

Sources of Resistance in Cotton to Different Phases of Bacterial Blight Disease Prevalent at Hambantota

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INTRODUCTION

BACTERIAL blight of cotton caused by *Xanthomonas malvacearum* (E. F. Sm.) Dowson has in recent years become increasingly recognized as a major disease reducing cotton yields in several countries of Africa, Asia, and the American continent (13).

This disease has been reported from over 14 cotton-growing countries (3, 6, 11). The occurrence and severity of the disease varies not only with different countries and seasons but also with the varieties cultivated and their reaction to the different phases of the disease in anyone location. In Egypt, for example, the disease is of minor importance and appears late in the cropping season and does not cause any appreciable damage (4). In the U. S. A. severe epiphytotics have been recorded in the different states at different times. In 1959 the disease was severe in Texas and caused serious crop losses.

In Sudan the disease is partially controlled by drastic and expensive palliative measures (13). In areas where it is endemic and climatic conditions are generally favourable for the development of severe epiphytotics effective control of the disease could be achieved chiefly by breeding and selection of cotton varieties that show a high degree of field resistance.

In the main cotton-growing areas of Hambantota the disease is fatal on susceptible varieties but the widely cultivated variety H. C. 101 has hitherto shown a high degree of resistance. Under high cultural regimes such as with increased use of fertilizer and intensive cropping with irrigation, this variety has shown a sharp decline in resistance and therefore requires further improvement.

Breeding and selection of cotton varieties resistant to infection by *X. malvacearum* has been accomplished in several countries (1, 5). In Sudan a successful breeding programme aimed at incorporating resistant genes into commercial cotton resulted in varieties homozygous for these gene combinations without impairing the quality of lint and other economic characters (8, 9). In the U. S. A. Stoneville 20, believed to contain a major and minor gene complex has been extensively used in hybridization for bacterial blight resistance (2, 7). Knight, after an extensive survey of a wide range of genetic material established the presence of ten major genes for resistance and in addition a series of modifier and minor gene complexes (10).

The pathogen *X. malvacearum* is known to exist in the form of several physiologic races differing in pathogenicity. These have been classified broadly into two strains, *X. malvacearum* Strains I and II indexed on susceptibility to destruction by bacteriophage types and on pathogenicity reactions. The isolates of the pathogen originating from Hambantota District where the disease is endemic have been identified as phage type I of the bacterium (Hayward, A. C. personal communication). Phage types I and II are widely distributed in Africa and Asia but in some areas only one type may occur.

The results reported in this paper have been obtained from an evaluation of cotton genetic stocks for their relative resistance to bacterial blight in the Maha 1962/63 and 1963/64 cropping seasons. The experiments were conducted at the Cotton Research Station, Hambantota and will broadly illustrate the reaction spectrum of the different genetic stocks to the strain I of the pathogen endemic in the Hambantota area.

MATERIALS AND METHODS

The field experiment each season took the form of randomized block design, each block having a dimension of 84' × 36' within which 41 cotton varieties were randomized. Each variety was represented by a row of 10 hills with 4 plants per hill. The hills were spaced 3' between rows and 2' within rows. Each block was surrounded by a border sown with naturally infected seed of the highly susceptible variety B. P. 79. This served as a bombardment strip for initiation and even spread of the disease in the experimental area. The crop received heavy nitrogen dressings and infected crop residues from the previous season were evenly scattered between plants to induce an epidemic of the disease.

Artificial Inoculation

In screening for resistance for bacterial blight of cotton it is necessary to subject all varieties in the test to equal chance of infection (12). The high plant density of 4 plants per hill, heavy nitrogen fertilizer application and bombardment strips of the highly susceptible variety all favoured the development of a severe epiphytotic.

To assure uniform seed borne infection the test seed material was soaked for 2-3 hours in a suspension of the pathogen prepared by dispersing infected crop residues in water. The seeds were hand sown in holes and covered with small quantities of infected crop residue and soil. When the plants were 5-6 weeks old, two fortnightly sprays of bacterial suspension prepared by filtering infected trash soaked in water for 10-12 hours were applied to ensure uniform leaf infection (5). A further two sprays of bacterial suspension were given when the crop was mature to ensure stem and boll infection.

Disease rating

The assessment of susceptibility to primary infection was made fortnightly where detail records were taken of lesions on cotyledonary leaves and the newly developing flush. The disease estimation was expressed as per cent diseased plants per plot while the degree of susceptibility of each variety to different phases of bacterial blight was rated on a severity scale ranging from 0-4 where 0 = no infection, 1 = mild infection, 2 = moderate infection, 3 = severe infection and 4 = very severe infection.

The shape, size, colour and character of the individual lesions constituted the main basis for severity ratings. Small sized, restricted lesions without an initial water-soaked appearance was rated a mild infection while large, water-soaked and actively spreading lesions regarded as severe infection.

