DAN 26L DISEASES OF COTTON - FINAL REPORT

CONTENTS

1. DISEASE SURVEYS

INTRODUCTION

Commercial cotton (*Gossypium hirsutum* L.) fields in the McIntyre, Gwydir, Namoi and Macquarie valleys of New South Wales were inspected in November and March each season. Commercial fields in the Bourke area were also inspected during March surveys. The incidence and/or severity of the diseases present were recorded for each crop as well as information on cultivar, planting time, growth stage, cropping history, cultural practices and method of irrigation. The amount of cotton debris from previous cotton crops that was present on the soil surface was also estimated during the November survey. The purpose of these surveys was to determine the distribution and relative importance of the various diseases of cotton that occur in New South Wales and to collect field data on various aspects of the epidemiology of these diseases.

Disease assessments were generally based on a step point method using 25 to 50 metres between samples depending on the size of the field. Care was taken to avoid sampling in areas of the crop adjacent to the head ditch or tail drain. The growth stage of the crop was recorded according to the key presented in Chiarappa (1971).

November surveys.

Debris from previous cotton crops was sampled using a quadrat ($0.1 m^2$) that was thrown 10 times. The debris collected from within the quadrat was oven dried before weighing. The incidence of bacterial blight of seedlings (for the susceptible cultivar Deltapine 90) was estimated by inspecting 20 samples, each of 10 plants. It is difficult to assess the incidence of seedling diseases which occur as seed rots and pre and post-emergent damping-off. The viability of the seed and the activity of insects in the soil also have an effect on the final plant stand. An estimate of the combined effects of all these factors in 21 commercial fields in the 1987/88 season and 83 fields in the 1988/89 season was derived from the sowing rate (supplied by the grower) and the final plant stand which was determined by counting the number of plants per metre of row at 20 sites in each field.

March surveys.

The incidence of Verticillium wilt (*Verticillium dahliae* Kleb) was estimated using 20 samples, each of 10 plants. Each plant was inspected by actually splitting the stem to check for the characteristic discoloration caused by *V. dahliae*. The incidence of boll rots and boll blight was estimated by inspecting 20 samples, each of 10 bolls. Soil samples were collected in March 1988 and March 1989 from fields which had a long history of cotton cultivation so that the population of nematodes could be assessed. Ten sub samples (0-15cm) were taken from between cotton plants and bulked for each field. Samples were kept under refrigeration and sent to the nematologist, Mr. R. McLeod at the Biological and Chemical Research Institute at Rydalmere in Sydney for the extraction and identification of nematodes. Cultivar trials organised by Cotton Seed Distributors Ltd of Wee Waa were also inspected during March of each season.

(i) Bacterial blight

The incidence and severity of bacterial blight in recent seasons has been one of the major factors in the declining popularity of the susceptible cultivar "Deltapine 90". The success of efforts by Cotton Seed Distributors Ltd to reduce levels of seed infestation are indicated in Table 1. The incidence of bacterial blight on seedlings in November has declined dramatically and this has been reflected in recent seasons by lower levels of blight on bolls prior to harvest (Table 2).

Table 1. The incidence of bacterial blight on cotton seedlings in commercial crops in New South Wales growing areas in November 1986, 1987, and 1988*.

	Percentage of seedlings with blight symptoms		
Valley/area	November 1986	November 1987	November 1988
McIntyre	35.4 (10)	2.25 (9)	0.3 (5)
Gwydir	8.75 (12)	4.4 (10)	0.1 (5)
Namoi	25.25 (8)	5.38 (4)	0.31 (8)
Macquarie	3.67 (11)	0.5 (6)	0.08 (6)
MEAN	17.11 (41)	2.67 (29)	0.21(24)

*number in brackets after each value indicates the number of crops surveyed.

Table 2. The incidence of bacterial blight on bolls in commercial cotton crops in New South Wales in March 1987, 1988, 1989*.

	Boll blight (%)		
Valley/area	March 1987	March 1988	March 1989
McIntyre	19.44 (9)	23.38 (4)	3.5 (5)
Gwydir	19.61 (9)	36.43 (7)	5.67 (6)
Namoi	28.81 (8)	28.75 (4)	5.5 (8)
Macquarie	13.27 (11)	5.0 (7)	6.64 (8)
Bourke	---	8.87 (9)	21.2 (5)
MEAN	19.68 (37)	18.66 (31)	7.96(32)

*number in brackets after each value indicates the number of crops surveyed.

(ii) **Verticillium wilt**

Verticillium wilt was favoured by environmental conditions in the 1987/88 and 1988/89 seasons especially in the Namoi Valley (Table 3). It would appear that the incidence of this disease in the area between Narrabri and Merah North in the Namoi Valley has increased significantly over the last five seasons (Table 4). A similar increase in the incidence of verticillium wilt was observed in a drip irrigated field at Merah North that was sown to repeated cotton crops over four seasons (Table 5).

Table 3. The incidence (%) of verticillium wilt of cotton in commercial fields in NSW production areas.

	Season				
Valley/area	1984/85	1985/86	1986/87	1987/88	1988/89
McIntyre	2.6	0.5	1.4	2.2	1.8
Gwydir	1.9	2.3	0.2	3.7	0.8
Namoi	4.7	5.4	9.6	13.0	23.7
Macquarie	5.6	0.7	2.0	2.9	6.3
Bourke	0.0	0.0	0.0	0.4	0.4
No. of crops inspected	46	50	64	92	95

Table 4. The incidence of verticillium wilt in cotton crops in the Namoi Valley between Narrabri and Merah North as estimated during surveys in March 1985, 1986, 1987, 1988 and 1989.*

Season	Mean incidence of Verticillium wilt
1984-85	8.3% (7)
1985-86	9.0% (7)
1986-87	15.0% (11)
1987-88	24.5% (11)
1988-89	45.4% (13)

*number in brackets indicates the number of crops inspected.

Table 5. The incidence of verticillium wilt in subsequent cotton crops under drip irrigation in a field at Merah North (Kerribee field 18).

Season	% verticillium wilt
1984-85	1.5%
1985-86	15.0%
1986-87	24.0%
1987-88	46.0%

A review of data collected over five years of disease surveys indicates the positive relationship between repeated cotton cultivation and the incidence of verticillium wilt if data from the Namoi Valley are excluded (Table 6). The data also suggest that rotations being used in the Namoi Valley are having little effect on the incidence of the disease. This may be due to inadequate control of alternative weed hosts during the cereal and fallow stages of the rotation. No clear relationship between the amount of debris from a previous cotton crop and incidence of verticillium wilt has been observed (Figure 1). Gin trash from modules harvested from severely infested fields has provided a rich source of inoculum for a verticillium nursery at the Research Station.

Commercial cotton cultivars growing in Cotton Seed Distributors Ltd cultivar trials (11 trials over 3 seasons) were inspected to determine the relative resistance/susceptibility to verticillium wilt. The results (Table 7) are inconclusive because of the large variability within each trial site (see Table 8).

Table 6. The effect of cotton cropping history on the mean incidence of verticillium wilt in NSW production areas.#

	Mean incidence of verticillium wilt	
Cotton cropping history	excluding Namoi Valley	Namoi Valley only
fourth year cotton	2.77% (30) *	18.1% (11)
third year cotton	2.52% (17)	18.12% (4)
second year cotton	1.65% (44)	18.08% (25)
cotton rotation	1.09% (13)	22.18% (14)
no cotton in previous 3 years	0.28% (16)	2.47% (10)

* number in brackets indicates the number of crops inspected.

based on March surveys over four season.

