

COTTON RESEARCH & DEVELOPMENT
CORPORATION



FINAL REPORT

DISEASES OF COTTON

DAN 69C

1992 - 1995

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NSW AGRICULTURE

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DISEASES OF COTTON

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SUMMARY

Disease surveys in November and March of each season have been undertaken on a regular basis since 1983. The results of these surveys indicate the relative importance of those diseases which are present and provide an indication of the effects of various cultural and environmental factors on disease development. Disease surveys also present an ideal way to monitor the effects of disease control strategies as they are implemented.

Verticillium wilt is the most widespread and important disease of cotton in Australia with the potential to reduce yields by 20-25% in some fields when weather conditions are favourable. Seedling disease is always present and effective control is important so that the costs and problems associated with replanting can be avoided. Mycorrhizas have been shown to be important in the early season growth of cotton in some areas.

The purpose of these studies was to develop recommendations to growers for the more effective control of verticillium wilt and seedling diseases and to develop a better understanding of the importance of mycorrhizas so that cropping strategies to maximise early season growth of cotton seedlings can be developed.

The increasing importance of Black root rot, the recent occurrence of Fusarium wilt and the significant epidemics of alternaria leaf spot in Pima cotton have also demanded attention.

The following conclusions and recommendations have resulted from this work:

- i) Current fungicide seed treatment recommendations for cotton should be retained. There are no new fungicides which give a higher level of protection against seedling disease and there is no evidence for increasing the rate of PCNB used in cotton seed treatments in Australia to that which is used in the USA.
- ii) The use of hopper-box or in-furrow fungicides for seedling disease control is usually not advantageous but may give yield increases in some situations.

- iii) The repeated use of wilt-resistant cultivars in fields where verticillium wilt has been prevalent results in a significant decline in the incidence of the disease. The use of a resistant cultivar along with extra cultivation, trash removal and crop rotation increases the rate of decline in disease incidence.
- iv) The possibility that more virulent strains, or defoliating strains of the verticillium wilt pathogen may occur is of great concern and needs to be investigated thoroughly.
- v) Mycorrhizal fungi are capable of surviving at adequate levels for at least 17 months in the absence of a host and despite cultivation.
- vi) The use of foliar Zinc, Potassium polyphosphate and Wuxal[®] treatments did not ameliorate the stunting and slow early season growth which are symptoms of poor mycorrhizal development.
- vii) Cultivar resistance to black root rot has not been detected under conditions of high disease pressure.
- viii) With permanent beds and minimum tillage inoculum of the black root rot pathogen becomes concentrated in a band in the centre of the hill.
- ix) Baytan[®] seed treatments can provide some control of black root rot of cotton.
- x) The distribution and occurrence of fusarium wilt of cotton must be monitored.

Farming systems experiments. The CRC for Sustainable Cotton Production has established long term farming systems experiments in the Macquarie Valley, the Namoi Valley and near Dalby in Queensland. The pathology research programme at Narrabri has responsibility for monitoring mycorrhizal colonisation and the incidence of black root rot, verticillium wilt, bacterial stunt (Galathera syndrome), etc in these important long term experiments.

Student supervision and collaboration. The pathology programme at Narrabri has fostered and benefited from the involvement of the following students:

Honours	1994	Therese Honess	University of New England
PhD	1991-1995	David Nehl	University of New England
PhD	1994-1997	Emma Colson	University of Sydney
PhD	1994-1995	Emily Whitten	University of New England (Withdrawn)
PhD	1995-1998	Therese Honess	University of New England

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Dr Stephen J. Allen

Australian Cotton Research Institute, Narrabri,

Abstract

The results of disease surveys in November and March of each season are presented. These results show the relative importance of those diseases which are present and provide an indication of the effects of various cultural and environmental parameters on disease epidemiology. Disease surveys also present an ideal way to monitor the effects of disease control strategies as they are implemented.

Verticillium wilt is the most widespread and important disease of cotton in Australia with the potential to reduce yields by 20-25% in some fields when weather conditions are favourable. The repeated use of wilt-resistant cultivars in fields where verticillium wilt has been prevalent resulted in a significant decline in the incidence of the disease. The use of a resistant cultivar along with extra cultivation, trash removal and crop rotation increased the rate of decline in disease incidence. The possible occurrence of more virulent strains or defoliating strains of the verticillium wilt pathogen needs to be monitored closely.

Seedling diseases are always present and effective control is important so that the costs and problems associated with replanting can be avoided. Current fungicide seed treatment recommendations for cotton should be retained. There were no new fungicides which gave a higher level of protection against seedling disease and there was no evidence for increasing the rate of PCNB used in cotton seed treatments in Australia to that which is used in the USA. The use of hopper-box or in-furrow fungicides for seedling disease control was usually not advantageous but may give yield increases in some situations.

