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Research article

Behavior

Cardamom Bushy Dwarf Virus Infection in Large Cardamom Alters Plant Selection Preference, Life Stages, and Fecundity of Aphid Vector, *Micromyzus kalimpongensis* (Hemiptera: Aphididae)

Amalendu Ghosh,[1] Amrita Das,[1] S. Vijayanandraj,[2] and Bikash Mandal[2,3]

[1]Indian Agricultural Research Institute, Regional Station, Kalimpong 734 301, West Bengal, India (amal4ento@gmail.com; amritapatho@gmail.com), [2]Advanced Centre for Plant Virology, Indian Agricultural Research Institute, New Delhi 110 012, India (aananda143@gmail.com; leafcurl@rediffmail.com), and [3]Corresponding author, e-mail: leafcurl@rediffmail.com

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Abstract

Cardamom bushy dwarf virus (CBDV) causes foorkey disease of large cardamom (*Ammomum subulatum* Roxburgh) in the eastern sub-Himalayan mountains. Although the aphid *Micromyzus kalimpongensis* Basu (Hemiptera: Aphididae) is known as a vector of CBDV, its behavior in dissemination of CBDV has not been investigated. In the present study, *M. kalimpongensis* was observed to colonize in higher number on CBDV-infected large cardamom plants compared with the healthy plants in the several plantations in Sikkim and Darjeeling hills. The affinity of *M. kalimpongensis* to the diseased large cardamom plants was further confirmed in a contained field experiment with intact plant as well as in a laboratory bioassay with the plant extract, where significantly higher number of aphids settled on the diseased plants or extracts compared with the healthy counterparts. Aphids grown on CBDV-infected large cardamom plants had shortened nymphal period and increased longevity and fecundity compared with those grown on the healthy plants. In the contained field experiment, *M. kalimpongensis* migrated to the CBDV-infected plants, colonized there, acquired CBDV, and once the diseased plants withered, migrated to healthy plants, which eventually became diseased. Our results suggest a general pattern of spread of CBDV by *M. kalimpongensis* where CBDV-infected plants attract or arrest and stimulate emergence and migration of viruliferous aphids that otherwise are sedentary in the underground plant parts of large cardamom. To our knowledge, this is the first study that shows the influence of a plant virus from the family *Nanoviridae* in altering behavior of its insect vector that favors its dissemination.

Key words: *Ammomum subulatum*, foorkey, CBDV, vector–virus–host interaction

Large cardamom (*Ammomum subulatum* Roxburgh, Zingiberales: Zingiberaceae) is a perennial plantation crop cultivated in the sub-Himalayan mountains. India is the largest producer and exporter of large cardamom in the world. Cultivation of large cardamom is affected by foorkey disease (Raychaudhuri and Chatterjee 1958), which is distributed in almost all the major large cardamom-growing areas of Sikkim and Darjeeling (Mandal 2010). The foorkey-affected large cardamom plants show profuse vegetative growth of excessively stunted tillers from the pseudorhizome. The diseased plant becomes sterile and unproductive. The virus associated with foorkey disease was initially identified as a new nanovirus, cardamom bushy dwarf virus (CBDV; Mandal et al. 2004). Subsequently, the genome characterization of CBDV established it as a new species under the genus *Babuvirus*, family *Nanoviridae* (Mandal et al. 2013).

An insect vector and virus sharing the same host influence each other in a variety of ways (Hammond and Hardy 1988, Stout et al. 2006). Viruses modify their hosts by inducing physical and chemical changes that influence the host selection behavior of vectors (Thaler et al. 1999, Hatcher et al. 2004) leading to enhanced transmission. This is widely known in animal pathosystems (Hurd 2003, Vyas et al. 2007, Lefèvre and Thomas 2008), where both host and vector are mobile. In the plant–virus pathosystem, most of the plant viruses depend on insect vectors for transmission from one host to another, where the host is immobile and the vector is mobile.

Aphid is one of the most important insect vectors of plant viruses spreading 50% of insect-transmitted plant viruses (Ng and Perry 2004). Virus is transmitted by aphids in a variety of ways: nonpersistent, semipersistent, and persistent-circulative manners (Ng and Perry, 2004). Mutualistic interactions between plant viruses