs and future weed burdens. This may limit crop choice and reduce flexibility in systems.

Summer weed control can be expensive but is necessary to prevent problems with excessive growth and/or moisture and N loss from the soil. [6]

1.6 Fallow chemical plant-back effects

Plant-back periods are the obligatory times between the herbicide spraying date and the safe planting date of a subsequent crop.

Some herbicides have a long residual. The residual is not the same as the half-life. Although the amount of chemical in the soil may break down rapidly to half the original amount, what remains can persist for long periods, for example sulfonylureas (chlorsulfuron). This is shown in Table 1 where known. Herbicides with long residuals can affect subsequent crops, especially if they are effective at low levels of active ingredient, such as the sulfonylureas. On labels, this will be shown by plant-back periods, which are usually listed under a separate plant-back heading or under the 'Protection of crops etc.' heading in the 'General Instructions' section of the label. [7]

Growers who use the herbicide Sakura on wheat crops need to be very careful of plant-back periods for growing oats for either grain, hay or forage. There is a 630-day plant back from using Sakura on wheat before growing a subsequent oat crop.

Table 1: Residual persistence of common pre-emergent herbicides, and noted residual persistence in broad acre trials and paddock experiences [8]

Herbicide	Half-life (days)	Residual persistence and prolonged weed control
Logran® (triasulfuron)	19	High. Persists longer in high pH soils. Weed control commonly drops off within six weeks
Glean® (chlorsulfuron)	28–42	High. Persists longer in high pH soils. Weed control longer than Logran
Diuron	90 (range 1 month to 1 year, depending on rate)	High. Weed control will drop off within six weeks, depending on rate. Has had observed long-lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.) and to a lesser extent broadleaf weeds such as fleabane
Atrazine	60–100, up to 1 year if dry	High. Has had observed long lasting (>3 months) activity on broadleaf weeds such as fleabane
Simazine	60 (range 28–149)	Med./high. 1 year residual in high pH soils. Has had observed long lasting (>3 months) activity on broadleaf weeds such as fleabane

6 DAFWA (2015) Summer weeds, https://www.agric.wa.gov.au/postharvest/summer-weeds

7 B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf

8 B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf

Herbicide	Half-life (days)	Residual persistence and prolonged weed control
Terbyne® (terbulthylazine)	6.5–139	High. Has had observed long-lasting (>6 months) activity on broadleaf weeds such as fleabane and sow thistle
Triflur® X (trifluralin)	57–126	High. 6–8 months residual. Higher rates longer. Has had observed long-lasting activity on grass weeds such as black/stink grass (*Eragrostis* spp.)
Stomp® (pendimethalin)	40	Medium. 3–4 months residual
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months residual
Balance® (isoxaflutole)	1.3 (metabolite 11.5)	High. Reactivates after each rainfall event. Has had observed long-lasting (> 6 months) activity on broadleaf weeds such as fleabane and sow thistle
Boxer Gold® (prosulfocarb)	12–49	Medium. Typically quicker to break down than trifluralin, but tends to reactivate after each rainfall event
Sakura® (pyroxasulfone)	10–35	High. Typically quicker breakdown than Trifluralin and Boxer Gold; however, weed control persists longer than Boxer Gold

Sources: CDS Tomlinson (ed,) (2009) The pesticide manual. 15th edn. British Crop Protection Council, Farnham, UK. Extoxnet, http://extoxnet.orst.edu California Dept Pesticide Regulation Environmental Fate Reviews, http://www.cdpr.ca.gov

1.7 Seedbed requirements

Oats seed needs good soil contact for germination. This can be assisted with press wheels, coil packers or rollers. Soil type determines the implement that produces the ideal seedbed.

Between 70 and 90% of seeds sown produce a plant if vigour and germination are high.

Depth of sowing, disease, crusting, moisture and other stress in the seedbed all reduce the number of plants establishing. Field establishment is unlikely to be more than 90% and may be as low as 60% if seedbed conditions are unfavourable.

For successful crop establishment, seed needs to be placed into soil with enough seedbed moisture for germination to occur, or into dry soil with the expectation of rainfall to increase soil moisture levels such that germination may occur. In north-western New South Wales, it is common for soil profiles to have high levels of plant-available water in the root-zone, coupled with a dry seedbed. This scenario may require the practice of 'moisture seeking', that is, placing seed deeper in the soil than is generally recommended with the main aim of ensuring timely crop establishment. This generally involves using tines to open a furrow to a depth of >7.5 cm, then placing seed into it, followed by a press-wheel to close moist soil around the seed. Cox and Chapman (2007) reported that 'moisture seeking' increases cropping frequency and improves timeliness of crop establishment.

