Solanum macrocarpon, a wild brinjal, is not a source of resistance against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee

Brinjal (eggplant, aubergine, *Solanum melongena* L.) is one of the important vegetables. However, its yield and marketable quality are severely affected by brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). There are no confirmed sources of resistance in the crop germplasm against this monophagous pest[1]. Conventional methods of management of BSFB, including chemical and biocontrol methods, have so far not been encouraging either. *Bt* transgenic technology has offered promise of sustainable management of BSFB in brinjal[2]. However, presently there is an indefinite moratorium on the commercial cultivation of *Bt* brinjal (and other GM food crops) in India. Therefore, it is important to systematically screen the brinjal germplasm for possible sources of genetic resistance against BSFB.

Many reports and reviews claim that some of the cultivated accessions of *S. melongena* possess resistance to BSFB[3–7]. A suggestion was made that selecting genotypes with higher glycoalkaloid (solasodine) content, total phenols and polyphenol oxidase activity would help improve resistance to BSFB infestation without affecting the yield potential[8]. *Solanum macrocarpon*, also called as African eggplant or gboma eggplant (syn. *S. integrifolium* Poiret var. *macrocarpum*, *S. melongena* L. var. *depressum* Bail.), has been contemplated to show resistance to BSFB. There are reports which indicate that wild brinjal species, including *S. macrocarpon* are resistant to BSFB[9–11]. While screening the brinjal germplasm for source of resistance to the BSFB, most breeders tend to grow accessions of wild brinjal species, including *S. macrocarpon* along with cultivated *S. melongena* accessions in screening plots. A major problem with this type of phenotypic screening is that *S. macrocarpon* usually does not get infested to the extent as that of *S. melongena.* The possible reasons are the comparatively thicker and exceptionally longer clasping calyx which covers most part of the fruit thus providing protection to the fruit, very hardy developing fruits which may make it extremely difficult for the larvae to scrap and bore into, and higher glycoalkaloid content[12]. Further, the ‘choice or no-choice’ options presented to BSFB indicates that it exercises the option of avoiding *S. macrocarpon* when abundant alternate choices are available in the form of more palatable cultivated *S. melongena* varieties. Wild species may also either lack volatile attractants or emit volatile repellents affecting host plant selection by adult insects. This type of apparent resistance is called non-preference or antixenosis, and is typically not an ideal resistance mechanism in crop improvement. When the preferred cultivated brinjal is available as a choice along with other wild species, BSFB tends to choose the cultivated varieties over the less edible wild forms. Hence data collected under such circumstances are unreliable unless resistance is proved through artificial inoculation. In reality, it is not known if *S. macrocarpon* is really resistant to BSFB.

There have also been attempts of interspecific hybridization between *S. melongena* and *S. macrocarpon* in trying to introgress the probable resistance gene(s), but the F1 progeny was fully sterile without any conclusive interpretations[13]. Another study analysed biochemical components that possibly provide resistance to BSFB, and reported that the phenol content was highest in the shoots and fruits of *S. macrocarpon* and therefore inferred that *S. macrocarpon* is resistant to BSFB[14]. Total phenol and total chlorophyll contents in round fruited varieties of *S. melongena* were found to influence BSFB incidence[15]. Interspecific hybridization in eggplant was attempted between *S. melongena* and *S. viarum* with the assumption that the latter may contain genetic resistance to BSFB[16]. Similarly, genotypes in the interspecific (F6 and backcross) progenies of *S. melongena* × *S. viarum* with a high or moderate level of various biochemical components such as glycoalkaloid solasodine, total phenol content and enzymes like peroxidase and polyphenol oxidase were found to suffer less from BSFB[17]. Cytogenetic analysis of the F1 hybrid between *S. incanum*, another wild species of brinjal and *S. melongena* var. American Wonder, was carried out with similar premise[18]. At our Institute also, breeding for resistance to BSFB using *S. macrocarpon* as a possible source is underway[19,20].

