The Effect of Environment on the Response of Bean Cultivars to Infection by Strains of Bean Common Mosaic Virus

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ABSTRACT

The New York 15, Florida, and Puerto Rico, and type strains of bean common mosaic virus were compared on *Phaseolus vulgaris* (bean) cultivars commonly used as strain differentials in growth chambers programmed to 35 C and 24 C with 8 h of artificial light with approximately 26,900 lux and in a greenhouse with variation in temp from 20 C at night to 30 C during the day with sunlight intensity of approximately 19,358 lux maximum. Response of cultivars to infection with the same strain often varied in the different test environments. Standardization of procedures for strain recognitions by investigators is needed. A tentative procedure for strain recognition and comparison is discussed.

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Bean common mosaic virus (BCMV) continues to cause large losses in bean plantings (*Phaseolus vulgaris* L.) in some countries. Resistance to prevalent strains of the virus is readily available in several countries and has been incorporated into commercial cultivars to an extent that BCMV is of relatively minor importance. The possibility of chance introductions of BCMV-infected seeds has increased as new international programs of bean improvement are established. The introduction of new strains of BCMV into a country could present a serious problem, even in those countries where resistance is available to the prevalent strains. Therefore, identification of foreign strains is of importance if potentially dangerous strains are to be excluded from a geographic area where they are not yet present. Our observations reported here suggest a need for an international standardization of procedures for recognition of strains of BCMV, and some of the factors we feel important in their identification are discussed.

MATERIALS AND METHODS.—The type strain (8), New York 15 strain (9), and the Puerto Rico strain (1) were obtained from infected seed maintained by J. P.

Meiners. The Florida strain (12) was obtained from M. J. Silbernagel in dried infected bean leaves.

Bean cultivar 'Stringless Green Refugee' was used as a source of infected leaves in the preparation of inoculum. Nine days after inoculation, leaves with symptoms were ground with phosphate buffer (pH 6.8, 0.1 M, 5 ml/g of leaf tissue) and the resulting leaf sap preparation was used to manually inoculate the primary leaves of bean cultivars previously dusted with 400-mesh Carborundum. Seeds of each cultivar were planted in individual pots with steamed soil, so that each cultivar was represented by three plants in each of three pots in every test environment condition. Bean cultivars were usually ready for inoculation 14 days after planting. Plants in two pots were inoculated, but plants in the third pot were not.

Test environments were: (i) a Sherer-Gillett growth chamber Model No. 3714, programmed to have approximately 26,900 lux for 8 h of light and 16 h of darkness at 35 C; (ii) another growth chamber of the same model programmed similarly, but at 24 C; and (iii) a greenhouse with moderate temp varying from 20 C at night to 30 C in the hottest part of the day and sunlight with approximately 19,358 lux maximum. The test plants were kept in the greenhouse until just before inoculation and in the test environments for 2 wk after inoculation. At this time their leaves were used as sources of sap for back-inoculations to the 'Monroe' (10) or 'Red Mexican U.I. (University of Idaho) 35' cultivars to test for BCMV infection especially in those cultivars with slight or no symptoms of systemic infection. Experimentation was started in March 1972 and essentially completed in August 1972 at Beltsville, Maryland. Further testing of unusual responses were made in the growth chambers and greenhouse in Beltsville, Maryland and in a screened greenhouse in Mayaguez, Puerto Rico for another 5 mo. Temperature conditions in Puerto Rico varied from 25 C at night to 42 C in the hottest part of the day, and sunlight intensity was approximately 19,358 lux maximum.

RESULTS.—Table 1 summarizes results of three trials in which common bean cultivar differentials and four strains of BCMV were tested in the growth chambers and in the greenhouse in Beltsville, Maryland. Cultivars 'Beka', 'Bountiful', 'Black Valentine', 'Columbia Pinto', 'Prelude', 'Pure Gold Wax', and 'Stringless Green Refugee' expressed mild to severe systemic symptoms of infection in all environmental conditions and with all four strains.

There were other cultivars that consistently responded in a similar manner to a BCMV strain in the three environmental conditions. 'Great Northern U.I. 123' with the type and New York 15 strains, 'Imuna' with the Florida and Puerto Rico strains, and 'Michelite 62' with all four strains. In several other cases, however, the symptoms of infection or the apparent development of the virus in its host differed in the three environments. Examples of this were: Great Northern U.I. 123 with the Puerto Rico strain; Imuna, a cultivar from the Netherlands (6), with the type and New York 15 strains;

TABLE 1. Reaction of bean cultivars to inoculation with bean common mosaic virus strains in three environmental conditions

