2006 Beltwide Cotton Conferences, San Antonio, Texas - January 3 - 6, 2006

THE EFFECTS OF CROP ROTATION WITH WHEAT ON THE INCIDENCE OF FUSARIUM WILT OF COTTON IN AUSTRALIA

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Abstract

Winter cereals are the most common rotation crops used in cotton production systems in Australia. The incidence of Fusarium wilt in cotton seedlings was increased by 40% following crop rotation with either wheat or barley when compared to the incidence of Fusarium wilt after a 18 month bare fallow. Field experiments were established to investigate the impact of various wheat residue management strategies on the incidence of Fusarium wilt in the subsequent cotton crop. Either burning or incorporating wheat residues soon after harvest resulted in less disease than that which occurred after retaining the wheat residues on the surface. The results again emphasized the importance of wheat residues on the epidemiology of Fusarium wilt in cotton in Australia.

Introduction

Fusarium wilt of cotton caused by *Fusarium. oxysporum* f.sp. *vasinfectum* is a significant problem for cotton growers in Australia. The disease was observed on 27% of the 67 farms inspected during the 2004/05 Australian cotton disease survey (Nehl et al, 2005). There is a considerable effort (Allen, 2004) to identify a range of control strategies that can be integrated into a disease management program that will enable farmers to continue to grow cotton profitably. The strategies that are being evaluated include breeding for better host resistance, seed treatments that induce resistance, trash management, crop nutrition, delayed planting and crop rotation.

Cooper (1999) completed a survey of the rotation crops used in the New South Wales cotton industry and found that 74.3% of growers used wheat as their main rotation crop. A further 9.2% of cotton growers used either barley or oats as their main rotation crop. When a winter cereal is used in rotation with cotton it is normally followed by a 9 month period of fallow prior to planting the next crop of cotton (Table 1).

Table 1. Annual schedule of sowing and harvesting operations for a cotton-wheat-fallow rotation, a long bare fallow rotation and continuous cotton in the Australian environment.

Season	Months	Cotton/wheat rotation	Long bare fallow	Continuous cotton
Spring	Sept. – Oct. – Nov.	Sow cotton	Sow cotton	Sow cotton
Summer	Dec. – Jan. – Feb.	Cotton	Cotton	Cotton
Autumn	Mar. – Apr. - May	Pick cotton/sow wheat	Pick cotton	Pick cotton
Winter	June – July – Aug.	Wheat	Fallow	Fallow
Spring	Sept. – Oct. – Nov.	Harvest wheat	Fallow	Sow cotton
Summer	Dec. – Jan. – Feb.	Fallow	Fallow	Cotton
Autumn	Mar. – Apr. - May	Fallow	Fallow	Pick cotton
Winter	June – July – Aug.	Fallow	Fallow	Fallow
Spring	Sept. – Oct. – Nov.	Sow cotton	Sow cotton	Sow cotton

Cereals such as wheat or barley are not regarded as hosts of *F. oxysporum* f.sp. *vasinfectum.* However, the residues of cereal crops appear to provide a favorable substrate for saprophytic colonization. Smith and Snyder (1975) suggested that soil populations of *F. oxysporum* f.sp. *vasinfectum* could increase more rapidly under repeated cropping to cereals such as barley than under continuous cotton in California. The pathogen was readily isolated from barley crop debris in the soil. Tio *et al*. (1977) recommended a wheat chaff medium for preparing and distributing Fusarium inoculum for field experiments.

Several field experiments were established to investigate the impact of cereal rotations on Fusarium wilt of cotton and to compare various options for managing cereal crop residues. These options included baling and removing the straw, burning the straw, cultivation to incorporate the straw into the soil as soon as possible after harvest and retaining the straw for as long as possible to allow weathering prior to cultivation and incorporation.

Methods

The three field experiments described were all established in commercial, furrow irrigated fields with cotton grown on raised beds on a one meter spacing. All ground preparation, planting and cultivation operations were performed with 8-row equipment. Inspections of previous cotton crops had shown that Fusarium wilt of cotton was well established across the chosen trial areas. A cotton-wheat-fallow-cotton rotation was standard practice for all three of the cotton growers involved. Data was analysed using a REML mixed model spatial analysis in Genstat Release 6.1.

