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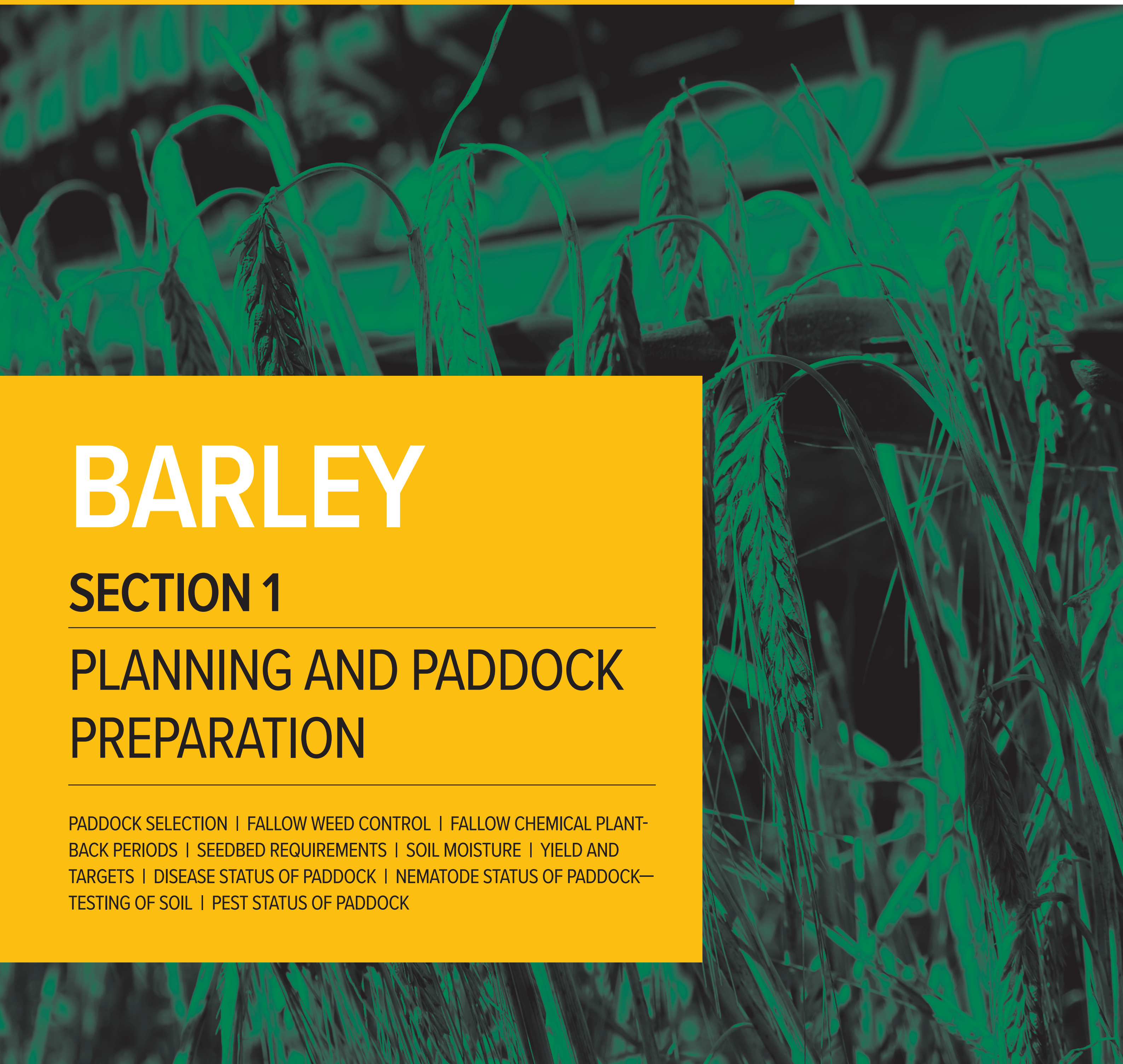
GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



