Fusarium crown rot in central and southern cropping systems: it's all a numbers game

Steven Simpfendorfer[1]

[1] NSW DPI Tamworth

Keywords

yield loss, crop rotation, canola, pulse, summer crop, double-break

GRDC codes

DPI2207-004RTX: Integrated management of Fusarium crown rot in Northern and Southern Regions

DPI2207-002RTX: Disease surveillance and related diagnostics for the Australian grains industry

Take home message

- Yield loss from Fusarium crown rot (FCR) is a function of the percentage of plants which get infected within a paddock
- The increased frequency of winter cereal crops within a rotation sequence elevated the probability of having much higher levels of FCR infection
- Rotation to non-host break crops such as canola and pulses does not fully eliminate FCR in all paddocks but considerably reduces the probability of having high levels of infection
- A two-year break may be required in paddocks with high FCR inoculum levels
- Rotation history remains a good indicator of likely FCR risk within individual paddocks but there is still some variability in actual levels of infection
- PreDicta®B or cereal stubble testing are useful tools to further refine crop rotation and other integrated disease management decisions to limit losses from FCR
- An integrated approach is required to reduce losses from FCR. There is no 'magic bullet'.

Background

Fusarium crown rot (FCR), caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to winter cereal production across the central and northern NSW grain production region. FCR is also present in southern NSW but often goes unrecognised or can be misdiagnosed. The causal fungus is stubble-borne with inoculum surviving between seasons as mycelium (cottony-growth) inside retained winter cereal stubble and/or grass weed residues. Crop rotation to non-host break crops such as canola and pulses (e.g. chickpea, lupin or faba bean) remains a key management strategy for FCR. However, the process revolves around decomposition of *Fp* infected cereal stubble during these break crop and fallow phases which is in turn dependent on moisture availability and time. Consequently, the season in which a break crop is grown influences its effectiveness at facilitating decomposition of cereal stubble and reducing FCR inoculum levels. Conversely, recent research has highlighted when relative humidity is >92.5% that *Fp* can colonise vertically up retained standing cereal stubble in a process termed 'saprotrophic growth'. At 100% relative humidity this saprotrophic growth can occur at a maximum rate of 1 cm per day (Petronaitis *et al.,* 2020). The FCR fungus can therefore saprotrophically grow to the cut height of the cereal stubble under prolonged or accumulated periods of rainfall, effectively increasing inoculum loads. This can then result in FCR infected cereal stubble being spread out the back of the header during the harvest of lower stature break crops such as chickpeas, increasing FCR risk for the next cereal crop (Petronaitis *et al.,* 2022).

This dynamic between cereal stubble decomposition and saprotrophic growth appears to complicate the management of FCR within farming systems but what are paddocks across the region telling us?

What did we do?

Under a co-investment with GRDC, NSWDPI has been providing a free cereal stubble testing service to growers and advisors over the past two seasons. These samples were collected either during late grain filling or post-harvest from individual paddocks across central NSW, northern NSW and southern Qld, along with background information including the previous two crops within the rotation. Winter cereal stubble samples (bread wheat, durum, barley or oats) were trimmed and plated on laboratory media to determine the incidence of FCR based on distinctive growth of *Fp* in culture. Infection levels were then categorised as being either low (≤10% FCR), medium (11–25% FCR), high (26–50% FCR) or very high (≥51% FCR). This data provides an unbiased snapshot of FCR infection levels in winter cereal crops across the region under varying crop rotations over the last two seasons. But why is the level of FCR infection so important? It is simple, yield loss only occurs in cereal plants infected with FCR, with the actual extent of yield loss strongly dependent on the extent of moisture and temperature stress during grain filling. Growers may not have much influence over seasonal conditions and stress during this critical period, but they can influence the percentage of plants infected with FCR. Reduce FCR infection levels and you reduce the risk of yield loss by that same level. As a rough rule of thumb, 100% FCR infection can result in 80% yield loss in durum wheat, 60% in bread wheat and 40% in barley, if prolonged hot and dry conditions occur during grain filling. Granted that these are worst case scenario values from replicated and inoculated field trials across seasons, but even halving FCR infection levels to 50% reduces potential yield loss to 40% in durum, 30% in bread wheat and 20% in barley, if the spring conditions turn hot and dry.

What did we find?