Slow early season growth of cotton may be caused by several factors including black root rot and poor mycorrhizal development. The results of field experiments showed that mycorrhizal fungi were capable of surviving at adequate levels for at least 17 months in the absence of a host and despite cultivation. The use of foliar Zinc, Potassium polyphosphate and Wuxal[®] treatments did not ameliorate the stunting and slow early season growth which are symptoms of poor mycorrhizal development.

Black root rot is now present in nearly all cotton growing areas of NSW. Cultivar resistance to black root rot was not detected under conditions of high disease pressure. With permanent beds and minimum tillage inoculum of the black root rot pathogen became concentrated in a band in the centre of the hill where seed for the subsequent crop was to be planted. Baytan[®] seed treatments provided some control of black root rot of cotton.

The distribution and incidence of fusarium wilt should be monitored closely.



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DISEASES OF COTTON



NSW AGRICULTURE

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A final report prepared for the Cotton Research and Development Corporation

1. Introduction

Disease surveys in November and March of each season have been undertaken on a regular basis since 1983. The results of these surveys indicate the relative importance of those diseases which are present and provide an indication of the effects of various cultural and environmental parameters on disease epidemiology. Disease surveys also present an ideal way to monitor the effects of disease control strategies as they are implemented.

Verticillium wilt is the most widespread and important disease of cotton in Australia with the potential to reduce yields by 20-25% in some fields when weather conditions are favourable. Seedling disease is always present and effective control is important so that the costs and problems associated with replanting can be avoided. The increasing importance of Black root rot and the recent occurrence of Fusarium wilt have demanded attention. Mycorrhizas have been shown to be important in the early season growth of cotton in some areas.

The purpose of these studies was to develop recommendations to growers for the more effective control of verticillium wilt and seedling diseases and to develop a better understanding of the importance of mycorrhiza so that cropping strategies to maximise early season growth of cotton seedlings can be developed.

2. Objectives

- (i) To develop and/or evaluate control strategies for verticillium wilt and seedling diseases of cotton and to develop a better understanding of those factors that slow down early season growth.
- (ii) To monitor the distribution and importance of diseases in irrigated and dryland cotton by regular disease surveys.

3. Results and Discussion

Verticillium Wilt

The results of the disease surveys (Table 1) show a significant decline in the incidence of Verticillium wilt in commercial cotton crops in the last three years. This decline coincides with an increased adoption of resistant cultivars, an increase in the use of raking and burning and a consequent decrease in the amount of crop debris retained from one season to the next. The cool, wet January and early February in 1995 were particularly favorable for infection of cotton by the Verticillium wilt pathogen

TABLE 1

	Incidence of Verticillium wilt (%) in commercial crops										
	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
McIntyre	2.6	0.5	1.3	2.3	1.9	13.2	10.7	8.5	6.9	8.0	11.5
Gwydir	2.9	2.1	0.2	3.7	0.8	4.2	1.7	5.3	0.8	0.5	1.4
Namoi	5.3	7.1	9.1	13.0	23.7	31.2	23.5	23.7	10.5	8.9	10.3
Macquarie	6.4	4.8	1.9	3.1	6.7	10.0	2.1	7.5	2.1	2.5	1.0
Bourke	-	-	-	0.0	0.4	18.3	4.5	9.1	8.1	7.7	1.1
TOTAL	4.5	3.7	4.1	5.4	9.6	16.5	10.3	12.5	5.8	4.8	5.7
Resistant cvs.	0	0	0	0	0	0	1.1%	9.4%	25.6%	42.6%	59.6%
Rake & burn	1.8	0	0	0	1.1%	7.5%	35.6%	24.0%	40.0%	40.0%	50.9%
Trash (g/m ²)	93.7	94.1	138.1	67.3	147.0	139.4	94.1	73.4	49.1	37.2	42.1

The results of the disease surveys also indicate a significant reduction in the incidence of Verticillium wilt in fields where a resistant cultivar is grown repeatedly. This effect is being substantiated in three long term (5 year), replicated trials in the Verticillium wilt nursery at the Australian Cotton Research Institute. One trial is comparing Siokra 1-4 (susceptible) and Sicala V1 or V2 (resistant) under conditions of repeated cultivation and minimum tillage with trash retained from season to season (see Figure 1). The other two trials also compare the resistant and susceptible cultivars with the addition of Integrated Pest Management (IPM) practices. The incidence of

Verticillium wilt in a susceptible cultivar grown in either a cereal fallow rotation or back-to-back with retention of trash is being compared to the incidence of the disease in a resistant cultivar grown in either a double crop rotation or back-to-back with removal of crop residues and extra cultivation. These experiments are due for completion in 1997. Preliminary results indicate that the use of IPM practices along with a resistant cultivar accelerates the reduction in the incidence of Verticillium wilt when compared to the use of a resistant cultivar alone.