However, here we examine the veracity of resistance of *S. macrocarpon* to BSFB and conclusively show that *S. macrocarpon* is susceptible to BSFB and therefore cannot be utilized in the resistance breeding programmes. For developing cultures of BSFB, a method standardized in our laboratory was used[21,22]. Infested brinjal fruits were collected from field samples and cut open partially to ascertain the presence and active feeding of later instar larvae. The fruits were maintained on sand beds allowing the completion of the larval stages. Well-developed larvae come out of the bored fruits and entered the sand for pupation. Pupae were collected and maintained in insect cages till the emergence of adult moths. Male and female adult moths were immediately separated and each pair of male and female moth was placed in glass test tubes (8–10 cm diameter × 20 cm height) containing supported cotton swabs dipped in a feeding solution mix of honey, glucose, multivitamin and multimineral syrup and streptomycin. The tubes were covered with black cotton cloth to facilitate aeration and egg-laying. Eggs were collected and allowed to hatch naturally. Freshly hatched, first instar neonate larvae were used for challenge inoculation onto *S. melongena* and *S. macrocarpon* plants maintained in the insect-proof nethouses. Using fine camel hair brush, the larvae were transferred onto growing meristematic tips, leaf petiolar junctions and growing young fruits. Observations were recorded at timely intervals 3 days post-challenge inoculation. Any visible symptom like bored holes with/without extruding excreta, wilting and drooping of the apical shoot meristem, scraping of tissues and presence of actively feeding larvae and completion of their life cycle was taken as susceptibility to BSFB, while absence of these symptoms even after prolonged periods of more than 10 days was considered as the expression of resistance.

We found that *S. macrocarpon* was susceptible both in the open natural cultivation without insect challenge as well as insect challenge inoculation with BSFB

(Figure 1). BSFB was able to infect both the shoot meristem tips as well as developing fruits, suggesting that *S. macrocarpon* is vulnerable to BSFB in all stages. The extent of susceptibility, however, was more in the latter case. Also, larvae of BSFB were found to search for the fruit rather than the tougher calyx region when challenged onto the fruits per se. The first instar larvae completed all the stages before pupating in the soil. Since fruit is the economic part, any damage to it reduces its quality and marketability. Patterns and extent of infestation and damage on the affected parts were comparable in both *S. melongena* and *S. macrocarpon* (Table 1), indicating that *S. macrocarpon* is equally susceptible to infestation by BSFB.

In the past, screening for resistance to insect pests in general was undertaken separately and independently by breeders, germplasm curators, entomologists and biochemists[23,24]. While breeders simply evaluate extant germplasm for field resistance without challenge inoculations of BSFB, entomologists mainly study insect bionomics with limited access to a few varieties. Besides, rearing of BSFB under controlled conditions has been a challenge and therefore rarely BSFB cultures are developed and used by them. The present study attempts to address the issue of *S. macrocarpon* as a probable source of genetic resistance against BSFB by systematic screening under natural and artificial infestation. *S. macrocarpon* is extremely botanically variable. Interspecific crossability experiments involving many groups of *S. macrocarpon sensu stricto* may or may not produce fertile F1 and F2 hybrids. Besides, basis (morphological and biochemical) for resistance exhibited by *S. macrocarpon* towards BSFB may vary. Without initially understanding the basis of possible resistance mechanism, it is not prudent to straightaway use *S. macrocarpon* in breeding experiments. Besides, *S. macrocarpon* is also susceptible to a number of pests and diseases (http://database.prota.org/PROTAhtml/Solanum macrocarpon_EN.htm). It, therefore, is not useful for transferring the assumed genetic resistance to BSFB straightaway into cultivated brinjal cultivars as the linkage drag will be heavily biased in favour of a number of undesirable plant traits. To this end, this report examines the presence of genetic resistance in *S. macrocarpon* against BSFB through a systematic screening involving challenge inoculation with BSFB larvae and shows that *S. macrocarpon* is not an ideal candidate for resistance breeding as it is equally, if not more, susceptible to the pest. This study necessitates the need for rigorous screening of brinjal germplasm using artificial infestation with BSFB to avoid false positives in resistance breeding programmes.

