Leveraging seed treatments and management strategies to effectively minimise loss from Fusarium crown rot

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Take home message

- Current fungicide seed treatments registered for the suppression of Fusarium crown rot (FCR) inconsistently reduce the extent of yield loss from FCR.
- Victrato® had consistent, strong activity on limiting yield loss from FCR.
- However, under high infection levels, substantial yield loss may still occur in drier seasons. Victrato **does not** provide complete control of FCR, with efficacy likely reduced when prolonged dry soil conditions occur around the seed zone.
- Fungicide seed treatments, including Victrato, should not be considered standalone control options for FCR.
- Seed treatments should be used as an additional tool within existing integrated disease management strategies for FCR.

Introduction

Fusarium crown rot (FCR), caused predominantly by the fungal pathogen *Fusarium pseudograminearum* (*Fp*), is a major constraint to winter cereal production across Australia. A range of integrated management strategies including crop rotation, varietal selection, inter-row sowing, sowing time, stubble and fallow management are required to minimise losses. A number of fungicide seed treatments have been registered for the suppression of FCR in recent years, with a further product Victrato® from Syngenta likely to be available to Australian growers in 2024. Although chemical companies conduct their own widespread field evaluation across Australia, growers and their advisers value independent evaluation of the potential relative fit of these fungicide seed treatments within integrated management strategies for FCR.

What we did

A total of 15 replicated plot experiments (generally 2m x 10m with minimum of three replicates) were conducted across NSW from 2018–2021, with one additional field experiment conducted in Victoria (Horsham) and two in WA (Merredin and Wongan Hills) in 2018 only (Table 1). The winter cereal crop and number of varieties differed between experiments with wheat (W), barley (B) and/or durum (D) evaluated in each experiment (Table 1).

Six fungicide seed treatments: Nil, Vibrance® (difenoconazole + metalaxyl-M + sedaxane at 360mL/100kg seed), Rancona® Dimension (ipconazole + metalaxyl at 320mL/100kg seed), EverGol® Energy (prothioconazole + metalaxyl + penflufen at 260mL/100kg seed) and the unregistered product Victrato (Tymirium™ technology based on cyclobutrifluram at 40 and/or 80g active ingredient/100kg seed). All fungicide seed treatments were applied in 1kg to 3kg batches using a small seed treating unit to ensure good even coverage of seed. Note that not all six seed treatments were examined in 2020 and 2021.

All field experiments used an inoculated vs uninoculated randomised complete block design with inoculated plots infected by *Fp* inoculum grown on sterilised wheat grain added at 2.0g/m of row at sowing. This ensures high (>80%) FCR infection in inoculated plots, with uninoculated plots only exposed to background levels of *Fp* inoculum naturally present across a site. This design allows comparison between the yield effects of the various fungicide seed treatments in the presence and absence (background levels) of FCR. Yield loss from this disease is measured as the difference between inoculated and uninoculated treatments.

What did we find

Averaged across all cereal entries

Lower levels of in-crop rainfall between March and September generally lowered the yield potential at each site in each season, but also increased the extent of FCR yield loss. This was highlighted in the nil seed treatments where yield loss ranged from 11% to 48% in 2018, 14% to 20% in 2019, 11% to 37% in 2020 and 9% to 11% in 2021 (Table 1).

Table 1: Effect of various fungicide seed treatments on yield loss (%) associated with Fusarium crown rot infection in 18 replicated inoculated vs uninoculated field experiments – 2018 to 2021.

