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Growth of the fusarium crown rot pathogen in post harvest cereal stubble over a summer fallow, Narrabri 2019–20

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Key findings

- The fusarium crown rot pathogen (*Fusarium pseudograminearum* (Fp)) can grow vertically to the height the cereal stubble was cut at harvest over a summer fallow, so will progress further in taller-length stubble (i.e., 32 cm or 45 cm above ground level i.e., harvest height).
- Pathogen growth was restricted at or after harvest by cutting the stubble shorter (i.e., 17 cm harvest height).
- Altering harvest height of cereal crops can affect stubble-borne pathogens dispersal such as Fp during the subsequent harvest of lower stature chickpea crops. Any implications this has on the disease risk for successive cereal crops within a rotation sequence is yet to be determined.
- Cereal stubble management treatments did not significantly affect soil moisture levels after a summer fallow or the following chickpea break crop performance in 2020 at Narrabri.

Introduction

The effects of fusarium crown rot (FCR), caused by the fungus *Fusarium pseudograminearum* (Fp), have increased in Australia over the past four decades. It associated with conservation-agriculture practice adoption such as cereal stubble retention. Despite the yield penalties associated with FCR, stubble retention is important for soil structure, moisture and fertility in the northern grains region (NGR) of NSW and southern Qld. Finding ways to limit the negative effects of disease whilst retaining cereal stubble is therefore essential.

Cropping practises are continually evolving, and new cropping trends could be reducing the efficacy of current disease management strategies. For example, adopting higher harvest heights (i.e., stripper fronts), light tillage (i.e., Kelly chaining) and rotations with shorter stature break crops (e.g., chickpea, *Cicer arietinum*) are becoming common in the NGR. The stripper front harvesting systems improve harvest efficiency by rapidly stripping plant heads at harvest, and increases retained stubble biomass (as standing stubble height is increased). It is unknown how such an increase in vertical cereal stubble height will affect Fp survival and/or growth.

Fusarium is capable of surviving in post harvest cereal stubble for ~three years and can also continue to colonise (i.e., grow) in post harvest cereal stubble by a process known as saprophytic colonisation. Additional stubble remaining from stripper front harvested cereal crops could increase Fp colonisation as there is more vertical stubble to colonise compared with the growth possible in stubble remaining from conventional or shorter harvest heights. Lowering or modifying an Fp-infected cereal crop harvest height could restrict standing cereal stubble colonisation, which could be beneficial for preventing further increases in Fp inoculum levels during fallow or non-host periods.

The effects of harvest height modification on Fp vertical colonisation over a summer fallow was investigated at Narrabri using a range of cereal harvest height and stubble management options in a two-year (durum–wheat–chickpea) rotation spanning the 2019–20 growing season. Soil moisture and chickpea yield under the different cereal stubble management treatments established in the 2019 season were measured during the 2020 season.

Site details

Location	Australian Cotton Research Institute, Narrabri, Latitude 30° 20′ 28.84″ S, Longitude 149° 59′ 80.39″ E.
Rainfall	In 2019, 195.7 mm of rainfall was recorded at the site, of which 75 mm fell in the growing season (Table 1). Supplementary irrigation was required for durum wheat establishment in 2019. The fallow rainfall (2019–20) was 323.4 mm. In 2020, 726 mm of rainfall was recorded at the site, of which 296.4 mm fell in the growing season. No irrigation was required in 2020.
Chickpea variety	PBA Seamer(1)
Chickpea sowing date	27 May 2020.
Fertiliser	40 kg/ha Granulock Z®.
Sowing rate	Target 30 plants/m^2.
Insect management	Targeting *Helicoverpa* spp: Fastac Duo® 250 mL/ha (alpha cypermethrin 100 g/L) applied on 20 October.
Disease management	Seed treated with P-Pickel T® (1:5 water dilution applied at 1 L/100 kg seed).
Harvest date	9 November 2020.

Table 1 Rainfall (mm) for Narrabri during 2019 and 2020.

Season	2019 growing season							2019-20 fallow						2020 growing season						
Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (month)	20.8	0.6	15.8	0.6	1.2	6.0	30.0	4.0	89.8	107.8	61.4	47.6	12.8	23.0	21.2	20.6	35.6	73.2	3.6	119.2
Rainfall (season)	75.0							323.4						296.4						
Rainfall (annual)	195.7							615.8												
Decile year*	< decile 1 (367)							> decile 9 (584.2)												
Long term average (annual)	584.2																			

* Decile values are for Narrabri Airport, NSW. Totals for each year and season are reported alongside the long-term average (with decile year indicators)

Treatment

Cereal stubble treatments (established 2019–20)

In 2019, cereal stubble from durum wheat, DBA Lillaroi(1) with extensive Fp colonisation was established via inoculation (2 gm–1 row of Fp-colonised grain inoculum). A range of cereal harvest heights (low, medium or high) and harvest trash (trash returned to plot or trash removed off plot) treatments were applied at harvest in 2019.

Stubble heights were measured after durum wheat harvest:

- low stubble averaging 17 cm.
- medium stubble averaging 32 cm.
- high stubble averaging 45 cm.

