GEOGRAPHIC ORIGIN OF PEA SEEDBORNE MOSAIC VIRUS: AN HYPOTHESIS

Hampton, R. 0. USDA, Agricultural Research Servia
Oregon State University, Corvallis, OR US

It was previously reported (4) that the USDA Plant Introduction (P.I.) Pisum collection contained at least 420/1835 pea seedborne mosaic virus (PSbMV)-infected seedlots, 40% of which (168/420) had originated in India. Moreover, original seeds of many recent accessions from northern India were tested and found to transmit PSbMV. Fortuitously, 23 seedlots simultaneously introduced from northern India were found to contain PSbMV-immune germplasm. This unparalleled concentration of PSbMV inoculum and PSbMV-immune Pisum germplasm in northern India caused us to wonder whether this region may have been the center of origin for this virus, and consequently also the center of PSbMV-immune germplasm; hence, the subject of this paper.

Origin of PSbMV inoculum. Of 472 Pisum accessions introduced from India in 1969-70 and tested (4) for seed transmission of PSbMV, introduced seeds of 138 transmitted the virus to 3% to 2 5% of their seedlings. In the P.I. number sequence between PI 356858 and 356978 (120 accessions), seed-transmission of PSbMV occurred in at least 5 3 (4 4%). Among these 138 infected accessions from India, exact locations could be mapped for 45 (Fig. 1). Of these 45 infected accessions, 35 (78%) had originated within the state of Uttar Pradesh or very near its border, with 7 of the remaining 10 originating in other states of northern India.

More 1969-70 Pisum accessions (472/672, 70%) had been introduced from Uttar Pradesh than from all other regions combined (Table 1), this single factor accounting for the predominance of infected seedlots from this state. The preponderance of collections (453/472, 97%) from northern India is significant, I believe, indicating a greater degree of Pisum adaptation and cultivation in this temperate region of the subcontinent. Wherever limited collections were made in the tropical south, however, at least 2 51 of the accessions were found to contain PSbMV. All nine accessions from Tamil Nadu, in SE India, contained PSbMV.

Origin of PSbMV-immune germplasm. Of 672 Pisum accessions introduced from India in 1969-70, 509 were tested for immunity by PSbMV-inoculation in 1979 (4), identifying 23 sources of immunity. Thereafter, the remaining 163 accessions were also tested, revealing another 12 accessions containing plants that were PSbMV-immune (neither approximately 300 commercial pea lines from developed countries nor 200 P.T. accessions from developed countries was found to contain PSbMV-immune germplasm). Whereas these accessions had originated from 2 1 countries, 34/35 accessions containing PSbMV-immune plants originated in India. Of these, 33/34 came from northern India, the majority from Uttar Pradesh (8 locations shown in Fig. 1). The remaining 1/34 from India came from Maharashtra (W. India). The only PSbMV-immune accession (1/35) originating outside of India came from Malaysia, an area into which immigrations from India occurred after 800 A.D.

Hypothesis. Thus, these investigations indicate that the geographic concentration of PSbMV inoculum and the coincidence of PSbMV-infected Pisum

seedlots and PSbMV-immune germplasm in northern India is a unique association, probably not occurring in any other region in the world. Notwithstanding the inadequacy of supplementary, definitive information, I hypothesize that northern India indeed represents an original epicenter of PSbMV from which the virus was disseminated to other parts of the world in infected Pisum seeds.

Properties of present PSbMV strains suggest that an acquired viral genetic ability to induce its transmission through host seeds would have greatly favored survival of the virus. For instance, there are no known non-Pisum, persistent inoculum-reservoir hosts of PSbMV from which disease spread (by aphids) could occur, i.e., the virus perennates exclusively in infected seeds. Without seedborne inoculum, therefore, survival of the virus would have been dependent upon spread from a continuous supply of infected annual host plants. The probability of occasional inoculum discontinuities, causing breaks in the disease cycle and loss of PSbMV, is substantial. This deficiency would have been further aggravated bv a very narrow host range, characteristic of present-day PSbMV strains. Survival of PSbMV in its center of origin, then, would certainly have been favored by seed-transmissibility in Pisum.

Development and proliferation of PSbMV-immune Pisum lines in northern India (genotype sbm.sbm) (5) suggests that in some cases PSbMV immunity conferred a yielding-ability advantage, compared to PSbMV-susceptible lines. Such lines likely would have been noticeable to aboriginal growers and could have been chosen for superior yields, without knowledge of cause. At the same time, other Pisum lines providing continuous seedborne inoculum may have tolerated infection and yielded satisfactorily despite the presence of PSbMV. Both mechanisms proceeding simultaneously would thus have accounted for the perpetuity of both PSbMV inoculum and PSbMV-immune lines, to the time of Pisum germplasm collections in 1969-70.