BARLEY

SECTION 1

PLANNING AND PADDOCK PREPARATION

PADDOCK SELECTION | FALLOW WEED CONTROL | FALLOW CHEMICAL PLANT-BACK PERIODS | SEEDBED REQUIREMENTS | SOIL MOISTURE | YIELD AND TARGETS | DISEASE STATUS OF PADDOCK | NEMATODE STATUS OF PADDOCK—TESTING OF SOIL | PEST STATUS OF PADDOCK

Planning/Paddock preparation

Growers planning to plant barley should use market signals to assist them when deciding which varieties to sow. Market demand, pricing signals and the location of segregations should be considered in partnership with the agronomic management needed. Consideration should also be given to the risk associated with delivering malt/food grade barley when determining how much area to plant to each malt/food variety. [1]

1.1 Paddock selection

Paddock selection is critical for reliable malting barley production, but less important for feed barley. When selecting paddocks to grow barley, consider the following:

- Nitrogen status should be appropriate for expected yield level
- Soil pH($CaCl_2$) should be ≥5.0 and soil aluminium <5%
- Avoid soils prone to waterlogging
- In rotation, ideally sow after a root-disease break crop
- Avoid barley on barley
- Barley may be sown after wheat if disease or seed contamination is not a problem
- Avoid varietal contamination.

Results from research in the southern grains region suggest that paddocks with pre-sowing soil nitrate-N levels >150 kg/ha are unsuitable for malting barley production. Paddocks with pre-sowing nitrate-N of 100–150 kg/ha were less likely to achieve barley of malting quality than those with <100 kg/ha. [2]

Informed paddock selection, suitable crop rotation and the planting of disease-resistant varieties are the best tools to minimise disease.

Paddock rotation and history

Crop sequencing/rotation is a key part of a long-term approach to tackling weed, disease and moisture challenges in farming systems.

1.1.1 Benefits of barley as a rotation crop

Barley is a good rotation crop for breaking disease and weed cycles, and providing high stubble levels. [3] It fits well into the farming systems as a winter cereal crop.

Advantages of barley include:

- less susceptible to frost than wheat at early growth stages
- somewhat lower N fertiliser requirements than wheat if expecting similar yields
- matures faster and can be harvested earlier than wheat
- vigorous plant growth and high Water Use Efficiency (WUE)
- vigorous early growth—some varieties establish groundcover, which smothers weeds
- produces more dry matter than wheat, leaving very good stubble cover and valuable straw for livestock feeding

1 DAFWA (2016) 2017 barley variety sowing guide for Western Australia. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/3766

2 L Lenaghan, T Fay, M. Evans (2001) Paddock selection is critical for reliable malt barley production. Australian Agronomy Conference/the Regional Institute, http://www.regional.org.au/au/asa/2001/4/b/lenaghan.htm

3 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

- as a cereal can iregrow to produce a good grain crop when grazed before stem elongation
- a good break crop due to differences in foliar disease responses compared with wheat.

Growers should soil and plant tissue test and record paddock rotations to determine adequate crop nutrition. [4]

1.1.2 Disadvantages of cereals as a rotation crop

Growing cereals in continuous production can be difficult because of the rising incidence of:

- difficult-to-control and herbicide-resistant weeds, particularly grass weeds
- disease build-up (e.g. crown rot, *Rhizoctonia*, cereal cyst nematode, root lesion nematode, take-all)
- N depletion and declining soil fertility.

Crop rotation is a key strategy for managing Australian farming systems, and improvements in legume and oilseed varieties and their management have facilitated this shift.

In many of Australia's grain-growing regions, broadleaf crop options have been seen as riskier and less profitable than cereals. This perception has been driven, in part, by fluctuating prices and input costs associated with the broadleaf crop in the year of production, and difficulties in marketing. However, when the profitability of the entire rotation is assessed, it is often more profitable to include broadleaf crops in the crop sequence.

