

CROSS PROTECTION AGAINST *FUSARIUM* WILT OF COTTON BY
NONPATHOGENIC *FORMAE SPECIALES* OF *FUSARIUM OXYSPORUM*
BY

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Resistance to *Fusarium* wilt of cotton was induced by preinoculation with the nonpathogenic *formae speciales* of *Fusarium oxysporum* before inoculation of the host with the pathogen as well as by mixed inoculation. A better and stable resistance of the disease was always obtained in the case of preinoculation (51.12 to 65.33%) as compared to mixed inoculation (33.33 to 38.67%). Germination of conidia of the pathogen was significantly reduced in the extracts of seedlings inoculated with the nonpathogenic *formae speciales*. The mechanism of such resistance might be due to the formation of antifungal substances in the host as a result of infection with the nonpathogens.

INTRODUCTION

Several workers have demonstrated control of *Fusarium* wilt by prior or simultaneous inoculation of the hosts with some nonpathogenic isolates (Borloug, 1945; McClure, 1951; Perry, 1959; Matta, 1966; Davis, 1967; Langton, 1969). Inhibition of wilt symptoms caused by *F. oxysporum* f. sp. *udum* in pigeon pea and *F. oxysporum* f. sp. *ciceri* in gram have been already demonstrated by Kaiser and Sengupta (1977, 1980). Further studies were undertaken to induce resistance to *F. oxysporum* f. sp. *vasinfectum* in cotton (*Gossypium* as.) by preinoculation or mixed inoculation with some nonpathogenic *formae speciales* of *F. oxysporum*, the results of which are presented in this paper.

MATERIALS AND METHODS

The ff. sp. of *F. oxysporum* used for inoculation of cotton seedlings were *F. oxysporum* ff. sp. *vasinfectum*, *udum* and *ciceri*, the causal organisms of wilt of cotton, pigeon pea and gram respectively.

Cross protection experiments were conducted in two ways: (1) by prior inoculation with f. sp. of *F. oxysporum* nonpathogenic to cotton followed by inoculation with *F. oxysporum* f. sp. *vasinfectum* and (2) by mixed inoculation with both. The methods used for this study were same as have been described elsewhere in details (Kaiser and Sengupta, 1977).

Disease symptoms of the inoculated seedlings were assessed visually by using different disease indices ranging from 0.00 (no symptom) to 4.00 (complete wilting and death of the seedlings). The degree of resistance (D. R.) induced against *F. oxysporum* f. sp. *vasinfectum* in cotton seedlings were calculated by the following formulae :

$$D. R. = 100 \frac{(D. 1.) d}{(D. 1.) p} \times 100 \text{ and}$$

$$D. R. = 100 \frac{(D. 1.) m}{(D. 1.) p} \times 100$$

where D. R. = the degree of resistance induced, (D. 1.) d = disease index of preinoculated seedlings, (D. 1.) m = disease index of mixed inoculated seedlings and (D. 1.) p = disease index of the seedlings inoculated with the pathogen.

Mechanism of resistance was observed by studying the antifungal properties of the cross infected cotton seedlings against the germination of conidia of *F. oxysporum* f. sp. *vasinfectum*, the method followed was similar as described elsewhere (Kaiser and Sengupta, 1977).

RESULTS

Reduction of *F. oxysporum* f. sp. *vasinfectum* in cotton could be achieved both by preinoculation with the nonpathogenic ff. sp. of *F. oxysporum* before inoculation with *F. oxysporum* f. sp. *vasinfectum* as well as by mixed inoculation (Table 1). A better control of the disease was always obtained in case of preinoculation (51.12 to 65.33%) as compared to mixed inoculation (33.33 to 38.67%). Less number of seedlings were killed (1 to 2) in case of preinoculation as compared to mixed inoculation where greater number of seedlings were killed (3 to 6).