Soil acidity is a major constraint to farming in Western Australia. Extensive surveys of soil pH profiles across the south-west show that more than 70% of surface soils and almost half of subsurface soils are below appropriate pH levels. [9]

Soil acidity is an economic and natural resource threat throughout the south-western agricultural area of Western Australia. Production loss and sustainability are of major concern to farmers, with more than 14.25 million hectares of wheatbelt soils currently estimated to be acidic or at risk of becoming acidic to the point of restricting production. The estimate of production loss for the wheatbelt due to acidity is $498 million (Herbert 2009), or about 9% of the annual crop. [10]

9 DAFWA (2015) Soil acidity, https://www.agric.wa.gov.au/climate-land-water/soils/soil-constraints/soil-acidity

10 DAFWA (2015) Soil acidity in Western Australia, https://www.agric.wa.gov.au/soil-acidity/soil-acidity-western-australia

Approximately 161,000 soil samples, including about 67,000 from the subsurface, collected from over 93,000 sites across the south-west agricultural area from 2005–2012 were used to assess the current soil acidity situation (Gazey *et al.* 2013). These samples show that 72% of topsoils and 45% of subsurface soils were below the targets pHCa of 5.5 and 4.8, respectively. Mapping of this information at the farm scale showed that the extent and severity of acidity varies geographically and with soil type (Figure 1).[11]

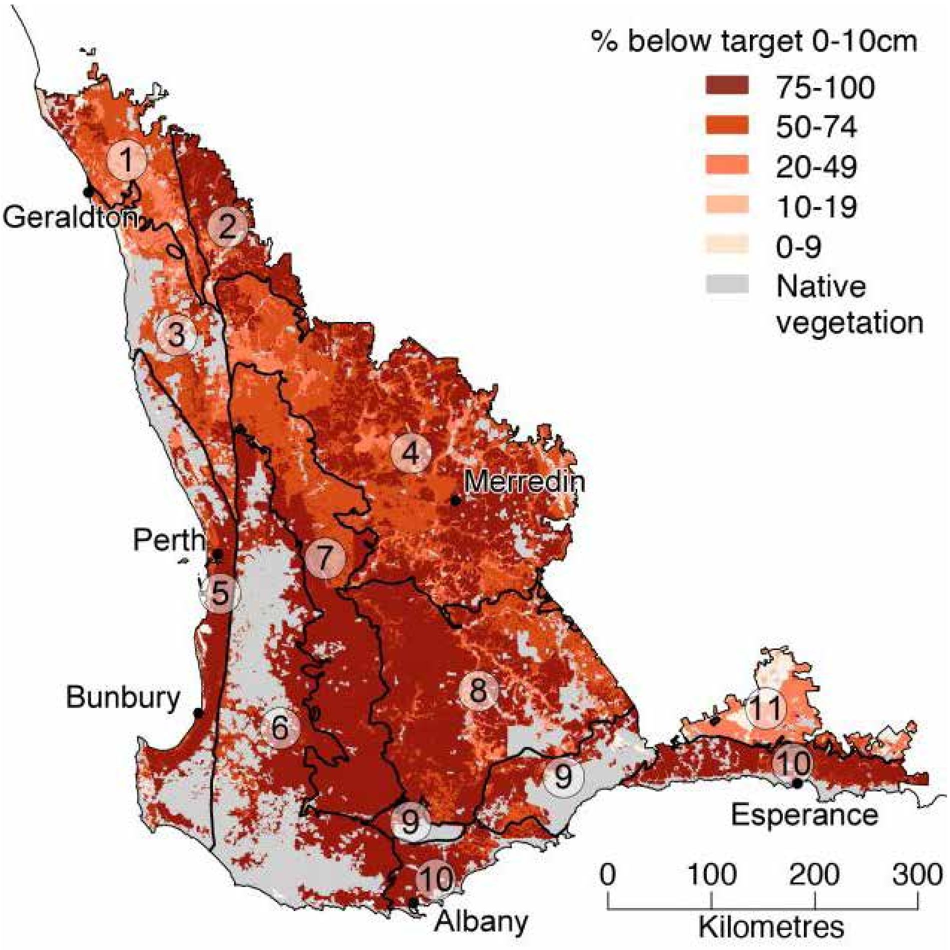

Figure 1: The south-west of Western Australia showing the agricultural area divided into Agricultural Soil Zones (AgZones) in relation to various wheatbelt towns. [12]

Salinity, primarily caused by excess sodium chloride (NaCl or salt) in the soil, is a concern in many agricultural areas. Excessive soil salts can reduce the performance of oats.