A broadleaf crop is often included in the crop sequence to counteract limitations in the cereal phase (weeds, disease, N), so the broadleaf crop's financial impact may be considerably better if considered across the crop sequence. [5]

Examples of rotations and their suitability for the production of malting barley

- **Following canola**: With the advantage of low root disease incidence and reduced soil N supply after oilseeds, this is the ideal situation for the production of plump malting barley that is not too high in protein.
- **Following oats**: This rotation is again well suited to the production of malting barley as take-all will be reduced and soil N level lowered. Oats are quite tolerant of waterlogging whereas barley is very susceptible, so be careful not to choose a high-risk waterlogging paddock on which oats happened to have yielded well.
- **Following pasture**: The suitability of barley as a crop after pasture will depend on the soil N status and soil type. After a good medic stand on heavy soils it is likely that soil N would be too high and wheat would be a much more profitable alternative. On lighter soils with a weaker clover base, barley would be a better proposition.
- **Following field peas**: On heavy soils, barley following field peas is likely to lead to high protein levels in most years, rendering it unsuitable for malting. Feed barley can be grown in this situation but the returns are unlikely to be competitive with high protein wheat.
- **Second cereal following field peas**: Barley is well suited to the role of second cereal in the rotation unless soil N levels are very high.
- **Following lupins**: On light soils, barley following lupins is likely to yield well but the protein level may be a problem depending on soil N supply. If wheat following lupins generally gives protein levels of 10.5% or more then it is likely

4 DAF Qld (2014) Barley—planting and disease guide. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/145587/Barley-Planting-Guide-2014.pdf

5 M Peoples (2012) Returns from break crops can challenge wheat. GRDC Ground Cover Issue 98, 27 April 2012, http://www.grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-98-Supplement-Crop-Sequencing/Returns-from-break-crops-can-challenge-wheat

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GRDC (2013) Crop sequencing—what are the key issues to making profitable and sustainable decisions? GRDC Update Papers.

GRDC Online Farm Trials: Barley and wheat disease management using foliar and fertiliser fungicides.

that soil N will be too high for malting barley. Likewise, wheat protein levels of 10.5% or less indicate that malting barley can be safely grown in most years.

- **Second cereal following lupins**: Where take-all levels may be high following the wheat crop, barley yield is likely to be restricted to around 2 t/ha when grown as the second cereal. [6]

1.2 Fallow weed control

Summer weeds can rob subsequent crops of soil N and stored soil water. They can also reduce crop emergence by causing physical and/or chemical interference at seeding time.

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

A study by the Cooperative Research Centre (CRC) for Australian Weed Management found 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%. [7]

Paddocks generally have multiple weed species present at one time, making weed-control decisions more difficult. Knowing the paddock and controlling weeds as early as possible are important for good control of fallow weeds. Information is included for the control of most common problem weeds. For advice on individual paddocks, growers should contact their agronomists. See Section 6: Weed Control.

Return on investment

Benefits of fallow weed control are significant. In low-rainfall areas across Australia, growers are likely to gain financially from summer weed control, according to the Agricultural Production Systems Simulator (APSIM) simulations. For low-rainfall areas, there is a 70–99% chance of making a profit from summer weed control. The greatest impact was calculated in areas with a higher proportion of summer rain.

The highest return on investment in summer weed control is likely to be on loams, light clays and loamy duplex soils or soils with a plant available water capacity of more than 100 mm. Returns will be better in the part of the rotation where soil water that would support continued weed growth is already present, for example, pulse stubbles or long fallows. In high-rainfall areas, the potential for an economic return is lower and more variable than low-rainfall areas. The chance of making a profit from summer weed control is 30–80%. Despite this, it is important not to avoid summer weed control. Uncontrolled weed growth in high-rainfall areas is likely to lead to a rapid build-up of weeds and disease, reducing returns in the short to medium term. [8]