Table 7. A comparison of the incidence of verticillium wilt (%) in commercial cotton cultivars at various sites throughout N.S.W. production areas based on assessments of Cotton Seed Distributors Ltd. cultivar trials in March of each season.

		commercial cultivars					
season	location	Dpl90	Siokra1-1	Siokra1-2	Siokra1-4	Sicala3-1	Sicala3-2
86/87	Moree	1.0	2.0	-	-	1.0	-
86/87	Narrabri	28.0	36.0	-	-	45.0	-
87/88	Moree	0	-	<1	-	0	-
87/88	Narrabri	1.25	-	2.75	-	1.75	-
87/88	Merah N.	4.2	-	10.0	-	7.8	-
87/88	Breeza	0	-	0.5	-	0.5	-
87/88	Warren	28.7	25.5	30.7	27.5	34.2	29.7
88/89	Boggabilla	36.2	-	-	22.5	-	13.0
88/89	Narrabri	60.7	-	85.7	75.7	-	87.3
88/89	Breeza	14.0	-	-	25.3	-	13.3
88/89	Warren	17.8	-	-	19.0	-	19.5

Table 8. The incidence of verticillium wilt (%) on commercial cultivars in Cotton Seed Distributors Ltd. cultivar trials at Warren and Boggabilla.

		rep.1	rep.2	rep.3	rep.4	mean
Warren 9/3/89	Siokra 1-4	8	41	20	7	19.0
	Sicala 3-2	2	53	22	1	19.5
	Deltapine90	16	11	43	1	17.8
	83203-510	54	19	2	3	19.5
Boggabilla 1/3/89	Siokra 1-4	30	9	39	12	22.5
	Sicala 3-2	9	16	26	1	13.0
	Deltapine90	17	69	8	51	36.2
	83203-189	11	4	5	82	25.5

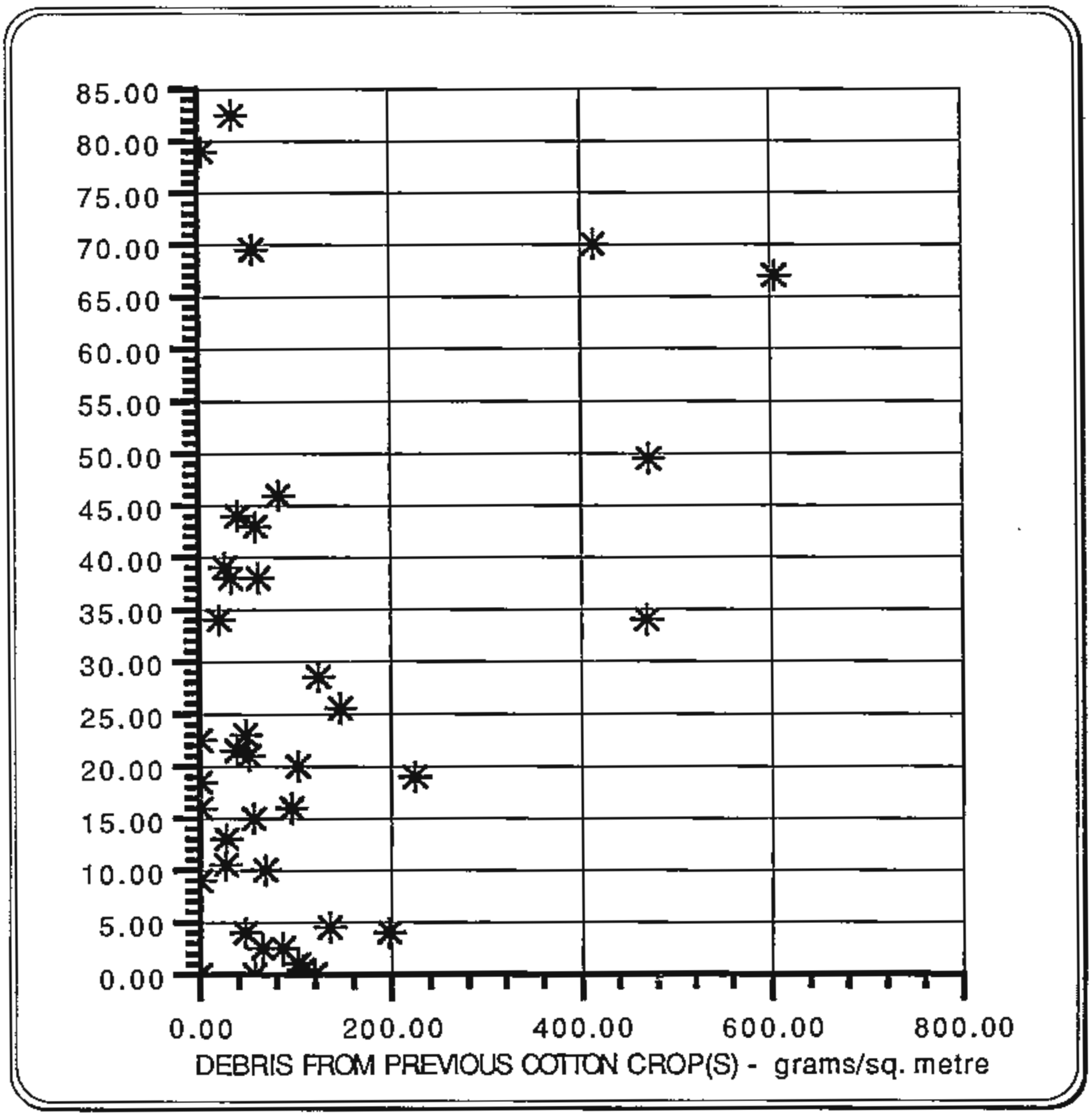

Figure 1. The relationship between the incidence of verticillium wilt (%) and debris from the previous cotton crop(s) based on inspection of crops between Narrabri and Merah North during the 1985/86, 1986/87, 1987/88 and 1988/89 seasons.

(iii) Seedling diseases

It has been difficult to separate the potential causes of seed and seedling mortality during disease surveys. For this reason estimates are based on the difference between the number of seeds planted per metre and the number of surviving plants per metre at the time of the survey (November each season). Seedling mortality therefore includes factors such as seed viability, seedling diseases, insect activity and herbicide effects. The results (Table 9) indicate direct losses in seed and do not estimate the costs of replanting, low or irregular plant stands and damaged root systems on surviving plants.

In the 1988/89 season seedling mortality was greatest in the Macquarie and Namoi Valleys; Siokra and Sicala were more affected than Deltapine 90 and there was no apparent difference in mortality between conventional tillage and permanent bed systems (Table 10). Many of the areas where Siokra and Sicala are planted are typically cooler and therefore more prone to seedling diseases whereas Deltapine 90 is typically grown in the warmer areas that are more conducive to seedling growth.

Table 9. Cotton seed/seedling mortality in commercial crops in NSW production areas (November surveys).

Season	No. of fields inspected	Mortality (%) *
1987/88	21	49.5
1988/89	83	37.1

*Number of plants/metre established as a percentage of number of seeds/metre sown.

Table 10. Cotton seedling mortality in commercial crops in NSW production areas in the 1988/89 season.

	Seedling mortality (%) *	No. of fields
Location		
McIntyre	32.7	16
Gwydir	33.3	21
Namoi	39.8	30
Macquarie	41.2	16
Cultivar		
DP90	31.7	23
Siokra 1-4	41.0	32
Sicala 3-2	41.8	16
Tillage System		
Conventional	37.9	18
Permanent beds	36.2	21

*Number of plants/metre established as a percentage of number of seeds/metre sown.