Seasonal effects

In total, 718 winter cereal stubble samples were processed from the 2022 and 2023 harvest which consisted of 598 bread wheat, 62 barley and 58 durum wheat crops (data not shown). There were 249 cereal crops sampled in 2022 and 469 in 2023 (Figure 1). The levels of FCR infection have risen from 2022 to 2023, with the proportion of paddocks with very high levels (≥51% FCR) rising from 18% to 30%. Over the same period the proportion of paddocks with high levels of infection (26–50% FCR) have also risen from 20% in 2022 up to 30% in 2023 (Figure 1).

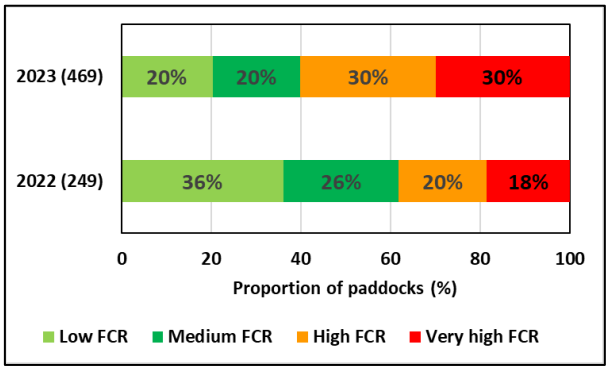

Figure 1. Proportion of winter cereal paddocks with varying levels of Fusarium crown rot (FCR) infection in 2022 and 2023.
Number in brackets (Y-axis) is the number of paddocks sampled in each year.
Low FCR = ≤10%, Medium FCR = 11–25%, High FCR = 26–50%, Very high FCR = ≥51%

FCR inoculum levels are a function of the percentage of plants infected and the quantity of stubble produced within a season. FCR infection is favoured by wet conditions which also generally increase biomass (i.e. stubble) production and yield of cereal crops. Consequently, larger inputs of FCR inoculum occur in wetter seasons such as 2021 and 2022 even though these conditions may not favour expression of FCR as whiteheads and yield loss from this disease. This data supports random crop disease surveys, conducted by NSWDPI with co-investment from GRDC, which have been showing a progressive build-up of FCR inoculum levels in this region from 2020 onwards. Milder temperatures and frequent rainfall during grain filling in 2021 and 2022 reduced FCR expression in these seasons. This was not the situation in 2023, with a return to warmer and drier conditions during spring which unfortunately also coincided with elevated FCR infection levels within central and northern cropping systems (Figure 1).

Sub-region levels of FCR

In total, 14 samples were from South Australia (SA), 14 from Victoria (Vic), 30 from south-west NSW (SWNSW), 43 from south-east NSW (SENSW), 131 from central-west NSW (CWNSW), 57 from central-east NSW (CENSW), 163 from north-west NSW (NWNSW), 173 from north-east NSW (NENSW) and 93 from southern Qld (SQld). FCR infection levels in the last two cereal crops have been highest in SQld, NWNSW and NENSW with the proportion of paddocks with very high levels (≥51% FCR) at 38%, 33% and 32%, respectively (Figure 2). The proportion of paddocks in this highest category of FCR infection level was lower at 23% in SWNSW, 18% in CWNSW and 14% in CENSW. A lower proportion of paddocks with FCR in this highest category were measured at 7% in SA, 5% in SENSW and 0% in Vic. However, all regions had relatively high FCR levels (≥26% FCR in high or very high categories) ranging from 14% of paddocks in SA up to 62% in NENSW (Figure 2).