Year	Location	Crop[A]	Rainfall[B] (mm)	Yield[C] (t/ha)	%Yield loss from Fusarium crown rot[D]					
					Nil	Vibrance	Rancona Dimension	EverGol Energy	Victrato 40gai[E]	Victrato 80gai[E]
2018	Merriwagga, NSW	2W	63	1.44	44	nd[F]	nd	32	25	18
	Mallowa, NSW	2W	73	1.73	48	nd	nd	nd	26	24
	Gilgandra, NSW	2W	93	2.14	42	35	27	28	16	9
	Merredin, WA	2W	182	2.66	35	nd	nd	nd	23	13
	Horsham, Vic	2W	185	2.56	21	nd	nd	nd	+2[I]	+5
	Wongan Hills, WA	2W	291	3.27	11	nd	nd	nd	1	0
2019	Gulargambone, NSW	W/B	141	3.12	20	2	5	9	-[G]	+2
	Narrabri, NSW	W/B	200[H]	4.01	14	10	9	7	-[G]	6
2020	Boomi, NSW	3W/D	202	4.91	37	nd	28	nd	24	18
	Gurley, NSW	W/B	234	6.50	13	nd	nd	nd	-[G]	1
	Rowena, NSW	W/B	247	6.21	12	7	nd	4	-[G]	2
	Trangie, NSW	3W/D	412	4.13	26	20	23	19	4	2
	Gilgandra, NSW	3W/D	420	4.07	12	6	7	7	3	0
	Armatree, NSW	3W/D	425	4.37	11	nd	nd	7	3	+1
2021	Boomi, NSW	3W/D	349	5.74	10	-[G]	-[G]	-[G]	2	+1
	Armatree, NSW	3W/D	404	6.67	11	-[G]	-[G]	-[G]	2	1
	Wongarbon, NSW	3W/D	424	5.68	9	-[G]	-[G]	-[G]	6	4
	Rowena, NSW	3W/D	454	6.80	11	-[G]	-[G]	-[G]	1	0

[A] Winter crop type variety numbers where W = wheat variety, B = barley variety and D = durum variety.

[B] Rainfall in-crop from March to September at each site. Critical time for fungicide uptake off seed and expression of FCR.

[C] Yield in uninoculated treatment (average of varieties) with nil seed treatment.

[D] Average percentage yield loss from FCR for each seed treatment (averaged across varieties) compared with the uninoculated/nil seed treatment.

[E] gai = grams of active ingredient. Victrato is an unregistered product.

[F] nd = no difference, % yield loss from FCR with fungicide seed treatment not significantly different from the nil seed treatment. Values only presented when reduction significantly lower than the nil seed treatment.

[G] All treatments not included at these sites.

[H] Included two irrigations at GS30 and GS39 of 40mm and 30mm respectively due to drought conditions.

[I] Results with a plus in front of them show that the treatment yielded higher than the uninoculated nil treatment (that is, the treatment reduced impact from both the added FCR inoculum as well as natural background levels of Fusarium present at that site.

Vibrance and Rancona Dimension significantly reduced the extent of yield loss from FCR in six of fourteen experiments, whilst EverGol Energy reduced FCR yield loss in eight of fourteen field trials (Table 1). However, the unregistered product Victrato significantly reduced yield loss from FCR in 14 of 14 trials at the 40gai rate and 18 of 18 field experiments at the 80gai rate (Table 1). The reduction in yield loss was also generally stronger with this product compared with the other fungicide seed treatments and better at the 80gai than the 40gai rate (Table 1).

Significant yield loss (9% to 26%) still occurred with Victrato at drier sites. These dry conditions increased the yield loss from FCR (>35% in nil seed treatment). However, the 80gai rate at these disease conducive sites at least halved the yield loss compared with the nil seed treatment (Table 1). Yield loss from FCR was lower at the wetter sites (<26%). Victrato reduced yield loss to <6%, with increased yields at some sites due to the effects of background levels of FCR infection being reduced (Table 1). Moisture stress during grain filling exacerbates yield loss from FCR and favours the growth of *Fp* within the base of infected plants. Dry soil conditions throughout the season at the seeding depth, is likely to restrict the movement of fungicide actives off the seed coat and into surrounding soil and restrict uptake by root systems. This would reduce movement of the fungicides into the sub-crown internode, crown and tiller bases where FCR infection is concentrated. It is currently not clear if reduced efficacy of Victrato under drier conditions may be related to one or both of these factors.

What about durum

Durum wheat is known to have increased susceptibility to FCR compared with many wheat and barley varieties. The increased prevalence of FCR in farming systems aided by the adoption of conservation cropping practices, including retention of cereal stubble, has often seen durum removed from rotations due to this risk. The durum variety DBA Lillaroi⦶ was compared with three bread wheat varieties at four sites in 2020 (Table 1).

Table 2: Effect of Victrato seed treatment at two rates on the extent of yield loss[A] (%) from Fusarium crown rot in three bread wheat (W) and one durum (D) variety at three sites in 2020. Note: Victrato is not yet registered.

