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Effect of row placement, stubble management and ground engaging tool on crown rot and grain yield in a no-till continuous wheat sequence

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ABSTRACT

Crown rot (CR), caused by the fungus *Fusarium pseudograminearum* (*Fp*), is a constraint to wheat production in semi-arid regions globally with limited management options to control the disease. *Fp* is a stubble-borne pathogen hence inoculum becomes concentrated in the previous cereal rows in a no-till system. Two field experiments in northern New South Wales (NSW), Australia, were conducted to examine whether inter row sowing reduces the impact of CR. The first examined the effect of wheat stubble (standing stubble and slashed), row cleaners (moved sideways with row cleaners or undisturbed) and row placement (on or between rows) on the incidence and severity of *Fp* and yield of durum wheat [*Triticum turgidum* L. ssp. durum (Desr.)] in a wheat–wheat sequence. The second examined row placement plus ground engaging tool (disc vs tine) imposed on *Fp*-moderately susceptible bread wheat (*Triticum aestivum* L.) and *Fp*-very susceptible durum wheat varieties in a third consecutive wheat crop. In experiment 1; sowing between rows reduced incidence of *Fp* by 6%, reduced whiteheads/m^2 by 27% and increased yield by 6% compared with sowing on the row. Moving inoculum away from the sown row using row cleaners also reduced incidence of *Fp* (by 3.7%) and whiteheads (by 13.6%) but this did not express as an increase in yield. In experiment 2; sowing between rows led to a 12% reduction in incidence of *Fp* compared with sowing on the row, but this did not translate into a significant yield advantage. Sowing with a tine increased plant establishment, tiller density and grain yield compared to sowing with a disc. Under high disease pressure, the *Fp*-moderately susceptible variety out-yielded the *Fp*-very susceptible variety by 20%. Inter-row sowing provided a yield advantage when sowing a second consecutive wheat crop but it did not provide a yield advantage under a third cereal in sequence. Integrating the individual management tools (row placement, residue management, ground engaging tool, varietal choice) appear to be useful additions to integrated management to reduce the impact of CR in a no-till system.

1. Introduction

Inter-annual variability in rainfall and the quantity of plant available water (PAW) stored in the soil at planting are the major factors contributing to the year-to-year variation in dryland wheat yield in the northern New South Wales (NSW) cropping region of Australia (Nix, 1975; Cornish et al., 1998). This semi-arid region is dominated by vertosols (Isbell, 1996) which are characterised by high PAW capacity which, coupled with a summer dominant rainfall pattern, has shaped the cropping systems in this region (Verrell, 2004). Capturing and storing water in the fallow is a risk minimisation strategy to off-set the possibility of low in-crop rainfall. No-till fallow systems have increased in the region since 1985 and has led to an increase in CR incidence which appears further linked to the use of very susceptible durum wheat [*Triticum turgidum* L. ssp. durum (Desr.)] varieties, expansion of residue retention and an increase in the use of nitrogen fertiliser (Wildermuth et al., 1997a; Burgess et al., 2001; Verrell, 2004). Crown rot is also of increasing importance in other countries including the USA (Smiley et al., 2005), Turkey (Tunali et al., 2006), South Africa (Lamprecht et al., 2006) and most recently China (Li et al., 2012). Currently strategies for managing CR are to control grass weed hosts, rotate susceptible cereals with non-host crops, burn infected residue and grow moderately susceptible bread

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wheat (*Triticum aestivum* L.) varieties that reduce disease development (Burgess et al., 2001).

The CR fungus, *Fusarium pseudograminearum* (*Fp*), survives as mycelium inside winter cereal and grass weed residue (Wearing and Burgess, 1977). Infection and development of CR are influenced by the interaction between soil and plant water potential (Papendick and Cook, 1974; Beddis and Burgess, 1992; Verrell, 2004), soil nitrogen (N) (Wildermuth et al., 1997a; Felton et al., 1998; Verrell, 2004), variety and inoculum load. The disease can kill tillers and whole plants (Wildermuth et al., 1997b) and can also lead to the formation of whiteheads – a symptom associated with small or no grain development (Burgess et al., 2001). Whiteheads can be symptomatic of CR and their incidence is related to yield loss (Burgess et al., 2001).