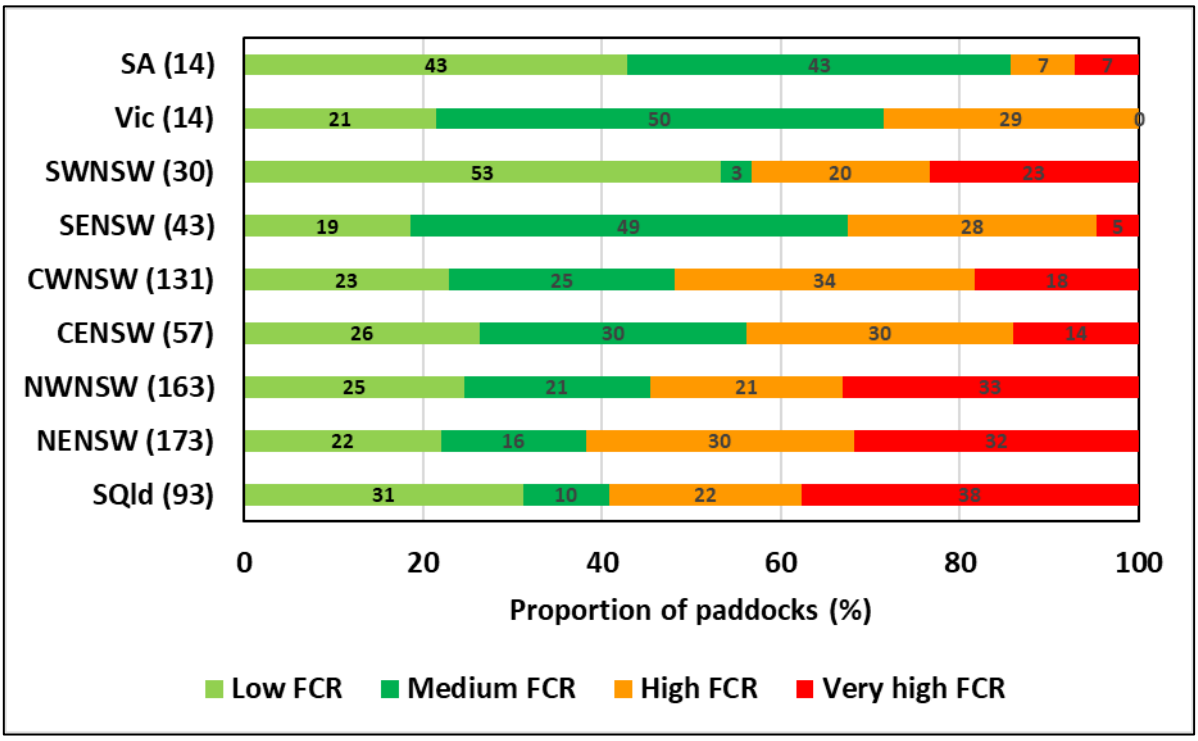

Figure 2. Proportion of winter cereal paddocks in 2022 and 2023 with varying levels of Fusarium crown rot (FCR) infection across sub-regions.

Number in brackets (Y-axis) is the number of paddocks sampled from each sub-region.

Low FCR = ≤10%, Medium FCR = 11–25%, High FCR = 26–50%, Very high FCR = ≥51%

Influence of a single break – what do the numbers say?

Adopt a cereal-cereal-cereal 'rotation' and there is a 27% chance of having high (26 to 50%) and 50% chance of having very high (≥51%) FCR infection (Figure 3). If the preceding crop was a summer break crop, then cotton (22% high FCR and 39% very high FCR in 18 paddocks) was potentially slightly better than sorghum (40% high FCR and 34% very high FCR in 35 paddocks). Fallowing the paddock rather than growing a crop did not reduce FCR levels in the subsequent 32 winter cereal crops tested with 35% having high and 41% very high FCR infection. If the preceding crop was a winter pulse or canola break crop then this risk of very high FCR in the 2022 or 2023 cereal crop was reduced further to 14% (average of pulse species) and 12%, respectively (Figure 3). In terms of pulse break crops, faba bean (14% high FCR and 7% very high FCR in 29 paddocks) was more effective than chickpea (22% high FCR and 20% very high FCR in 51 paddocks) and lupin (50% high FCR and 0% very high FCR in 17 paddocks; Figure 3).

