AUSTRALIAN CROP ACCREDITATION SYSTEM

WHEAT PROTOCOLS

SECTION 1
AGRONOMIC CHARACTERISTICS

DESCRIPTORS

These are characteristics which are virtually independent of the environment

- seed colour (white, red , purple)
- presence or absence of awns
- head type (club, etc).
- maturity classification
- growth habit
- specific genetic traits
- transformations

PRINCIPLES FOR THE EVALUATION OF OTHER CHARACTERS

1. Each character will be evaluated relative to an agreed set of standards. Standard/check varieties must be chosen to fairly evaluate the relative performance of the new varieties in the target environment(s). Data from the new variety and checks must come from the same experiments. As variations in seed size and nutrient content can bias results, seed should come from the same source wherever possible.

2. The data for all characters which are measured objectively, e.g by weight, length or weight per unit area, must be presented in the original metric units (g, mm, t ha^{-1}) and not transformed into percentages or non-continuous scores.

3. For all characters which can be measured objectively, data must be obtained from randomised replicated experiments and be analysed by analysis of variance, or other method of equal rigour. Standard errors must be presented.

4. All data collected from the nominated target area should be included so that an accurate picture of the new cultivar's performance is presented. The exclusion of any data from the analysis must be justified.

5. Records must be maintained in a manner which can be audited. Trial data must be made available for auditing if required by the accreditation committee. Raw data from all trials, sample and data analysis must be maintained for at least five years.

1. PROTOCOLS FOR INDIVIDUAL AGRONOMIC CHARACTERS

Where relevant the following characteristics are assessed in relation to check varieties which will usually be represented in the yield trials.

1.1 Seed weight

Assessed as weight in grams of 1000 grains.
From a minimum of 5 experiments grown over 2 or more years.
Comparisons must be made with checks of similar maturity.

1.2 Hectolitre weight (test weight)

Assessed as the weight (grams) of one hectolitre of grain using standard equipment as used at grain receival sites.
From a minimum of 5 experiments over 2 or more years.
Comparison must be made with checks of similar maturity.

1.3 Screenings

From the same sites as grain size,
Relevant industry standards must be used and screen size must be specified
From a minimum of 5 experiments over 2 or more years.
Comparisons must be made with checks of similar maturity.

1.4 Coleoptile length

Assessed in mm.
Test lines are surface sterilised using 0.5% hypochlorite for 30 seconds, or equivalent, and rinsed. A check cultivar with long coleoptiles and one with short coleoptiles must be included. The control filter papers (Ekwip 32*46 cm grade R6) are soaked in a solution of 0.0025mM $ZnSO_4.7H_2O$,0.5mM $Ca(NO_3)_2.4H_2O$, 0.015mM H_3BO_3 and drained for 2-3 minutes. Approximately 8 seeds each of 2 test lines and 3 seeds of each check are included per paper (use an 8:3:3:8 design). The design can be varied, but the checks must be included in each roll. Seeds are placed embryo downwards at a spacing of approximately 2 cm across the middle of the paper. The papers are rolled and covered in aluminium foil. They are then stored upright at 15^{o}C for 12-14 days. The lengths of the coleoptiles are then measured.
Any other published method may be used, and must be referenced
From a minimum of 3 experiments grown in 2 or more years.

1.5 Early vigour

A visual rating on a 1 to 9 scale (1 poor vigour, 9 high vigour).
From a minimum of 4 experiments grown over 2 or more years.
The check must be in the mid range for each experiment.
Care must be taken to distinguish vigour from growth habit.

1.6 Maturity

Maturity should be classified as ear emergence relative to appropriate standard cultivars for a given sowing date range for a given environment or region. Days + or - the standard.
From 10 experiments over three years.

1.7 Zinc efficiency

Assessed as the ratio of yield in a low zinc soil to yield in the same soil with zinc fertiliser added. A check known to be efficient and one known to be inefficient must be included.
Comparisons must be from the same site.
From a minimum of 3 experiments grown over 2 or more years.

1.8 Manganese efficiency

Assessed as the ratio of yield in a low manganese soil to yield in the same soil with manganese fertiliser and foliar sprays applied to eliminate the deficiency. A check known to be efficient and one known to be inefficient must be included. The manganese level in the soil should be too low for a standard cultivar.
Comparisons must be from the same site.
From a minimum of 3 experiments grown over 2 or more years.

1.9 Copper efficiency

Assessed as the ratio of yield in a low copper soil to yield in the same soil with copper fertiliser added. A check known to be efficient and one known to be inefficient must be included. The copper level in the soil should be too low for a standard cultivar.
Comparisons must be from the same site.
From a minimum of 3 experiments grown over 2 or more years.

1.10 Iron efficiency

Assessed as the ratio of yield in a low iron soil to yield in the same soil with iron fertiliser and foliar sprays applied to eliminate the deficiency. A check known to be efficient and one known to be inefficient must be included. The iron level in the soil should be too low for a standard cultivar.
Comparisons must be from the same site.
From a minimum of 3 experiments grown over 2 or more years.

1.11 Boron tolerance

Assessed as the ratio of the length of the longest roots of seedlings grown in 0.572 M boric acid to those grown under standard sterile conditions. A check known to be tolerant to boron and one known to be intolerant should be included in each roll. The control filter papers (Ekwip 32*46 cm grade R6) are soaked in a solution of 0.0025mM $ZnSO_4.7H_2O$,0.5mM $Ca(NO_3)_2.4H_2O$, 0.015mM H_3BO_3 plus 100 mg/litre of boron as boric acid, and drained for 2-3 minutes. Approximately 8 seeds each of 2 test lines and 3 seeds of each check are included per paper (use an 8:3:3:8 design). The design can be varied, but the checks must be included in each roll. Seeds are placed embryo downwards at spacings of approximately 2 cm across the middle of the paper. The papers are rolled and covered in aluminium foil. They are then stored upright at 15^{o}C for 12-14 days. The lengths of the longest roots are then measured.
Alternative published methods may be used and must be referenced.
From a minimum of 3 experiments grown over 2 or more years.