By comparison, oats are substantially less tolerant to salt than barley. However, oats is slightly more tolerant than sorghum. [13]

For oats, a 10% yield reduction in yield is likely when soil salinity reaches 5 dS/m. A 50% reduction in yield is likely when soil salinity reaches 8–10 dS/m. [14]

A soil pHCa between 5.5 and 8.0 provides the best conditions for most agricultural plants. If the pHCa drops below 5.0, plants that are highly sensitive to acidity, such

[11] DAFWA (2015) Soil acidity in Western Australia, https://www.agric.wa.gov.au/soil-acidity/soil-acidity-western-australia

[12] DAFWA (2015) Soil acidity in Western Australia, https://www.agric.wa.gov.au/soil-acidity/soil-acidity-western-australia?page=0%2C0

[13] Pacific Seeds (2006/07) Pacific Seeds Yearbook 2006/2007 - Oats Agronomy Guide, https://www.pacificseeds.com.au/images/stories/winter_forage/information/yearbookoatsagronomy2006.pdf

[14] 'Oat Science and Technology' (1992) edited by Marshall and Sorrells

as canola and barley, are adversely affected. Plants that are more tolerant of acidity continue to grow normally until the pHCa falls below 4.5. Below pHCa 4.4 most plants, except the very highly acid tolerant plants like oats, narrow-leaf lupins and the native pasture grass *Microlaena* spp, show a significant reduction in production.[15]

1.8 Soil moisture

1.8.1 Dryland

Water availability is a key limiting factor for oats production in the northern grainbelt of Australia. Varieties with improved adaptation to such conditions are actively sought and studies have been carried out to identify the physiology of these adaptive traits. Field experiments have been undertaken under a range of moisture availability conditions commonly encountered by winter crops grown on the deep Vertosol soils of this region.

Technologies to support decision-making:

Several technologies provide information useful in decision-support without requiring excessive investment.

Devices for soil monitoring

In-situ devices that have relatively small zones of measurement and rely on good soil–sensor contact to measure soil water are at a disadvantage in shrink–swell soils where soil movement and cracking are typical. This is more important in dryland than irrigated systems as seasonal soil water levels vary from above field capacity through to wilting point or lower. Consequently, the potentially high levels of error associated with cracking and soil movement and high levels of inherent soil variability mean that increased device replication would be necessary to achieve confidence in results. This comes at an increased capital cost. Some devices (capacitance; time domain reflectometry, TDR) also have an upper measurement limit over which they are unable to accurately measure soil water. This may be a problem on high clay soils where moisture content at drained upper limit is likely to be >50% volumetric, the common limit for these devices. By comparison, using a portable electromagnetic induction (EMI) device to measure bulk electrical conductivity and calculate soil water has a number of advantages. The EMI is quick, allowing for greater replication, measures the soil moisture of a large volume of soil (to 150 cm depth), is not affected by cracking or soil movement, and does not require installation of an access tube, thus making it available for use on multiple paddocks. However, it is unsuitable for saline soils and does not apportion soil water to particular layers within the soil profile.[16]

New thoughts on soil moisture monitoring

Despite an extensive range of monitoring instruments now available, measuring paddock soil moisture is still a considerable challenge. Among the suite of instruments currently on offer, one that is increasingly being used by researchers and agronomists is the EM38 (Geonics Ltd, Ontario, Canada). This electromagnetic induction instrument is proving to have significant potential for determining soil properties useful in precision agriculture and environmental monitoring. It is now commonly used to provide rapid and reliable information on properties such as soil salinity and soil management zones, both of which relate well to crop yield. It is also used widely in agronomic and environmental applications to monitor soil water within the root-zone. It provides an efficient means to monitor crop water use and plant-available water (PAW) in the soil profile throughout the growing season so that informed management decisions can be made (e.g. the application, timing and conservation of irrigation water and fertiliser). EM38 datasets

15 B Upjohn, G Fenton, M Conyers (2005) Soil acidity and liming. Agfact AC. 19. 3rd edition. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/167209/soil-acidity-liming.pdf

16 N Dalgliesh, N Huth (2013) New technology for measuring and advising on soil water. GRDC Update Papers Goondiwindi March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/New-technology-for-measuring-and-advising-on-soil-water

have also proved valuable to test and validate water balance models that are used to extrapolate to other seasons, management scenarios and locations.

