Options for managing Fusarium wilt with crop rotations

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Fusarium wilt can cause extremely high losses in cotton crops when susceptible varieties are grown on heavily infected soils, and weather conditions are favourable for the development of the disease. It is also recognised that growing cotton varieties with low resistance (low F–rank) to the disease in infected areas will rapidly hasten the build up of the fungus in the soil.

Fusarium is now widespread on the Darling Downs, at St George and from the McIntyre Valley into northern NSW. To date the disease has not been recorded in the Emerald, Hillston or Tandou cotton production regions.

Growers in production districts of known high disease incidence have been seeking effective crop rotation options to assist in the management of Fusarium wilt.

Research projects funded by CRDC and the Australian Cotton CRC over the past three years have sought to further understand the disease-crop interactions and to determine a 'best bet' crop rotation option for cotton growers battling Fusarium wilt. Trials have been conducted in the field at "Cowan" at Norwin on the Darling Downs, and in the glasshouse at Toowoomba DPI&F.

CROP ROTATION EXPERIMENTS

Field trial

The influence of growing different rotation crops on the level of *Fusarium oxysporum f.sp. vasinfectum* (Fov) in the soil was monitored over three years in a summer field crop rotation experiment. The irrigated trial consisted of six treatments x three replications x eight rows x 150 metre plots.

In the 2001–02 and 2002–03 seasons of the trial, the same crop was grown into the same plot. The maize plots were a forced fallow during 2002–03 when strong winds during a severe storm in December 2002 blew seedling plants out of the ground.

In 2003–04, the entire trial area was over-sown with cotton — variety Nu Emerald RR. Mungbean plots were replanted with Sicot 14B six weeks later due to 95 per cent seedling mortality.

Bioassays were conducted on soil collected at three set sampling times to determine soil disease inoculum levels. Samples were collected in October, February and June of each year of the trial. Siokra 1–4 was sown into the collected soil (50 seeds per two trays). After six weeks the surviving seedlings were rated on a scale of zero to five based on the degree of internal stem browning. Ratings were used to convert data to a MDI (Mean Disease Index).

The disease rating scale was:

- 0 – no discolouration;
- 1 – discolouration confined to base of stem;
- 2 – discolouration to the cotyledon;
- 3 – discolouration extending beyond the cotyledon;
- 4 – complete vascular discolouration of the stem; and,
- 5 – seedling dead.

Glasshouse trial

The experiment consisted of 19 treatments, each with six replications. Small glasshouse pot trials, using soil naturally infested with Fov, were used to examine different rotation options over five crop cycles with cotton over sown across all treatments in the final cycle (Table 1). Root material was left in pots between cycles but stubble was removed. All pots

Key points from three years of trials

- Results highlight the importance of a fallow preceding a cotton crop grown on Fusarium wilt infected soils. Significantly, more cotton plants survived until maturity following a bare fallow rotation compared to cotton following either maize, cotton or sorghum crops.
- Greatest plant death and severity of disease in cotton occurred where soybean and mungbean crops had previously been grown.
- Residue and organic matter levels may influence field pathogen survival and disease incidence.
- Grow only the most resistant cotton varieties available (varieties with high F-ranks) in fields known to be infected with Fusarium wilt.

The rotation trial site at 'Cowan' Norwin.

were initially sown with Siokra 1–4 in two eight week cycles at the start of the experiment to ensure an even inoculum level.

Isolations were made from plants grown in the glasshouse experiment to determine if the wilt fungus had colonised the different crops. Root and stem tissue was examined microscopically — any Fusarium colonies were forwarded to the DPI&F Indooroopilly Plant Pathology laboratories for Vegetative Compatibility Group testing.

RESULTS

Field trial — 'Cowan'

Results showed significantly more cotton plants survived until maturity following a bare fallow rotation compared to cotton plants grown following either maize, cotton or sorghum crops. The greatest percentage of cotton plant death and severity of disease in cotton occurred where soybean or mungbean crops had previously been grown (Table 2).

Glasshouse trial

Rotation cycles that included a fallow treatment either one or two crops before growing cotton generally resulted in less severe Fusarium wilt (lower MDI) compared to cycles where a fallow treatment was not included or occurred early in the cycle (Table 1).