1.12 Herbicide tolerance

Measured as the ratio of the grain yield of a weed-free crop sprayed with the recommended rate of a herbicide to the yield of an unsprayed, weed-free crop. A second measure is the ratio of the grain yield of a weed-free crop sprayed with twice the recommended rate of a herbicide to the yield of an unsprayed, weed-free crop.
From a minimum of 2 experiments grown over 2 years.

1.13 Tillering

A visual rating on a 1 to 9 scale (1 low tillering, 9 high tillering).
The check has to be in the mid-range for each experiment and plant populations (plants per unit area) need to be presented.
From a minimum of 10 experiments grown over 2 or more years.

1.14 Flowering date.

50% of culms in a plot to anthesis. Calendar date or days from seeding (calendar date)
From a minimum of 3 experiments grown over 2 or more years.

1.15 Plant height

Maximum height estimated for the plants in each plot between flowering and maturity.
From a minimum of 5 experiments grown over 2 or more years.

1.16 Lodging

A visual rating on a 1 to 9 scale (1 on the ground, 9 no lodging).
From a minimum of 5 experiments where lodging occurs.

1.17 Shattering

A visual rating on a 1 to 9 scale (1 high shattering, 9 low shattering), measured prior to harvest
From a minimum of 5 experiments where shattering occurs.

1.18 Tolerance to sprouting

This is tolerance to germinability at harvest ripeness. Assessed as days to 50% emergence.
A check cultivar known to be tolerant and one known to be intolerant must be included.
Plots must be covered with translucent plastic, or a suitable alternative, to exclude rain from the time the plants start turning yellow (approximately 20 days prior to harvest ripeness). Plant maturity should be checked at 2 day intervals, and at physiological maturity (visually determined by the loss of chlorophyll from leaves and stems, or the cessation of movement of a coloured dye into the upper stem and rachis of stem cuts, which occurs at approximately 18% moisture content). Ears are harvested by hand at random from the main tillers. These are stored at ambient temperature, under cover for 5 days, during which time the grain moisture declines to less than 12%. Ear samples are gently hand threshed, and the grain stored at -20ºC. Shrivelled, broken and black point affected grains must be removed.
Germination tests are used to determine dormancy or germinability. Replicate samples of 50 grains are incubated on filter paper moistened with water (5ml on a 9cm diameter No1 filter paper) at 20ºC for 7 days. Grains are scored as germinated when the pericarp is ruptured and a shoot can bee seen.
Numbers of germinated grains are counted at 1 or 2 day intervals.
From a minimum of 2 experiments grown over 2 years.

1.19 Yield

This needs to be assessed relative to the checks in the target environment nominated by the breeder, which may not be a recognised agro-ecological zone. There have been 3 agro-ecological environments recognised in the Northern Region, 6 in the Southern Region (including an irrigation environment) and 5 in the Western Region. These are subject to continuing research. A target environment, as defined by the breeder submitting data for accreditation, would generally consist of one or more of these agro-ecological environments, but other target environments may be nominated.

Any relevant GXE analysis should be referenced.

Data should be presented from a minimum of 30 sites grown over 3 or more years. The number of sites may be unevenly distributed across years. The coefficients of variation after spatial or blocking adjustment should be rated to determine whether a trial should be excluded for excessive variability.

Data should be presented for all sites where the new variety was evaluated in the target environment. Specific sites can be eliminated from the analysis by argument, such as damage by an uncontrollable factor, for example mice or uneven waterlogging, or trials which are exceptionally low yielding.

The minimum plot size is 1m x 5 m (measured centre to centre). Variations from this must be justified. Data should only be obtained from plots with other plots grown along their long axes (bordered plots).

SITE CHARACTERISATION

Site data is not accredited information, but is an important contributor to explaining GXE and other effects.
The minimum desirable characterisation is given below.
Other soil measurements would be highly desirable.
The following site characterisation information should be kept for each experiment.

1. Location of the trial. This can be given as a grid reference, but in addition should be given by the nearest town.

2. Paddock history. For the previous 3 seasons, including herbicide use and disease status.

3. Soil type. May be given with an appropriate reference, such as Stephens, C.G. (1962), 'A Manual of Australian Soils'.

4. pH. 0-10 cm depth.

5. Soil P. 0 – 10 cm depth.

6. Soil Nitrogen. 0 – 10 cm depth. Sampling at additional depth may be required for some regions.

7. Soil moisture at seeding, using an appropriate indicator.

8. Monthly rainfall. At each site, or nearby. This should be recorded for the growing season, and with pre-season rainfall where appropriate.

9. Sowing date.

10. Seeding rates and dressings, fertilisers, herbicides, insecticide and fungicide rates and dates.

11. Harvest date.

12. Plot dimensions and statistical design of the experiments.

13. Seasonal observations for site and crop.

SECTION 2
QUALITY CHARACTERISTICS

2.1 SAMPLE COLLECTION

2.1.1 Samples must be collected from trials used for the collection of yield and other agronomic data.

2.1.2 Trials from which samples are drawn should be representative of the target area as proposed by the breeder.

2.1.3 Trials must include control varieties which are appropriate for the purposes of comparison.

2.1.4 Grain samples should be cleaned through a Carter Dockage Tester or equivalent using a 2mm sieve to retain the main grain fraction.