Effective weed control can reduce weed numbers in subsequent years and run down the seedbank. Uncontrolled weeds contribute massively to the soil seed bank, creating increased costs of control 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. [9]

6 DAFWA (1995) The Barley Book. Department of Agriculture and Food, Western Australia, http://researchlibrary.agric.wa.gov.au/bulletins/44/

7 DAFWA (2016) Summer weeds. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2516

8 GRDC (2012) Summer fallow—make summer weed control a priority. Western Region. Summer Fallow Management Fact Sheet, January 2012

9 DAFWA (2016) Summer weeds. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2516

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GRDC (2015) Summer weeds reduce moisture and nitrogen. GRDC Update Papers.

GRDC (2014) Summer fallow spraying. Fact sheet.

GRDC (2014) Summer fallow weed management.

GRDC (2011) Achieving good pre-emergent spray results. GRDC Update Papers.

GRDC: Weed Webinars.

GRDC: Integrated Weed Management Hub.

1.3 Fallow chemical plant-back periods

Plant-back periods are the obligatory times between the herbicide spraying date and 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. This is the case with sulfonylureas (SUs, e.g. chlorsulfuron).

Residual persistence and half-lives of common herbicides are shown in the Table 1. Herbicides with long residuals can affect subsequent crops, especially if they are effective at low levels of active ingredient, such as the SUs. 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. [10]

There are also in-crop herbicides that have plant-back periods. Some are mentioned in Table 1.

Table 1: *Half-life of common pre-emergent herbicides and residual persistence from broadacre trials and paddock experiences*

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 6 weeks
Glean® (chlorsulfuron)	28–42	High. Persists longer in high-pH soils. Weed control longer than Logran®
Diuron	90 (range: 1 month–1 year, depending on rate)	High. Weed control will drop off within 6 weeks, depending on rate. Long-lasting activity observed 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. Long-lasting (>3 months) activity observed on broadleaf weeds such as fleabane
Simazine	60 (range: 28–149)	Med./high. 1 year of residual in high-pH soils. Long-lasting (>3 months) activity observed on broadleaf weeds such as fleabane
Terbyne® (terbuthylazine)	3-60 in biologically active soil	High. Long-lasting (>6 months) activity observed on broadleaf weeds such as fleabane and sow thistle
Triflur® X (trifluralin)	57–126	High. 6–8 months residual. Higher rates longer. Long-lasting activity observed on grass weeds such as black/stink grass
Stomp® (pendimethalin)	40	Medium. 3–4 months of residual
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months of residual
Balance® (isoxaflutole)	1.3 (metabolite: 11.5)	High. Reactivates after each rainfall event. Long-lasting (>6 months) activity observed on broadleaf weeds such as fleabane and sow thistle

10 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

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Australian Pesticides and Veterinary Medicines Authority.

NSW DPI (2016) Weed control winter crops.

NSW DPI (2012) Using pre-emergent herbicides in conservation farming systems.

GRDC Online Farm Trials: Residual herbicides. Group B & C carry-over.

BASF: Clearfield Production System

WA Barley Variety Guide 2017

https://www.agric.wa.gov.au/barley/2017-barley-variety-sowing-guide-western-australia

Herbicide	Half-life (days)	Residual persistence and prolonged weed control
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®
Ally® (metsulfuron-methyl)	30 (range: 14–180)	Persists longer in high-pH soils and after a dry year

Sources: CDS Tomlinson (ed,) (2009) The pesticide manual. 15th edn. British Crop Protection Council, Farnham, UK. Extoxnet. California Dept Pesticide Regulation Environmental Fate Reviews.

1.3.1 Avoid damage from residual herbicides

Select an appropriate herbicide for the weed population present and consider what the re-cropping limitations may do to future rotation options. Read the entire herbicide label, including the details in fine print.

Users of chemicals are required to keep good records, including weather conditions. In the case of unexpected damage, accurate records can be invaluable, particularly spray dates, rates, batch numbers, rainfall, soil type(s) and pH.