A highly significant reduction in the conidial germination of *F. oxysporum* f. sp. *vasinfectum* was observed in the extracts of cotton seedlings inoculated with the nonpathogens as compared to those in the extracts of seedlings inoculated with the pathogen, uninoculated ones as well as in sterile distilled water (Table 2). Conidial germination in the extracts of seedlings inoculated with the pathogen itself also showed a significant reduction as compared to uninoculated ones, but did not show any significant difference in germination with that in distilled water.

DISCUSSION

Several mechanisms have been proposed for cross protection in *Fusarium* wilts (Davis, 1967) : (1) obstruction to the pathogens by accumulation of gums and tyloses in the xylem vessels by the nonpathogens, (2) formation of antifungal substances in the host as a result of fungal infection, (3) antibiotics

Table 1. Cross protection against *F. oxysporum* f. sp. *vasinfectum* in cotton with nonpathogenic formae speciales of *F. oxysporum*(a)

Treatment	Time after inoculation (days)	Disease index		No. of seedlings killed		Degree of resistance	
		Preinoculated	Mixed inoculated	Preinoculated	Mixed inoculated	Preinoculated	Mixed inoculated
<i>F. oxysporum</i> ff. sp.							
<i>udum</i> x <i>vasinfectum</i>	10	1.20	1.45	0	0	55.56	46.30
	15	1.50	2.00	1	3	53.85	38.46
	20	1.83	2.50	2	6	51.12	33.33
<i>ciceri</i> x <i>vasinfectum</i>	10	0.75	1.40	0	0	72.23	48.15
	15	1.00	2.00	1	3	69.24	38.46
	20	1.30	2.30	2	4	65.33	38.67
<i>udum</i> (control)	10	2.70	2.70	2	2		
	15	3.25	3.25	6	6		
	20	3.75	3.75	10	10		
uninoculated (control)	10	0.00	0.00				
	15	0.00	0.00				
	20	0.00	0.00				

(a) Data collected on 12 seedlings of each treatment.

Table 2. Conidial germination of *F. oxysporum* f. sp. *vasinfectum* in the extracts of cotton seedlings inoculated with different formae speciales of *F. oxysporum*(a) (Extracts collected 7 days after inoculation).

Extracts of seedlings inoculated with <i>F. oxysporum</i> f sp.	Conidial germination (%) (after 24 hours)(b)
<i>vasinfectum</i>	71.78 b
<i>udum</i>	37.83 c
<i>ciceri</i>	27.65 d
Uninoculated (control)	90.00 a
Sterile distilled water (control)	71.96 b

(a) Values not sharing the same letter are significantly different ($P=0.05$) as determined by Duncan's multiple range test.

(b) Statistical analysis was carried out with data transformed into angular value.

of fungal origin and (4) alteration of host metabolism. In the present study, significant reduction in the conidial germination of the pathogen in the extracts from the host inoculated with the nonpathogenic ff. sp. of other hosts as compared to extracts from the host inoculated with the pathogenic f. sp. itself, uninoculated host as well as in sterile distilled water seem to lend support to the second possibility as listed above. Similar mechanism of resistance against *F. oxysporum* f. sp. *udum* in pigeon pea has been recorded by Kaiser and Sengupta (1977). These results suggest that while in the extract of healthy seedlings there was a factor stimulating conidial germination, the extracts of inoculated seedlings contained an antifungal substance. The host probably reacted differently with the pathogenic and nonpathogenic ff. sp., producing more antifungal substance in the incompatible combination.

The resistance to *Fusarium* wilt infection in cotton seedlings was greater and more stable in the preinoculated case than in the mixed inoculation. Matta *et al* (1969) observed that nonpathogenic forms of *F. oxysporum* induced in tomato plants greater initial increase in the phenol content than the pathogenic f. sp. Mixed inoculation with the pathogenic and nonpathogenic ff. sp. were, on the contrary, no more effective in inducing phenol accumulation 24 hours after infection than the pathogen alone. The greater and more stable resistance in the preinoculated case in the present study might be due to the same reactions.

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