

# Expression of Resistance to *Xanthomonas campestris* pv. *phaseoli* in *Phaseolus vulgaris* Under Tropical Conditions

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## ABSTRACT

Webster, D. M., Temple, S. R., and Galvez, G. 1983. Expression of resistance to *Xanthomonas campestris* pv. *phaseoli* in *Phaseolus vulgaris* under tropical conditions. *Plant Disease* 67:394-396.

The bean (*Phaseolus vulgaris*) cultivar Jules and the PI 207262 line are moderately resistant to *Xanthomonas campestris* pv. *phaseoli* in the temperate zone but appeared susceptible in field evaluations in the tropics. Susceptibility to the pathogen was related to environmental factors that caused very early maturity and poor growth; blight resistance was expressed relative to controls when these factors were altered to permit more normal growth of Jules and PI 207262. The effect of environmental factors on resistance to common blight was observed in evaluations made at 44 and 55 days after planting but not at 34 days.

Common bacterial blight, caused by *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye (XCP), is a serious disease of beans (*Phaseolus vulgaris* L.) in much of the lowland tropics. One of the goals of the bean program at the Centro Internacional de Agricultura Tropical (CIAT, Cali, Colombia) is the development of cultivars with resistance to XCP. A principal step in achieving this goal is the identification of sources of resistance to this pathogen. Two of the most promising sources of genetic resistance, according to screening carried out in the United States, are PI 207262 and certain Great Northern cultivars, such as Jules (2-4). The common bacterial blight resistance of Jules and similar sources has been studied carefully in controlled environments and is generally highly heritable and expressed in a very stable manner (5,11). Furthermore, although pathogenic variation in XCP has been demonstrated, blight resistance is generally expressed relative to susceptible controls (6,8,10). In repeated evaluations in the field in the tropics, however, Jules and PI 207262 performed as if they were susceptible to XCP (CIAT, unpublished).

Under the short tropical day length at CIAT, Jules and PI 207262 are induced to flower very early and produce a stunted plant compared with locally grown

cultivars. In addition, Jules and PI 207262 are relatively susceptible to fungi that cause such blight diseases as Alternaria blight (*Alternaria* sp.) and angular brown leaf spot (*Isariopsis griseola* Sacc.) (= *Cercospora* sp.?), which are not severe on locally grown cultivars.

Andrus (1) has discussed the effect of plant vigor on expression of resistance in beans to bacterial pathogens. It seemed possible that the susceptible reaction of Jules and PI 207262 in the tropics did not result from inadequacy of resistance factors in the host but from poor growth of the host. The purpose of this investigation was to determine the effects of other foliar blights and day length on the expression of resistance to common bacterial blight in dry beans.

## MATERIALS AND METHODS

The XCP strain Xp123, originally isolated from dry beans at CIAT, was one of the most virulent in an evaluation of strain variability (CIAT, unpublished). The culture was lyophilized from a suspending medium of 5% peptone and 10% sucrose. Stock cultures were obtained by streaking lyophilized material onto yeast-dextrose carbonate agar (YDCA) (9), grown for 1 day at 28 C, then stored at 4 C for as long as 2 mo. Refrigerated stocks were not transferred again; when viability dropped, they were replaced by streaking from another lyophilized culture.

Beans were planted at CIAT in 8-m rows, 60 cm between rows, and after 10 days, seedlings were thinned to 40 cm between plants. Furrow irrigation was used when necessary. Main plots were day length and fungicide applications, and each was arranged with subplots, *Phaseolus* lines, in a split-split block design of four blocks and three replicates (7). Within each block, there was one row of each of five lines of beans: *P.*

*acutifolius* Grey line P597 and dry bean cultivars Jules, PI 207262, Porrillo Sintetico (Porrillo), and Puebla 152, randomized separately within each block. The *P. acutifolius* line P597, which was highly resistant to XCP, was included as a check so that any mechanical damage resulting from inoculation could be recognized. Jules and PI 207262 are considered moderately resistant to XCP in the temperate zone (2,3). Both grow in Colombia as prostrate vines, although Jules has a more erect growth habit than PI 207262. Porrillo and Puebla 152 are susceptible to XCP but are otherwise well adapted to the tropics. Porrillo has an erect vine growth habit, whereas Puebla 152 grows as a prostrate vine.

Natural day length at CIAT is always close to 12 hr. Supplemental lighting provided by two 300W, 200V incandescent bulbs suspended 2 m above the ground and 2 m from the ends to the center row extended the photoperiod to 16 hr. A 15-m unplanted buffer zone separated blocks with lights from blocks without lights.