The EM38 is an easy-to-use, geophysical surveying instrument that provides a rapid measure of soil electrical conductivity. Soil calibrations or qualitative assessments can be used to convert this to estimates of soil water in the root-zone. This information is vital to farm management decisions based on accurate knowledge of soil PAW.[17]

Calibration of monitoring devices

Electronic monitoring tools require calibration to convert the device output signal into information easily understood by the user (e.g. millivolts to volumetric soil water or PAW). This requires the development of a relationship between sensor output and physically measured soil moisture content at moisture levels from dry to wet. The resulting calibration is then used to convert device output signal to gravimetric or volumetric water content. To calculate the availability of soil moisture for crop use (in mm of available water) requires further processing of the data and knowledge of a soil's PAW capacity (PAWC). A suitable characteristic may be identified from the APSoil database or SoilMapp, or electronic sensor output may be used to identify the soil's water content operating range, to make reasonable assumptions on values for drained upper limit and crop lower limit. An alternative is to use Soil Water Express (Burk and Dalgliesh 2012), a tool which uses the soil's texture, salinity and bulk density to predict PAWC and to convert electronic sensor output to meaningful soil water information (mm of available water).

Modelling of soil water

Simulation of the water balance should be considered as an alternative to field-based soil water monitoring. Considering the error surrounding in-field measurement and issues with installation of sensing devices, there is a reasonable argument that the modelling of the water balance, when initialised with accurate PAWC and daily climate information, is likely to be as accurate as direct measurement. APSIM and Yield Prophet successfully predict soil water and they should be considered for both fallow and cropping situations. CliMate is a logical choice for managing fallow water (Freebairn 2012). [18]

1.9 Yield and targets

1.9.1 Seasonal outlook

Australia's climate, and in particular rainfall, is among the most variable on earth; consequently, crop yields vary from season to season. In order to remain profitable, crop producers must manage their agronomy, crop inputs, marketing and finance to match each season's yield potential. [19]

Before planting, identify the target yield required to be profitable:

- Do a simple calculation to see how much water you need to achieve this yield.
- Know how much soil water you have (treat this water like money in the bank).
- Think about how much risk your farm can take.
- Consider how this crop fits into your cropping plan, will the longer term benefits to the system outweigh any short-term losses?

[17] Foley (2013) A 'how to' for getting soil water from your EM38 field measurements. GRDC Update Papers Goondiwindi March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/A-how-to-for-getting-soil-water-from-your-EM38-field-measurements

[18] N Dalgliesh, N Huth (2013) New technology for measuring and advising on soil water. GRDC Update Papers Goondiwindi March 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/New-technology-for-measuring-and-advising-on-soil-water

[19] T McClelland (2012) Yield-Prophet®—What difference can it make to crop decision making? GRDC Update Papers 6 February 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Yield-Prophet-What-difference-can-it-make-to-crop-decision-making

- Avoiding a failed crop saves money now and saves stored water for future crops. [20]

Mobile applications (apps) are providing tools for ground-truthing precision agriculture data. Apps and mobile devices are making it easier to collect and record data on-farm. The app market for agriculture is evolving rapidly, with new apps regularly becoming available. For more information, download the GRDC Update paper, Managing data on the modern farm.

Yield Prophet®

Scientists have aimed to support farmers' capacity to achieve yield potential by developing the Agricultural Production Systems Simulator (APSIM). APSIM is a farming systems model that simulates the effects of environmental variables and management decisions on crop yield, profits and ecological outcomes.

Yield Prophet® delivers information from APSIM to farmers (and consultants) to aid their decision-making. Yield Prophet has enjoyed a measure of acceptance and adoption amongst innovative farmers and has made valuable impacts by assisting farmers to manage climate variability at a paddock level.

Yield Prophet is an online crop production model designed to present grain growers and consultants with real-time information about their crops. This tool provides growers with integrated production risk advice and monitoring decision-support relevant to farm management.

Operated as a web interface for APSIM, Yield Prophet generates crop simulations and reports to assist decision-making. By matching crop inputs with potential yield in a given season, Yield Prophet subscribers may avoid over- or under-investing in their crop. The simulations provide a framework for farmers and advisers to:

- forecast yield
- manage climate and soil water risk
- make informed decisions about N and irrigation applications
- match inputs with the yield potential of their crop
- assess the effect of changed sowing dates or varieties
- assess the possible effects of climate change

Farmers and consultants use Yield Prophet to match crop inputs with potential yield in a given season. This is achieved primarily by conducting scenario analyses in which the effects of alternative management options on crop yield and potential profitability can be assessed and applied, and can thereby influence decision-making.

How does it work?