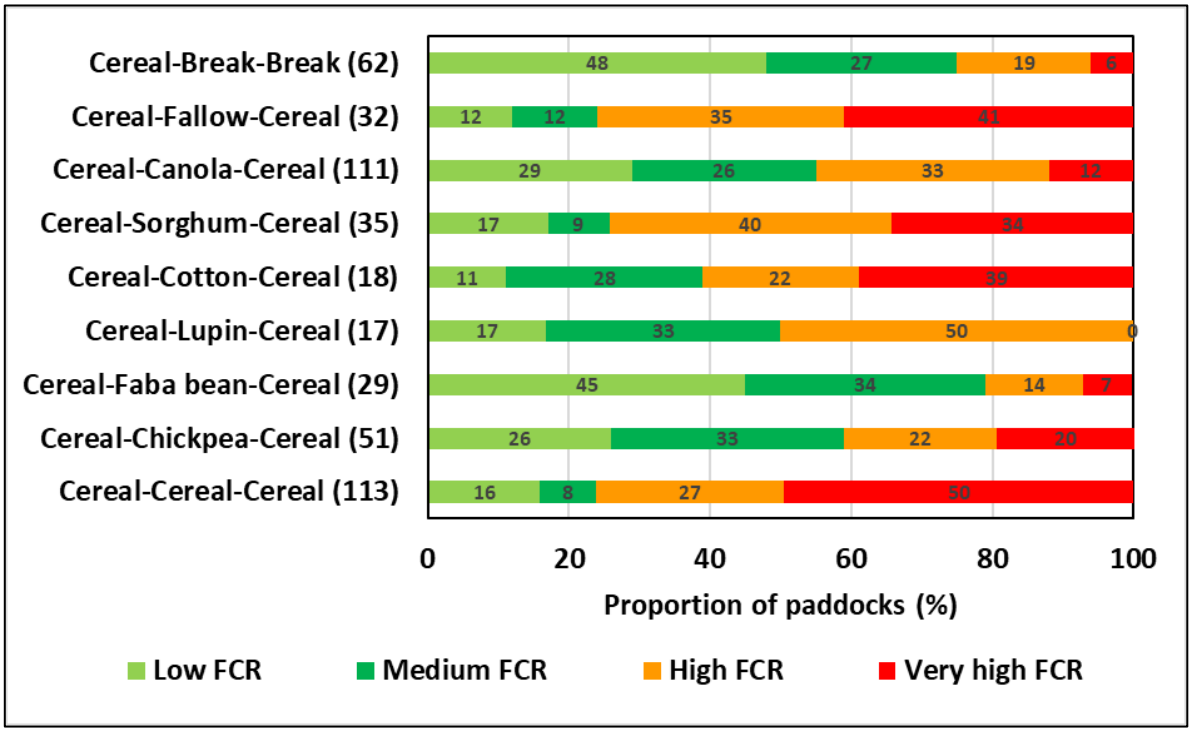

Figure 3. Proportion of winter cereal paddocks in 2022 and 2023 with varying levels of Fusarium crown rot (FCR) infection under different crop rotations.
Number in brackets (Y-axis) is the number of paddocks sampled from each rotation sequence.
Low FCR = ≤10%, Medium FCR = 11–25%, High FCR = 26–50%, Very high FCR = ≥51%

There are a number of potential variables such as FCR infection levels in cereal crops two years ago, stubble management (e.g. burning or cultivation), seed source (e.g. Fusarium grain infection from 2022 FHB epidemic), grass weed management, inter-row sowing, and harvest height which could also underly this data and introduce variability. Clearly non-host crop or fallow periods reduce the probability of higher FCR infection levels and consequently yield loss from this disease so playing the rotation numbers works. However, a one-year break may not be sufficient under higher FCR infection levels. A two-year break further reduced the probability of high and very high FCR infection levels in 2022 or 2023 cereal crops which dropped to 19% and 6%, respectively (Figure 3).

What is the effect of one break crop in three years?

Alright, let's try presenting differently and having a 'glass half full' approach. Assume low and medium FCR infection levels result in <25% whiteheads in a season conducive to disease

expression, so does not trigger the 'I told you not to sow another cereal crop in that paddock' argument with your agronomist. In a three-year consecutive cereal situation (cereal-cereal-cereal), there is a 24% probability of this happening. This increased to 33% if the paddock was in fallow two years ago and 28% if it was a pulse crop two years ago. However, the likelihood of this outcome reduced to 23% if it was canola and 20% if it was a summer crop two years ago (Figure 4). Some may like these probabilities and continue to roll the dice whilst others may be swayed more by the probabilities around the second wheat crop having high or very high FCR infection levels (Figure 4).