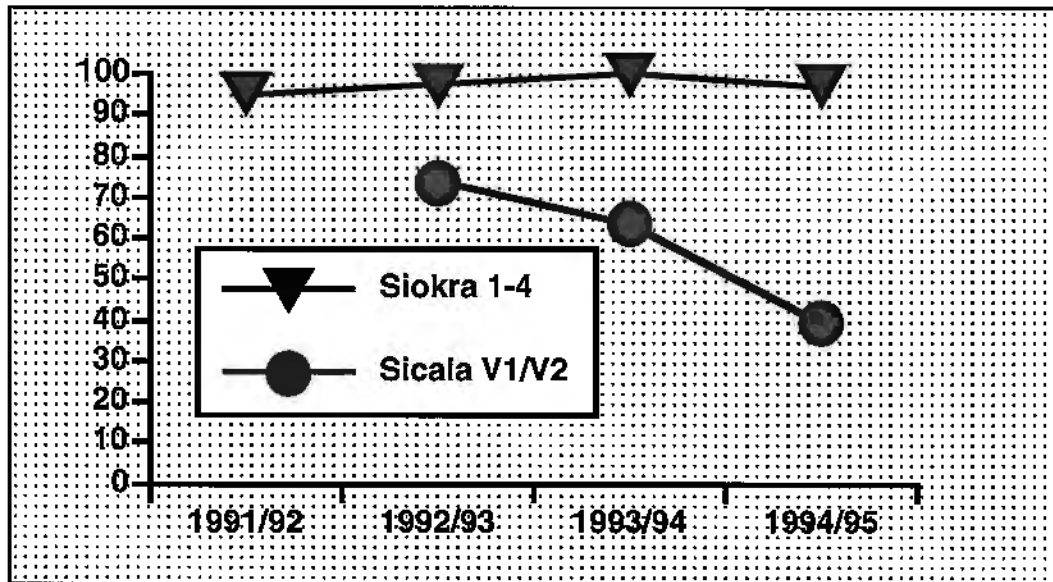


Figure 1. The incidence of Verticillium wilt (%) in plots with repeated cultivation of either a resistant (Sicala) or a susceptible (Siokra) cotton cultivar.

Isolates of the pathogen which causes Verticillium wilt have been collected from all areas of NSW and especially from fields of the resistant cultivars. These collections have been supplied to Dr Bruce Lyon at the University of Sydney who is developing techniques to characterise variation in the pathogen and determine the presence or absence of more virulent or aggressive strains.

Seedling Diseases

The importance of seedling diseases is dependent on early season weather conditions and seedling mortality in those commercial crops surveyed has varied from 20 to 40% (Table 2). Seedling mortality is derived from the seed rate used by the grower and the established stand count determined during the November disease survey. It should be noted that seedling mortality also includes seed viability and the effects of soil insect activity. The average stand achieved by growers was 10 plants per metre.

TABLE 2

	Seedling mortality			Stand count (plants/metre)		
	1992/93	1993/94	1994/95	1992/93	1993/94	1994/95
McIntyre Valley	32.4	22.3	24.6	10.87	10.61	9.29
Gwydir Valley	40.9	25.3	20.1	7.40	9.46	9.67
Namoi Valley	31.9	32.2	27.5	11.24	9.58	11.00
Macquarie Valley	32.5	32.6	24.7	10.61	10.61	12.05
MEAN	34.4	28.1	24.3	10.01	10.04	10.72

The current standard seed treatment is PCNB, metalaxyl & thiodicarb. Each year, in conjunction with Cotton Seed Distributors and Deltapine Australia, about 20 current and potential fungicide and insecticide seed treatments are evaluated at sites on the Darling Downs and at Narrabri. The rate of PCNB used in Australia is less than 60% of the rate used in the USA. Both US and Australian rates of PCNB have been evaluated in the seed treatment trials. No treatments or

rates of application have been found to be better than the current Australian standards. Detailed results have been published annually in the CSD Trial Results Handbook.

Yield benefits associated with the use of seed treatments have been investigated in early and late October sown trials each season. Treatments have included untreated seed, fungicide-treated seed and seed treated with both fungicide and insecticide. Stand counts and seed cotton yields from these experiments are presented below (Table 3). No consistent yield benefit associated with the use of fungicide seed treatments has been demonstrated.

TABLE 3

Season (time of sowing)	Stand counts (plants per metre of row)*						Seed cotton yield (Kg / hectare)			
	92/93 early	92/93 later	93/94 early	93/94 later	94/95 early	94/95 later	92/93 early	92/93 later	94/95 early	94/95 later
Untreated	5.25	6.01	9.26	11.65	12.40	10.58	5682	4949	5320	4688
PCNB Metalaxyl	7.69	7.46	9.80	13.16	13.38	12.06	6101	4955	5327	4611
PCNB Metalaxyl Triadimenol	8.09	7.44	10.89	13.37	13.18	12.63	5816	4962	5084	4889
PCNB Metalaxyl Thiodicarb	5.63	6.68	10.15	12.36	12.74	11.23	5601	4848	5014	4764
LSD (5%)	0.63	0.58	n.s.	0.75	n.s.	1.17	262.6	n.s.	n.s.	n.s.

* - Stand counts at 42 days after sowing except in 1993/94 when hail destroyed the experiment and stand counts at 21 days after sowing are presented.