Before sowing in 2020, an additional stubble management treatment (Kelly chain) was applied to a selection of plots. This treatment was applied in combination with the harvest height treatments, to plots that had previously had cereal harvest trash retained.

Experiment design and statistical analysis

Design:

- Randomised block design, with three replicate blocks, in which
- cereal stubble management treatments (factorial combination of cereal harvest height and harvest trash, plus Kelly chain treatments) were randomly assigned to plots.

Analysis:

- The response variables, length of maximum colonisation and soil moisture content (SMC) percentage, were analysed across sampling times using a linear mixed model framework. Treatments, sampling time and their interaction were the fixed effects, while structural terms were fitted as the randoms.
- Response variables related to chickpea crop performance were also analysed.
- All models were fit using the ASReml-R package in the R statistical computing environment.

Results

Colonisation of cereal stubble by Fp over fallow (2019–20)

The maximum height the Fp colonised in the post harvest cereal stubble increased significantly over the 2019–20 fallow in the medium and tall stubble (P <0.001, Figure 1). Maximum colonisation height increased significantly in medium (+15.2 cm) and tall (+21.4 cm) cereal stubble over the fallow (Figure 1).

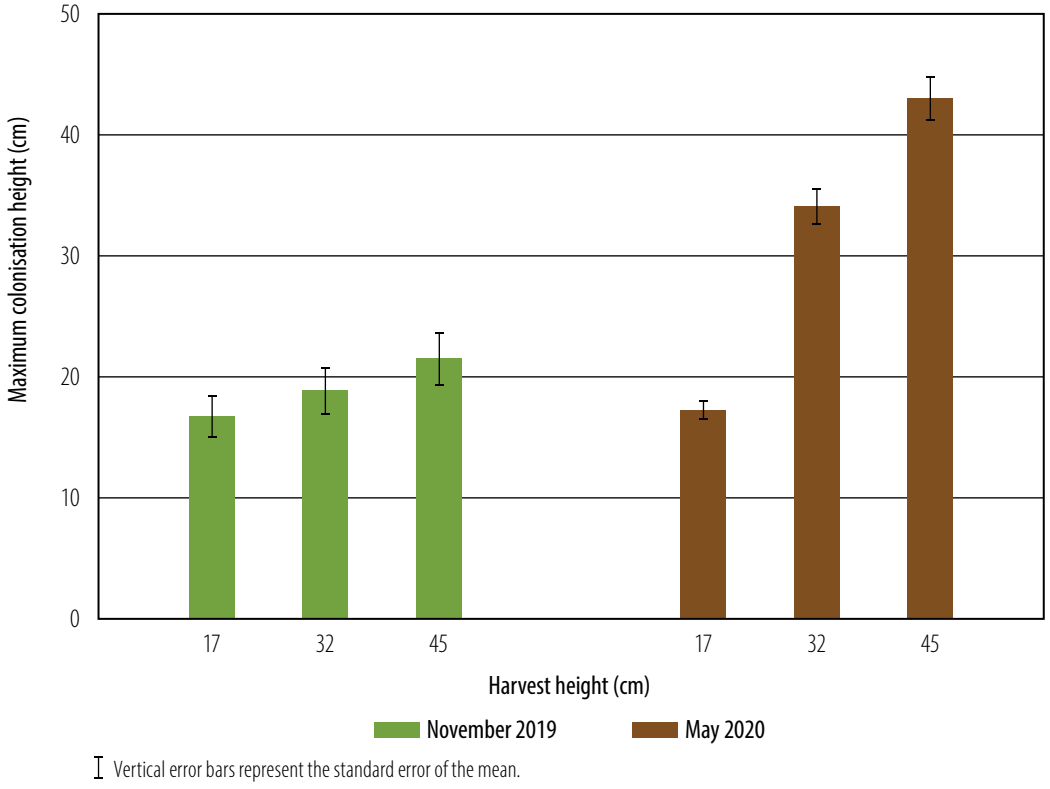


Figure 1 Maximum vertical colonisation (cm) of cereal stubble by *F. pseudograminearum* at the start (November 2019) and end (May 2020) of summer fallow in Narrabri.

Fuserium graminearum height did not change in the short cereal stubble because the fungus had already reached the cut height by harvest in 2019.

The high rainfall (323 mm; Table 1) over the summer was conducive to Fp saprophytic colonisation.

There was no effect of cereal harvest trash treatment (retained, removed or Kelly chained) on maximum colonisation at each time point (P >0.1).

These results demonstrate that Fp will continue to colonise to the cut cereal stubble height and suggests that lower cereal harvest heights might be effective at preventing Fp progression in infected standing stubble during the fallow period.

Chickpea establishment (2020)

Chickpea establishment ranged from 32 plants/m^2 to 39 plants/m^2. There was no significant effect from cereal stubble management treatments on establishment i.e., cereal stubble height (P = 0.18), harvest trash (retained, removed or Kelly chained) (P = 0.42) or stubble height and harvest trash (P = 0.61) (data not shown).