2.1.5 As a guide, grain samples of cleaned samples (see 1.5) should meet grain quality specifications such as:

Test weight >= 78 kg/hl
Kernel weight >= 30 g/1000 kernels
Falling Number >= 300 seconds
Screenings =< 5%
Moisture =< 12%

Trial sites which have been exposed to environmental or disease situations that would be likely to adversely affect the validity of end-product quality test results should be excluded. If included, justification should be provided.

2.1.6 Samples should be stored under conditions which maintain the integrity of the quality of the sample such as:

Without pesticide treatment or pickling
In conditions free from moulds, fungi, insect or rodent infestation
Not in contact with treated particle board
Control varieties and test varieties to be stored under the same conditions. Suggested desirable storage temperature is below 25°C.

Data to be presented for a minimum of 4 trials in each of 2 years.

2.2 ANALYSIS OF SAMPLE

2.2.1 A laboratory conducting sample analysis must demonstrate satisfactory competency. Laboratory accreditation or certification is desirable and is encouraged. A minimum requirement would be regular participation and satisfactory performance in the interlaboratory testing programs such as:

The annual RACI Cereal Chemistry Division Check Sample for
- protein content
- moisture
- ash
- damaged starch

The biennial RACI Cereal Chemistry Division Physical Dough Testing Check Sample for
- Farinograph parameters
- Extensograph parameters

The RACI Cereal Chemistry Division check sample for
- RVA parameters

2.2.2 Analysis may be conducted on:

2.2.2.1 All individual replicates from each site, and/or

2.2.2.2 A site composite prepared from equal quantities of each replicate at a site. All replicates should be included. Replicates should not vary greatly in grain quality parameters. As a guide:
Protein content should not vary by more than 2%.
Moisture should not vary by more than 1%.
Kernel weight should not vary by more than 5 g/1000 kernels.
Falling Number should be >300.
Test weight should be >78 kg/hl., and/or

2.2.2.3 A composite prepared from site composites to achieve a sample of a test variety within an appropriate protein range. Control varieties and test varieties are to be blended in the same proportions from the same sites. Site composites should not vary greatly in grain quality parameters. As a guide:
Protein content should not vary by more than 2%.
Moisture should not vary by more than 3%.
Kernel weight should not vary by more than 5g/1000.
Test weights should be >78 kg/hl.
Falling Numbers should be >300 seconds.
Screenings of any sample should be < 5%.

Note: the data on which compositing is based must be submitted together with the results., and/or

2.2.2.4 If appropriate a composite may be prepared from site composites to achieve a sample of the test variety at a specific protein content for comparison to the control variety at equivalent protein content. This should only be necessary for some end-product testing procedures. The control varieties and test variety may be blended from different sites or in different proportions but details, including data on individual sites, must be provided

2.2.3 The protein content of samples and control varieties must be appropriate to the envisaged grade(s) or end use purpose(s). Analysis at a range of protein contents to test sensitivity of quality is appropriate.

2.2.4 Analytical methods must be as approved by the accreditation committee and will normally be accepted international methods. Acceptable methods and parameters for which the accreditation committee will accept data for accreditation are specified in the attached schedule. Where multiple standard methods are indicated the same method shall be used for the control and test varieties. Full details must be provided of methods used to measure parameters not covered by the attached schedule.

2.2.5 Records must be maintained in a manner which can be audited

2.3 ANALYSIS OF DATA

2.3.1 Data must be appropriately analysed to achieve a comparison of test variety with control varieties.

2.3.2 All data must be included in the analysis so as to present an accurate picture of the test varieties performance. Any data not included in the analysis must be justified.

2.3.3 Summary data comparing the test variety with the control varieties must be presented for each site or composite.

2.3.4 A brief statement of the quality of the variety should be submitted for ACAS approval.

2.4 LATE MATURITY ALPHA AMYLASE

Whilst no protocol is prescribed at present, a comment on any known experience with LMAA with the new variety must be appended.

SCHEDULE OF PARAMETERS AND ANALYTICAL METHODS

Sampling should be in accordance with ICC methods 101/1, 110, 130 or 138, or AACC methods 64-60, 64-70A, 64-71
NIR spectroscopy may be used for protein, moisture and hardness, provided calibration is made to the following standard methods.

Protein content (wheat, semolina or flour)	Dumas method (AACC 46-30) or modified Kjeldahl methods (RACI 02-01(1988), AACC 46-08, 46-12, 46-13). Protein to be expressed as %N x 5.7 on a fixed moisture basis (11% wheat, 14% flour and semolina).
Moisture	RACI 01-01 (1987), ISO 712-1985, ICC 110/1, AACC 44-19
Grain hardness	PSI (AACC 55-30), NIR (AACC 39-70A)
Kernel weight	Neither ICC, AACC, nor RACI list an official method for kernel weight. Data will be accepted if not less than 500 kernels of dockage free grain are to be weighed to the nearest 0.1 gram. Kernel weight to be expressed as grams per thousand kernels.
Test weight	The only international official method is AACC 55-10 which is not entirely appropriate. Data will be accepted from either a calibrated Franklin or Schopper chondrometer. Test weight to be expressed as kg/hl.
Falling Number	AACC56-81B, ICC 107, RACI 05-08, ISO 3093-1982
Flour extraction	Buhler MLU202 laboratory experimental mill based on AACC 26-20, 26-21A, 26-30A, 26-31, or 26-41. Flour extraction to be expressed as a percentage of milled products.
Farinograph Water Absorption	RACI 06-02 (1967).
Farinograph Dough Development Time	RACI 06-02 (1967).
Farinograph Breakdown	RACI 06-02 (1967).
Farinograph Stability	RACI 06-02 (1967).
Extensibility	RACI 06-01 (1967).
Extensograph Resistance (maximum)	RACI 06-01 (1967).
Visco-Amylograph peak viscosity	RACI 06-03 (1976)
Visco-Amylograph pasting temperature	RACI 06-03 (1976)
RVA initial gelatinisation temperature	ICC 162 using STD-1
RVA peak viscosity	ICC 162 using STD-1
RVA minimum viscosity	ICC 162 using STD-1
RVA final viscosity	ICC 162 using STD-1
CIELAB Colour (dry flour or semolina)	RACI 09-02 (1995) using a Minolta Chroma meter, or equivalent. Colour to be expressed as the coordinates L^*, a^* and b^*
Hunterlab Colour	To be expressed as the coordinates L,a and b, whiteness index WI, or yellowness indices YI-1 or YI-2.
Kent Jones Colour Grade	RACI 09-01 (1988)
Yellow pigment in flour or semolina	ICC 152, AACC 14-50
Ash	AACC 08-01, 08-12
Damaged starch	RACI 04-02 (1992).