Variety	**Boomi 2020**			**Trangie 2020**			**Gilgandra 2020**			**Armatree 2020**		
	Nil[B]	**Victrato 40gai**	**Victrato 80gai**	**Nil**	**Victrato 40gai**	**Victrato 80gai**	**Nil**	**Victrato 40gai**	**Victrato 80gai**	**Nil**	**Victrato 40gai**	**Victrato 80gai**
LRPB Lancer ⦶ (W)	29	23	20	30	10	8	13	2	0	9	4	+7[C]
Mitch⦶ (W)	39	18	11	13	+2	+5	9	2	1	5	0	0
LRPB Trojan ⦶ (W)	34	22	18	20	4	2	12	1	0	14	2	2
DBA Lillaroi ⦶ (D)	48	32	24	45	11	6	16	5	+2	14	6	+2

[A] Average percentage yield loss from FCR for each seed treatment compared with the uninoculated/nil seed treatment for that variety.

[B] Nil = no seed treatment.

[C] Results with a plus in front of them show that the treatment yielded higher than the uninoculated nil treatment (that is, the treatment reduced impact from both the added FCR inoculum, as well as natural background levels of Fusarium present at that site).

The extent of yield loss from FCR with nil seed treatment was generally higher in the durum variety (14% to 48%) compared with the three bread wheat varieties (5% to 39%). The bread wheat variety Mitch[D] tended to have reduced yield loss from FCR compared with the other entries, apart from the Boomi site (Table 2). Yield loss from FCR was reduced with Victrato in both the bread wheat and durum varieties (Table 2). Even in the higher loss site at Boomi in 2020, the 80gai rate halved the extent of yield loss in the durum variety Lillaroi[D], with better efficacy in the other three sites.

Conclusions

Current fungicide seed treatments registered for the suppression of FCR can inconsistently reduce the extent of yield loss from this disease. Victrato, due to be registered in 2024, appears to have more consistent and stronger activity on limiting FCR yield loss. In the absence of fungicide seed treatments, average yield loss from FCR infection across the 18 sites over three seasons was 21.5%. The 80gai rate of Victrato significantly reduced the level of yield loss from FCR down to an average of 4.9% across these 18 field experiments. Under high infection levels, as created with artificial inoculation in these experiments, significant yield loss may still occur (up to 24% measured), particularly in drier seasons.

Dry soil conditions around the seeding depth throughout a season may reduce the uptake of fungicides applied to the seed coat. Drier seasons also exacerbate FCR expression, which would place additional pressure on fungicide seed treatments. However, even under these conditions, Victrato at the 80gai rate still at least halved the level of yield loss from FCR.

Fungicide seed treatments, including Victrato (once registered), should not be considered standalone control options for FCR. Rather, they should be used as an additional tool within existing integrated disease management strategies for FCR.

Integrated management of FCR

To manage the risk of yield losses in cereals, firstly identify paddocks at highest risk of Fusarium crown rot. 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 are to use effective weed management programs to reduce grass weed hosts in-crop and fallow situations which serve as alternate hosts for the FCR fungus. Also remember, the larger the grass weed when controlled, the longer that residue serves as a potential inoculum source. Furthermore, 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 prior to sowing, so knowing the risk level within paddocks is important. This can either be through PreDicta B testing (SARDI) or stubble testing (NSWDPI).

If medium to high FCR risk, then:

- Sow a non-host break crop (for example, 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.
    - ***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 with 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 substantially reduce soil moisture storage during fallow periods.

- *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 bailing and removal of cereal straw can reduce fallow efficiency.
- ***Stubble burning*** depending on the completeness of the burn, above ground inoculum is destroyed. 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.
- ***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. When relative humidity is >92.5%, the FCR fungus 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. Consequently, harvesting and leaving retained cereal stubble longer (for example, 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. 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 within 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 half 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 (30–35cm 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 hasten moisture stress and make 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 a part of an integrated management approach.

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Useful resources

PreDicta®B sampling procedure (Sampling_protocol_Predicta_B_South_and_West_V2.pdf (pir.sa.gov.au))

Petronaitis T, Forknall C, Simpfendorfer S, Backhouse D (2020) (Stubble Olympics: the cereal pathogen 10cm sprint)

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

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