(iv) Phytophthora boll rot

Phytophthora boll rot occurs when crops are exposed to heavy rainfall in late February and March. The disease was relatively common in the 1987/88 season (Table 11). Low fruiting branches, low plant populations and lodging of maturing plants favour the disease. the incidence of the disease was lowest on crops of the cultivar Deltapine 90 which has an erect habit and fruits close to the stem (Table 12). Phytophthora boll rot was most severe in two fields of Sicala and one field of Siokra where plant populations were particularly low (< 5 plants/metre). The mean incidence of phytophthora boll rot in these three fields was 8.3 percent.

Table 11. The incidence of phytophthora boll rot in commercial cotton crops in NSW during 1988. *

	No. of fields inspected	No. of fields where disease was present	Range	Mean incidence when present
McIntyre Valley	14	11 (79%)	0.1-2.5%	1.2
Gwydir Valley	19	8 (42%)	0.1-5%	1.1
Namoi Valley	24	9 (37%)	0.1-3%	1.8
Macquarie Valley	19	12 (63%)	0.1-2.5%	1.0
Bourke area	9	0	---	---

*fields with a plant stand < 5 plants/metre were omitted.

Table 12. The incidence of phytophthora boll rot on current commercial cultivars in commercial crops and in Cotton Seed Distributors Ltd (CSD) cultivar trials. *

	Phytophthora boll rot (%)	
	from March 1988 disease survey of commercial crops	from CSD cultivar trials
Deltapine 90	0.9	0.3
Siokra	1.4	1.3
Sicala	1.1	1.3

*Replicated trials at Boggabilla, Breeza, Moree, Narrabri and Warren.
Commercial fields with a plant stand < 5 plants/metre were omitted.

(v) Black root rot

Pale, unthrifty cotton plants featuring a cylindrical black layer of diseased tissue in the swollen crown region of the stem and stunted cotton seedlings with blackened root systems were collected from commercial crops in north-western New South Wales. These symptoms were similar to those ascribed to *Thielaviopsis basicola* on cotton in the U.S.A. Attempts to isolate the causal agent using standard media failed because of contamination. A method using fresh carrot segments was successfully used to isolate *T. basicola* from diseased plant material. This constitutes the first record of *T. basicola* on cotton in Australia. Black root rot caused by *T. basicola* has recently been described as a serious threat to cotton production in California in the U.S.A.

Note: In November and December 1989 this disease was detected on a second property in the Namoi Valley and on a property near Dalby in Queensland. Soybean is also a host for the causal agent however black root rot of soybean has not yet been observed in Australia.

(vi) Nematodes

Overseas literature suggests that "nematodes are a problem wherever cotton is grown". Plant parasitic nematodes were not detected in irrigated cotton soils in March 1988 and March 1989 (Tables 13 and 14). If nematodes were present it would be expected that populations would be at a maximum at the end of the growing season when samples were taken.

(vii) Alternaria leaf spot

This disease was recorded for the first time in commercial cotton fields in New South Wales. It was observed on the lower leaves of cotton growing in the Maules Creek area east of Narrabri in February 1988 and in March 1988 caused premature defoliation of fields near Moree and Boomi.

Alternaria leaf spot has caused considerable concern to growers in some Queensland cotton growing areas. In response to this concern Queensland Cotton funded a visit to Emerald to evaluate the situation. A significant relationship between crop nutrition and the incidence of the disease was observed. Crops on the poorer Downs soils and crops affected by premature senescence were particularly susceptible to the disease when periods of wet weather were experienced. The disease was not a problem in crops on alluvial soils. As a result of this visit a new project proposal was submitted to the Cotton Research Council to support an investigation into the problem in Queensland.

Table 13. A survey of nematodes present in irrigated cotton fields throughout New South Wales in March 1988. *

Location		nematodes/500 g soil			
		non-parasitic nematodes including *Aphelenchus avenae*	non-parasitic nematodes - *Rhabditis* spp.	stunt nematodes	root lesion nematodes
Alcheringa	Boggabilla	---	30	---	---
Telleraga	W. of Moree	1400	---	---	---
Benwerrin	Croppa Creek	1700	---	---	---
Colly Farms	Collarenebri	---	780	---	---
Nbri ARS	Narrabri	3000	---	3	---
Drayton	Breeza	---	70	---	---
Auscott	Warren	660	---	---	---
Byron	Narromine	700	---	---	---
Letoka	Bourke	1400	---	---	1

*Extraction, counting and identification by Mr. R.W. McLeod, BCRI.

Table 14. A survey of nematodes present in irrigated cotton fields throughout New South Wales in March 1989. *

Location		nematodes/500g soil			
		non plant nematodes	*Aphelenchus avenae*	root lesion nematode	stunt nematode
Top Box	Garah	900	25	---	---
Midkin	Moree	1600	---	---	---
Red Mill	Moree	800	---	---	---
Auscott	Narrabri	1600	---	---	---
Drayton	Breeza	650	10	20	10
Beloka	Wee Waa	800	20	---	---
Burratippi	Trangie	3200	160	60	---

*Extraction, counting and identification by Mr. R.W. McLeod, BCRI

(viii) **Premature senescence**

In recent seasons a condition now referred to as premature senescence has been observed in many commercial crops. The growing point of affected plants ceases growth and top leaves turn red/purple followed by marginal necrosis and in some cases death of top leaves. Lower, shaded leaves remain unaffected and green. Inspection of Cotton Seed Distributors Ltd cultivar trials has shown that some cultivars are more prone than others (eg N74-720-199B). The condition has been widespread although severe occurrences have been noted in association with a blocked drip line (Maules Creek), a nil nitrogen strip (Boomi) and waterlogged areas in a new field (Warren).

U.S. researchers have suggested some similarities between premature senescence and the Californian "Potassium deficiency syndrome" which is thought to be induced by an isolate of the verticillium wilt pathogen. Attempts to isolate any pathogen from plants affected by premature senescence have failed.

A comparison of the tissue analyses of affected and healthy plants from the same field in a crop at Emerald (Table 15) shows that plants with premature senescence had lower levels of several elements including phosphorus, zinc and potassium. Premature senescence may result from the withdrawal of these elements from the growing point of the plant and translocation to the developing bolls. This possible explanation is in agreement with work by researchers in India and Mississippi.

Table 15. A comparison of the tissue analyses of healthy plants and plants affected by premature senescence in a field at Emerald in March, 1989.

	healthy plants	affected plants	difference
Sulphur %	1.398	1.236	- 12%
Phosphorus %	0.527	0.317	- 40%
Zinc ppm	30.040	24.630	- 18%
Iron ppm	63.896	73.752	+ 15%
Manganese ppm	50.960	52.384	+ 3%
Magnesium %	1.035	1.048	+ 1%
Calcium %	3.892	3.809	- 2%
Copper ppm	10.132	9.520	- 6%
Potassium %	0.967	0.486	- 49%

2. SEED SCHEME TO REDUCE BLIGHT INFESTATION OF PLANTING SEED

INTRODUCTION

In response to yield losses caused by severe epidemics of bacterial blight (*Xanthomonas campestris* pv. *malvacearum* (Smith) Dye) and evidence that infested seed was a major factor contributing to the occurrence of severe epidemics, the cotton seed industry undertook a programme "to reduce the level of blight in planting seed to less than 0.03% within five years". This programme includes:-

(i) the isolation of nurseries from infested crops and the application of copper hydroxide to nurseries early in the season.

(ii) a relocation of pure seed production to the drier western cotton production areas.

(iii) an assessment of the incidence of bacterial blight on bolls and the use of this as one of the criteria for accepting or rejecting pure seed crops.

(iv) "cleaning" of gins by extended processing of the blight immune cultivars prior to processing pure seed cotton of the susceptible cultivar.

The success of these practices is being monitored by testing seed lots for contamination by the pathogen.