SECTION 3
DISEASE CHARACTERISTICS

GENERAL PRINCIPLES

3.1 Screening conditions

The data should reflect field reactions as likely to be experienced in crops in the target area. Seedling, glasshouse or other new methods of assessment can be used as supporting evidence providing they can be shown to reflect field circumstances. For some diseases identification of the presence of a known effective resistance gene can be used as evidence for resistance.

3.2 Target area

Suggested target areas are given for each disease. The target area is defined as:
an area where a disease of "high public risk", *sensu* Ballantyne *et al.* (1994), occurs on susceptible wheats, or an area where the potential average annual loss exceeds 5% of yield (Brennan and Murray 1998).
Other areas will be considered if the submitter provides evidence that supports the claim, ie. new information on the distribution of the disease or new loss estimates that justify a change in target areas. New varieties are being developed for areas outside the current wheat growing areas. In these cases there is little information on the diseases of potential concern. Such data will be considered on a case-by-case basis.

3.3 Disease identification

Evidence must be presented that the disease for which claims are made was identified by a plant pathologist or other person competent to identify that disease. It is desirable but not essential that representative specimens of the disease be lodged with a herbarium.

3.4 Pathogen variation

Pathogen variation must be taken into account in making claims. Where appropriate and possible the race(s) or isolate(s) used should be stated. For leaf and stem rust the race(s) used in the tests or present in trials should be identified. For more variable pathogens, an appropriate or sufficiently wide range of isolates should be used in generation of disease data. In making claims advice should be sought on such variation.

3.5 Regional variation

The resistance rating claim must take into account any regional variation in the pathogen populations and / or environments. The claims being made for a variety must match the environments in which it has been tested for disease resistance. It is the responsibility of those seeking accreditation to seek advice on such issues.

3.6 Check varieties

Data must be compared with approved check varieties that support the classification being claimed. Evidence for the inheritance of resistance from a known parent variety will also be accepted.

3.7 Disease levels

There must be a sufficient level of disease in the susceptible check varieties to provide confidence in the data. These levels will vary with diseases.

3.8 Replication

Data must be replicated. The level of replication within and between sites will depend on the disease and will vary depending on the uniformity of data. As a general rule, data will be required from at least four sites in three years in the target area, or from field or glasshouse testing with known pathogenic races. Statistical evidence using analysis of variance or other generally accepted procedures will be required for assessment of data.

3.9 Scoring scales

The scoring scale used should reflect crop damage or else a close correlation with crop damage must be evident. For leaf diseases, percentage leaf area infected is preferred to reaction type scales.
Data can be presented using a numerical scale but for farmer extension it will be converted to the preferred rating scale of:

R	Resistant
MR	Moderately Resistant
MS	Moderately Susceptible
S	Susceptible
VS	Very Susceptible

Where necessary intermediate ratings can be used.

As a general guide:

The rating scale is based on the principal that for fungal diseases an:

R signifies that the disease will rarely or ever be observed on the variety and that there will be no significant yield loss. For nematodes it signifies that very few nematodes will be produced on the variety and that the variety can be relied upon as a disease break.

MR signifies that whilst disease may be observed on a variety under high inoculum pressure no yield losses are expected and certainly no losses greater than 5%. For nematodes an MR will be expected to provide a disease break under most conditions but that nematodes will be seen on roots more readily.

MS yield losses for plants under disease pressure will rarely be expected to exceed 15%.

S losses can be expected to exceed 15%.

VS is reserved for varieties that should not be sown where the disease in question is a regular occurrence or risk.

It is not expected that yield loss data be provided. This is only provided as a conceptual framework. The framework is not relevant for diseases that rarely cause significant yield loss in an environment.

The following scale can be used to rate tolerance to nematodes or other reactions:

VT	Very Tolerant
T	Tolerant
MT	Moderately Tolerant
MI	Moderately Intolerant
I	Intolerant
VI	Very Intolerant

3.10 Disease resistance/tolerance breakdown

ACAS should be advised immediately of any known breakdown in the disease resistance/tolerance of a variety that would affect the accuracy of previously supplied data. Breakdown may be on a local, regional or national basis. ACAS will accept information on changes in disease status from the breeder of the variety or other reliable sources.

