National Variety Trials (NVT) disease screening – a project snapshot from 2020

Brad Baxter[1], Dr Natalie Moore[2], Sean Bithell[3], Dr Steven Simpfendorfer[3], Dr Joop van Leur[3], Dr Kurt Lindbeck[1], Dr Ben Ovenden[1] and Dr Andrew Milgate[1]

[1] NSW DPI, Wagga Wagga
[2] NSW DPI, Grafton
[3] NSW DPI, Tamworth

Key findings

- Yearly screening is required to quantify and monitor the reaction of current and new varieties to diseases of economic importance.
- Natural changes in virulence occur in pathogen populations or when exotic pathotypes are introduced to Australia. These can affect host plant (variety) resistance ratings in both cereal and broadleaf crops.
- Five wheat stripe rust pathotypes of significance were detected in the NSW cropping regions during 2020; four were present in NSW Department of Primary Industries (NSW DPI) stripe rust nurseries.
- Host resistance can vary significantly depending on the stripe rust pathotypes present.
- Growers and advisers are kept up to date with latest resistance ratings each year through nationally co-ordinated National Variety Trials (NVT) pathology trials across a wide range of crops and diseases.

Introduction

Under the new NVT Pathology Services Agreement 2019–23, the total number of diseases and crop species being screened in NSW has increased. Eight different crop types, both cereal and broadleaf, are annually screened for a total of 17 different diseases across three climatically and agronomically diverse sites within NSW (NSW DPI research stations based at Grafton, Tamworth and Wagga Wagga).

Inherent diversity between the three screening sites facilitates matching optimal climatic conditions with different pathosystems to maximise disease development, spread the risk of nursery failure and fill current crop species knowledge gaps.

The data generated from this project forms part of national, state or regional resistance ratings that appear in publications such as the NSW Winter crop variety sowing guide (NSW DPI 2021) and on the NVT website (NVT GRDC 2021).

What do we do?

Each year, cereal and pulse seed from a common source are sent out to NVT service providers across Australia through a coordinated national process. NSW DPI receives seed sets for screening against 17 different diseases across cereal (Table 1) and pulse varieties (Table 2).

Individual crop seed sets are made up of commercially available varieties and near-release lines from breeders. There are two seed sets within each crop type: AUS and NVT. There are sets for wheat, barley, oat and the pulse crops. The AUS sets (such as AUSBAR i.e. AUS barley set) are a collection of commercially and regionally important varieties. The NVT sets are breeding lines made up of retention or first lines. Retention lines are breeding lines that have been in the NVT set for more than one year. First lines, as the name suggests, are lines that are in the NVT set for the first time. Resistance ratings for first lines are generally marked as provisional until more data is available in subsequent years of evaluation. Current commercial varieties can receive provisional ratings for new pathotypes

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or new diseases with limited data sets. By including near-release breeding lines, the NVT system provides growers with independent disease ratings to inform their variety choice and the necessary management required for a new variety once it is commercially available. This prevents a lag in developing disease resistance ratings once a new variety is released.

Table 1 Cereal diseases screened annually in NSW under the NVT Pathology Services Agreement 2019–23.

Disease	Scientific name	Crop type	Screening location	Type of screening
Barley scald	*Rhynchosporium secalis*	Barley	Wagga Wagga	Field
Net form of net-blotch	*Pyrenophora teres f. teres*	Barley	Wagga Wagga	Field
Spot form of net-blotch	*Pyrenophora teres f. maculata*	Barley	Grafton and Wagga Wagga	Field
Leaf rust	*Puccinia hordei*	Barley	Wagga Wagga	Field
Bacterial blight	*Pseudomonas syringae spp*	Oats	Wagga Wagga	Field
Leaf or crown rust	*Puccinia coronata var. avenae*	Oats	Grafton and Wagga Wagga	Field
Septoria blotch	*Phaeosphaeria avenaria*	Oats	Wagga Wagga	Field
Stem rust	*Puccinia graminis f. sp. avenae*	Oats	Grafton and Wagga Wagga	Field
Septoria tritici blotch	*Zymoseptoria tritici*	Wheat and triticale	Wagga Wagga	Field and glasshouse
Leaf rust	*Puccinia recondita*	Wheat and triticale	Wagga Wagga	Field
Stripe rust	*Puccinia striiformis f.sp. tritici*	Wheat and triticale	Grafton, Tamworth, Wagga Wagga	Field
Yellow leaf spot	*Pyrenophora tritici-repentis*	Wheat and triticale	Grafton and Wagga Wagga	Field

Table 2 Pulse diseases screened annually in NSW under the NVT Pathology Services Agreement 2019–23.