The 'Korolea' Field Experiment near Boggabilla in New South Wales

The incidence of Fusarium wilt of cotton after wheat-fallow and barley-fallow rotations was compared to the incidence of Fusarium wilt after a long (18 months) bare fallow. The three treatments were replicated three times in plots that were 8m wide and 74m long and positioned in a section of the field where Fusarium wilt of cotton had previously been confirmed. The previous cotton crop had been harvested in March, 1998 and the wheat and barley plots were planted in May, 1998 and harvested in November, 1998. The wheat and barley residues were incorporated soon after harvest and the plots were fallowed through until cotton (var. Sicot 189) was planted across all plots in October, 1999. The incidence of Fusarium wilt was assessed in November, 1999 at six weeks after planting by counting the number of living and dying seedlings in 20m of row in each plot.

The 'Condamine Plains' Field Experiment near Pampas in Queensland

This field experiment investigated the effect of three different wheat residue management strategies on the incidence of Fusarium wilt in the subsequent cotton crop. The previous cotton crop had been harvested in April, 2003 and wheat was planted in May, 2003 and harvested in November, 2003. The wheat residues in every alternate set of 8 rows were incorporated to a depth of 15 to 20cm using a Lely power harrow 11 days after the cereal harvest. The residues in each alternate set of the remaining 8-row strips were burnt the following day. The standing cereal residues in the remaining strips were retained on the surface and left to weather. The whole field received three cultivations with a chisel plough between January and June, 2004. There were thus 10 full replications across the field with each plot being 8 rows (8m) by the length of the field (600m). Cotton (var. Sicot 14B) was planted across the entire field in October, 2004. Disease assessments were completed on 10m sections of row at 50m (row 3), 100m (row 4) and at 150m (row 5) from the tail-water end of the field. The initial plant stand was recorded 20 days after planting and the number of plants surviving to the end of the season with either no vascular discoloration or very restricted (<5%) vascular discoloration was determined immediately after harvest in May, 2005 by cutting plants off at ground level using secateurs. This enabled the calculation of disease incidence.

The 'Dunbar' Field Experiment near Pampas in Queensland

This field experiment also investigated the effect of three different wheat residue management strategies on the incidence of Fusarium wilt in the subsequent cotton crop. The previous cotton crop had been harvested in April, 2003 and wheat was planted in May, 2003 and harvested in November, 2003. However, in this field the bulk of cereal residues were baled and removed from the field two days after the cereal harvest. The remaining wheat residues in every alternate set of 8 rows were incorporated 8 days after the cereal harvest. Though difficult, the remaining residues in each alternate set of the remaining 8-row strips were burnt 7 days later. The short, standing cereal residues in the remaining strips were left to weather for several months prior to incorporation in July, 2004. There were 4 full replications across the field with each plot being 8 rows (8m) by the length of the field. Cotton (var. Sicot 80B) was planted across the entire field in October, 2004. When inspecting the experiment during the fallow period it was noted that the wheat harvester had left an obvious one-meter-wide 'trail', or windrow, of fine cereal residue (immature or light seed, stalks, awns, glumes etc) down each of the plots. Disease assessments were completed on 10m sections of row in and out of the header windrow at 100m and at 200m from the tail-water end of the field. The initial plant stand was recorded 17 days after planting and the number of plants surviving to the end of the season with either no vascular discoloration or very restricted (<5%) vascular discoloration was determined immediately after harvest in April, 2005 by cutting plants off at ground level using secateurs. This enabled the calculation of disease incidence.

Results

The results of each of the field experiments are presented in Tables 2, 3, 4 and 5. The incidence of Fusarium wilt of cotton following either a wheat or barley crop rotation was 40% higher than that in cotton after a long bare fallow

(Table 2). Either incorporating or burning wheat residues soon after harvest reduced disease incidence by 26% when compared to retaining the residues on the surface (Table 3). When the bulk of wheat residues were baled and removed from the field then there was no significant differences between incorporating or burning the remaining residues or retaining them on the surface (Table 4). Following the baling and removal of the bulk of wheat residues the incidence of Fusarium wilt was found to be 27% higher in the header windrows than in the remainder of the field (Table 5).