RESULTS AND DISCUSSION

The results revealed positive differences in the severity of infection to the different phases of the disease in all varieties of cotton tested in the two successive seasons at Hambantota. 34 varieties exhibited varying susceptible reactions to all phases of bacterial blight disease. Seven varieties emerged resistant to the more destructive phases of black arm and boll blight infection, while retaining an appreciable mild severity grading for angular leaf spot and vein blight phases of

the disease. The average disease ratings, on arc sin angular transformation, were statistically analysed. Table 1 summarises the disease ratings of the seven varieties that emerged resistant to black arm and boll blight but exhibited a varying susceptible reaction to angular leaf spot and vein blight.

The results illustrated in Table 1 show the existence of a wide variation in the severity to angular leaf spot and vein blight phases both in relation to variety and age of crop. The angular leaf spot phase was encountered in all varieties; in HC 101, for example, an increase in severity of over 50 per cent. was evident from 2-4 months while in the more susceptible variety 5143 C $\times$ 06 a similar increase was less conspicuous.

These varieties arranged serially according to their increasing order of susceptibility to angular leaf spot appear below:—

(1) HC 101; (2) 5143 C $\times$ 5143 C—S 36; (3) BP 79 $\times$ ML 12; (4) 5143 $\times$ C $\times$ 5143—S 18; (5) BP 79 $\times$ ML 72; (6) 5143 C $\times$ 06 and (7) BP 79 $\times$ CO 3-56.

Although the average severity of angular leaf spot was rated mild, a close comparison of the disease estimates on individual plants revealed a fair variation in severity from 0 to 3. This variation within a variety may be attributed to genetic heterozygosity in the plant population rather than to uneven infection. The disease in this instance was uniformly distributed in the experimental area in the two successive trials.

In contrast to angular leaf spot conspicuous differences in susceptibility to vein blight and petiolar infection were observed in the different varieties. For example, HC 101, BP 79 $\times$ ML 12 and BP 79 $\times$ ML 72 exhibited a high degree of resistance and were not statistically different. HC 101, however, was the least infected and by far the superior variety in its character for resistance to vein blight phase of the disease. The variety 5143 C $\times$ 5143 $\times$ S 36 showed extreme resistance up to first two months in the field but showed a sharp increase in disease from then onwards. Resistance of other varieties too declined with increasing age of the crop while in HC. 101 the rate of increase was relatively less.

The differential rates of increase in severity of angular leaf spot and vein blight with advance in age in some cotton varieties are illustrated in Figures 1 and 2. A close study of differential rates of increase in disease is therefore useful to determine the relative degree of susceptibility or tolerance of cotton varieties.

TABLE 1.—Variety Reaction in Cotton to Angular Leaf Spot and Vein Blight at Different Stages in Growth of the Crop

Variety	<i>Angular Leaf Spot</i> <i>Severity Ratings in Equivalent Angles</i>								<i>Vein Blight</i> <i>Severity Ratings in Equivalent Angles</i>							
	<i>2 months</i>		<i>3 months</i>		<i>4 months</i>		<i>Mean</i>		<i>2 months</i>		<i>3 months</i>		<i>4 months</i>		<i>Mean</i>	
HC 101 ..	..	7.04	..	9.90	..	16.95	..	11.32	..	0.00	..	0.00	..	2.43	..	0.81
BP. 79×ML 12 ..	..	26.42	..	29.20	..	33.21	..	29.61	..	5.74	..	6.55	..	7.71	..	6.66
BP. 79×ML 72 ..	..	27.13	..	34.76	..	38.06	..	33.32	..	5.74	..	6.55	..	7.77	..	6.67
5143 C×5143 C×S. 36	..	11.54	..	15.68	..	31.63	..	19.62	..	0.00	..	8.13	..	26.21	..	11.46
5143C×06 ..	..	42.71	..	45.00	..	45.86	..	44.52	..	18.24	..	18.24	..	19.64	..	18.71
5143 C×5143×S 18	..	22.63	..	31.82	..	40.11	..	31.52	..	9.98	..	26.06	..	30.00	..	22.01
BP 79×C0.3-56 ..	..	42.88	..	51.94	..	53.13	..	49.32	..	35.24	..	41.27	..	43.74	..	40.08
Significant at		P = 0.01									P = 0.01					
Least Significant difference		6.13									9.66					
Co-efficient of variation		11.05%									35.70%					

The variety H. C. 101 showed the least infection of angular leaf spot in early stages of growth of the crop and the increase in severity of the disease was progressive and slow. Similarly, the variety 5143 C $\times$ 5143 C-S. 36 showed relatively less disease in the early stages but in contrast to HC 101 the disease increased rapidly in its severity toward the later stages of crop growth. Disease development in the variety 5143 C $\times$ 06, however, was different showing a relatively high intensity of angular leaf spot in the early stages and the increase in severity thereafter with the advance in age of the crop was negligible. This variety though exhibiting some degree of susceptibility to initial infection shows a high degree of tolerance in its ability to withstand the attack with the advance in growth of the crop.