The cotton industry in Australia is also concerned that new, more virulent races of the blight pathogen now present in parts of Africa and the U.S.A. are not introduced into Australia. Consequently efforts have been made in conjunction with Cotton Seed Distributors Ltd of Wee Waa and the Australian Cotton Foundation to prevent the accidental introduction of blight via seed lots in quarantine and uncleaned second-hand machinery from overseas.

(i) Seed Assays

Infected seed has been shown to be a major factor contributing to the occurrence of severe epidemics of bacterial blight of cotton. Samples of planting seed are obtained by accumulating load samples or batch samples at the Cotton Seed Distributors Ltd delinting plant and seed testing laboratory near Wee Waa. One hundred seeds are planted into each seedling tray which contains a 1:1 mixture of sand and peat moss or peanut shell. Six thousand seedlings in 60 trays are tested simultaneously in a section of a glasshouse which is maintained at 30 to 35°C. Following emergence the seedlings are exposed to 15 minutes of misting each hour between 9.00 am and 2.00 pm each day and for 15 minutes at 6.00 pm. The misting sprays (11 litres/hour) are mounted on the side of each bench and are directed upwards to minimize secondary spread. Seedlings are assessed for the presence or absence of bacterial blight symptoms on cotyledons at 14 to 16 days after planting.

Between 18,000 and 30,000 seeds have been tested each year. The results of these tests (Table 16) show a significant reduction in the level of bacterial blight infestation of planting seed. These results have been further reflected in the declining incidence of blight in seedlings in commercial cotton crops (Table 1).

Table 16. Bacterial blight infestation of Deltapine planting seed.

season	blight infested seed (%)
1984/85	3.30
1985/86	12.00
1986/87	2.10
1987/88	0.95
1988/89	0.25

(ii) Assessment of bacterial blight in pure seed crops.

The incidence of bacterial blight on bolls in pure seed crops was assessed as part of the pathology programme at Narrabri Agricultural Research Station for the 1984/85, 1985/86 and 1986/87 seasons. The "transfer" of the Technical Officer (Miss Karyl-Lee West) from the pathology programme at the Research Station to the pure seed programme with Cotton Seed Distributors Ltd at Wee Waa was accompanied by the transfer of this function and responsibility.

The results of these assessments have been used as a basis for accepting or rejecting pure seed crops (Table 17).

Table 17. The incidence (%) of bacterial blight on bolls in Cotton Seed Distributors Ltd pure seed crops of the cultivar Deltapine 90. (1987/88 and 1988/89 results - *personal communication*, K-L West; CSD).

	1986/87	1987/88	1988/89
no. of pure seed crops	12	14	18
mean incidence (%) of blight on bolls	29.5	7.3	3.4
(range)	(16 - 41%)	0 - 36%	0 - 30%
no. of crops rejected because of blight	12	4	3

(iii) Spraying CSD Nurseries with Kocide

Field experiments at Narrabri Agricultural Research Station showed that applications of Kocide (copper hydroxide) were effective in reducing infection of cotton by the blight pathogen. Consequently blight susceptible lines in Cotton Seed Distributors Ltd nurseries are subjected to several ground-rig applications of Kocide early in the season using equipment from N.S.W. Agriculture & Fisheries as part of the pathology programme.

(iv) **Bactericide in picker water**

Experiments at Narrabri showed that blight infestation of seed is greatly increased during the picking and ginning process and attempts to disinfect gin saw blades were shown to be ineffective (Final Report DAN 8L - 1986). The use of the bactericide "Busan" (TCMTB) as a preharvest spray and in picker water was evaluated in the 1986/87 season. This treatment allowed the seed cotton to carry the bactericide throughout the picking and ginning process and thereby also apply bactericide to processing equipment. Unfortunately the trial was exposed to very wet conditions before treatment and harvest which allowed seed to become infested prior to treatment. Similarly the very wet, delayed harvests of the 1987/88 and 1988/89 seasons have prevented the repeat of this trial. The results of the initial trial, though not significant, indicated some positive effects of the treatment (Table 18).

Table 18. The effect of "Busan" treatments at harvest on bacterial blight infestation of planting seed.

Treatment	bacterial infestation *
1 untreated	3.6
2 Busan - preharvest spray - 1 ml/litre	1.5
3 Busan - preharvest spray - 10ml/litre	1.3
4 Busan in picker water	2.6
5 Busan - preharvest - 1 ml/litre and in picker water	1.6
6 Busan - preharvest - 10ml/litre and in picker water	2.8

* x 10^8 cfu/100 seeds after incubation.

(v) **Reducing blight infestation by seed storage**

Experiments in the U.S.A. showed a decline in the level of blight infestation of seed with time when seed was stored in the laboratory. A similar experiment was conducted at Narrabri comparing fuzzy and delinted seed stored in a field shed for 2 years and delinted seed stored in a laboratory (Table 19). The level of seed infestation declined rapidly in the first 6 months particularly in delinted seed samples. Seed stored fuzzy maintained the highest levels of seed infestation.

Table 20. The survival of bacterial blight within cotton seed under different storage conditions.

	blight infestation of seed (%)		
storage environment	laboratory 20-25^{o}C constant	field shed 5-40^{o}C variable	
seed condition	delinted	delinted	fuzzy *
July 1987	3.5	3.5	3.5
Sept I987	1.1	1.1	0.9
Dec 1987	0.6	0.7	1.5
Mar 1988	0.8	0.8	1.3
July 1988	0.2	0.6	1.8
Dec 1988	0.7	1.2	2.9
Feb 1989	0.9	0.6	2.3
June 1989	0.5	0.7	0.4

*Fuzzy seed was delinted immediately prior to testing.

(vi) **Seed entry through quarantine**

The cotton industry became concerned that quarantine procedures were not sufficient to prevent introduction of new races of the blight pathogen. There was considerable circumstantial evidence of symptomless epiphytic passage of blight through quarantine on introduced cotton lines. Normal glasshouse conditions are unsuitable for infection and symptom development and the presence of the blight pathogen remains undetected if suitable environmental conditions are not provided.

After considerable consultation between Cotton Seed Distributors Ltd, Plant Quarantine and Plant Pathologists the quarantine conditions for cotton introductions were changed to include:

(a) intermittent misting of seedlings during the first 3 - 4 weeks of growth.

(b) two applications of copper hydroxide to control epiphytic populations on resistant hosts.

Since the introduction of these procedures, problems have occurred on two occasions. In Brisbane it was decided to apply copper hydroxide on a regular, frequent schedule which resulted in copper toxicity to seedlings. In Sydney difficulties were encountered because of very cool conditions combined with frequent misting of seedlings. The provision of adequate (25^{o}C+) temperatures solved the problem.

(NOTE - see Appendix I -The Quarantine Review Committee - Bacterial Blight of Cotton in Australia).

(vii) **Contamination of second-hand machinery being imported into Australia from overseas**

There are considerable economic advantages in purchasing second-hand machinery overseas. Consequently there is a significant flow of such equipment into Australia. Second-hand agricultural machinery is subject to quarantine inspection on arrival in Australia. This inspection is for the detection of soil and plant materials. There are no mandatory treatments required.

Specialized second-hand machinery for the cotton industry in Australia usually originates from the U.S.A. and may be delivered on farm in Australia within 4-6 weeks of purchase. During 1987 and 1988 these imports included a bale press from Texas, two lint cleaners from California, at least 8 cotton strippers from Texas and in excess of 20 spindle pickers from various states in the U.S.A.

On site/farm inspections of the bale press, lint cleaners, three spindle pickers and one cotton stripper yielded significant levels of soil and plant material contamination. A thirty minute inspection of a spindle picker produced over 370 grams of cotton debris and soil including unopened and partly opened bolls, boll walls, sticks (up to 25 cm long), lint and leaf material.