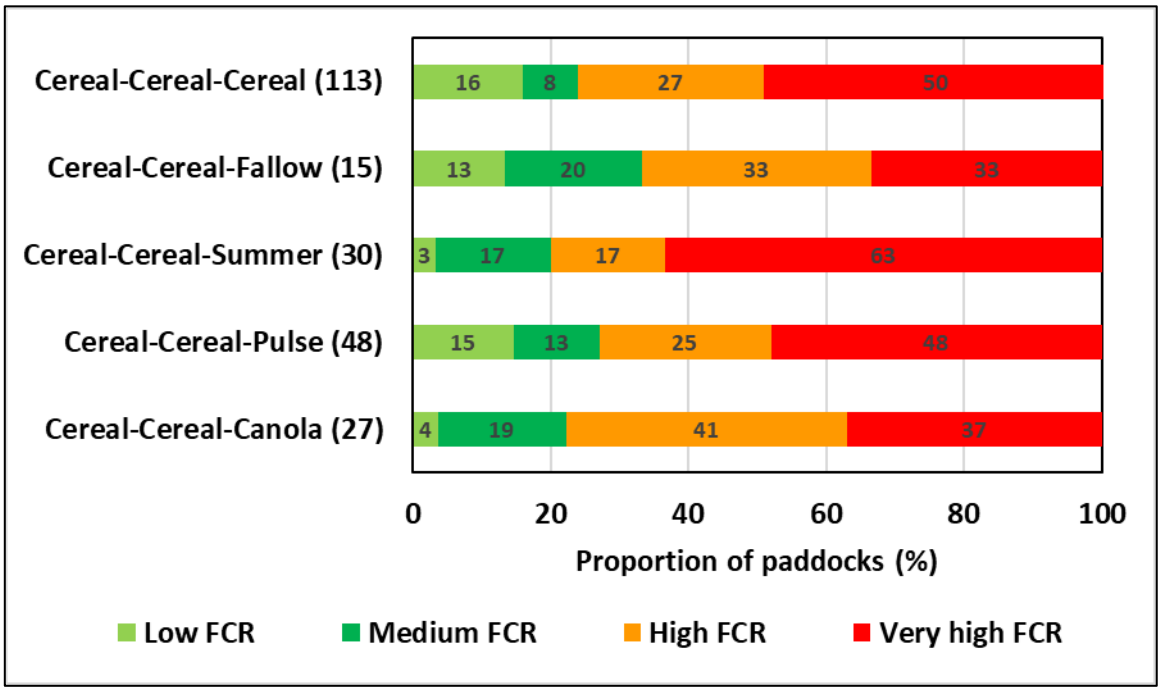

Figure 4. Proportion of winter cereal paddocks in 2022/23 with varying levels of Fusarium crown rot (FCR) infection under different crop rotations.
Number in brackets (Y-axis) is the number of paddocks sampled from each rotation sequence.
Low FCR = ≤10%, Medium FCR = 11–25%, High FCR = 26–50%, Very high FCR = ≥51%

Conclusions

Recent crop history within individual paddocks is a useful guide to the likely risk of FCR infection. However, not all paddocks and underlying crop management are the same so there is variability in the actual numbers, but the rotation sequence clearly drives the probability of having higher or lower levels of FCR infection. This further highlights the value of testing to establish actual FCR infection levels within a paddock using PreDicta®B or cereal stubble plating to further guide crop rotation and other integrated disease management decisions within individual paddocks.

Integrated management of FCR

To manage the risk of yield losses in cereals, firstly identify the risk of Fusarium crown rot in each paddock. High-risk paddocks generally include durum, bread wheat or barley crops being sown into a paddock with a history of stubble retention and tight cereal rotations (including oats). Other considerations include:

- Use effective weed management to reduce grass weed hosts in crop and fallow situations which serve as alternate hosts for the FCR fungus.

- Remember the larger the grass weed when controlled the longer that residue serves as a potential inoculum source
- Given the recent Fusarium head blight epidemic in 2022, ensure that you are sowing seed free of Fusarium infection as infected seed introduces FCR infection into paddocks.

All other management options are implemented prior to sowing so knowing the risk level within paddocks is important. This can be quantified through PreDicta® B testing (SARDI) or stubble testing (NSW DPI).

If medium to high FCR risk, then:

- Sow a non-host break crop (e.g., lentil, field pea, faba bean, chickpea, canola). A two-year break may be required if FCR inoculum levels are very high.

If still considering sowing a winter cereal:

- Consider stubble management options in terms of both impacts on FCR inoculum but also fallow soil moisture storage.

    a. ***Cultivation*** accelerates stubble decomposition which can decrease FCR risk (as the causal pathogen is stubble-borne) BUT it takes moisture and time. Cultivation also increases the spread of Fusarium crown rot inoculum across a paddock in the short term and increases exposure of below ground infection points (coleoptile, crown and sub-crown internode) in cereal plants to contact stubble fragments infected with the FCR fungus. Cultivation close to sowing therefore increases the incidence of plants which get infected with FCR. Cultivation can also significantly reduce soil moisture storage during fallow periods.

    b. ***Stubble baling*** removes a proportion of the above ground inoculum from a paddock potentially reducing FCR risk. The pathogen will then be concentrated in the shorter stubble butts and below ground in the previous rows. Hence, baling in combination with inter-row sowing is more likely to reduce FCR risk. Reduced ground cover after baling and removal of cereal straw can reduce fallow efficiency.