The fungicide treatment consisted of alternate spray applications of benomyl at 0.5 kg/ha and manzeb at 3 kg/ha at 2-wk intervals beginning 3 wk after planting. Benomyl is a systemic fungicide and controls Alternaria leaf spot and angular brown leaf spot as well as many other diseases caused by fungi. Manzeb controls rust caused by *Uromyces phaseoli* (Reben) Wint. var. *typica* Arth. as well as many of the same diseases controlled by benomyl. Neither fungicide is considered to have any effect on common bacterial blight. A row of the cultivar Porrillo separated blocks with fungicides from blocks without fungicides. In addition, a row of Porrillo bordered each replicate. Replicates were separated by five rows of maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* (L.) Moench).

Plants were inoculated with XCP strain Xp123 at weekly intervals beginning 3 wk after planting and continuing for the duration of the experiment. Inoculum was prepared from the growth of 2-day-old plate cultures on YDCA and diluted with water to an absorbance at 600 nm that corresponds with  $5 \times 10^7$  colony-forming units per milliliter. This suspension was sprayed onto plants at 3 kg/cm<sup>2</sup>, with the sprayer nozzle held at least 3 m from plants to avoid excessive mechanical damage.

Disease evaluations were made at 34,

Part of a dissertation submitted by the first author in partial fulfillment of the requirements for the Ph.D. degree in Plant Pathology at the University of Wisconsin. Supported by a fellowship and research grant No. 74-17422 from the National Science Foundation.

Accepted for publication 11 September 1982.

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44, and 55 days after planting and were based on a severity index that considered lesion size and proportion of leaves infected. The entire experiment was conducted twice, during December

1975–February 1976 and April–June 1976.

## RESULTS

An analysis of variance was not made on data from the first experiment, December 1975–February 1976, because severe damping-off led to low plant populations. The days to flower and disease reactions of both experiments were very similar; therefore, only the results of the second experiment are reported. Data from the P597 line were omitted from the analysis because P597 remained symptomless and the variance associated with it was zero.

The flowering date for each line was recorded when 50% of the plants had produced one or more flowers. All five lines were day length sensitive, but the difference in flowering date between 12- and 16-hr day lengths was greatest for Jules and PI 207262 (Table 1). With the 16-hr day length, there was a range in the flowering dates among lines of only 4 days.

At 34 days after planting, Jules was the most resistant of the *P. vulgaris* lines and Puebla 152 and Porrillo were the most susceptible to XCP. At this first evaluation date, there was no effect of day length or fungicide on disease severity ratings (Tables 2 and 3).

By 44 days after planting, there was a great effect of day length on disease severity of Jules and a smaller effect (not significant,  $P > 0.05$ ) on disease severity of PI 207262. Day length did not have any apparent effect on disease severity of Puebla 152 or Porrillo (Table 3). This differential response of lines to day length gave a significant ( $P < 0.01$ ) interaction (L × D) in the analysis of variance (Table 2).

Data from the final evaluation date at 55 days showed a great effect of day length on disease severity of Jules and PI 207262 (Table 3). Disease ratings for Puebla 152 and Porrillo also tended to be less severe with long days but not

significantly so ( $P > 0.05$ ) (Tables 2 and 3).

The analysis of data from the evaluation at 55 days also showed a significant ( $P < 0.05$ ) interaction of fungicides with lines. The source of this interaction was an effect of fungicides on common bacterial blight severity of PI 207262, and to a lesser extent, on that of Jules. There was no effect on disease severity of the two adapted lines, Porrillo and Puebla 152.

## DISCUSSION

The differential effect of fungicides indicates a greater susceptibility of PI 207262, and to a lesser extent, of Jules to fungi as opposed to XCP. The fungi that cause angular brown leaf spot and Alternaria blight often infect tissue that is under stress or is senescent, and under these conditions, these fungal diseases cause symptoms that resemble those of common bacterial blight. It is also possible that secondary infections by weakly pathogenic fungi could increase the severity of common bacterial blight. Benomyl and manzeb had no effect on disease severity of the inoculated adapted lines, Porrillo and Puebla 152.

Coyne et al (5) studied the effects of maturity on disease severity and on populations of bacteria in leaves of bean lines resistant and susceptible to XCP and concluded that susceptibility increases as plants mature. Webster et al (11) evaluated the resistance to XCP of greenhouse-grown seedlings and adult plants of F<sub>4</sub> families from crosses involving Jules and PI 207262 as parents. In the greenhouse, there was little difference among families in rates of maturity and there was only a small effect of maturity on family rank; resistance to the pathogen may have declined, but it was still expressed, relative to blight susceptible families, even after pod set.