If chemical residues could be present, choose the least susceptible crop (refer to product labels). Optimise growing conditions to reduce the risk of compounding the problem with other stresses such as herbicide spray damage, disease and nutrient deficiency. These stresses make a crop more susceptible to herbicide residues.

Be wary of compounding a residue problem by planting a herbicide-resistant crop and spraying with more of the same herbicide group. Growers may avoid the problem with residues in the short term, only to be faced with herbicide-resistant weeds in the longer term. This can also have an additive effect on non-herbicide-resistant crops. [11]

1.3.2 Genetic controls

The Clearfield® Production System is designed to deliver extended weed control and increased yield potential and crop quality. [12] It matches selected seed varieties with Intervix® (active ingredients imazamox and imazapyr), a custom-designed herbicide that can only be used on Clearfield® varieties. Refer to the herbicide label for weed species that can be controlled.

In 2013 Australian growers were offered access to the world's first registered Clearfield® barley, Scope. In 2017, a new Clearfield® variety with improved traits, Spartacus CL$^{\Phi}$, was released.

1.4 Seedbed requirements

Barley seed needs good soil contact for germination. Some 70–90% of seeds sown produce a plant. Inappropriate sowing depth, disease, crusting, moisture deficiency and other stresses all reduce the numbers of plants that become established. Field establishment rates can be ≤60% if seedbed conditions are unfavourable. [13]

11 Agriculture Victoria (2013) Avoiding crop damage from residual herbicides, http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/chemical-residues/managing-chemical-residues-in-crops-and-produce/avoiding-crop-damage-from-residual-herbicides

12 Crop Care (2011) Clearfield best management practice. Crop Care Australasia Pty Ltd, http://www.cropcare.com.au/Assets/501/1/2011ClearfieldBMPWeb.pdf

13 N Fettell, P Bowden, T McNee, N Border (2010) Barley growth & development. PROCROP Series. Industry & Investment NSW, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/516180/Procrop-barley-growth-and-development.pdf

1.5 Soil moisture

APSIM-Barley

The APSIM-Barley module of APSIM simulates the growth and development of a barley crop in a daily time-step on an area basis (per m^2, not single plant). [14]

This can be a useful tool for barley growers. For more information, visit: APSIM-Barley.

1.5.1 Subsoil constraints

Soils with acidic subsoils, compactions layers or high levels of chloride and/or sodium or boron in their subsurface layers are often referred to as having subsoil constraints. There is growing evidence that subsoil constraints affect yields by increasing the lower limit of a crop's available soil water and thus reducing the soil's PAWC. [15]

1.6 Yield and targets

1.6.1 Variety yield comparisons

See the National Variety Trial website to compare the performance of current barley varieties in WA. See Section 2.2: Varieties for information on barley varieties.

1.6.2 Seasonal outlook

The Department of Agriculture and Food, Western Australia (DAFWA) provides up to date information about the coming season and its potential impacts on cropping and agriculture. To assist in making more informed on-farm decisions, DAFWA provides statistical seasonal rainfall forecasts, modelled plant available soil water at the start of the growing season and risk of frost occurring at different locations. The Statistical Seasonal Forecast (SSF) system uses historical relationships between global sea surface temperature and sea level pressure with rainfall in south-west Australia to produce forecasts of rainfall for future months. DAFWA seasonal climate information can be found at https://www.agric.wa.gov.au/drought/seasonal-climate-information.

For tips on understanding weather and climate drivers including the Southern Oscillation Index, visit the Climate Kelpie website. Case studies of farmers across Australia recruited as 'Climate Champions' as part of the Managing Climate Variability R&D Program can be accessed at: Climate Kelpie MCV Climate Champion program.

Australian CliMate is a suite of climate analysis tools delivered on the Web, iPhone, iPad and iPod Touch devices. CliMate allows users 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 Niño/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/australian-climate/id582572607?mt=8.