Disease: Stem Rust

Causal Agent:
Puccinia graminis f.sp. *tritici*

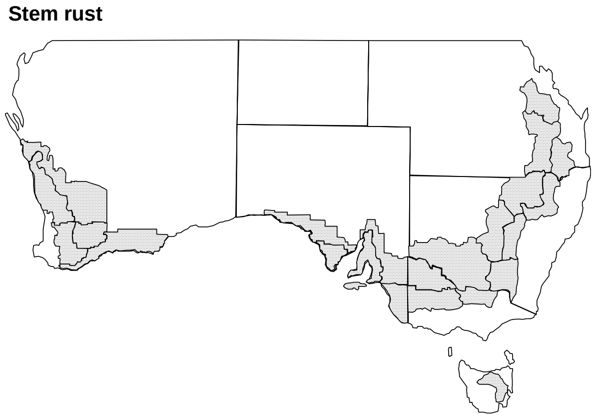
Pathogenic variability:
High

Virulence/Resistance:
Major gene and combinations of major genes widely used in Australia

Regional variation:

New races spread quickly throughout Australia (Zwer *et al.* 1985). Resistance to current races is virtually essential for successful wheat production in Queensland and NSW, and highly desirable in all other areas.

Target area:



Screening Methods

Generally, breeding lines are assessed by the National Rust Control Program based at the Plant Breeding Institute, University of Sydney, Cobbitty, NSW. Data on stem rust resistance from this source are given preference. Data from other sources will need to be justified, and should be collected according to the following:

1. Screening methods should be consistent with those in McIntosh *et al.* (1995). Stage of plant development when the assessment was made must be given.
2. Field — include location and an indication of weather conditions during the development of the epidemic
   - 2.1. natural epidemic — must include identification of the race(s) present
   - 2.2. artificial inoculation — must include the identity of the race(s) used
3. Controlled Environment — must include the identity of the race(s) used, and day length and temperature
4. Gene Identification — the standard nomenclature for stem rust resistance genes must be followed (McIntosh *et al.* 1995).

Rating Scales

Rating scales suitable for stem rust assessment are in McIntosh *et al.* (1995). This reference provides conversions of several rating scales to Immune, Very Resistant, Resistant, Moderately Resistant, Moderately Susceptible, and Susceptible. Where an extreme amount of rust develops by comparison to the check lines, a rating of Very Susceptible should be made.

Disease: Leaf Rust

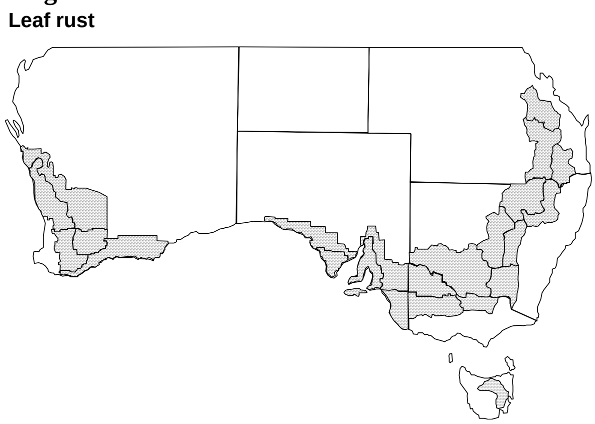
Causal Agent:
Puccinia recondita f.sp. *tritici*

Pathogenic variability:
High

Virulence/Resistance:
Major gene and combinations of major genes widely used in Australia

Regional variation:
New races spread quickly throughout Australia. Resistance to current races is highly desirable in all areas.

Target area:



Screening Methods

Generally, breeding lines are assessed by the National Rust Control Program based at the Plant Breeding Institute, University of Sydney, Cobbitty, NSW. Data on leaf rust resistance from this source are given preference. Data from other sources will need to be justified, and should be collected according to the following:

1. Screening methods should be consistent with those in McIntosh *et al*. (1995). Stage of plant development when the assessment was made must be given, since some genes for leaf rust resistance are not expressed at the seedling stage.
2. Field
   - 2.1. natural epidemic — must include identification of the race(s) present
   - 2.2. artificial inoculation — must include the identity of the race(s) used
3. Controlled Environment — must include the identity of the race(s) used
4. Gene Identification — the standard nomenclature for leaf rust resistance genes must be followed (McIntosh *et al*. 1995).

Rating Scales

Rating scales suitable for leaf rust assessment are in McIntosh *et al*. (1995). This reference provides conversions of several rating scales to Immune, Very Resistant, Resistant, Moderately Resistant, Moderately Susceptible, and Susceptible. Where an extreme amount of rust develops by comparison to the check lines, a rating of Very Susceptible should be made.

Disease: Stripe Rust

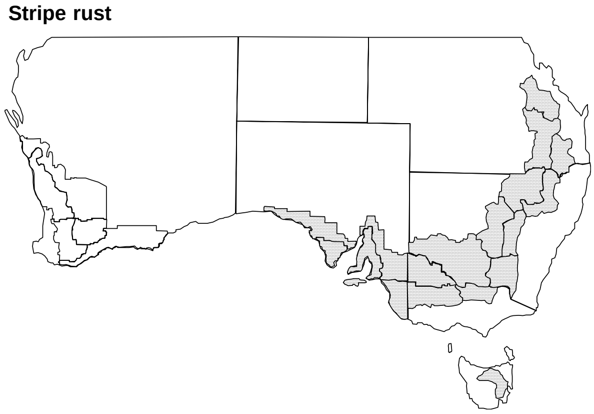
Causal Agent:
Puccinia striiformis f.sp. *tritici*

Pathogenic variability:
High

Virulence/Resistance:
Polygenic adult plant resistance is widely used in eastern Australian breeding programs. Single gene seedling resistance has not proved durable.

Regional variation:
New races spread quickly throughout eastern Australia, although older races have persisted in northern NSW and Qld. Resistance to current races is highly desirable in eastern states. Stripe rust has not been recorded in WA.