Table 2. The incidence of Fusarium wilt of cotton following either a long bare fallow or a cereal fallow rotation at 'Korolea' near Boggabilla in New South Wales.

Crop rotation	Disease incidence (%)
Long (18 months) bare fallow	29.9 a
Wheat-fallow rotation with wheat residues incorporated	42.4 b
Barley-fallow rotation with barley residues incorporated	41.6 b

P=0.01, values followed by the same letter are not significantly different.

Table 3. The impact of three different management strategies for wheat crop residues on the incidence of Fusarium wilt in the subsequent crop of cotton at 'Condamine Plain' near Pampas in Queensland.

Management strategy for wheat crop residues	Disease incidence (%)
Residues incorporated soon after harvest	30.49 b
Residues burnt soon after harvest	30.47 b
Residues retained on the surface and exposed to weathering	41.39 a

P<0.001, values followed by the same letter are not significantly different.

Table 4. The impact of three different management strategies for wheat crop residues on the incidence of Fusarium wilt in the subsequent crop of cotton at 'Dunbar' near Pampas in Queensland.

Management strategy for wheat crop residues	Disease incidence (%)
Straw baled then remaining residues incorporated soon after harvest	26.73
Straw baled then remaining residues burnt soon after harvest	27.95
Straw baled then remaining residues retained on the surface and exposed to weathering	27.93

P=0.095, no significant differences.

Table 5. The effect of wheat crop residues on the incidence of Fusarium wilt in the subsequent crop of cotton at 'Dunbar' near Pampas in Queensland.

Relative abundance of wheat crop residues	Disease incidence (%)
Wheat harvested - Straw baled – very low levels of wheat residue remaining	25.90
Wheat harvested - Straw baled – abundant residues in wheat harvester windrows	32.85

P=0.032

Discussion

Winter cereals such as wheat, oats and barley are the preferred rotation crops for over 80% of Australian cotton growers and cereal residues appear to have a significant impact on the epidemiology of Fusarium wilt of cotton. As mentioned previously, Smith and Snyder (1975) suggested that rotation of barley with cotton in California may have resulted in a greater increase in the population of the Fusarium wilt pathogen than that which occurred with continuous cotton. Although there was no direct comparison between continuous cotton and a cotton–wheat rotation in Australia there was a significant increase in the incidence of Fusarium wilt in the subsequent cotton crop after either a wheat or barley rotation when compared to a long bare fallow. The use of long, bare fallows is not considered to be an economic or practical option for Australian cotton growers. It is possible that the common use of winter cereal rotations with cotton has been one of the contributing factors in the rapid increase in the distribution, incidence and importance of Fusarium wilt of cotton in Australia.

Since cereal rotations are a significant factor in the epidemiology of the disease then the management of cereal residues is an important issue. These results suggest that cereal residues should be burnt, baled or incorporated into the soil as soon as possible after harvest to minimize the saprophytic build-up of the pathogen. The occurrence of

139mm rainfall within 10 days of incorporation into the soil would have contributed to a rapid breakdown of the wheat residues in the 'Condamine Plains' experiment. It is possible that incorporation into the soil might not be as effective under dry seasonal conditions.

References

Allen, S.J. 2004. Diseases – National Update. Proceedings of the 12th Australian Cotton Conference, Gold Coast, Queensland. August 2004.

Cooper, J.L. 1999. A grower survey of rotations used in the New South Wales cotton industry. Australian Journal of Experimental Agriculture 39: 743-755.

Nehl, D.B., S.J. Allen, P.A. Lonergan and G. McNamara. 2005. Cotton Pathology 2004-2005:pp92-94. *In* Variety Trial Results Book 2004-2005. Cotton Seed Distributors Ltd, Wee Waa, NSW, Australia.

Smith, S.N. and W.C. Snyder. 1975. Persistence of *Fusarium oxysporum* f.sp *vasinfectum* in fields in the absence of cotton. Phytopathology 65:190-196.

Tio, M., L.W. Burgess, P.E. Nelson and T.A. Toussoun. 1977. Techniques for the isolation, culture and preservation of the Fusaria. Australian Plant Pathology Society Newsletter 6(1): 11-15.