In this study, maturity of Jules and PI 207262 was influenced by day length, and disease severity in the second and third

**Table 1.** Effect of day length on induction of flowering of *Phaseolus* sp. in the field at CIAT

Line	Days to flower	
	12-Hr day length	16-Hr day length <sup>a</sup>
P597 <sup>b</sup>	35	45
Jules	29	45
PI 207262	30	43
Puebla 152	36	43
Porrillo	40	47

<sup>a</sup> Day length extended 4 hr with light from incandescent bulbs.

<sup>b</sup> *P. acutifolius*; other four lines are *P. vulgaris*.

**Table 2.** Analysis of variance of effects of day length (D) and fungicide (F) applications on severity of common bacterial blight on *Phaseolus* sp. lines (L)

Days after planting	Source <sup>x</sup>	df	Mean square <sup>y</sup>
34	L	3	14.0502**
	L × D	3	0.0502
	L × F	3	0.0368
	L × D × F	3	0.0203
	E <sub>d</sub> <sup>z</sup>	24	0.0253
44	L	3	6.3915**
	L × D	3	1.6666**
	L × F	3	0.0700
	L × D × F	3	0.0430
	E <sub>d</sub>	24	0.0518
55	D	1	7.6400*
	E <sub>a</sub>	2	0.1722
	F	1	0.7931*
	E <sub>b</sub>	2	0.0368
	L	...	3.4809**
	L × D	...	1.7132**
	L × F	...	0.2292*
	L × D × F	...	0.0426
	E <sub>d</sub>	...	0.0684

<sup>x</sup> Only sources of treatment effects that are significant, and interactions with lines, are listed.

<sup>y</sup> \* =  $P < 0.05$ ; \*\* =  $P < 0.01$ .

<sup>z</sup> E = error.

**Table 3.** Effects of day length, fungicide application, and time of evaluation on severity of common bacterial blight on five *Phaseolus* sp. lines

Days after planting	Day length (hr)	Fungicide treatment <sup>a</sup>	Jules	PI 207262	Porrillo	Puebla 152	P597	LSD <sub>0.05</sub> at:		
								D <sub>1</sub> F <sub>1</sub> L <sub>1</sub> -D <sub>1</sub> F <sub>1</sub> L <sub>2</sub>	D <sub>1</sub> F <sub>1</sub> L <sub>1</sub> -D <sub>1</sub> F <sub>2</sub> L <sub>1</sub>	D <sub>1</sub> F <sub>1</sub> L <sub>1</sub> -D <sub>2</sub> F <sub>1</sub> L <sub>1</sub>
34	16	Yes	1.35 <sup>b</sup>	3.38	3.70	3.65	1.00	0.27 <sup>c</sup>	0.30	0.69
		No	1.35	3.07	3.69	3.70	1.00			
	12	Yes	1.40	3.09	3.81	3.70	1.00	0.38	0.39	0.76
		No	1.57	3.04	3.76	3.67	1.00			
44	16	Yes	1.65	3.11	3.93	3.96	1.00	0.38	0.39	0.76
		No	1.61	3.25	3.99	3.97	1.00			
	12	Yes	3.16	3.50	4.00	4.08	1.00	0.44	0.48	0.77
		No	3.27	3.75	3.72	4.07	1.00			
55	16	Yes	2.35	3.19	4.32	4.08	1.00	0.44	0.48	0.77
		No	2.42	3.91	4.44	4.30	1.00			
	12	Yes	4.01	4.19	4.71	4.33	1.00	0.44	0.48	0.77
		No	4.37	4.78	4.74	4.27	1.00			

<sup>a</sup> Alternately applied benomyl at 0.5 kg/ha and manzeb at 3 kg/ha at 2-wk intervals from April to June 1976.

<sup>b</sup> Average disease severity. Severity index: 1 = no visible lesions, 2 = lesions covering less than 25% of the leaf surface on fewer than 10% of the leaves, 3 = lesions covering less than 25% of the leaf surface on 10–50% of the leaves, 4 = lesions covering more than 25% of the leaf surface on 10–50% of the leaves, and 5 = lesions covering more than 25% of the leaf surface on more than 50% of the leaves.

<sup>c</sup> Least significant difference for lines (L), fungicides (F), and day length (D): D, 12 or 16 hr; F, yes or no; L, between any of the five *Phaseolus* sp. lines.