Target area:



Screening Methods

1. Generally, breeding lines are assessed by the National Rust Control Program based at the Plant Breeding Institute, University of Sydney, Cobbitty, NSW. Data on stripe rust resistance from this source are given preference. However, there is some field data that show differences in adult plant reaction that may be location specific. Thus, data from other sources will be useful, and should be collected according to the following:
   - 1.1. Screening methods should be consistent with those in McIntosh *et al.* (1995). Stage of plant development when the assessment was made must be given.
   - 1.2. Field
     - 1.2.1. natural epidemic — must include identification of the race(s) present
     - 1.2.2. artificial inoculation — must include the identity of the race(s) used
   - 1.3. Controlled Environment — must include the identity of the race(s) used
   - 1.4. Gene Identification — the standard nomenclature for stripe rust resistance genes must be followed (McIntosh *et al.* 1995).

Rating Scales

Rating scales suitable for stripe rust assessment are in McIntosh *et al.* (1995). Conversion of the rating scale to Immune, Very Resistant, Resistant, Moderately Resistant, Moderately Susceptible, Susceptible and Very Susceptible will be based on comparisons with known control lines.

Disease: Septoria tritici blotch

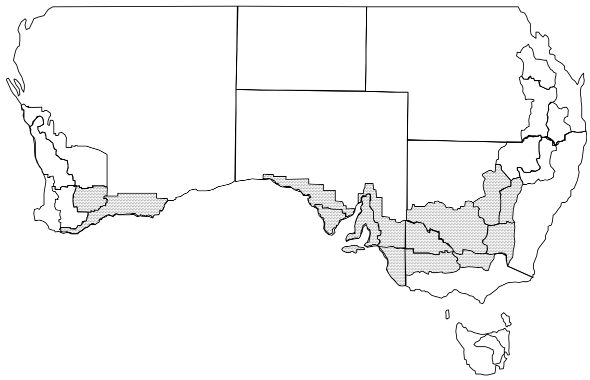
Causal Agent:
Mycosphaerella graminicola

Pathogenic variability:
low. Ballantyne and Thomson (1995) showed pathogenic variation between isolates.

Virulence/Resistance:
controlled by polygenic resistance in Australia

Regional variation:
Differences in reactions of cultivars observed between Western Australia and eastern Australian wheat areas. Ballantyne

Target area:
Septoria tritici blotch



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Septoria nodorum blotch

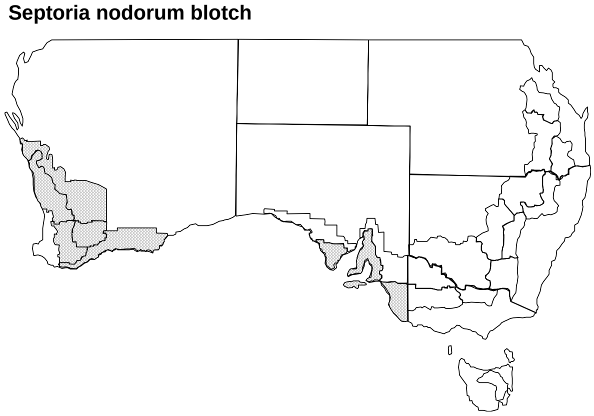
Causal Agent:
Phaeosphaeria nodorum

Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Yellow spot

Causal Agent:
Pyrenophora tritici-repentis

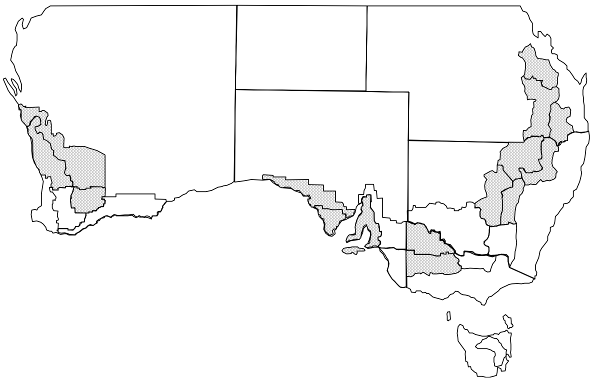
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

Yellow spot



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Barley yellow dwarf

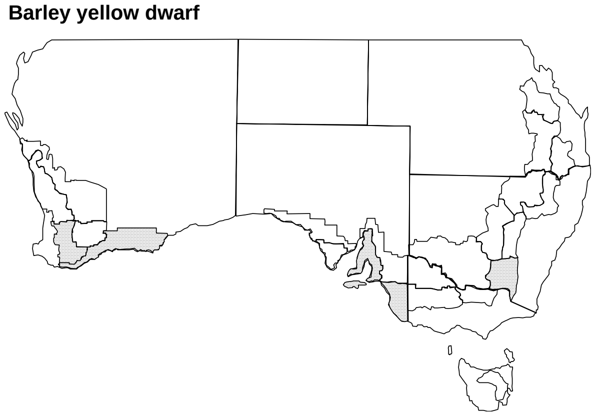
Pathogenic variability:

Regional variation:

Causal Agent:
Barley Yellow Dwarf Virus

Virulence/Resistance:

Target area:



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Flag smut

Causal Agent:
Urocystis agropyri

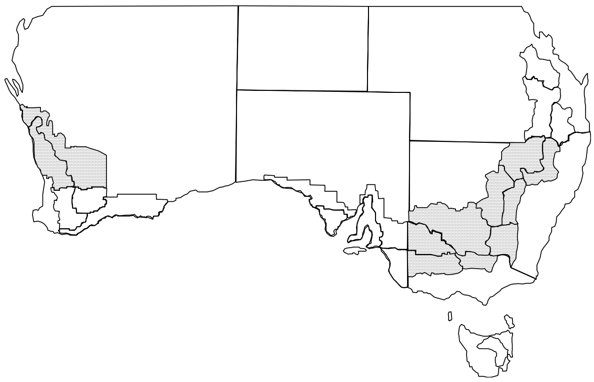
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