The use of in-furrow and hopper-box fungicide treatments for seedling disease control have been evaluated in three completed trials at Narrabri. Two trials in the 1993/94 season were aborted as a result of extensive hail damage. Significant yield advantages from the use of extra fungicide treatments were gained in only one of the three experiments (Table 4).

TABLE 4

	Seed Cotton Yield (Kg/Ha)		
	1992/93	1994/95 (1)	1994/95 (2)
Untreated seed	5672	-	-
Treated seed (PCNB Metalaxyl)	5923	5450	4749
Treated seed + SM-9 in furrow spray	-	6087	5619
Treated seed + Rizolex in-furrow spray	5670	6233	-
Treated seed + Terraclor Super X 20-5 Hopper-box dust	5279	5863	5292
Treated seed + Terraclor Apron Hopper-box dust	-	5937	5150
Treated seed + Terraclor Super X granule	5566	6162	4927
Treated seed + Ridomil PC 11G	5419	5950	5004
Treated seed + Aliette-Rovral granule	5394	6275	5589
Treated seed + Rizolex Hopper-box dust	5699	-	-
Treated seed + P-Pickle-T	5497	-	-
LSD (5%)	258.2	n.s.	513.4

The occurrence of seedling diseases is most commonly related to environmental factors and the use of a seed treatment, hopper-box or in-furrow fungicide does not ensure increased yield over that resulting from the use of no fungicide treatment in all seasons and in all fields. However, there will be occasions when fungicide treatments will enable higher yields of seed cotton.

Slow early season growth (Mycorrhizas)

Slow early season growth may result from adverse weather conditions, nutritional factors, physical characteristics of the soil, infection by *Thielaviopsis basicola* which causes black root rot, the presence of the 'Galathera syndrome' or the poor development of mycorrhizas. The poor development of mycorrhizas may result from reduced populations of mycorrhizal fungi in the soil. Reduced populations of mycorrhizal fungi in the soil may result from either excessive cultivation or the occurrence of long periods during which suitable hosts are not present.

Three field trials were established to evaluate the effect of various winter crop-summer fallow rotations on the development of mycorrhizas, early season growth and seed cotton yield of subsequent cotton crops. Treatments included bare fallows (cultivated and uncultivated), canola (non-mycorrhizal), linseed (highly dependent on mycorrhizas), wheat and chickpea. The results (Table 5) show that the variation in early season growth and seed cotton yield could not be attributed to differences in mycorrhizal development. This indicates that mycorrhizal fungi are capable of surviving at adequate levels for at least 17 months in the absence of a host and despite cultivation. The observed differences in early season growth and seed cotton yield appear to result from other factors associated with the use of different rotation treatments.

TABLE 5

	1992/93			1993/94		1994/95§		
	VAM*	MSW#	SCY+	MSW#	SCY+	VAM*	MSW#	SCY+
Bare fallow - uncultivated	30.34	1.58	5554	1.00	5122	48.61	0.74	5802
Bare fallow - cultivated	37.91	1.60	5645	0.83	5021	40.39	0.67	5839
Wheat	35.51	1.80	5496	1.20	4178	38.07	0.74	5661
Chickpea	25.09	1.45	5436	0.97	4708	35.55	0.67	5615
Linseed	30.89	1.73	5602	0.95	4425	39.00	0.63	5375
Canola	30.47	1.32	5311	1.11	4378	35.41	0.68	5510
LSD (5%)	7.23	n.s.	241.3	0.17	242.5	n.s.	n.s.	n.s.

§ - Winter rotation crops established poorly due to insufficient water and extreme pest pressure.

* VAM - % mycorrhizal infection of cotton roots at six weeks after planting.

MSW - Mean Seedling Weight in grams (Tops only, oven dry - at six weeks after planting).

+ SCY - Seed Cotton Yield Kg/Ha

In conjunction with a PhD student (Emily Whitten) from the University of New England seven summer crops were established in November, 1994 so that the rooting profiles of the different crops could be determined and the distribution of mycorrhizal infection and location of inoculum production by mycorrhizal fungi in the soil profile could be determined. The results of this work are still to be finalised.

A site on the property 'Merinda' was identified as being mycorrhizal deficient in November, 1994. Plants in the affected area were stunted (mean tops dry weight = 0.6g) with only 3% of the roots colonised by mycorrhizal fungi while nearby unaffected plants were much larger (mean tops dry weight = 3.6g) and 59% of the roots colonised by mycorrhizal fungi. Foliar Zinc, Potassium polyphosphate and Wuxal® treatments were applied with the co-operation of Mr Mark Hickman in an attempt to compensate for the deficiency in mycorrhizal colonisation. None of the foliar treatments improved cotton growth and one treatment was very phytotoxic.

Black root rot

The results of disease surveys have indicated that black root rot caused by *Thielaviopsis basicola* is much more widely distributed than at first thought and it appears that the disease is present in most cotton growing areas of NSW. Whole fields or large areas of fields of cotton affected by the disease have been seen at Warren, Trangie, Wee Waa and Narrabri while odd plants or small patches of affected plants have been recorded near Mungindi, Moree, Baan Baa and Burren Junction.