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 all years. It explores the readily available weather data and 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 and helps to answer the following questions:

14 APSIM. Crop module documentation: Barley. Agricultural Production Systems Simulator, http://www.apsim.info/Documentation/Model,CropandSoil/CropModuleDocumentation/Barley.aspx

15 Z Hochman et al. (2007) Simulating the effects of saline and sodic subsoils on wheat crops growing on Vertosols. Australian Journal of Agricultural Research 58, 802–810, http://www.publish.csiro.au/paper/AR06365.htm

- How is the crop developing compared with 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? [16]

1.6.3 Fallow moisture

For a growing crop, there are two sources of water: that stored in the soil before planting, and that falling as rain while the crop is growing. Long-range forecasts and tools such as the SOI can indicate the likelihood of the season being wet or dry. [17]

HowWet?—a climate analysis tool

HowWet? estimates how much rain has been stored as plant-available soil water during the most recent fallow period; it estimates how much N has been mineralised as nitrate-N in soil; and it provides a comparison with previous seasons. This information aids in the decision of what crop to plant and how much N fertiliser to apply.

1.6.4 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 the use of both water stored in the soil and rainfall during the growing season.

Water Use Efficiency relies on:

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

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) × (crop water supply (mm)–estimate of soil evaporation (mm))

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

The French–Schultz model has been useful in providing growers with performance benchmarks; where yields fall well below these benchmarks, it may indicate something 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. [18]

MORE INFORMATION

GRDC (2012) Water Use Efficiency of grain crops in Australia: principles, benchmarks and management.

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

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

18 GRDC (2009) Converting rainfall to grain. Northern Region. Water Use Efficiency Fact sheet, https://grdc.com.au/__data/assets/pdf_file/0029/225686/water-use-efficiency-north.pdf.pdf

1.7 Disease status of paddock

PestFax is a free weekly informative and interactive reporting service during the growing season. It provides risk alerts, current information and advice on pests and diseases threatening crops and pastures throughout the grain belt of WA during each growing season. Diseases remain a major threat to barley production in Australia but are generally well controlled. In 2009, the average annual loss from barley diseases is estimated at AU$252 million, or $66.49/ha. “

Continuous cereal cropping increases the risk of diseases such as crown rot.

See Section 9: Diseases for more information on diseases.

1.7.1 Soil testing for disease

PreDicta B is a DNA-based soil testing service to identify which soilborne 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:

- CCN (*Heterodera avenae*)
- take-all (caused *by Gaeumannomyces graminis* var. *tritici (Ggt*) and *G. graminis* var. *avenae (Gga))*
- Rhizoctonia bare patch (caused by *Rhizoctonia solani* AG8)
- RLN (*Pratylenchus neglectus, P. thornei* and *P. Quasitereoides*
- crown rot (caused by *Fusarium pseudograminearum*)
- stem nematode (*Ditylenchus dipsaci*).

Continuous cereal cropping increases the risk of diseases but testing gives growers the ability to identify soil diseases prior to planting.

Grain producers can access PreDicta B from Primary Industries and Regions SA/South Australian Research and Development Institute. 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. This is best achieved by sending samples of affected plants to the local plant pathology laboratory. DDLS–Plant pathology services WA.

For more information, visit: PreDicta B.

1.8 Nematode status of paddock—testing of soil

Root-lesion nematodes (RLN) are found over 5.74 million hectares (or ~65%) of the cropping area of Western Australia. Populations potentially limit yield in at least 40% of these infested paddocks.

The main species found in broadacre cropping in WA are *Pratylenchus neglectus*, *P. quasitereoides* (originally described as *P. teres*), *P. thornei* and *P. penetrans*.

Barley may be more susceptible to *P. quasitereoides* than to *P. neglectus*. [19]

Paddocks should be tested for plant parasitic nematodes so that optimal management strategies can be implemented. Testing will tell growers and advisers whether nematodes are present and at what density, and which species are present.