The nature and origins of the material detected constitute a threat to the cotton industry in Australia. Potential pest and disease introductions include pink bollworm, boll weevil, fusarium wilt, severe strains of verticillium wilt and new races of bacterial blight. The use of a selective medium (ethanol streptomycin agar) allowed the isolation of *Verticillium* sp. and *Fusarium* sp. from sticks found on one of the spindle pickers.

Implications

The presence of soil and/or plant material on second-hand machinery constitutes a weak link in the effectiveness of quarantine attempts to prevent the introduction of exotic pests and pathogens into Australia. This weakness potentially impacts on a range of agricultural crops throughout Australia and does not only involve the cotton industry.

Those involved in bringing second-hand machinery into Australia should ensure thorough cleaning of such equipment prior to importation. The inspection of this machinery by quarantine officers also needs to be thorough. The efficacy and feasibility of fumigation could be considered.

3. BACTERIAL BLIGHT RACE IDENTIFICATION

ACCEPTED FOR PUBLICATION

The Predominance of Race 18 of ***Xanthomonas campestris pv. malvacearum*** on cotton in Australia

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ABSTRACT
Allen, S.J.and West, K-L.D. (1989) The predominance of race 18 of *Xanthomonas campestris pv. malvacearum* on cotton in Australia. Plant Disease:

Isolates of *Xanthomonas campestris pv. malvacearum* were collected from commercial cotton crops growing in all major cotton production areas of New South Wales during each of the growing seasons between 1983 and 1988. Isolates from production areas of Queensland were obtained during the 1984-1985 season. All 67 collections were tested on the ten standard differential cotton cultivars in a growth chamber and all were found to be race 18. Races 1,2,3,4,5,7,9 and 10 of the blight pathogen which had been recorded on cotton in Australia prior to 1980 were not detected in this study. The predominance of race 18 has been associated with severe epidemics of bacterial blight on susceptible cotton cultivars in recent seasons and consequently the wide acceptance of new cultivars with resistance to race 18 of *X. campestris pv. malvacearum.*

Bacterial blight of cotton *(Gossypium hirsutum* L.) caused by *Xanthomonas campestris pv. malvacearum* (Smith) Dye has caused significant losses to growers in Australia (2,3,6). The incidence and severity of bacterial blight on the Deltapine cultivars has been a major factor in the reduction of the area sown to susceptible cultivars from 100 per cent of the total cotton area in 1984 to 28 per cent in 1988. Locally developed blight resistant cultivars are now widely accepted.

X. c. pv. *malvacearum* was first recorded in Australia in 1923 (10). Brinkerhoff (5) tested thirteen isolates of the blight pathogen that had been collected from cotton plants growing in New South Wales in 1964 and found that all isolates were race 1. Subsequent studies (1,7) showed that race 1 was the only race detected in Australia prior to 1974 with only one exception (1). According to A.C. Hayward *(personal communication)* race 18 was detected on seedlings of cv. Deltapine smooth leaf in quarantine at Kununurra in Western Australia in 1966. Races 2,3,4,5,7,9,10 and 18 were reported to be present in Australia between 1974 and 1983.

Race 18 was first recorded on commercial cotton in Australia in 1974 in Queensland where 9 out of 16 collections were found to be race 18 (1,7). These studies also showed that 12 out of 16 collections from New South Wales during 1974 to 1977 were race 18 and 5 of the 14 collections from New South Wales and Queensland between 1979 and 1983 were found to be race 18 (1,7).

Hussain and Brinkerhoff (9) reported that race 18 was first identified in Pakistan in 1977. In 1984 Hussain (8) reported that race 18 was dominant in Pakistan. He found that 75.7 per cent of isolates tested were race 18 and race 18 was present at 90.9 per cent of the localities from which samples were collected.The objective of this study was to determine the relative abundance of the various races of the bacterial blight pathogen on cotton in Australia.

MATERIALS AND METHODS

Leaves infected by *X.c.* pv. *malvacearum* were collected from commercial cotton crops and dried in a plant press prior to storage at 20-25C. Samples were collected from all cotton production areas of New South Wales during each of the growing seasons between 1983 and 1988. Isolates from cotton production areas in Queensland were collected during the 1984-1985 season by Dr Melda C. Moffett of the Queensland Department of Primary Industries and were provided as pure cultures on yeast extract agar slants in McArtney bottles. Single cell cultures were derived from each collection and grown on sucrose peptone agar at 30C prior to inoculation of the ten differential cultivars described by Bird (4).

The differential cultivars were grown in a sand, peat moss (1:1) mixture in 10 cm plastic pots with four seedlings in each pot. Four cotyledons of each cultivar (one cotyledon on each seedling) were scratch inoculated using a turbid bacterial suspension with fine sterile sand added to aid abrasion. Inoculated seedlings were incubated in a growth chamber at 30C, 12 hr day and 20C, 12 hr night. After 10 days the differential host reactions were assessed as either resistant or susceptible.

A reference culture of race 1 of *X. c.* pv. *malvacearum* was also tested as a check of the differential cultivars.

RESULTS AND DISCUSSION

All 67 collections of the blight pathogen were found to be race 18 and none of the other races previously recorded in New South Wales and Queensland were detected in this study. A single cell isolate of the reference culture produced reactions on the differential cultivars that were consistent with race 1 of the pathogen.

All cotton seed for planting in Australia is produced under the supervision of one grower controlled company called Cotton Seed Distributors Ltd and is stored, acid-delinted, treated and despatched from one facility in north-western New South Wales. Prior to 1985 precautions to reduce levels of seed infestation by *X c.* pv.

malvacearum in commercial cotton planting seed were not considered necessary. It was shown (2,3) that the use of planting seed infested with *X. c.* pv. *malvacearum* was a major factor contributing to severe epidemics of bacterial blight of cotton in Australia. In 1985 Cotton Seed Distributors Ltd developed an objective to reduce the level of blight infestation in planting seed to less than 0.03 per cent within five years.

The complete dominance of race 18 of *X c* pv. *malvacearum* over other races in Australia has resulted from the aggressiveness of this race of the pathogen and the efficient dispersal of this race provided by a single source of infested seed for the entire industry in Australia.

ACKNOWLEDGEMENTS

We are grateful to Dr Melda C. Moffett for providing collections of the blight pathogen from Queensland and to the Australian Cotton Research Council for financially supporting this study.

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4. ESTABLISHMENT OF A VERTICILLIUM NURSERY

Attempts to use replicated trials in commercial fields to compare the resistance or susceptibility of various cotton lines and cultivars to infection by *Verticillium* sp. have been unsuccessful because of variability (See Table 8). The incidence of verticillium wilt in cotton fields adjacent to gin waste dumps was found to be very high (80%+).

A verticillium nursery was established at the Narrabri Agricultural Research Station using gin waste from modules picked from fields which had a high incidence of verticillium wilt. The disease has been further encouraged by:

(a) over fertilizing
(b) late planting
(c) frequent irrigation
(d) the use of a low plant stand

During the 1988/89 season the nursery was planted with alternating rows of the three current cultivars Siokra, Sicala and Deltapine 90 and the development of verticillium wilt was monitored throughout the season (Table 21).

Table 21. The incidence of verticillium wilt in current commercial cultivars growing in the verticillium nursery in the 1988/89 season

		Incidence of verticillium wilt (%)		
		Deltapine 90	Siokra	Sicala
January	1989	17.4	20.1	20.3
February	1989	71.1	77.7	74.7
April	1989	92.6	95.5	93.8

The verticillium nursery is to be extended and CSIRO cotton breeders are planning to use the site for genotype selection and or evaluation. Experiments to evaluate raking and burning, biocontrol treatments and rotation options are also planned for this site.