Flag smut



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Crown rot

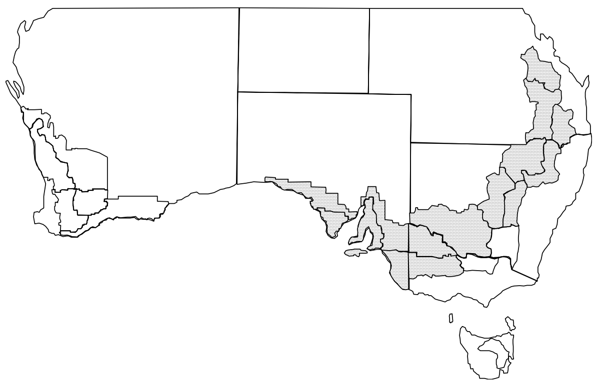
Causal Agent:
Fusarium graminearum

Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:



Screening Methods (Method of Wildermuth and McNamara 1994)

1. Each prospective variety will be tested at the adult stage for two years in field trials. All tests should be conducted in a soil which is conducive to crown rot.
2. If a line is placed in different disease categories in different tests it should be retested before it is placed in a disease category.
3. The line should be compared with standard varieties whose reactions to crown rot span the range of susceptibility to the disease.
   3.1. In bread wheat, these varieties would be Puseas, Vasco, Hartog, Gala and 2-49.
4. Varieties/lines should be grown in soil inoculated with *Fusarium graminearum* Group 1. In Queensland, inoculum is added as ground colonized wheat/barley grain in single rows (2.0 g/m of row) and seed is dusted with benomyl (Benlate 50 WP) at a rate of 0.5 g a.i./kg seed.
5. At maturity, tillers should be examined for the presence of crown rot. These data should be compared with the standard varieties and the variety/line classified as highly susceptible, susceptible, or partially resistant (tolerant).

Rating Scales

Varieties/lines will be classified as HS, S or MR from (5) above.

Disease: Common root rot

Causal Agent:
Bipolaris sorokiniana

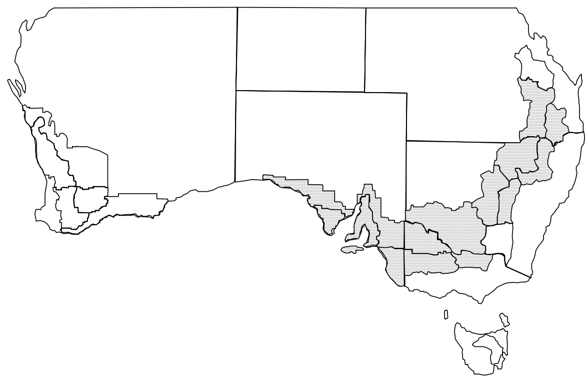
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

Common root rot



Screening Methods (Method of Wildermuth and McNamara 1994)

1. Each prospective variety will be tested at the adult stage for two years in field trials.
2. Each line should be compared with standard varieties whose reaction to common root rot span the range of susceptibility to the disease.
   2.1. In bread wheat, these varieties should be Timgalen and Kite.
3. Varieties/lines should be grown in soil known to have a high population of *Bipolaris sorokiniana*.
4. After anthesis, plants should be removed from the soil and the sub-crown internode rated for the degree of necrosis (Wildermuth *et al*. 1992).
5. These data should be compared with the standard lines and the variety/line classified as highly susceptible, susceptible, or partially resistant.

Rating Scales

From (5) above, the variety/line will be rated as MR, S, or VS.

Disease: Cereal cyst nematode

Causal Agent:
Heterodera avenae

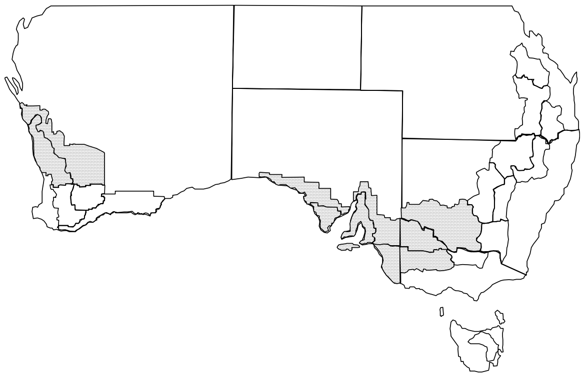
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

Cereal cyst nematode



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Root lesion nematode (1)

Causal Agent:
Pratylenchus thornei

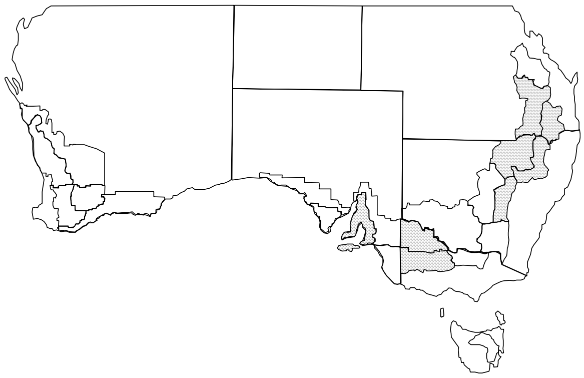
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

Pratylenchus thornei **nematode**



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Root lesion nematode (2)