Discussion. The antiquity of peas in northern India must be regarded as relevant to the possible origin of PSbMV in that area. Centers of earliest old-world occurrence of Pisum are still partially and only generally defined (2, 6, 7). The general region of Afghanistan and India is proposed as an "Eastern subcenter" of earliest occurrence, with Iraqi Kurdistan, southern Turkey, and Ethiopia as a "Western subcenter". It is therefore conceivable that Pisum could have occurred naturally in northern India, in very early times. Ashraf (1) believes that if peas had been introduced into northern India, such introduction may have been as long as 1,200 years ago, and is currently searching ancient Sanskrit manuscripts for mention of pea-like plants. Peas could have been transported from Turkey or Kurdistan through Afghanistan to India via established trade routes in ancient times. However, knowledge of pea seeds in ancient trade is either non-existent or very obscure. There appear to have been no archeological investigations capable of indicating ancient food-use of peas in India, certainly nothing equivalent to those (3) suggesting food-use of peas in 7,000 BC in Iraqi Kurdistan.

Table 1. Record of all US Pisum plant introduction accessions reported to contain PSbMV-imniune plants (1971-1981).

Accession No.	Cit. No.[1/]	Origin[2/]	Notes
175877	2	Turkey	
193586	1	Ethiopia	
193835	1	Ethiopia	
244054	1	Yemen	Heterogeneous for gene sbm
269774	2	(England)	Origin unavailable (NA)
269818	2	(Russia)	Leningrad collection (NA)
314795	4	(Australia)	'12561' (NA)
343305	4	(Idaho)	'G-18318' (NA)
343328	4	(Idaho)	'G-18458' (NA)
343333	4	(Idaho)	'G-18463' (NA)
347328	4	U.P.[3/], India	
347329	3	U.P., India	
347422	4	U.P., India	
347442	4	Maharashtra, India	
347452	3	U.P., India	
347455	3	U.P., India	Heterogeneous for gene sbm
347456	3	U.P., India	Heterogeneous for gene sbm
347464	3,4	U.P., India	Heterogeneous for gene sbm
347466	4	U.P., India	
347467	3,4	U.P., India	Heterogeneous for gene sbm
347468	3	W.Bengal, India	
347469	3	U.P., India	
347470	3	U.P., India	
347482	4	U.P., India	
347484	3	U.P., India	Heterogeneous for gene sbm
347485	3	U.P., India	
347487	3	U.P., India	
347492	3,4	U.P., India	Heterogeneous for gene sbm
347494	3	U.P., India	
347523	3	U.P., India	
347528	4	U.P., India	
356984	3	U.P., India	
357003	3	U.P., India	
357005	4	U.P., India	
357015	3	U.P., India	
357023	3	U.P., India	Heterogeneous for gene sbm
357026	3	Bihar, India	
357038	3	U.P., India	
378158	3	Malaysia	

1/ P.I.'s reported in the following citations:

1. Plant Dis. Reptr. 55:408-410. 1971.
2. Plant Dis. Reptr. 56:131-132. 1972.
3. Plant Dis. Reptr. 63:95-99. 1979.
4. Pisum Newsletter 12:27-28. 1980.
5. Neth. J. PI. Path. 87:1-10. 1981.

2/ Of 39 Pisum accessions reported to contain PSbMV-immune germplasm, 36 had identifiable origins. The first four, introduced in 1949-57, came from the "Western subcenter" of Pisum origin; the remainder, introduced in 1969-70, were from the "Eastern subcenter".