(ii) **CSD seed treatment trial 1988/89**

Objective: To evaluate current and potential seed treatments for seedling disease control in co-operation with the staff of Cotton Seed Distributors Ltd.

Method: 30 treatments x 10 replicates; Nearest neighbour design; planted 30/9/88 with cone seeder; 100 seeds per 10m plot; stand assessed 20/10/88 and 11/11/88; vigour assessed 21/10/88, 28/10/88 and 4/11/88.

Results: See Table 23.

Conclusions: No fungicides were significantly better than Terraclor; there was no advantage from the addition of apron; all insecticides significantly improved stand - especially promet; all insecticides significantly improved seedling vigour - especially semevin.

Table 23. A comparison of current and potential seed treatments for the control of seedling diseases of cotton (1988/89).

	stand (plant/plot)		vigour*	
days after sowing	20	42	21	35
fungicides				
untreated	75.0	69.3	8.0	98.
terraclor	79.0	70.8	7.8	98.3
rizolex	75.7	69.6	8.2	98.1
rypyth	80.4	71.6	8.1	99.6
GLC 668	72.9	66.7	7.5	99.2
beret	73.9	68.4	8.1	101.5
fungicide alone	72.9	66.5	5.4	85.8
fungicide + apron	72.2	66.5	5.1	82.1
fungicide + apron + orthene	76.4	70.3	9.3	107.9
fungicide + apron + semevin	78.2	70.7	11.5	119.1
fungicide + apron + promet	81.0	73.0	8.5	101.2

* based on true leaf production and expansion.

(iii) Seed treatment evaluation of moncerin and euparen

Objective: To evaluate "Moncerin" and "Moncerin combi" (= moncerin +euparen) for control of seedling diseases of cotton.
Method: 4 treatments x 8 replicates; Nearest neighbour design; planted 30/9/88 with cone seeder; 100 seeds/plot; watered on 4/10/88 and 31/10/88; assessed 20/10/88 and 14/11/88 (ie 20 and 45 days after sowing).
Results: See Table 24.
Conclusion: Moncerin combi was not significantly better than the current seed treatment Terraclor-apron.

Table 24. A comparison of Terraclor-apron with Moncerin and Moncerin combi for the control of seedling diseases of cotton.

	Number of plants/plot	
	20 days after sowing	45 days after sowing
Terraclor-apron	80.1	71.6
Moncerin combi	78.6	71.0
Moncerin	72.5	66.9
Untreated	64.4	59.1

(iv) In furrow fungicide granules for seedling disease control

Objective: To evaluate Ridomil PC11G as an in-furrow fungicide treatment for the control of seedling diseases in cotton.
Method: 1987/88 - one row of a 4 row Kinze planter was fitted with a herbicide/insecticide box, drop tube and band diffuser to apply 110gm product/100 metres of row; 24 rows in field 6 at Auscott, Narrabri and 24 rows in field 18 at Narrabri Agricultural Research Station.
1988/89 - replicated trial planted with cone seeder; 100 seed + 11.5g Ridomil PC11G per 10 metre plot at two sites. One site was well prepared with high beds and watered prior to planting and the second site was prepared late with low beds and watered after planting. Plant stand was assessed at 20 and 42 days after sowing.
Results: 1987/88 - no apparent differences between treated and untreated rows at either site. 1988/89 - See Table 25.
Conclusion: In-furrow fungicide granules had no effect on stand establishment when mixed with covering soil in the 1987/88 trial, but increased stand when placed with the seed in the furrow in the 1988/89 trial. In furrow fungicide granules were most effective when used under "poor" planting conditions which included low beds and watering after planting.

Table 25. The efficacy of in-furrow fungicide granules for control of seedling diseases of cotton.

	good conditions# (surviving plants/plot)		"poor" conditions* (surviving plants/plot)	
Days after sowing	20	42	20	42
untreated	64.25	60.6	60.3	52.0
Ridomil PC11G	68.3	63.9	66.1	59.1
difference	+ 6.4%	+ 5.4%	+ 9.6%	+ 13.6%

#good conditions - high beds, watered prior to planting
*"poor" conditions - low beds, watered after planting

(v) Natural spread of bacterial blight of seedlings

Objective: To monitor the natural spread of bacterial blight of seedlings under field conditions.
Methods: 10 plots each 3 rows x 2 metres; the cotyledons on a single plant in the middle of the centre row were inoculated with blight 28/10/87; individual plants in each plot were checked for blight symptoms on 11/11/87, 26/11/87 and 14/12/87 (row direction :north - south).
Results: See Table 26.
Conclusions: Rainfall which occurred on 6-7/11/87, 11-12/11/87, 21/11/87 and 1-2/12/87 effectively dispersed the blight pathogen within the row and across rows.

Table 26. The natural spread of bacterial blight on seedlings under field conditions.

	% of seedlings with blight symptoms			
days after inoculation	row on east side	centre row	row on west side	total
14 (11/11/87)	0	0 *	0	0
29 (26/11/87)	6.1	54.6	6.1	22.6
47 (14/12/87)	76.0	87.2	43.4	72.0

*symptoms on inoculated plant only

(vi) The effect of boll maturity on bacterial blight development

Objective: To investigate the effect of boll maturity on the susceptibility of cotton bolls to infection by the bacterial blight pathogen.
Method: Cotton flowers were tagged on 7/1/87, 22/1/87 and 3/2/87. In the field experiment bolls were harvested on 23/3/87 and disease incidence determined. In the greenhouse experiment all tagged bolls were inoculated by pin prick (dipped in a blight suspension) on 20/2/87 and assessed on 3/3/87.
Results: See Tables 27 and 28.
Conclusion: The susceptibility of cotton bolls decreases with increasing maturity.

Table 27. The effect of boll maturity on the natural occurrence of bacterial blight on cotton bolls under field conditions.

Flowering date	7/1/87	22/1/87	3/2/87
% infection (23/3/87)	23.6%	50.6%	25.5%

Table 28. The effect of boll maturity on the development of lesions of bacterial blight on cotton bolls under greenhouse conditions.

Age of boll at time of inoculation (days after flowering)	44	29	17
incidence of blight (%)*	33.5	84.4	89.7
mean lesion diameter (mm) *	0.97	1.86	3.03

*11 days after inoculation

(vii) Bactericides for blight control (1986/87)

Objective: To evaluate Kocide (copper hydroxide), Kocide plus an antibiotic (Agrimycin) and potassium nitrate as foliar sprays for the control of bacterial blight on cotton.
Methods: 4 treatments x 6 replicates; each plot 4 rows x 12m; cultivar Deltapine 90; planted 13/10/86; spray applications 14/11/86, 12/12/86, 8/1/87; assessments 18/12/86, 2/2/87.
Results: See Table 29.
Conclusions: Potassium nitrate does not have curative and protective activity against bacterial blight on cotton under Australian conditions; the addition of an antibiotic did not improve the efficacy of Kocide.

NOTE 1: This experiment was in response to claims by visiting South African cotton specialists that potassium nitrate applications eradicated and/or completely controlled bacterial blight.

NOTE 2: This experiment was repeated in 1987/88 with similar results.

Table 29. The effect of foliar sprays on the severity of bacterial blight on cotton.