Field experiments were established on the property 'Merinda' near Wee Waa to (i) determine the efficacy of seed treatment fungicides, (ii) compare the resistance/susceptibility of current commercial cultivars and some cultivars from California and Texas, and (iii) evaluate cultural control methods. The population of *T. basicola* spores within the soil in the infected fields at 'Merinda' was estimated using fresh carrots as a medium (from four sites within the trial area, early in the season):

Centre of bed	120 to 200 spores / gram of soil
10cm from centre of bed	25 to 70 spores / gram of soil
30cm from centre of bed	70 to 130 spores / gram of soil

Cotton seedling root infection by *T. basicola* was assessed on a 0 - 4 scale as follows:-

0 = no disease

1 = up to 25% of tap root blackened

2 = 26 to 50% of tap root blackened

3 = 51 to 75% of tap root blackened + a few lateral roots blackened

4 = 76 to 100% of tap root blackened + few or no lateral roots remaining

(After Tabachnik et al, 1979)

Seed treatment and in-furrow fungicides. Baytan® (triadimenol) and Kodiak® (*Bacillus subtilis*) are recommended for the control of black root rot in the USA. Raxil® (tebuconazole) was recommended by Bayer as a fungicide which could be effective. Results of the field experiments at 'Merinda' indicate that Baytan® can sometimes give effective control of the disease (Tables 6, 7, 8).

Disease pressure was high in all plots and no treatments have given consistent satisfactory control of the black root rot pathogen. Overseas reports suggest that only 50 to 100 spores per gram of soil are sufficient to give maximum disease severity. These studies have shown that there may be between 120 and 200 spores per gram of soil in the centre of the bed at the 'Merinda' site.

TABLE 6 - 1992/93

	Mean Black root rot score	Tops dry weight (g/plant)
Treated seed (TAS)	3.8	1.34
TAS + Baytan (1.5ml/kg)	4.0	1.33
TAS + Baytan (3.0ml/kg)	3.5	1.38
TAS + Raxil (2.0ml/kg)	3.9	1.49
TAS + Baytan HB(1.5g/kg)	3.9	1.49
TAS + Baytan HB(2.5g/kg)	1.8	1.45
LSD (5%)	--	n.s.

TABLE 7 - 1993/94

	Mean Black root rot score	Plant stand (plants /m)	Tops dry weight (g/plant)
Treated seed (TAS)	2.95	5.97	0.250
TAS + Baytan (1.5ml/kg)	3.38	8.15	0.375
TAS + Baytan (2.0ml/kg)	3.16	7.42	0.368
TAS + Baytan (3.0ml/kg)	2.97	6.98	0.318
TAS + Raxil (2.0ml/kg)	2.99	6.84	0.275
TAS + Raxil (3.0ml/kg)	3.08	6.84	0.272
LSD (5%)	n.s.	1.21	0.058

TABLE 8 - 1994/95

	Mean Black root rot score	Tops dry weight (g/plant)	Seed cotton yield (kg/ha)
Untreated	3.77	0.26	3,996
TAS + Baytan (1.5ml/kg)	3.72	0.26	4,003
TAS + Baytan (3.0ml/kg)	3.53	0.26	4,002
TAS + Kodiak (0.33g/kg)	3.72	0.27	3,912

No significant differences

Cultivar resistance or susceptibility. Five commercial cultivars were evaluated in an experiment taken through to harvest during the 1994/95 season (Table 9). Despite heavy disease pressure and similar levels of disease on those cultivars tested - Sicala V2 and CS 189+ yielded significantly better than the other three cultivars. As noted previously disease pressure was high in all plots.

TABLE 9

	Black root rot	Seed cot. yld. Kg/ha	Gin out-turn	Lint yld Kg/ha
Sicala V2	3.78	3,843	41.8	1,606
CS 189+	3.72	3,698	39.9	1,476
Siokra L23	3.67	2,931	40.7	1,193
CS 8S	3.67	2,646	40.5	1,072
Siokra 1-4	3.79	2,563	41.4	1,061

A further selection of 18 cultivars which included lines from California and from the Multi-Adversity Resistance breeding programme at College Station, Texas were also evaluated in the field in the 1994/95 season. The mean black root rot score for all cultivars varied between 3.8 and 4.0 with no significant differences. Under conditions of high disease pressure there appears to be no resistance to the disease in the material evaluated.

Cultural control. The abundance of pathogen inoculum in the centre of the hill was noted. With permanent bed systems this concentrated band of inoculum is not disturbed and subsequent plantings result in seed being placed in the area where inoculum levels are highest. Overseas studies have shown that the incorporation of a 'hairy vetch' green manure crop significantly reduces the amount of pathogen inoculum in the soil. A field experiment was established at 'Merinda' during the 1994/95 season to compare the incidence and severity of black root rot in - a) permanent beds with minimum tillage, b) middle-busted beds and c) beds into which a 'hairy vetch' green manure crop has been incorporated. The dry conditions and unavailability of water for irrigation made it difficult to establish the 'hairy vetch' green manure crop early enough and prepare the other tillage treatments properly. Consequently, the seedbed was quite rough and establishment difficult. This experiment is to be repeated in the future when seasonal conditions are more favourable.