3/ U.P. - Uttar Pradesh

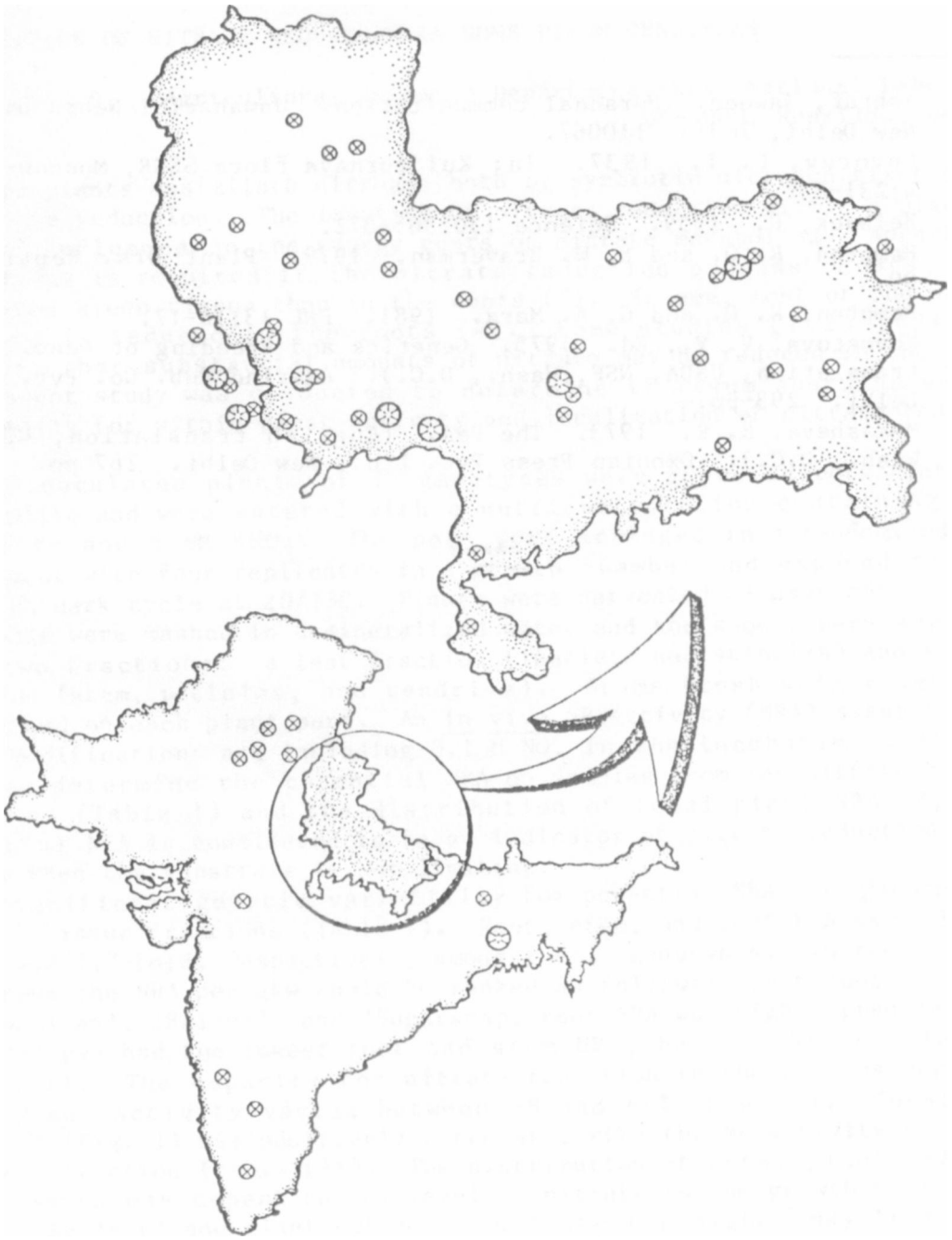

Fig. 1. Locations on the Indian subcontinent at which PSbMV-infected (small circles) and PSbMV-immune Pisum (large circles) germplasm originated. The state of Uttar Pradesh is shown in expanded scale. Adapted from ISBN 0 85152 637 3, 1:4,000,000 scale map.

1. Ashraf, Jaweed. Personal communication. Jawaharlal Nehru University, New Delhi, India 110067.
2. Govorov, L. I. 1937. In: Kul'turnaya flora SSSR, Moscow-Leningrad 4:231-336.
3. Helbaek, H. 1959. Science 130:365-372.
4. Hampton, R. 0. and S. W. Braverman. 1979. Plant Dis. Reptr. 63:95-99.
5. Hampton, R. 0. and G. A. Marx. 1981. PNL 13:16-17.
6. Khvostova, V. V., Ed. 1975. Genetics and Breeding of Peas. (English translation, USDA, NSF, Wash., D.C.). Amarind Pub. Co. Pvt. Ltd., New Delhi. 293 pp.
7. Makasheva, R. R. 1973. The Pea. (English translation, USDA, NSK, Wash., D.C.). Oxonian Press Pvt. Ltd., New Delhi. 267 pp.

*****