	% leaf area infected with blight	
	Assess.1 18/12/86	Assess.2 2/2/87
Untreated	0.37	1.51
Kocide (1.5g/l)	0.15	1.30
Kocide + Agrimycin (1.5 + 0.6g/l)	0.23	1.57
Potassium nitrate (35g/l)	0.27	1.51

(viii) Verticillium wilt - crop loss assessment (1986/87)

Objective: To estimate the effect of verticillium wilt of cotton on yield quantity and quality.
Methods: 3 replicates; 2 cultivars -(Siokra and Deltapine 90); 3 times of inoculation -(late December, late January and late February); 8 levels of disease incidence -(0, 1, 2, 5, 10, 20, 60 and 100% of plants inoculated by syringe at the base of the stem); Nearest neighbour design; plots 4 rows x 10 metres.
Results: See Table 30.
Conclusion: Yield of cotton is most severely affected by verticillium wilt when infection occurs mid season. When 100% of plants were inoculated in late January the yield of Deltapine 90 was reduced by 14.4% and the yield of Siokra was reduced by 13.8%.

Table 30. The effect of verticillium wilt of cotton on yield of Siokra and Deltapine 90 in the 1986/87 season.

Level of infection (%) Time of inoculation		0 -	100 late Dec	100 late Jan	100 late Feb
Deltapine 90	plot yield (kg)	3.69	3.53	3.16	3.89
Siokra	plot yield (kg)	4.05	3.73	3.49	3.80
	micronaire	4.66	4.55	4.45	4.44

(ix) **Verticillium wilt - crop loss assessment (1987/88)**

Objective: To estimate the effect of verticillium wilt of cotton on yield quantity and quality.
Methods: 3 replicates; 2 cultivars -(Siokra and Deltapine 90); 3 times of inoculation -(late December, late January and late February); 8 levels of disease incidence -(0, 1, 2, 5, 10, 20, 60 and 100% of plants inoculated by syringe at the base of the stem); Nearest neighbour design; plots 4 rows x 10 metres.
Results: See Table 31.
Conclusion: Yield of cotton is most severely affected by verticillium wilt when infection occurs mid season. When 50% of plants were inoculated in late January the yields of Deltapine 90 and Siokra were reduced by 13.2% and 13.1% respectively. When 100% of plants were inoculated in late January the yield of Deltapine 90 and Siokra were reduced by 19.4% and 34% respectively.

Table 31. The effect of verticillium wilt of cotton on yield of Siokra and Deltapine 90 in the 1987/88 season.

Level of infection (%) Time of inoculation		0 -	100 late Dec	100 late Jan	100 late Feb
Deltapine 90	lint yield/plot (Kg)	2.22	2.08	1.79	2.22
	micronaire	3.94	3.96	3.98	4.07
Siokra	lint yield/plot (Kg)	2.12	1.93	1.40	2.11
	micronaire	3.61	3.64	3.05	3.61

(x) **Alternaria leaf spot**

Objective: To compare the reaction of current commercial cultivars to alternaria leaf spot of cotton.
Methods: Pot experiment in glasshouse; 6 replicates (pots) of each of 4 cultivars - Pima, Sicala 3-2, Siokra 1-4 and Deltapine 90; 4 plants per pot; inoculated with a spore suspension of *Alternaria macrospora* and incubated in glasshouse bay with humidifiers. Mean lesion size and number of lesions/leaf determined at assessment.
Results: See Figures 3 and 4.
Conclusions: Deltapine 90, Siokra and Sicala are similar in their reaction to alternaria leaf spot and all are more resistant to the disease than the cultivar Pima. Resistance was expressed mainly as a reduction in the number of lesions per leaf.

NOTE 1. This method of comparing the reaction of cultivars to alternaria leaf spot follows the method of research workers in Arizona.

NOTE 2. An attempt to compare the reaction of cultivars to alternaria leaf spot under field conditions at Narrabri failed despite use of overhead sprinklers, interspersed rows of Pima and artificial inoculation. The cultivar Pima was extensively defoliated by bacterial blight.

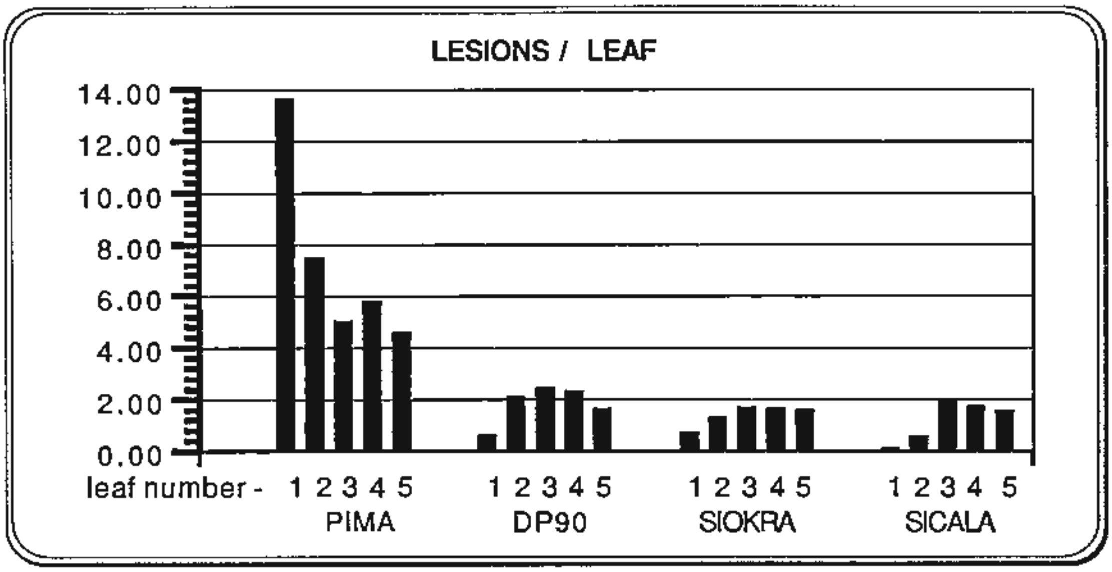

Figure 2. The reaction of several cotton cultivars to infection by alternaria leaf spot as indicated by the number of lesions per leaf. (leaves were numbered from the base of the plant)

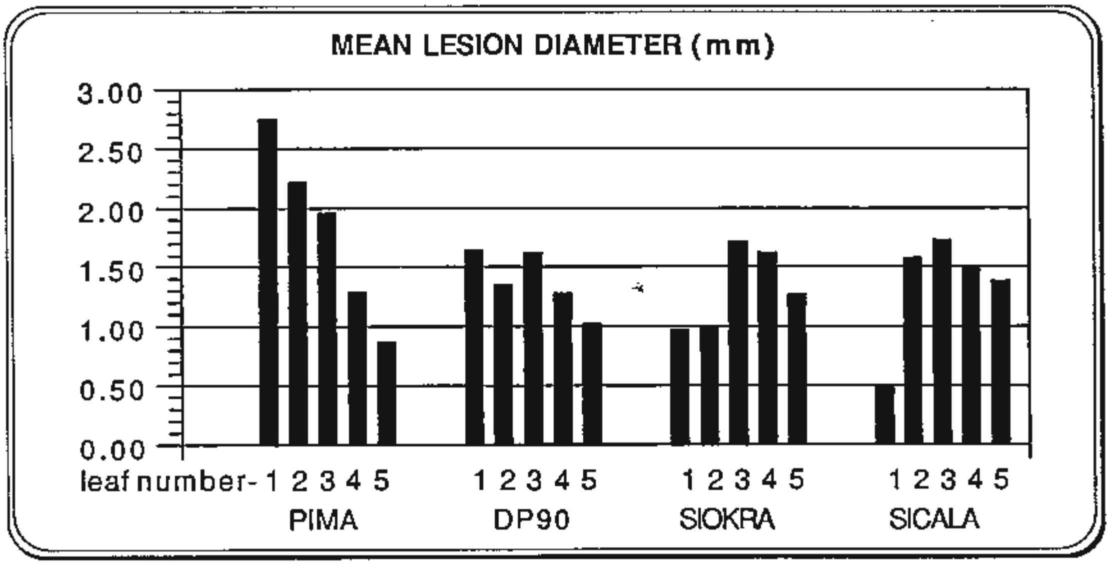

Figure 3. The reaction of several cotton cultivars to infection by alternaria leaf spot as indicated by mean lesion diameter (mm). (leaves were numbered from the base of the plant)

APPENDIX I

THE QUARANTINE REVIEW COMMITTEE

BACTERIAL BLIGHT OF COTTON IN AUSTRALIA
(causal agent: *Xanthomonas campestris* pv. *malvacearum)*

SUMMARY

1.Bacterial blight of cotton has caused total losses to growers in excess of $40 million over the last four seasons. The pathogen is seed borne and may survive on plants as an epiphyte causing no visible symptoms.