TABLE 1: Glasshouse trial — mean disease index (MDI) of cotton following different rotation sequences

CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4	COTTON	MDI
Chickpea	Chickpea	Chickpea	Chickpea	Cotton	0.5 a
Soybean	Wheat	Fallow	Fallow	Cotton	0.8 ab
Fallow	Fallow	Fallow	Fallow	Cotton	1.2 abc
Fieldpea	Fieldpea	Fieldpea	Fieldpea	Cotton	1.3 abc
Cotton	Wheat	Mungbean	Fallow	Cotton	1.3 abc
Sorghum	Chickpea	Fallow	Wheat	Cotton	1.6 bc
Millet	Millet	Millet	Millet	Cotton	2.0 cd
Pigeonpea	Pigeonpea	Pigeonpea	Pigeonpea	Cotton	2.1 cde
Cotton	Fallow	Cotton	Fallow	Cotton	2.6 def
Vetch	Vetch	Vetch	Vetch	Cotton	2.8 def
Maize	Oats	Cotton	Fallow	Cotton	2.9 def
Cotton	Cotton	Cotton	Cotton	Cotton	3.1 ef
Mungbean	Fallow	Cotton	Wheat	Cotton	3.3 fg
Sorghum	Sorghum	Sorghum	Sorghum	Cotton	3.6 fgh
Maize	Maize	Maize	Maize	Cotton	4.2 ghi
Lucerne	Lucerne	Lucerne	Lucerne	Cotton	4.2 ghi
Sunflower	Barley	Mungbean	Oats	Cotton	4.5 hi
Broccoli	Broccoli	Broccoli	Broccoli	Cotton	4.7 i
Sunflower	Sunflower	Sunflower	Sunflower	Cotton	4.8 i

Note
- Numbers within a column followed by the same letter are not significantly different
- MDI — derived by assessing the severity of vascular discolouration in surviving cotton seedlings after 6 weeks

Results from the small pot trials indicate that crops with larger root systems (sunflower, broccoli, lucerne, maize, sorghum) had more disease (higher MDI) in the following cotton compared to crops with

smaller root systems (fallow, chickpea, fieldpea, millet, pigeonpea), after these crops had been grown for four continuous cycles.

This reflects the role of residue and organic matter in pathogen survival and disease incidence.

Isolations of Fov have been made from mature plants growing in these pot trials including:

- Sunflower (five per cent);
- Maize (four per cent);
- Sorghum (three per cent) (roots only);
- Mungbean (24 per cent);
- Fieldpea (20 per cent);
- Vetch (20 per cent);
- Pigeonpea (12 per cent);
- Chickpea (four per cent); and,
- Lucerne (four per cent) (stems and roots).

From these results, legume crops should be considered with caution when planning rotations for infected fields due to their apparent susceptibility to infection by the Fusarium wilt pathogen, and potential to aid in the carryover and survival of the pathogen.

Fusarium oxysporum f. sp. vasinfectum has not been isolated from any seed from rotation crops of mungbean, sorghum, chickpea, soybean and millet that have been produced on the Darling Downs. Seed from other rotation crops has not yet been tested.

FUTURE RESEARCH

Further research into rotation options and the role of crop residue, organic matter and green manuring of crops in relation to pathogen survival is continuing.

Further work is required on determining the actual changes in spore numbers in the soils following the different crops rotations. Fusarium wilt will probably never be totally eliminated from the soil due to the long-lived nature of the fungal spores (up to 10 years).

So there is a real need for an integrated approach to ensure the best possible management of this disease.

The importance of a fallow in the rotation cycle, and in particular prior to a cotton crop, should not be overlooked. The saprophytic ability of the fungus to survive on vegetative material found in the soil between cotton crops presents an enormous challenge to develop and determine crop rotation options for disease management.

Economically a fallow does not offer an immediate cash return but indications from the trials suggest that the severity of the disease may be reduced in the following cotton crop. Whether potential yield increases occur as a result are yet to be investigated.

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TABLE 2: Field trial — assessment of plant survival, disease incidence and yield of cotton after various rotations

Rotation	Emergence count	Final plant count	% 0s & 1s#	Yield (bales/ha)
Fallow	127 a	67 a	33 a	6.5 a
Maize	119 a	46 b	16 b	5.7 ab
Sorghum	102 b	30 c	7 c	4.7 abc
Cotton	81 c	28 c	5 c	3.8 bc
Soybean	73 c	13 d	6 c	3.1 c
Mungbean (replanted)*	22 (76)	0 (23)	0 (19)	0 (2.9)

Note:
- # Per cent 0s and 1s: indicates five per cent or less vascular discolouration when stems are cut at the end of the season
- Numbers within a column followed by the same letter are not significantly different
- * Mungbean — replanted six weeks later due to 95 per cent initial seedling losses; the number in brackets shows counts of the replanted variety — data was not included in the statistical analysis.

Plants in the glasshouse rotation experiment with the initial Siokra 1-4 planting on the right.

Glasshouse rotation experiment showing five crop cycles.