Disease	Scientific name	Crop type	Screening location	Type of screening
Botrytis grey mould	*Botrytis cinerea* *Botrytis fabae*	Chickpea* and lentil	Grafton and Wagga Wagga	Field and glasshouse
Ascochyta blight	*Phoma rabiei*	Chickpea	Tamworth and Wagga Wagga	Field and glasshouse
Faba bean rust	*Uromyces viciae-fabae*	Faba beans	Tamworth	Field
Phytophthora root rot	*Phytophthora medicaginis*	Chickpea	Tamworth	Field
Bacterial blight	*Pseudomonas syringae pv.pisi* *Pseudomonas syringae pv syringae*	Field peas	Wagga Wagga	Field

* Chickpea botrytis grey mould disease screening (field and glasshouse) will be discontinued from 2021 onwards at both Grafton and Wagga Wagga screening sites.

The seed sets are sown at the three screening sites from April through to June each year. A disease nursery is made up of one or more individual experiments screening the same pathogen. For example, single or multiple experiments screening yellow leaf spot in wheat is considered a disease nursery. Each screening site has multiple disease nurseries, one nursery for each pathogen. Disease nurseries which will not cross-infect each other, such as wheat and barley diseases, can be sown in the same paddock. Diseases that will cross-infect each other, such as two barley diseases, are grown in separate paddocks. To reduce the chance of cross-infection of non-target disease, management options such as separation by physical distance, paddock rotation and changes to sowing timing are implemented. The disease nurseries are managed to best agronomic practices to ensure uniform establishment and plant health before inoculation. No fungicides are applied to prevent confounding effects on disease expression.

Each pathogen has a specific set of abiotic conditions that must be met to promote initial infection and favour disease development. These are predominately rainfall, humidity and temperature requirements. Within the nurseries, supplementary overhead irrigation can be used to promote further infection events and drive the disease epidemic during the growing season. Supplementary watering can be tailored to suit each pathogen.

Plants within the disease nurseries are inoculated using pathogen specific techniques. These include stubble inoculation, spore suspensions, inoculated seed dispersal and mycelial broth, or a combination of two or more techniques. The inoculation of a disease nursery is undertaken at a time point where the crop is at a susceptible growth stage and environmental conditions are conducive to infection events. This generally occurs before or after a rainfall event. Some disease nurseries, such as the stripe rust nurseries, rely on natural infection from wind-blown spores to initiate a disease epidemic. Infected plants from susceptible spreader rows are then used to ensure even disease pressure across nursery sites. In the case of stripe rust, inoculation is only used as a last option after receiving reports of stripe rust in commercial crops from the local region.

At the height of the disease epidemic, generally August–November depending on the disease, the disease development is visually assessed to determine the relative levels of host resistance between entries and check varieties. These assessments are then submitted into the NVT system to be combined with results from other service providers across Australia. Final ratings are then developed through a national consultative process between pathologists and breeders using all available historic and annual nursery data. These annually reviewed and agreed ratings are what appear in state-based variety sowing guides such as NSW DPI's Winter crop variety sowing guide, on the NVT website (https://nvt.grdc.com.au/) and in other extension material.

Why do we screen diseases each year?

Due to interactions between host, pathogen, environment and agronomic management practices, pathogens naturally evolve. These changes can increase or decrease the pathogen's virulence on different host varieties depending on the host's genetic makeup; the host plant can have different reactions to individual pathotypes. Also, environmental influences can affect the severity of disease expressed by the same pathotype in different years.

It is critical for the agricultural industry to be able to monitor these changes. By annually screening commercially available varieties and near-release breeding lines, changes can be tracked in pathogen populations over time by measuring changes in the level of host resistance. In turn, this allows researchers to provide advisors, growers and the broader industry with current information on individual varietal resistance ratings, pathotype population dynamics and distribution.

This information is important for growers and industry to guide the formulation of appropriate economic disease-management strategies. It also enables pathologists to forecast potential disease issues for the upcoming growing season. Knowing what pathotypes are in the natural population and which varieties are widely grown or becoming more popular can provide insight about which disease/s could be an issue. This allows information to be communicated to industry groups during the season about available and appropriate management options.

Practical examples of why we screen annually

During 2020, in the NSW DPI stripe rust screening nurseries, four different pathotypes were detected. The rust strains were pathotyped by the Australian Cereal Rust Survey based at Sydney University. These being:

1. 198 pathotype, 198 E16 A+ J+ T+ 17+
2. 239 pathotype, 239 E237 A- 17+ 33+
3. WA pathotype,134 E16 A+17+ 27+
4. 64 pathotype, 64E0A-, Tamworth nursery only.

Some wheat varieties had different reactions to each of the four pathotypes found in the disease nurseries in 2020 (Table 3). In this case, two popular wheat varieties, Rockstar$^{\Phi}$ and Vixen$^{\Phi}$, have a spread of resistance ratings from resistant to moderately resistant (R–MR) to susceptible to very susceptible (S–VS) depending on the pathotype present. This is due to the genetic makeup of these

varieties, i.e. the resistance genes within the plant. Each of the four stripe rust pathotypes are either virulent or avirulent to particular resistance gene/s within the host plant. This results in a range of stripe rust reactions and the need to have multiple resistance ratings.