Yield Prophet generates crop simulations that combine the essential components of growing a crop including:

- a soil test sampled prior to planting
- a soil classification selected from the Yield Prophet library of ~1000 soils, chosen as representative of the production area
- historical and active climate data taken from the nearest Bureau of Meteorology (BOM) weather station
- paddock-specific rainfall data recorded by the user (optional)
- individual crop details
- fertiliser and irrigation applications during the growing season

More information

GRDC (2013) Yield Prophet® - What difference can it make to crop decision-making

soilquality.org.au: Calculators - Wheat Yield Potential Calculator

[20] J Whish (2013) Impact of stored water on risk and sowing decisions in western NSW. GRDC Update Papers 23 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Impact-of-stored-water-on-risk-and-sowing-decisions-in-western-NSW

More information

http://www.climatekelpie.com.au/understand-climate/weather-and-climate-drivers/queensland#ElNino

http://www.climatekelpie.com.au/farmers-managing-risk/climate-champion-program

CropMate

Growers and advisers now have a readily available online tool. CropMate was developed by NSW Department of Primary Industries and can be used in pre-season planning to analyse average temperature, rainfall and evaporation. It provides seasonal forecasts and information about influences on climate, such as the impact of Southern Oscillation Index (SOI) on rainfall. The CropMate decision tool provides estimates of soil-water and N, frost and heat risk, as well as gross margin analyses of the various cropping options.

Download CropMate from the App Store on iTunes at: https://itunes.apple.com/au/app/cropmate-varietychooser/id476014848?mt=8

Australian CliMate

Australian CliMate is a suite of climate analysis tools delivered on the web, iPhone, iPad and iPod Touch devices. CliMate allows you to interrogate climate records to ask questions relating to rainfall, temperature, radiation, and derived variables such as heat sums, soil water and soil nitrate, as well as El Nino Southern Oscillation status. It is designed for decision makers such as farmers whose businesses rely on the weather.

Download from the Apple iTunes store at: https://itunes.apple.com/au/app/australianclimate/id582572607?mt=8 or visit http://www.australianclimate.net.au

One of the CliMate tools, 'Season's progress?', uses long-term (1949 to present) weather records to assess progress of the current season (rainfall, temperature, heat sums and radiation) compared with the average and with all years. It explores the readily available weather data, compares the current season with the long-term average, and graphically presents the spread of experience from previous seasons.

Crop progress and expectations are influenced by rainfall, temperature and radiation since planting. Season's progress? provides an objective assessment based on long-term records:

- How is the crop developing compared to previous seasons, based on heat sum?
- Is there any reason why my crop is not doing as well as usual because of below average rainfall or radiation?
- Based on the season's progress (and starting conditions from HowWet–N?), should I adjust inputs?

More information

Australian CliMate - Climate tools for decision makers

GRDC Update Paper (2013) Seasonal climate outlook improvements changes from historical to real time data

For inputs, Season's progress? asks for the weather variable to be explored (rainfall, average daily temperature, radiation, heat sum with base temperatures of 0, 5, 10, 15 and 20°C), a start month and a duration.

As outputs, text and two graphical presentations are used to show the current season in the context of the average and all years. Departures from the average are shown in a fire risk chart as the departure from the average in units of standard deviation. [21]

The Bureau of Meteorology has recently moved from a statistics-based to a physics-based (dynamical) model for its seasonal climate outlooks. The new system has better overall skill, is reliable, allows for incremental improvements in skill over time, and provides a framework for new outlook services including multi-week/monthly outlooks and the forecasting of additional climate variables. [22]

1.9.2 Fallow moisture

For a growing crop there are two sources of water: first, the water stored in the soil during the fallow, and second, the water that falls as rain while the crop is growing. As a farmer, you have some control over the stored soil water; you can measure how much you have before planting the crop. Long-range forecasts and tools such as the SOI can

[21] Australian CliMate—Climate tools for decision makers, www.australianclimate.net.au

[22] J Sabburg, G Allen (2013) Seasonal climate outlook improvements changes from historical to real time data. GRDC Update Papers 18 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Seasonal-climate-outlook-improvements-changes-from-historical-to-real-time-data

indicate the likelihood of the season being wet or dry; however, they cannot guarantee that rain will fall when you need it.[23]

HowWet?

HowWet? is a program that uses records from a nearby weather station to estimate how much PAW has accumulated in the soil and the amount of organic N that has been converted to an available nitrate during a fallow. HowWet? tracks soil moisture, evaporation, run-off and drainage on a daily time-step. Accumulation of available N in the soil is calculated based on surface soil moisture, temperature and soil organic carbon.

HowWet?:

- estimates how much rain has been stored as plant-available soil water during the most recent fallow period;
- estimates the N mineralised as nitrate-N in soil; and
- provides a comparison with previous seasons.

This information aids in the decision about what crop to plant and how much N fertiliser to apply.

Many grain growers are in regions where stored soil water and nitrate at planting are important in crop management decisions. This is of particular importance to northern Australian grain growers with clay soils where stored soil water at planting can constitute a large part of a crop's water supply.