Similar trends to vein blight phase of the disease is also evident in the test varieties. The variety HC 101 was free of infection in the early stages of crop growth but exhibited some susceptibility toward the end of the cropping season. The rate of increase in severity of infection in this variety was negligible and could be therefore classed as a highly resistant variety to the vein blight phase of the disease. The variety 5143 C $\times$ 5143 C-S. 36 like HC. 101 was free of disease in the early stages but showed a sharp increase in susceptibility towards the end of the cropping season. However, in contrast to these varieties, the variety 5143 C $\times$ 06 showed less resistance in the early stages in crop growth but maintained a high degree of tolerance during the rest of the cropping period.

A high degree of resistance in young plants combined with tolerance to disease with increasing age of crop would therefore, serve as an effective means of controlling the angular leaf spot and vein blight phase of bacterial blight. Both resistance and tolerance to disease could be exploited with advantage in breeding and development of new cotton varieties for cultivation in Ceylon.

Stem infection or Black Arm was present in a mild form in the variety 5143 C $\times$ 5143-S. 18 while the other six varieties were not affected by this phase of the disease.

As expected, primary or seed borne infection was negligible in the cotton varieties determined resistant to boll blight and black arm. The relatively low incidence of seed borne infection of 0.86 per cent and 2.5 per cent recorded for the varieties 5143 C $\times$ 5143-S. 18 and BP 79 $\times$ ML 72 respectively may be attributed to artificial inoculation of seed with bacterial suspension and to contamination in ginning

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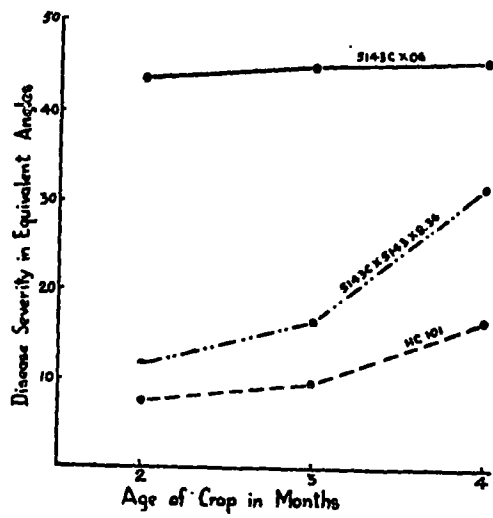


Figure 1.—Increase in Severity of Angular Leaf Spot with the Age of Crop.

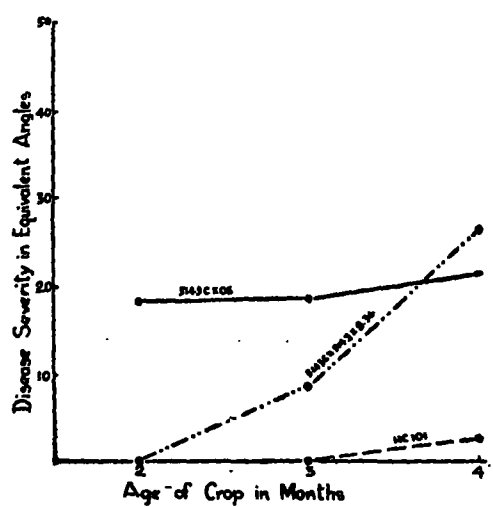


Figure 2.—Increase in Severity of Vein Blight with Age of Crop.

operations. This clearly emphasises an important practical proposition in reducing seed borne infection by the cultivation of varieties resistant to the boll blight phase which otherwise contaminates the seed.

The results clearly illustrate the necessity for incorporation of genetic factors for resistance to the more severe phases of bacterial blight disease. The currently recommended variety HC 101, though less susceptible and superior to the others tested require addition of genetic factors to strengthen its resistance to angular leaf spot in particular and to vein blight phase of the disease. Even if synthesis of bacterial blight resistant variety from the presently partially resistant and tolerant genetic stocks become a practical accomplishment, a vigilant and sustained search for new sources of resistance will be necessary as there is a likelihood of new and more virulent strains of the pathogen appearing which could prove fatal to cotton varieties hitherto determined as resistant.

SUMMARY

Forty one cotton genetic stocks were screened for resistance to the different phases of bacterial blight disease under natural and induced epiphytotic conditions at Hambantota. 34 varieties were determined susceptible while 7 emerged resistant to the more severe phases of the disease, namely black arm and boll blight.

The resistant varieties showed varying susceptibility to angular leaf spot and vein blight phases of the disease. The relative increase in susceptibility and tolerance to disease shown during the life of the crop provides a basis for future breeding and improvement of cotton varieties resistant to this disease.

To improve resistance of the cultivated variety HC 101 it would be necessary to incorporate genetic factors for resistance to angular leaf spot and vein blight. The cultivation of varieties that are resistant to boll blight will in addition minimise the incidence of seed borne infection.

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