Alternaria leaf spot

Alternaria leaf spot has become increasingly prevalent in recent years and was found in almost all of the commercial crops inspected during disease surveys in March, 1995. The severity of the disease was generally less than 0.1% (percentage leaf area infected) although disease severity was found to exceed 4% in three of the fields inspected. Pima cotton (*Gossypium barbadense*) is more susceptible to the disease than are cultivars of *Gossypium hirsutum*. The disease was prevalent in crops of Pima at Bourke in both the 1993/94 season when it caused premature defoliation, and in the 1994/95 season.

Alternaria leaf spot is a major problem in Pima cotton in Israel where the fungicide Folicur® (tebuconazole) is used post-flowering when there is more than one spot per 10 metres of row. A permit was obtained for the use of Folicur® on Pima cotton at Bourke and a large scale experiment was established with co-operation from Jason Fritsch and Perry Brown of Darling Farms to test the efficacy of either one or two applications of this fungicide against Alternaria leaf spot under Australian conditions. The results (Table 10) suggest a positive benefit from the use of the fungicide and further experiments are planned.

TABLE 10	Disease severity (%)#	Lint yield (kg/ha)
Untreated	19.1	1710.8
Folicur® (one application)	3.3	1727.6
Folicur® (two applications)	1.1	1750.1

Percentage leaf area infected

Fusarium wilt

Fusarium wilt was first reported by Dr J. K. Kochman from cotton crops on the Darling Downs of Queensland in 1993. The disease was reported for the first time in NSW in December, 1994 in a crop of 'organic' cotton near Boggabilla. Intensive examination of the affected field indicated that the disease had been present for some time. All cotton fields on all farms in the vicinity were inspected and found to be free of the disease. An outbreak of the disease near Mungindi was detected in January, 1995. Collaborative work with staff of the Queensland DPI, CSIRO and the University of Queensland has been established and brochures to assist in the identification of the disease have been produced.

Other diseases

Several other diseases were noted during disease surveys of commercial crops. Bacterial blight has occurred at low levels in the susceptible Deltapine cultivars. The severity of this disease and the occurrence of Phytophthora boll rot have been increased by the wet January-February conditions experienced in many production areas during 1994 and 1995. Sclerotinia boll rot of cotton was observed in a commercial crop near Boggabilla in March, 1995. No plant parasitic nematodes were detected in March, 1993 when soil samples were collected from ten fields with a long history of cotton cultivation.

4. Discussion with Reference to Objectives and Other Work

All of the objectives of the project have been addressed and the results have been communicated to the industry. The major difficulties encountered were related to the weather conditions in recent seasons. A severe hail storm destroyed several experiments in November, 1993 and the drought conditions with limited water availability have made the establishment of winter rotation crops and off-station trials very difficult.

The results of long term experiments evaluating strategies for reducing the incidence of verticillium wilt have been encouraging and these experiments need to be continued until 1997 at least. Preliminary results from Dr Bruce Lyon suggest the possible presence of more virulent and defoliating strains of the pathogen. These findings may have a substantial impact on strategies for the control of verticillium wilt in the future. Continued close collaboration with Dr Lyon is essential.

The original objectives did not include specific reference to black root rot. However, the increasing prevalence of this disease and recognition that it was a significant cause of slow early season growth in some areas warranted further investigation. Similarly, the occurrence of fusarium wilt in NSW and the impact of alternaria leaf spot on Pima cotton at Bourke were not anticipated in the project objectives. It was important that some efforts should be directed at these disease situations.

In the process of completing the project several mutually beneficial, collaborative links have been established and/or continued. ie.