Questions this tool answers

- How much longer should I fallow? If the soil is near full, maybe the fallow can be shortened.
- Given my soil type and local rainfall to date, what is the relative soil moisture and nitrate-N accumulation over the fallow period compared with most years? Relative changes are more reliable than absolute values.
- Based on estimates of soil water and nitrate-N accumulation over the fallow, what adjustments are needed to the N supply? [24]

Inputs

- A selected soil type and weather station
- An estimate of soil cover and starting soil moisture
- Rainfall data input by the user for the stand-alone version of HowOften?

Outputs

- A graph showing plant-available soil water for the current year and all other years and a table summarising the recent fallow water balance
- A graph showing nitrate accumulation for the current year and all other years

Reliability

HowWet? uses standard water-balance algorithms from HowLeaky? and a simplified nitrate mineralisation based on the original version of HowWet? Further calibration is needed before accepting with confidence absolute value estimates.

Soil descriptions are based on generic soil types with standard organic carbon (C) and C/N ratios, and as such should be regarded as indicative only and best used as a measure of relative water accumulation and nitrate mineralisation. [25]

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23 J Whish (2013) Impact of stored water on risk and sowing decisions in western NSW. GRDC Update Papers 23 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Impact-of-stored-water-on-risk-and-sowing-decisions-in-western-NSW

24 Australian CliMate—How Wet/N, http://www.australianclimate.net.au/About/HowWetN

25 Australian CliMate—How Wet/N, http://www.australianclimate.net.au/About/HowWetN

1.9.3 Water-use efficiency

Water-use efficiency is the measure of a cropping system's capacity to convert water into plant biomass or grain. It includes using water stored in the soil and rainfall during the growing season.

Water-use efficiency relies on:

- the soil's ability to capture and store water;
- the crop's ability to access water stored in the soil and rainfall during the season;
- the crop's ability to convert water into biomass; and
- the crop's ability to convert biomass into grain (harvest index).

Water is the principal limiting factor in rain-fed cropping systems in northern Australia. The objective of rain-fed cropping systems is to maximise the proportion of rainfall that crops use, and minimise water lost through run-off, drainage and evaporation from the soil surface and to weeds.

Rainfall is more summer-dominant in the northern region, and both summer and winter crops are grown. However, rainfall is highly variable and can range, during each cropping season, from little or no rain to major rain events that result in waterlogging or flooding.

Storing water in fallows between crops is the grower's most effective tool to manage the risk of rainfall variability, as in-season rainfall alone, in either summer or winter, is rarely enough to produce a profitable crop, especially with high levels of plant transpiration and evaporation.

Fortunately, many cropping soils in the northern region have the capacity to store large amounts of water during the fallow. [26]

Fallow efficiency: the efficiency with which rainfall during a fallow period is stored for use by the following crop.

$$\text{Fallow efficiency (\%)} = \frac{\text{change in plant available water during the fallow x 100}}{\text{fallow rainfall (mm)}}$$

Crop water use efficiency (WUE): the efficiency with which an individual crop converts water transpired (or used) to grain.

$$\text{Crop WUE (kg/ha/mm)} = \frac{\text{grain yield (kg/ha)}}{\text{crop water supply (mm) – soil evaporation}}$$

Systems water use efficiency (SWUE): the efficiency with which rainfall is converted to grain over multiple crop and fallow phases.

$$\text{SWUE (kg grain/mm rainfall)} = \frac{\text{total grain yield (kg)}}{\text{total rainfall (mm)}}$$

Ways to increase yield

In areas such as western New South Wales where yield is limited by water availability, there are four ways of increasing yield (Passioura and Angus 2010):

1. Increase the amount of water available to a crop (e.g. good summer weed control, stubble retention, long fallow, sowing early to increase rooting depth).
2. Increase the proportion of water that is transpired by crops rather than lost to evaporation or weeds (e.g. early sowing, early N, vigorous crops and varieties, narrow row spacing, high plant densities, stubble retention, good weed management).

[26] GRDC (2009) Water use efficiency—converting rainfall to grain. GRDC Fact Sheet Northern Region, http://www.grdc.com.au/uploads/documents/GRDC_Water%20Use%20Efficiency%20.North%20version%20231009.pdf

3. Increase the efficiency with which crops exchange water for carbon dioxide to grow dry matter, that is, transpiration efficiency (e.g. early sowing, good nutrition, high transpiration efficiency varieties).
4. Increase the total proportion of dry matter that is grain, that is, improve harvest index (e.g. early-flowering varieties, delayed N, wider row spacing, low plant densities, minimising losses to disease, high harvest index varieties).