Being a stubble-borne pathogen, CR inoculum should remain concentrated in the previous cereal rows, providing the cereal residue is not disturbed and redistributed through tillage. Davis et al. (2008) examined the effect of wheat seed placement, relative to standing stubble rows, on the incidence and severity of *Rhizoctonia* species. They found that because the inoculum of *Rhizoctonia* is not produced in the crowns and lower stems of the plant but in living and dead roots of the previous year crop, high inoculum densities were present in between the standing rows resulting in no benefit of inter-row sowing. Kabbage and Bockus (2002) found that take-all caused by *Gaeumannomyces graminis* var. *tritici* (*Ggt*) was less severe as the distance of seed placement to the inoculum source increased. Mathematical modelling suggested that sowing parallel to and between previous cereal rows would reduce yield loss to *Ggt* (Garrett et al., 2004). Unlike *Rhizoctonia*, the most significant inoculum source for *Ggt* is infected intact cereal crowns in the stubble row from the previous year (Moore and Cook, 1984).

These experiments aimed to determine whether spatial distribution of CR inoculum reduces disease in a following wheat crop by: (i) deliberately sowing into the inter-row space between the previous stubble rows, and/or (ii) by manipulating surface residue at sowing.

The use of GPS guidance precision planting technology allows growers to sow seed precisely between the standing rows of the previous cereal crop. Planting exactly between the previous year's stubble rows would maximise the distance between seed and *Fp* infected crowns and standing cereal residue.

Two field experiments were conducted to investigate the impact of inter-row sowing, stubble management, ground engaging tool and varietal susceptibility to *Fp*, on the quantity of *Fp* inoculum, the incidence and severity of CR and the yield and plant components of durum and bread wheat varieties. The experiments aimed to determine if a second and possibly third consecutive wheat crop could be sown under no-till through integration of these disease management components to limit the impact of CR.

2. Materials and methods

Two field experiments were conducted at the Tamworth Agricultural Institute (TAI) (31°09′S, 150°59′E) in the northern NSW cropping region of Australia from 2001 to 2005 (Table 1). The experiments were conducted on a brown vertisol (IUSS Working Group WRB, 2015) with clay contents of 54% and 60% at soil profile segments of 0–15 cm and 90–120 cm, respectively. The first experiment (*Tamworth-1*) looked at the interaction between

Table 1
Crop sequences, experimental treatments and their management details.
VS, *Fp*-very susceptible; MS, *Fp*-moderately susceptible.

Component	Tamworth – 1 2004	Tamworth – 2 2005
Experimental crop sequence		
2001	Durum (VS)	Durum (VS)
2002	Chickpea (Non- host)	Chickpea (Non- host)
2003	Durum (VS)	Durum (VS)
2004	Durum (VS)	Durum (VS) – IRS[a] only
2005	–	Durum (VS) and Bread (MS)
Experimental treatments		
Row cleaners	Plus	–
	Minus	–
Stubble	Standing	Standing
	Slashed and spread	–
Row placement	Sow between 2003 standing rows	Sow on 2003 standing rows
	Sow on 2003 standing rows	Sow on 2004 standing rows
Ground engaging tool	Disc seeder	Disc seeder
	–	Tine seeder
Variety	EGA Bellaroi	Sunvale (MS)
	–	Bellaroi (VS)
Management		
Plot size (m)	12 × 4	12 × 4
Replicates	4	4
Row space (m)	0.38	0.38
Sowing date	15 June 2004	29 July 2005
Sowing rates (kg/Ha)[b]		
Chickpea	80	80
Bread wheat	–	40
Durum wheat	50	50
Fertiliser rates (kg/ha)	100N/18P/20S	100N/18P/20S
Harvest dates	29 November	02 December

[a] IRS – inter row sown.
[b] Chickpea received no N fertiliser but was inoculated with commercial inoculant.