Bean cultivar	Reaction[a] to virus strain and environmental condition[b]											
	Type			New York 15			Florida			Puerto Rico		
	35C	24C	G	35C	24C	G	35C	24C	G	35C	24C	G
'Beka'	S	S	S	S	S	S	S	S	S	S	S	S
'Bountiful'	S	S	S	S	S	S	S	S	S	S	S	S
'Black Valentine'	S	S	S	S	S	S	S	S	S	S	S	S
'Columbia Pinto'	s	s	s	s	s	s	s	s	s	s	s	s
'Great Northern U.I. 123'[c]	L+	L+	L+	N−	N−	N−	N+	N+	L	s	N+	s
'Imuna'	s	N−	N−	s	N−	N−	s	s	s	s	s	s
'Michelite 62'[c]	L	L	L	s	s	s	L	L	L	L	L	L
'Monroe'[c]	L	L	L	L	L	L	L	L+	s	s	L	L
'Pinto U.I. 111'[c]	N+	N+	L+	s	s	L+	L	L	L	s	L+	L+
'Prelude'	s	s	s	s	s	s	s	s	s	s	s	s
'Pure Gold Wax'	S	S	S	S	S	S	S	S	S	S	S	S
'Red Mexican U. I. 34'	s	s	s	s	s	s	s	L+	L+	s	s	s
'Red Mexican U.I. 35'[c]	s	L	L	L+	L+	L+	s	L+	L+	s	L+	L+
'Sanilac'[c]	L+	L	L	s	s	s	L+	L	L+	s	s	L
'Stringless Green Refugee'[c]	S	S	S	S	S	S	S	S	S	S	S	S
'Top Crop'[c]	TN	N+	N+	TN	N+	N+	TN	N+	N+	TN	N+	N+

[a]S = strong symptoms of systemic infection; s = weak symptoms of systemic infection; N+ = systemic infection without symptoms; N− = no infection; L = local infection only; L+ = local symptoms, symptoms systemic infections; TN = top necrosis.

[b]Environments = Sherer-Gillett growth chambers Model No. 3714 with 8 h of light (approx. 26,900 lux) at 35 C and 24 C; and greenhouse (G) with 20 C night and 30 C day, light max 19,358 lux.

[c]Cultivars considered useful in differentiation of the four strains tested.

'Monroe' with the Florida and Puerto Rico strains; and 'Sanilac' with the Puerto Rico strain (Table 1).

Moreover, in some cases the response of a cultivar to infection by a strain was not uniform. In several cultivars, i.e. 'Pinto U.I. 111', Great Northern U.I. 123, and 'Top Crop', infections were not apparent. All inoculated plants without symptoms were checked for infection and some were found to be infected. Similarly, in certain cultivars, such as Sanilac, there was latent systemic infection in plants where only local symptoms were evident. Back-inoculations to Red Mexican U.I. 35 showed systemic development of the virus.

Eight cultivars which reacted differentially to infections by the four BCMV strains in 8 h days at 35 C and are footnoted in Table 1. The symptoms of systemic infection observed were those commonly associated with infections of BCMV (13). Local symptoms on the inoculated primary leaves varied from transitory light-yellow spots (Black Valentine, Fig. 1-A) to green rings with yellow centers (Pinto U.I. 111 Fig. 1-B) and necrotic green rings with or without yellow center (Michelite 62, Fig. 1-C), necrotic lesions (Red Mexican U.I. 35, Fig. 1-D; Monroe, Fig. 1-E) and concentric rings (Columbia Pinto, Fig. 1-F). If a cultivar was susceptible to the four strains tested, local symptoms were the same, regardless of the strain.

The severity of systemic symptoms varied. Generally the Florida and Puerto Rico strains were more virulent than the type and New York 15 strains. This difference among strains was observed in cultivars where the virus developed systemically and symptoms were expressed clearly. No consistent difference in virulence was observed in local symptom expression, but usually the Florida and Puerto Rico strains caused a larger number of necrotic lesions in cultivars Monroe and Red Mexican U.I. 35.

DISCUSSION.—Our observations demonstrated the effect that environmental conditions may have on the expression of symptoms in bean differentials infected with BCMV. Discrepancies in results due to environmental differences have already been reported (1). Identification of strains of BCMV from the literature is at present of little value since investigators have used a variety of environmental conditions for their tests, and also different sets of differentials.

All strains used in this study, except the Puerto Rico strain, (1) have been recognized as distinct for many years. Its morphology, host range, thermal inactivation point, dilution end point, seed transmission, and symptomatology correspond to that which is accepted for BCMV (13). The necessary information to distinguish it from other strains is given in Table 1.