The last three of these all improve WUE. [27]

Knowledge of evaporation for the northern growing region soils is limited yet it is the largest part of the water balance. Since 2010, Queensland Department of Natural Resources and Mines researchers have been measuring evaporation directly for a range of soils using lysimetry techniques. They found most, but not all, soils evaporate at a similar rate. There are significant interactions between soil water, climate and rainfall that influence this rate of evaporation. This data has been used to test current modelling assumptions, better parameterise models, and is now directly contributing to improving predictions of the soil water balance component of models such as APSIM, APSIM-SWIM, HowLeaky, and HowWet (via CLiMate), by providing more realistic responses for our soils and climates.

For more information, visit http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/How-much-water-is-lost-from-northern-crop-systems-by-soil-evaporation [28]

The French–Schultz approach

In southern Australia, the French–Schultz model is widely used to provide growers with a benchmark of potential crop yield based on available soil moisture and likely in-crop rainfall.

In this model, potential crop yield is estimated as:

Potential yield (kg/ha) = WUE (kg/ha.mm) x [crop water supply (mm) – estimate of soil evaporation (mm)]

where crop water supply is an estimate of water available to the crop, that is, soil water at planting plus in-crop rainfall minus soil water remaining at harvest.

In the highly variable rainfall environment in the northern region, it is difficult to estimate in-crop rainfall, soil evaporation and soil water remaining at harvest. However, this model may still provide a guide to crop yield potential.

The French–Schultz model has been useful in giving growers performance benchmarks where yields fall well below these benchmarks. It may indicate that something is wrong with the crop's agronomy or a major limitation in the environment. There could be hidden problems in the soil such as root diseases, or soil constraints affecting yields. Alternatively, apparent underperformance could be simply due to seasonal rainfall distribution patterns, which are beyond the grower's control. [29]

Challenging the French–Schultz model

Application of the French–Schultz model for the northern region has been challenged in recent times.

In the wheatbelt of eastern Australia, rainfall shifts from winter-dominated in the south (South Australia, Victoria) to summer-dominated in the north (northern New South Wales

[27] GRDC (2009) Water use efficiency—converting rainfall to grain. GRDC Fact Sheet Northern Region, http://www.grdc.com.au/uploads/documents/GRDC_Water%20Use%20Efficiency%20.North%20version%20231009.pdf

[28] GRDC (2014), How much water is lost from northern crop systems by soil evaporation. http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/How-much-water-is-lost-from-northern-crop-systems-by-soil-evaporation

[29] GRDC (2009) Water use efficiency—converting rainfall to grain. GRDC Fact Sheet Northern Region, http://www.grdc.com.au/uploads/documents/GRDC_Water%20Use%20Efficiency%20.North%20version%20231009.pdf

and Queensland). The seasonality of rainfall, together with frost risk, drives the choice of cultivar and sowing date, resulting in a flowering time between October in the south and August in the north.

In eastern Australia, wheat crops are therefore exposed to contrasting climatic conditions during the critical period for grain formation, that is, a window of about 20 days before and 10 days after flowering, which affects yield potential and WUE.

Understanding how those climatic conditions affect crop processes and how they vary from north to south and from season to season can help growers and consultants to set more realistic target yields across sites, locations and seasons.

Researchers have analysed some of the consequences of the shift from winter to summer rainfall between southern and northern regions in terms of implications for management and breeding. They advise caution on the use of simple rules of thumb (French–Schultz) for benchmarking WUE, and discuss the importance of more integrative and dynamic modelling approaches to explore alternatives to increase WUE at the single-crop and whole farming systems level, that is, $/ha.mm.

1.9.4 Nitrogen-use efficiency

Soil type, rainfall intensity and the timing of fertiliser application largely determine N losses from dryland cropping soils.

In cracking clay soils of the northern grains region, saturated soil conditions between fertiliser application and crop growth can lead to significant losses of N from the soil through denitrification. The gases lost in this case are nitric oxide, nitrous oxide and dinitrogen (N_2). Isotope studies in the northern region have found these losses can be >30% of the N applied. Direct measurements of nitrous oxide highlight the rapidity of loss in this process.

Insufficient rainfall after surface application of N fertilisers can result in losses from the soil through volatilisation. The gas lost in this case is ammonia. Direct measurements of ammonia losses have found that they were generally <15% of the N applied, even less in in-crop situations. An exception occurred with the application of ammonium sulfate to soils with free lime at the surface, where losses were >25% of the N applied. Recovery of N applied in-crop requires sufficient in-crop rainfall for plant uptake from otherwise dry surface soil. [30]

A balance of nutrients is essential for profitable yields. Fertiliser is commonly needed to add the essential nutrients P and N. Lack of other essential plant nutrients may also limit production in some situations.

Knowledge of the nutrient demand of crops is essential in determining nutrient requirements. Soil testing and nutrient audits assist in matching nutrient supply to crop demand.