It is important to know which species are present because crops and varieties have different levels of tolerance and resistance to different species of nematodes.

Diagnosis of RLN is difficult and can be confirmed only with laboratory testing, particularly to identify the species because all RLN species cause identical symptoms.

19 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region. Fact sheet, http://www.grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

If RLN infestation is suspected, growers are advised to check the crop roots. Carefully digging up and washing the soil from the roots of an infected plant can reveal evidence of infestation in the roots, which warrants laboratory analysis.

Testing services are available at Agwest Plant Laboratory at the Department of Agriculture and Food, Western Australia (DAFWA), and the DNA-based soil testing service PreDicta B, provided by the South Australian Research and Development Institute, can detect *P. neglectus*, *P. thornei* and *P. quasitereoides*. Growers are advised to contact their local DAFWA office for advice. [20]

If a particular species is present in high numbers, immediate decisions need to be made to avoid losses in the next crop to be grown. When low numbers are present, it is important to take decisions to safeguard future crops. Learning that a paddock is free of nematodes is valuable information because it may be possible to take steps to avoid future contamination. [21]

1.9 Pest status of paddock

1.9.1 Sampling for pre-season pests

Insect pests can seriously reduce plant establishment and populations, and subsequent yield potential.

Common pre-season pests include:

- Desiantha weevil
- cutworms
- false wireworm
- bryobia mites
- balaustium mites
- red-legged earth mites.

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
- High levels of stubble on the soil surface can promote some soil insects (i.e. a food source); however, pests may continue feeding on the stubble instead of on 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 decline if stubble levels are very low.

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

Recognising soil insects

For more information, see Section 7: Insect control.

Detecting soil-dwelling insects

Soil insects are often difficult to detect because they hide under trash or in the soil. Immature insects such as false wireworm larvae are usually found at the moist–dry soil interface.

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20 GRDC (2015) Tips and Tactics: Root-Lesion Nematodes, Western Region. Fact sheet, http://www.grdc.com.au/Resources/Factsheets/2015/03/Root-Lesion-Nematodes

21 DAF Qld (2009) Root lesion nematodes—management of root-lesion nematodes in the northern grain region. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

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GRDC (2015) Snail bait application. Fact sheet.

GRDC (2014) Mouse management a numbers game. Ground Cover Issue 111.

GRDC (2015) Surveillance and forecasts for mouse outbreaks in Australian cropping systems. GRDC Update Papers.

GRDC (2012) Mouse control—Western Region. Fact sheet.

For current chemical control options see Pest Genie or APVMA. [22]

1.9.2 Snails

Reports of snail damage are rising in the Western Region with reports from WA growers of snails damaging crops and requiring control—particularly in southern coastal districts and near Geraldton in the northern wheatbelt. [23]

Monitoring regularly, means pests can be detected early, ideally before seeding as there are more control options available at this time. Once the crop has been seeded and germination is commencing, control options are limited to baiting. At this time crops should be examined at night for slug and snail activity.

It is best to look for slugs and snails on moist, warm and still nights. Fresh trails of white and clear slime (mucus) visible in the morning also indicate the presence of slugs or snails. However, prior to and after applying control measures, it is necessary to estimate how many slugs and snails are present.

It is a good idea to monitor in:

- January/February to assess stubble management options for slug and snail management
- March/April to assess options for burning and/or baiting
- May to August to assess options for baiting especially along fencelines
- For snails three to four weeks before harvest to assess risk of snail contamination of grain and if required, implement options to minimise the risk. [24]

See Section 7.9: Pest slugs and snails for more information on snail management.

22 DAF Qld (2011) How to recognise and monitor soil insects. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/recognising-and-monitoring-soil-insects

23 J Paterson, 2013. Southern and western snail snapshot. GRDC Ground Cover Supplements 102. https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS102/Southern-and-western-snail-snapshot

24 DAFWA (2016) Identification and control of pest slugs and snails for broadacre crops in Western Australia. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2671