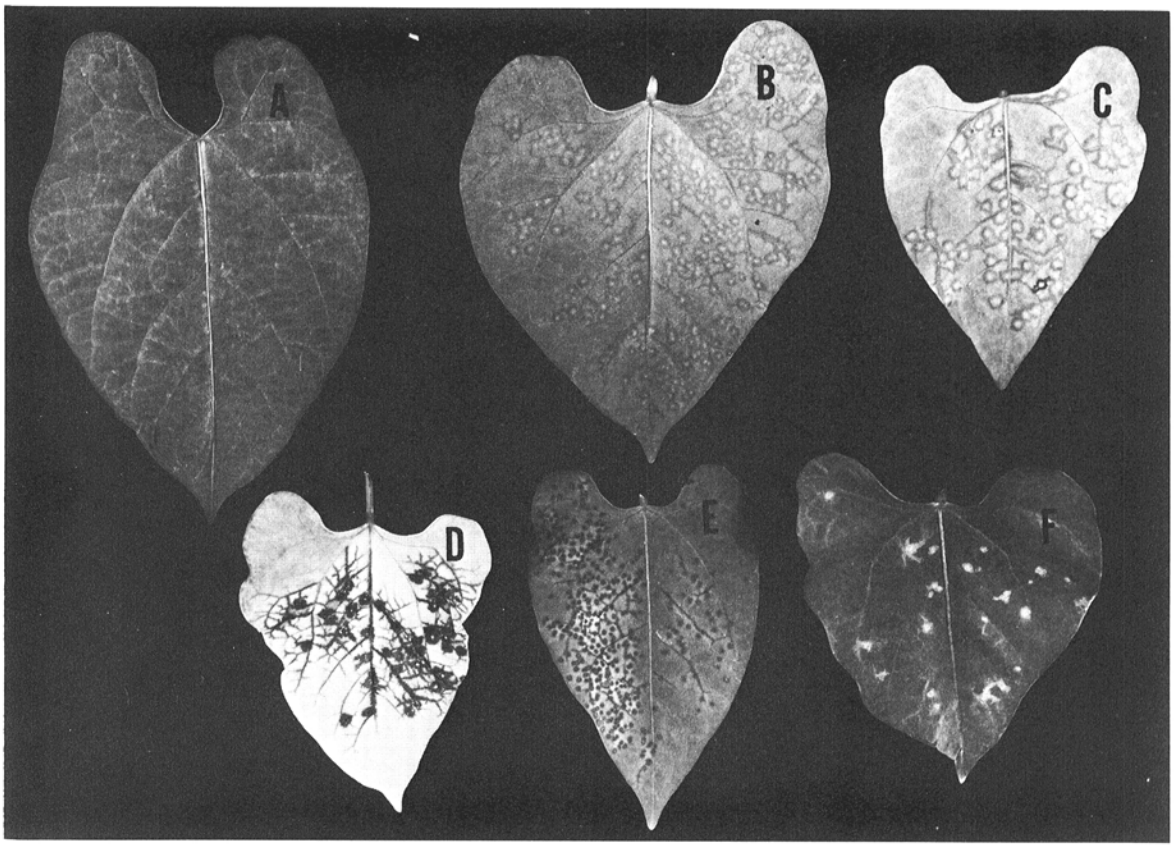

Fig. 1-(A to F). Local symptoms of bean cultivars inoculated with the Puerto Rico strain of bean common mosaic virus; **A)** 'Black Valentine', **B)** 'Pinto U.I. 111', **C)** 'Michelite 62', **D)** 'Red Mexican U.I. 35', and **E)** 'Monroe'.

The responses of cultivars to infections differed somewhat from those reported for the well-recognized strains (11). The symbols used in Table 1 are an attempt to avoid ambiguous terms such as resistant and tolerant (3). They are also an attempt to separate the idea of strain differentiation from that of testing for disease resistance. In this respect they are similar to those already used (2). A mutually satisfactory scheme for strain recognition and the use of symbols to describe the host responses perhaps can best be done on an international basis by both virologists and plant breeders.

Even when the source of inoculum is apparently the same and the test conditions similar, differences in response were apparent in our studies. Infection by the type strain in Columbia Pinto was not always detectable. The reason for this discrepancy is not clear, but may suggest differences in the initial titer of the strain upon inoculation.

Genetic uniformity of cultivars must be maintained. Outcrossing in beans is sufficient, especially in some tropical environments, so that in several generations a cultivar may be sufficiently different genetically to be of little use as a differential. A single depository of bean differentials where special care is taken to avoid genetic variations would be very useful.

Recently several new strains of BCMV have been reported (4, 5, 7), and some of them differ considerably from the usual characters of BCMV. One strain has been found to infect alfalfa (*Medicago sativa* L.) (5). The sources of resistance to BCMV in the United States have been adequate in the past but there is no assurance that these sources are sufficient if new foreign strains are introduced. The same potential danger could be of concern to countries where resistance is not generally available, but where very active legume improvement programs have been established.

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