    c. ***Stubble burning*** destroys above ground inoculum but depends on the completeness of the burn. Burning has no effect on the survival of the FCR fungus below ground in crown tissue even with a hotter summer burn. Hence the pathogen will be concentrated below ground in the previous rows with survival between seasons dependent on the extent of summer rainfall. Burning of cereal stubble can considerably reduce fallow soil moisture storage so a 'late Autumn' burn is preferable to an 'early Summer' burn. Stubble burning in combination with inter-row sowing is more likely to reduce FCR risk.

    d. ***Reducing cereal stubble height*** limits the length of stubble which the FCR fungus can vertically grow up during wet fallow periods restricting the overall inoculum load within a paddock. Consequently, harvesting and leaving retained cereal stubble longer (e.g. stripper fronts) leaves a greater length of stubble for subsequent potential saprotrophic growth of the FCR fungus. This is not a major issue in terms of FCR risk if the retained infected cereal stubble is left standing and kept intact. However, if the infected stubble is disturbed and redistributed across a paddock through grazing, mulching, cultivation or the subsequent sowing process then this can increase the incidence of FCR infection. Recent research in NSW has also demonstrated that increased cereal harvest height allowed saprotrophic growth of the FCR fungus above the harvest height of a following chickpea crop. This resulted in FCR infected cereal stubble being spread out the back of

the header during the chickpea harvest process increasing FCR risk for the next cereal crop (Petronaitis *et al.* 2022). Consider matching cereal stubble height at or after harvest in paddocks planned for a following shorter status break crop such as chickpea or lentils to prevent redistribution of retained FCR infected cereal stubble during the break crop harvest process.

- Select a cereal type and variety that has more tolerance to FCR ***and*** that is best suited to your region (see above results). Yield loss from FCR is generally durum>bread wheat>barley>oats. Recent research has shown that cereal type and varietal resistance has no impact on saprotrophic growth of the FCR fungus after harvest. Hence, cereal crop and variety choice does not have subsequent benefits for FCR risk with a paddock.
- Consider sowing a variety earlier within its recommended sowing window for your area. This will bring the grain filling period forward slightly and can reduce water and heat stress which exacerbates FCR expression and yield loss. However, this needs to be weighed against the risk of frost damage. Research across locations and seasons in NSW has shown that sowing at the start versus the end of a three-week recommended planting window can roughly halve the yield loss from FCR.
- If previous cereal rows are intact – consider inter-row sowing to increase the distance between the new and old plants, as most inoculum is in the stem bases of the previous cereal crop. Physical contact between an infected piece of stubble and the coleoptile, crown or sub-crown internode of the new cereal plants is required to initiate FCR infection. Research across locations and seasons in NSW (30–35 cm row spacings in stubble retained systems) has shown that inter-row sowing can roughly halve the number of wheat plants that become infected with FCR. Precision row placement can also provide greater benefits for FCR management when used in combination with rotation to non-host crops.
- Ensure nutrition is appropriate for the season. Excessive nitrogen will produce bulky crops that hastens moisture stress and makes the expression of FCR more severe. Whitehead expression can also be made more severe by zinc deficiency.
- Consider a seed fungicide treatment to suppress FCR. Fungicide seed treatments are not a stand-alone treatment and must be used as part of an integrated management approach.

References and further resources

PreDicta®B procedure - Sampling_protocol_PreDicta_B_Northern_regions.pdf (pir.sa.gov.au)

Petronaitis LT, Forknall C, Simpfendorfer S, Backhouse D (2020) Stubble Olympics: the cereal pathogen 10cm sprint - GRDC. GRDC Update paper

Petronaitis T, Forknall C, Simpfendorfer S, Flavel R, Backhouse D (2022) Harvest height implications for Fusarium crown rot management - GRDC. GRDC Update paper

Simpfendorfer S (2022) Fusarium crown rot seed fungicides - independent field evaluation 2018-2021 - GRDC

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers and their advisers through their support of the GRDC. The author would also like to acknowledge the ongoing support for northern pathology capacity by NSW DPI. This research would also not have been possible without the support of growers and advisors through submission of cereal stubble samples for testing and provision of background rotation data.

Useful discussions with Glenn Shepherd (IMAG consulting) around data presentation are also appreciated.

Contact details

Steven Simpfendorfer
NSW DPI, 4 Marsden Park Rd, Tamworth, NSW 2340
Ph: 0439 581 672
Email: steven.simpfendorfer@dpi.nsw.gov.au
X (Twitter): @s_simpfendorfer or @NSWDPI_AGRONOMY

Date published

August 2024