Chickpea grain yield (2020)

The cereal stubble management treatments applied in 2019–20 at Narrabri did not affect chickpea yield in the 2020 season i.e., standing cereal stubble height (harvest height) (P = 0.98), harvest trash treatment (trash retained, trash removed or Kelly chain) (P = 0.93) or a combination of harvest height and trash treatments (P = 0.46). Yields were uniform across the experiment, ranging from 2.1 t/ha to 2.2 t/ha.

Good fallow and in-season rainfall (Table 1) could have evened-out any influence that the differential cereal stubble heights and loads might have had on chickpea yield.

Height to lowest pod and crop height (2020)

There was no effect from cereal stubble management treatments applied in 2019–20 on lowest chickpea pod height in the 2020 season i.e., harvest height of standing stubble (P = 0.32), trash treatment (P = 0.72) or the combination of harvest height and trash treatments (P = 0.88).

The chickpea plants grown in shorter stubble were approximately 4 cm taller than plants in the medium and tall stubble treatments (P = 0.01, Figure 2). Additional heat or sunlight penetrating through the shorter cereal stubble during early establishment could have promoted chickpea growth, compared with medium or tall stubble. Cereal harvest trash treatments or the combination of stubble height and trash treatments did not affect chickpea canopy height (P = 0.72 and P = 0.88, respectively). Importantly, the increased canopy height in the short stubble treatments didn't appear to provide any flow-on benefits such as increased yield or improved height of lowest pods.

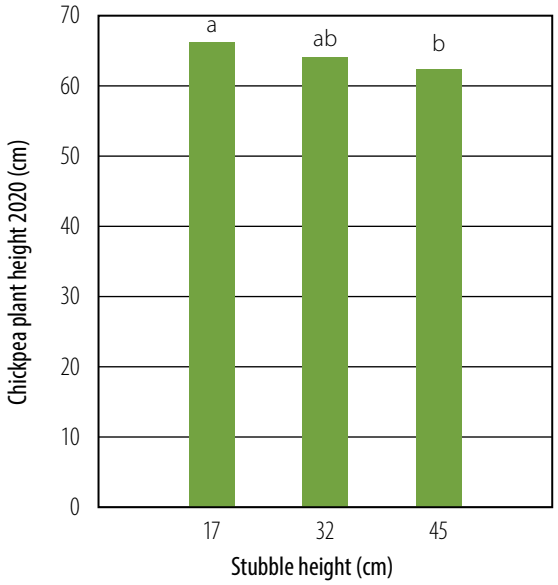
Soil moisture profiles (2019–20)

There were no significant differences in SMC resulting from cereal harvest height or trash treatments (or their interactions) when chickpea was sown in May 2020 (P >0.7). There appeared to be no detrimental effects from cereal stubble management treatments on SMC. The good rainfall at Narrabri over the 2019–20 fallow (Table 1) probably would have increased soil moisture over the fallow period and could have evened out the soil moisture at sowing in 2020.

The different stubble treatments might have affected SMC if the 2019–20 fallow had been drier. Instead, Narrabri went from a below decile 1 rainfall in 2019 to above decile 9 rainfall in 2020. Some interactions between SMC and cereal stubble treatments were approaching significance (P = 0.06) at chickpea harvest (in 2020) but no clear trends were evident (data not shown).

Conclusions

Growers need to be aware that Fp can vertically colonise the full length of standing cereal stubble in the field after harvest, given sufficient fallow rainfall. In our experiment, the maximum detection of Fp within standing stubble at harvest in 2019 was between 15 cm and 22 cm. By the end of a six-month summer fallow, the maximum Fp recovery height within standing stubble was equal to, or very close to, the cut height of the standing stubble at harvest in 2019 (> 40 cm in tall stubble). Similar results were obtained at a second experiment site located in Breeza, NSW.



Treatments with the same letter are not significantly different.

Figure 2 Height of chickpea plants i.e. canopy height (cm) at maturity appeared inversely correlated to the height of underlying cereal stubble at the Narrabri site.

Implementing lower harvest heights in cereal crops affected by FCR is a useful strategy to limit Fp colonisation in retained standing stubble during fallow and non-host periods, particularly if a wet summer is expected. This could help reduce inoculum build up within the standing stubble beyond the inoculum levels present at harvest. Inoculum spread might be prevented during the harvest of short-stature crops such as chickpea, when inoculum is present above the chickpea harvest height.

Lower stubble height, along with inter-row sowing, could together help lower inoculum levels. This approach could still be used with stripper fronts by stripping grain, then cutting stubble above colonisation height in a second pass to restrict vertical Fp colonisation. The cut fraction could be left between rows as mulch or baled, providing a better option than burning if extensive colonisation occurs during a wet summer fallow. Further vertical Fp colonisation (i.e., above the levels present at harvest) is less likely over a dry summer, but there can still be extensive colonisation during the growing season, with inoculum persisting for 2–4 years in intact stubble.

Modifying cereal harvest height for FCR management appears promising, with the experiment continuing in 2021 to determine the affect these stubble management practises have on FCR risk in a subsequent bread wheat and durum wheat sowing.

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