CODE	Title	Location	Researcher
DAN 100C	Detection, Distribution and Control of Early Season Growth Disorder of Cotton.	Narrabri	D.B. Nehl
DAQ60C	Survey of Cotton Diseases in Qld.	Toowoomba	J. K. Kochman
DAQ61C	Control of Premature Senescence of Cotton by Potassium Nutrition Management.	Emerald	G. Harden
DAQ68C	Characterisation of the Fusarium Wilt Pathogen in Australia and Cotton Disease Survey in Queensland. (replacing DAQ60C)	Toowoomba	J. K. Kochman
US 17C	Induced Resistance to Cotton Diseases as Part of Integrated Pest and Disease Management.	Sydney Narrabri	B. J. Deverall E. Colson
US 8C	Verticillium Wilt of Cotton: Genetic Fingerprinting of Fungal Pathogens and Wilt Tolerant Cotton Cultivars.	Sydney	B. Lyon D. Multani
US21C	Identification of VA Mycorrhizae	Sydney	P. A. McGee
CSP52C	Genetic Manipulation of Natural Plant Defences for the Control of Verticillium Wilt Disease of Cotton.	Canberra	H. McFadden
CSP70C	Breeding Improved Cotton Varieties.	Narrabri	G. A. Constable
UN1C	Microbial Degradation of Cotton Fibre: a Joint Project.	Sydney Narrabri	M. Pailthorpe S. J. Allen
UNE7C	Influence of Vesicular-Arbuscular Mycorrhizas on Growth, Development and Yield of Cotton.	Armidale Narrabri	J. F. Brown D. B. Nehl
UNE 26C	Black root rot of cotton.	Armidale	T. Honess J.F. Brown
CRC 2.5.1	Marker Techniques to Identify Verticillium Wilt Tolerant Cotton Genotypes.	Sydney	B. Lyon
CRC 2.5.2	Maximising Mycorrhizal Infection in Cotton.	Armidale Narrabri	J. F. Brown E. Whitten
CRC SYS	Farming Systems Experiments	Warren, Merali Nth & Warra	Numerous
CSD	Using Glucose Oxidase to Control Verticillium Wilt in Cotton.	Canberra	Fiona Murray
CRC TPP	Characterising Fusarium oxysporum from cotton.	Indooroopilly	S. Bentley/ Bob Davis

5. Conclusions, Recommendations and Application to Industry

- i) Current fungicide seed treatment recommendations for cotton should be retained. There are no new fungicides which give a higher level of protection against seedling disease and there is no evidence for increasing the rate of PCNB used in cotton seed treatments in Australia to that which is used in the USA.
- ii) The use of hopper-box or in-furrow fungicides for seedling disease control is usually not advantageous but may give yield increases in some situations.
- iii) The repeated use of wilt-resistant cultivars in fields where verticillium wilt has been prevalent results in a significant decline in the incidence of the disease. The use of a resistant cultivar along with extra cultivation, trash removal and crop rotation increases the rate of decline in disease incidence.
- iv) The possible occurrence of more virulent strains or defoliating strains of the verticillium wilt pathogen needs to be monitored closely.
- v) Mycorrhizal fungi are capable of surviving at adequate levels for at least 17 months in the absence of a host and despite cultivation.
- vi) The use of foliar Zinc, Potassium polyphosphate and Wuxal[®] treatments did not ameliorate the symptoms of poor mycorrhizal development.
- vii) Cultivar resistance to black root rot has not been detected under conditions of high disease pressure.
- viii) With permanent beds and minimum tillage inoculum of the black root rot pathogen becomes concentrated in a band in the centre of the hill.
- ix) Baytan[®] seed treatments can provide some control of black root rot of cotton.
- x) Applications of Folicur[®] can reduce the incidence of alternaria leaf spot in Pima cotton.
- xi) The distribution and occurrence of fusarium wilt of cotton must be monitored.

6. Communication of Results

Contributions to Journals

- Allen, S. J. and Young, A. M. (1993) *Coprinus cinereus* associated with a cotton module rot. *The Mycologist*. 7(2):73-74, British Mycological Society.
- Allen, S. J. (1995) Plant quarantine and diseases of cotton. *Australasian Plant Pathology* 24(1):70-73 (Invited paper).
- Allen, S. J. (1995) The effects of various cultural practices on the epidemiology of verticillium wilt of cotton in New South Wales. *Phytoparasitica* 23(1): 51-52
- Allen, S. J. (1995) Cotton Research & Development Funded Research into Verticillium wilt of cotton in Australia. *Phytoparasitica* 23(1): 71-72
- Nehl, D. B., Allen, S. J. and Brown, J. F. (1995) Mycorrhizal colonisation, root browning, pathogens and soil properties associated with a growth disorder of cotton in Australia. *Plant and Soil (In Press)*