Table 3 Differences in the reaction of wheat varieties Rockstar$^{\Phi}$ and Vixen$^{\Phi}$ to four different stripe rust pathotypes present in NSW DPI nurseries during 2020.

Variety	Resistance rating to stripe rust pathotypes			
	198 E16 A+ J+ T+ 17+	239 E237 A- 17+ 33+	134 E16 A+ 17+27+	64E0A-
Rockstar	MR	MS	MR–MS	S
Vixen	R–MR	MS–S	MR–MS	S–VS

When new pathotypes become more common in the environment, for example as the 198 pathotype did during 2020, all variety reactions are reviewed. This is important because as data from multiple environments is gathered, pathologists can assign ratings with greater confidence. This can lead to adjustments being made to a variety's rating to the same pathotype. For example, Catapult$^{\Phi}$ was rated resistant to moderately resistant (R–MR) in 2019 to the 198 pathotype and adjusted to moderately resistant to moderately susceptible (MR–MS) in 2020 once an additional year of data was obtained (Table 4).

Also note, that Catapult$^{\Phi}$ is S–VS to 64E04- stripe rust pathotype. This pathotype (64E0A-) is an older pathotype present in the Tamworth disease nursery during 2020. It (64E0A-) had a significantly higher reaction on many popular wheat varieties than their 2019 resistance rating indicated, including varieties such as Catapult$^{\Phi}$, Corack$^{\Phi}$, RockStar$^{\Phi}$ and Vixen$^{\Phi}$. Due to the popularity and size of plantings of these varieties, it is possible that 64E0A- (and 239 in the case of Vixen$^{\Phi}$) could become more common in the stripe rust population during the 2021 cropping season.

Table 4 Change in the reaction of the wheat variety Catapult$^{\Phi}$ to the 198 stripe rust pathotype between 2019 and 2020.

Year screened	Resistance rating to stripe rust pathotypes			
	198 E16 A+ J+ T+ 17+	239 E237 A- 17+ 33+	134 E16 A+ 17+ 27+	64E0A-
2019	R–MR	MR–MS	MR–MS	NA
2020	MR–MS	MR–MS	MR–MS	S–VS

NA = not applicable. 64E04- was not present in the population during 2019.

Growers and advisors should routinely check their varieties for changes in resistance ratings as pathotypes change over time. Varieties identified for change in 2021 include; Catapult$^{\Phi}$, RockStar$^{\Phi}$, Joey$^{\Phi}$, Borlaug 100$^{\Phi}$, Corack$^{\Phi}$, Devil$^{\Phi}$, DS Darwin$^{\Phi}$, Emu Rock$^{\Phi}$, Hatchet CL Plus$^{\Phi}$, LongReach Cobra$^{\Phi}$, LongReach Trojan$^{\Phi}$, SEA Condamine$^{\Phi}$, Sheriff CL Plus$^{\Phi}$, Vixen$^{\Phi}$, Wallup$^{\Phi}$, Sting$^{\Phi}$, Suncentral$^{\Phi}$ and Denison$^{\Phi}$ (Milgate et al. 2021).

Pulse crop disease screening

The broadleaf crop disease screening became a part of the NVT program in 2019. The program in its entirety screens chickpea, lentil, field pea, faba bean and lupin varieties and near-release lines. NSW DPI screen all the pulse crop types except for lupins to five different diseases (Table 2).

Within the program, NSW DPI screens agronomically important pulse diseases for northern NSW (nNSW) at Grafton and Tamworth. However, southern NSW (sNSW) is an emerging region for chickpea, faba bean and lentil crops, which have typically been considered nNSW, Victorian or South Australian pulse crops. The resistance ratings for these crop types are based on work completed outside the local region. These regions often have different farming systems and climatic conditions that are not entirely applicable to sNSW. NSW DPI is assessing host resistance under sNSW conditions at Wagga Wagga using local pathotypes to provide greater relevance for local growers.

Summary

Changes in pathogen virulence leading to a loss of effective host resistance genes can have disease management and economic effects on grower profitability. The ability to track and quantify these changes allows farm management decisions to be made with the most current knowledge. The ability to choose a more resistant variety to a particular disease and/or pathotype prevalent in a region has multiple flow-on effects for the farming system. It could increase yield while reducing the number of fungicides sprays required which, in turn, reduces machinery, labour and input costs. Minimising fungicide use also reduces the risk of developing fungicide resistance within both on-target and off-target fungal pathogen populations.

References

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Contact

Brad Baxter
Wagga Wagga Agricultural Institute, Wagga Wagga
brad.baxter@dpi.nsw.gov.au
0428 294 121

Dr Andrew Milgate
Wagga Wagga Agricultural Institute, Wagga Wagga
andrew.milgate@dpi.nsw.gov.au
02 6938 1990

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