1.10 Disease status of paddock

1.10.1 Soil testing for disease

Stubble testing

Some of the current strategies for managing crown rot are to control grass hosts prior to cropping, rotate susceptible cereals with non-host break crops, inter-row sowing, and grow tolerant wheat varieties. It is therefore very important for crown rot testing to be carried out on a paddock, so that growers and consultants can determine whether crown rot is present and if so, its severity. An informed decision can then be made regarding crop choice and farming system.

[30] G Schwenke, P Grace, M Bell (2013) Nitrogen use efficiency. GRDC Update Papers 16 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Nitrogen-use-efficiency

Testing involves a visual assessment on stubble followed by a precise plating test. This is the only way to accurately test for the disease. Results are provided to the grower and consultant within about four weeks of receiving the sample. [31]

Check your cereal crops for crown rot between grain-fill and harvest. Collect plant samples from deep within the paddock by walking in a large 'W' pattern, collecting five plants at 10 different locations. Examine each plant for basal browning, record the percentage of plants showing the symptom and then put in place appropriate measures for next year. To see the honey/dark brown colour more easily, the leaf sheaths should be pulled back. This symptom may not appear on all stems of an infected plant and is difficult to see in oats.

As a general rule, the risk for a cereal in the next season will be:

- low, if <10% of plants infected
- medium, if 10–25% of plants infected
- high, if >25% of plants infected [32]

Soil testing

PreDicta B (B = broadacre) is a DNA-based soil-testing service to identify which soil-borne pathogens pose a significant risk to broadacre crops prior to seeding.

It has been developed for cropping regions in southern Australia and includes tests for:

- cereal cyst nematode
- take-all (*Gaeumannomyces graminis* var. *tritici* (Ggt) and *G. graminis* var. *avenae* (Gga))
- rhizoctonia barepatch (*Rhizoctonia solani* AG8)
- crown rot (*Fusarium pseudograminearum*)
- root lesion nematode (*Pratylenchus neglectus* and *P. thornei*)
- stem nematode (*Ditylenchus dipsaci*)

More information

[South Australian Research and Development Institute - PreDicta B]

Northern region grain producers can access PreDicta B via Crown Analytical Services or agronomists accredited by the South Australian Research and Development Institute to interpret the results and provide advice on management options to reduce the risk of yield loss. PreDicta B samples are processed weekly from February to mid-May (prior to crops being sown) to assist with planning the cropping program.

PreDicta B is not intended for in-crop diagnosis. That is best achieved by sending samples of affected plants to your local plant pathology laboratory.

1.10.2 Cropping history effects

Continuous cereal cropping increases the risk of diseases including crown rot and tan spot. All winter cereals and many grassy weeds host crown rot, and it can survive for many years in infected plant residues. Infection can occur when plants come in close contact with those residues. [33]

Stubble burning is not recommended as a control for crown rot, and cultivation can increase incidence of seed–stubble contact. Inter-row sowing is a recommended strategy. High cereal intensity and including durum wheat in cropping programs are factors that increase crown rot levels. [34]

[31] Crown Analytical Services, https://sites.google.com/site/crownanalyticalservices/

[32] GRDC (2009) Crown rot in cereals Fact Sheet,, www.grdc.com.au/uploads/documents/GRDC_CrownRot_North.pdf

[33] GRDC (2012) Crown rot—about the crown rot disease. GRDC Hot Topics 10 July 2012, http://www.grdc.com.au/Media-Centre/Hot-Topics/Crown-Rot

[34] GRDC (2012) Crown rot—about the crown rot disease. GRDC Hot Topics 10 July 2012, http://www.grdc.com.au/Media-Centre/Hot-Topics/Crown-Rot

1.11 Insect status of paddock

1.11.1 Insect sampling of soil

Soil-dwelling insect pests can seriously reduce plant establishment and populations, and subsequent yield potential.

Soil insects include:

- cockroaches
- crickets
- earwigs
- black scarab beetles
- cutworms
- false wireworm
- true wireworm
- Desiantha weevil larvae
- slugs
- snails

Different soil insects occur under different cultivation systems and farm management can directly influence the type and number of these pests:

- Weedy fallows and volunteer crops encourage soil insect build-up.
- Insect numbers decline during a clean long fallow due to lack of food.
- Summer cereals followed by volunteer winter crops promote the build-up of earwigs and crickets.
- High levels of stubble on the soil surface can promote some soil insects due to a food source, but this can also mean that pests continue feeding on the stubble instead of germinating crops.
- No-tillage encourages beneficial predatory insects and earthworms.
- Incorporating stubble promotes black field earwig populations.
- False wireworms are found under all intensities of cultivation but numbers decline if stubble levels are very low.

Soil insect control measures are normally applied at sowing. Since different insects require different control measures, the species of soil insects must be identified before planting.