Causal Agent:
Pratylenchus neglectus

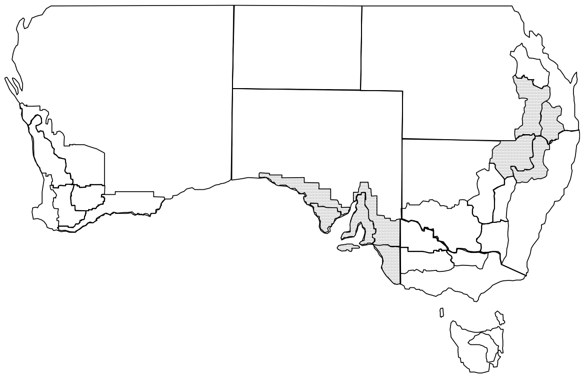
Pathogenic variability:

Virulence/Resistance:

Regional variation:

Target area:

***Pratylenchus neglectus* nematode**



Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Karnal bunt	**Causal Agent:** *Tilletia indica*
Pathogenic variability:	**Virulence/Resistance**:
Regional variation:	**Target area**:

Screening Methods

1.1. method

Rating Scales

Conversion of rating scale to R, MR, MS, S, VS

Disease: Russian wheat aphid

Causal Agent:
Diuraphis noxia

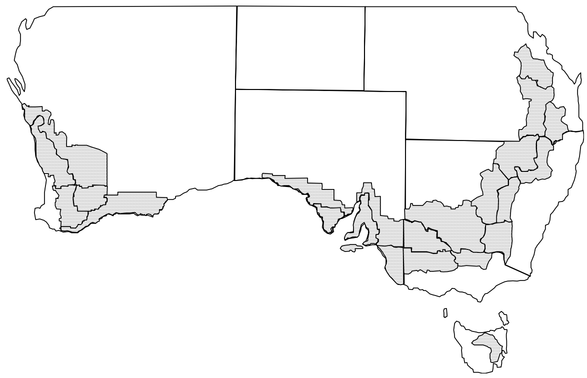
Pathogenic variability:
none demonstrated.

Virulence/Resistance:
resistance available in wheat and near relatives.

Regional variation:
Climate modelling shows that Russian wheat aphid could occur throughout the Australian wheat belt if it were introduced to Australia. The drier inland parts of the wheat belt would be very favourable growth and survival. The modelling indicates that D. noxia has potential to cause severe losses to the wheat crop should it arrive in Australia (Hughes and Maywald 1990).

Target area:

Russian wheat aphid



Screening Methods

1. Glasshouse and field tests are used overseas. Results from screening programs in Mexico, USA, South Africa and other locations where Russian wheat aphid is present are acceptable.
2. Molecular marker techniques are being developed to identify resistance genes. Results from these tests will be considered for acceptance.

Rating Scales

Rating scales will be converted to R, MR, MS, S, and VS.

References

Ballantyne, B., Murray, G.M. and Brennan, J.P. (1994). Assessing the threat to resistant cultivars from public risk diseases and pests. *Euphytica* **72**: 51–59.

Ballantyne, B. and Thomson, F. (1995). Pathogenic variation in Australian isolates of *Mycosphaerella graminicola*. *Australian Journal of Agricultural Research* **46:** 921–934.

McIntosh, R.A. , Wellings, C.R. and Park, R.F. 1995. *Wheat Rusts: An Atlas of Resistance Genes*. CSIRO Australia: East Melbourne.

Wildermuth, G.B. and McNamara, R.B. (1994). Testing wheat seedlings for resistance to crown rot caused by *Fusarium graminearum* Group 1. *Plant Disease* **78:** 949–953.

Wildermuth, G.B., Tinline, R.D. and McNamara, R.B. (1992). Assessment of yield loss caused by common root rot in wheat cultivars in Queensland. *Australian Journal of Agricultural Research* **43:** 43–58.

WHEAT DISEASES TO BE INCLUDED IN THE ACAS DATABASE

Wheat breeders have indicated that they wish to know the disease score for 14 diseases and one insect pest. Most of these are diseases that cause potentially more than 5% average annual loss in one or more areas of the Australian wheat belt, and are diseases for which resistance is currently sought or would be available for use in breeding programs. In addition, breeders wish to know the reaction of wheats to two exotic problems, Karnal bunt and Russian wheat aphid. Other diseases are not precluded and may be added at a breeder's request.

Diseases to be included in the data base

Disease	**Causal agent**	**Public Risk**	**Screening Method**
Stem rust	*Puccinia graminis* f.sp. *tritici*	high	McIntosh (1995)
Leaf rust	*Puccinia recondita* f.sp. *tritici*	medium	McIntosh (1995)
Stripe rust	*Puccinia striiformis* f.sp. *tritici*	high	McIntosh (1995)
Septoria tritici blotch	*Mycosphaerella graminicola*	medium	
Septoria nodorum blotch	*Phaeosphaeria nodorum*	low	
Yellow spot	*Pyrenophora tritici-repentis*	low	
Barley yellow dwarf	Barley Yellow Dwarf Virus	low	
Flag smut	*Urocystis agropyri*	low	
Crown rot	*Fusarium graminearum*	nil	Wildermuth & McNamara (1994)
Common root rot	*Bipolaris sorokiniana*	nil	Wildermuth & McNamara (1994)
Cereal cyst nematode	*Heterodera avenae*	nil	17
Root lesion nematode	*Pratylenchus thornei*	nil	10
Root lesion nematode	*Pratylenchus neglectus*	nil	8
Karnal bunt	*Tilletia indica*	high	?
Russian wheat aphid	*Diuraphis noxia*	?	?