2.Cotton seed introductions are presently made through quarantine stations at Canberra, Sydney and Brisbane under glasshouse conditions which are unsuitable for blight symptom development.

3.There is some circumstantial evidence of symptomless epiphytic passage of the blight pathogen through quarantine.

4.The Australian cotton industry has moved significantly to the growing of blight resistant cultivars and in the near future will be largely dependent on these resistant cultivars.

5.New races of the blight pathogen now in Africa and the U.S. are virulent on cultivars with a similar type of resistance to that present in the Australian cultivars. There is also a a new race of the pathogen present in South America.

6.The cotton industry is concerned that current quarantine procedures may not be sufficient to prevent introduction of these new races of the blight pathogen. The presence of the pathogen remains undetected if suitable conditions are not provided for symptom development. The industry would like to have cotton seed introductions confined to a single quarantine station and exposed to temperature and moisture conditions which would expose the pathogen if present.

1. Bacterial blight of cotton has caused total losses to growers in excess of $40 million over the last four seasons. The pathogen is seed borne and may survive on plants as an epiphyte causing no visible symptoms.

* Epidemics of bacterial blight in N.S.W. have been monitored during the last four seasons (Table 1).On the basis of these results the estimated loss to growers in NSW alone is in excess of $40 million. Significant losses have also been occurring in Queensland.

Table 1 Incidence of bacterial blight of cotton bolls (%) in commercial fields in NSW production areas over the last four seasons.#

season	1983/84	1984/85	1985/86	1986/87
Macquarie Valley	11.2	12.6	14.7	14.7
Namoi Valley	12.1	22.3	31.6	32.5
Gwydir Valley	13.8	27.5	14.9	22.6
McIntyre Valley	-	23.3	19.0	16.3
No. of fields surveyed	26	52	39	46

#- Deltapine cultivars only

* Overseas studies (1,2,3) and extensive studies at Narrabri Agricultural Research Station have shown that the pathogen survives within the seed despite acid-delinting (in conc. H_2SO_4 or in HCl gas) or chemical seed treatment .

* Overseas studies and studies by Dr Melda Moffett of the Queensland Department of Primary Industries (4,5,6) have demonstrated the ability of the pathogen to survive as an epiphyte/saprophyte (with no symptom expression) on the plant surfaces of both resistant and susceptible cultivars.

2. Cotton seed introductions are presently made through quarantine stations at Canberra, Sydney and Brisbane under glasshouse conditions which are unsuitable for blight symptom development.

* Between l973 and 1985 there were 494 cotton introductions through quarantine (Brisbane, 181; Sydney, 189; Canberra, 124). This represents an average of 38 introductions per year. This includes 155 lines introduced by Dr P. Lawrence of the Queensland D.P.I. at the start of his breeding programme in 1984-1985. (Source: Aust. Plant Introd. Review; Pacific Seeds, Toowoomba; Cotton Seed Distributors Ltd, Wee Waa.)

* Experience at Narrabri A.R.S. has shown that normal glasshouse conditions are unsuitable for infection and symptom development. Optimum temperatures for bacterial blight infection have been shown to be between 32° and 36°C (2). Brinkerhoff and Presley (7) showed that some cultivars were resistant to blight when grown at 19°C night and 25.5°C day or at 26.5°C night and day but susceptible when grown at 19°C night and 36.5°C day. Australian research has shown that symptoms develop slowly at temperatures below 25°C and no symptoms develop at all at 20°C (8). This study further showed that infection occurred at 20°C but symptom expression was prevented.

* These studies (2,7,8) have also demonstrated the need for leaf wetness and/or high humidity to allow infection and normal symptom development.

* Extensive testing of seedlings at Narrabri A.R.S. has shown that 16 to 21 days at temperatures of 25° to 30°C with intermittent misting each day from 9.30 am to 1.30 pm allows good symptom development.

3. There is some circumstantial evidence of symptomless epiphytic passage of the blight pathogen through quarantine.

* Prior to 1974 all isolates of the blight pathogen were identified as belonging to race 1 (9).

* In 1974 blight races 2,3,4,7,10 and 18 were detected (9).

* It is highly unlikely that this rapid proliferation of races was spontaneous. The occurrence of new races corresponded with large numbers of introductions from the United States, including material from Texas screened against the same races which appeared in Australia. The most likely explanation is symptomless epiphytic passage through quarantine (Dr Peter Fahy pers. comm.).

4. The Australian cotton industry has moved significantly to the growing of blight resistant cultivars and in the near future will be largely dependent on these resistant cultivars.

* Prior to the 1985-86 season 95 per cent of cotton grown in Australia was of the U.S. Deltapine type which is susceptible to Australian races of blight.

* In 1985-86 Siokra, which was developed in Australia by CSIRO plant breeders at Narrabri, was released and sown in approx. 10% of the cotton area. Siokra is completely resistant to bacterial blight of cotton. In the 1986-87 season 30 per cent of the cotton area was planted to Siokra and current projections for the coming 1987-88 season are 60-70 per cent Siokra.

* The CSIRO cotton breeding programme is about to release Sicala which is also resistant to blight. It is expected that these cultivars and others from this breeding programme will largely replace the susceptible U.S. cotton cultivars in the near future.

5. New races of the blight pathogen now in Africa and the U.S. are virulent on cultivars with a similar type of resistance to that present in the Australian cultivars. There is also a new race of the pathogen present in South America.

* Until recently there were 18 recognized races of the blight pathogen (9). Races 1,2,3,4,5,7,9,10 and 18 have been recorded in Australia (9).

* French (in Africa), U.S. and Australian cotton breeding programmes have developed and released cultivars with resistance or immunity to all 18 races of the pathogen.

* However, new races of the pathogen have developed in Chad, Upper Volta and Sudan and a plant breeder in Texas has introduced these new races to the U.S. and used them in field screening (10). These new races/isolates are virulent on the previously resistant French and U.S. cultivars. It is presumed that the current blight resistant Australian cultivars would also be susceptible to these new isolates.

* Another new race (Race 19) has recently been reported from Brazil (9).

6. The cotton industry is concerned that current quarantine procedures may not be sufficient to prevent introduction of these new races of the blight pathogen. The presence of the pathogen remains undetected if suitable conditions are not provided for symptom development. The industry would like to have cotton seed introductions confined to a single quarantine station and exposed to temperature and moisture conditions which would expose the pathogen if present.

* Cotton is a tropical crop and should be screened under conditions which allow 'normal' plant growth and disease expression ie. high temperatures and humidity.

* Exposure of seedlings to high temperatures (~ 30°C) and intermittent misting would facilitate detection of the pathogen on susceptible cotton cultivars.

* A continuation of the current Quarantine practice of applying Kocide (Copper hydroxide) at one month after emergence and a second before harvest should eliminate the limited epiphytic populations of the pathogen that may exist on resistant cultivars.

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