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- Allen, S. J. (1992) Verticillium wilt. *Proceedings of the sixth Australian Cotton Conference*, Broadbeach, Qld. pp185-190 (Invited paper).
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- Allen, S. J. (1993) Bacterial blight of cotton in Australia - A brief review. *Proceedings of UNE's Fourth Graduate Seminar in Plant Pathology and Mycology, 1993* .pp1-3.
- Nehl, D. B., Allen, S. J. and Brown, J. F. (1994) Microbial suppression of plant growth and mycorrhizal development in cotton grown in heavy clay soils. *Proceedings of World Cotton Research Conference - I*. Brisbane, Australia p 96.
- Pattison, A. B., Allen, S. J. and McLeod, R. W. (1994) Nematodes in cotton in New South Wales. *Proceedings of World Cotton Research Conference - I*. Brisbane, Australia p 167.
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- Allen, S. J. (1994) Disease management - An overview. *Proceedings of the seventh Australian Cotton Conference*, Broadbeach, Qld. pp247-252 (Invited paper).
- Honess, T. M., Allen, S. J. and Brown, J. F. (1994) Black root rot : An Australian perspective. *Proceedings of the seventh Australian Cotton Conference*, Broadbeach, Qld. pp271-278.
- Nehl, D. B., Brown, J. F. and Allen, S. J. (1994) Mycorrhizas and early season growth disorder : The lazy cotton plant gets into trouble. *Proceedings of the seventh Australian Cotton Conference*, Broadbeach, Qld. pp247-252 (Invited paper).
- Allen, S. J. (1994) The rise and fall of Verticillium wilt of cotton in Australia. *Proceedings of UNE's Fifth Graduate Seminar in Plant Pathology, 1994* .pp61-65.
- Allen, S. J. (1994) Biological components of the soil. *Proceedings of Cotton Soils Co-ordination Meeting*, December 1994 - Australian Cotton Research Institute, Narrabri.
- Allen, S. J. (1994) Soil-borne plant diseases. *Proceedings of Cotton Soils Co-ordination Meeting*, December 1994 - Australian Cotton Research Institute, Narrabri.
- Whitten, E. J., Allen, S. J. and Brown, J. F. (1995) The spatial distribution of arbuscular mycorrhizal fungi under field crops. 10th Biennial Australasian Plant Pathology Conference, Lincoln University, New Zealand.

Other Publications

- Allen, S. J., Constable, G. A., Nehl, D. B. and McGee, P. (1992) Mycorrhizas, early season cotton growth & the Galathera syndrome. *The Australian Cotton Grower* 13(1): 16-18.
- Allen, S. J. (1992) Cotton Pathology. *Cotton Seed Distributors 1992 Trial Results*, pp 35-36
- Allen, S. J. and Pattison, A. B. (1993) Cotton Pathology. *Cotton Seed Distributors 1993 Trial Results*, p 48
- Allen, S. J. (1994) Cotton Pathology. *Cotton Seed Distributors 1994 Trial Results*,
- Honess, T. M., Allen, S. J. and Brown, J. F. (1994) Black root rot : An Australian perspective. *The Australian Cotton Grower* 15(5): 44-46.
- Kochman, J. K., Allen, S. J. and Davis, R. (1995) Fusarium wilt of cotton. Cotton Seed Distributors Ltd.

Grower meetings, Presentations to consultants, Field days , Farm walks

- * Presentations to growers at the 1992 and 1994 ACGRA conferences.
- * Two presentations to meetings of Cotton Consultants Australia.
- * A presentation on Fusarium wilt to the McIntyre Growers Association.
- * Talks to grower groups from Emerald, St George and Goondiwindi during visits to ACRI.
- * Participation in CSD variety tour in 1993 and 1995 with presentations at Emerald (1), Theodore (1), St George (1), Dalby (1), Goondiwindi (1), Mungindi (2), Moree (2), Warren (2), Narrabri (1), Wee Waa (1) and Gunnedah (1).
- * Presentations at field days and on farm walks - Goondiwindi (4), Gwydir (2), Namoi (1), Upper Namoi (2), Warren (2) and Bourke (1).

7. Special Considerations

CoVert. The Cotton Research and Development Corporation established a committee in May, 1992 to co-ordinate those research projects which included work on aspects of Verticillium wilt and foster collaboration between the researchers involved. This committee (CoVert) has met on a regular basis. Progress reports from each of the projects concerned have been circulated to each member of the committee. A member of the committee attended the Sixth International Verticillium Symposium in Israel in June, 1994 and abstracts of all papers delivered at that meeting were also circulated. As a result many members of the group are now receiving an International Newsletter (Verticillium Views) and it is recommended that funds should be provided to enable a 'CoVert' representative to attend the next International Verticillium Symposium in Greece in 1997.

Fusarium wilt was first reported in Australia in 1993. Fusarium wilt is a soil-borne vascular wilt disease as is verticillium wilt and it is suggested that those researchers involved in fusarium wilt research be invited to join the 'CoVert' group. An appropriate time for future annual meetings would be in May at the conclusion of the growing and field trial season.

Farming systems experiments. The CRC for Sustainable Cotton Production has established long term farming systems experiments in the Macquarie Valley, the Namoi Valley and near Dalby in Queensland. The pathology research programme at Narrabri has responsibility for monitoring mycorrhizal colonisation and the incidence of black root rot, verticillium wilt, bacterial stunt (Galathera syndrome), etc in these important long term experiments.

Student supervision and collaboration. The pathology programme at Narrabri has fostered, and benefited from the involvement of the following students:

Honours	1994	Therese Honess	University of New England
PhD	1991-1995	David Nehl	University of New England
PhD	1994-1997	Emma Colson	University of Sydney
PhD	1994-1995	Emily Whitten	University of New England (Withdrawn)
PhD	1995-1998	Therese Honess	University of New England

Fusarium wilt. This disease is regarded as a major disease in many cotton growing areas of the world. Fusarium wilt has the potential to become a significant constraint to cotton production in Australia. It is important that the distribution, incidence and severity of the disease is monitored and strategies for controlling the disease and minimising its impact are developed as quickly as possible.