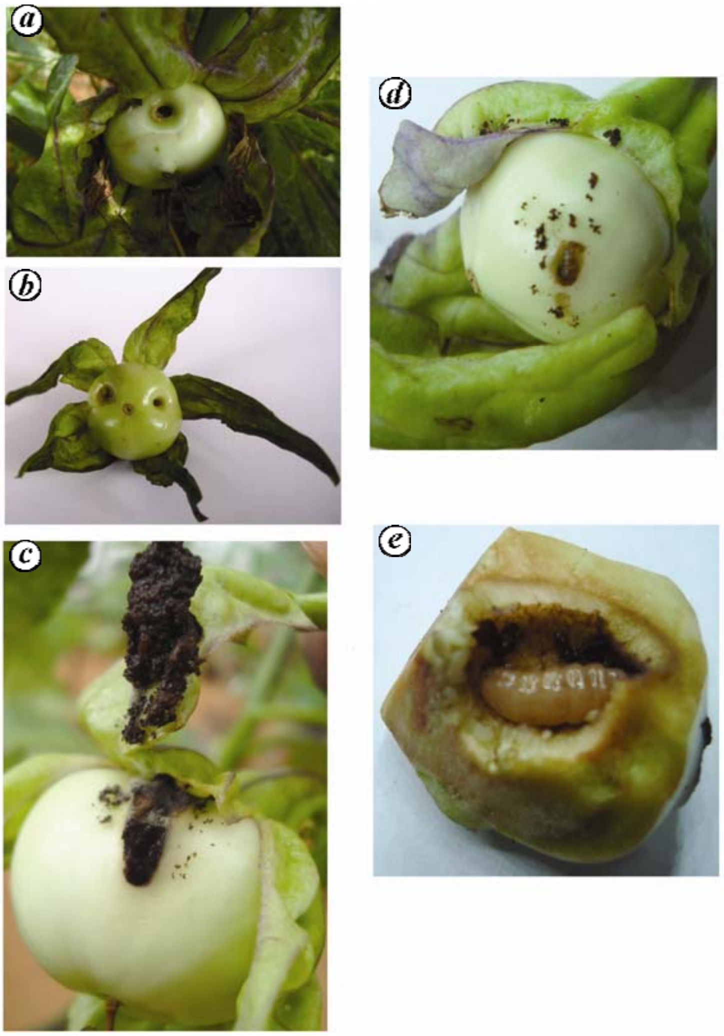

Figure 1. Extensive fruit damage on *Solanum macrocarpon* caused by brinjal shoot and fruit borer (BSFB). ***a***, ***b***, Natural infestation on single developing fruits; ***c***, Challenge inoculation with a single, first instar larva of BSFB showing extensive feeding as indicated by accumulated foecal debris; ***d***, Live, actively feeding third instar larva inside the fruit, and ***e***, Fruit cut open to show actively feeding and well-developed late instar larva.

Table 1. Evaluation of reaction of *Solanum macrocarpon* through natural and challenge inoculation infestion by brinjal shoot and fruit borer (BSFB)

Species (treatment)	No. of plants Tested (expected)	No. of plants that showed susceptibility (observed)	Susceptibility (%)	χ^2 test
Solanum melongena cv. Arka Keshav	50	50	100	0.18* (NS)
Solanum macrocarpon	50	47	94	

*Since calculated χ^2 value of 0.18 is less than the table χ^2 value of 3.841 for 1 degree of freedom, the difference in susceptibility between *S. melongena* and *S. macrocarpon* is non-significant (NS); therefore, both are equally susceptible to infestation by BSFB.

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VAGEESHBABU S. HANUR[1,*]
P. V. RAMI REDDY[2]
K. BOOPAL[1]
K. N. SRIVIDYA[1]
S. POOVARASAN[1]
SHRADDHA BHALEWAR[1]
M. S. SARASWATHI[1]

[1]*Division of Biotechnology, and*
[2]*Division of Plant Genetic Resources,*
Indian Institute of Horticultural Research,
Hesaraghatta Lake Post,
Bangalore 560 089, India
**For correspondence.*
e-mail: vageesh@iihr.ernet.in

Environmental significance of raised rann sediments along the margins of Khadir, Bhanjada and Kuar Bet islands in Great Rann of Kachchh, Western India

The harsh, inhospitable and difficult terrain of the Great Rann of Kachchh occupies almost half of the area of the seismically active Kachchh paleorift basin (Figure 1 *a*). Geomorphologically, the rann (meaning saline wasteland in local dialect) comprises a salt-encrusted flat expanse that is connected to the Arabian Sea to the west. The surface gets inundated by storm tides from the west and by annual monsoon precipitation while it presents itself as a dry, desolate, never-ending land devoid of life[1]. Historical accounts suggest that the rann was occupied by a shallow navigable sea[2]. This is also confirmed by the presence of several archaeological sites belonging to the Harappan civilization, including the port town of Dholavira located on the Khadir Island[3,4]. The upliftment of the rann surface and the subsequent drying up of the ranns are attributed to the recurrent seismic activity in the region[2,5–7]. Previous workers have described the Great Rann as ‘intriguing’ to ‘without any counterpart in the world’[1,8]. However, no precise data exist about the geological evolution and environmental conditions of the Great Rann so far. The present study is an attempt to delineate the Holocene environmental conditions in the Great Rann based on the study of raised rann sediments occurring along the margins of the tectonically active and fault-bound Khadir, Bhanjada and Kuar Bet islands.

The rocky islands form part of the E–W trending linear series of islands called the Island belt, with rugged hilly topography rising above the flat, salt-encrusted rann surface. The Island belt consists of four major islands, viz. the Pachcham, Khadir, Bela and Chorar, and smaller ones like the Bhanjada island to the west of Khadir and the Kuar Bet island to the northwest of Pachcham island (Figure 1 *b*, *c*). Each major island is a discrete tilt block that exposes south-dipping Mesozoic and Neogene marine sedimentary rocks[9]. All islands are characterized by steep, north-facing escarpments which mark the geomorphic expression of the E–W trending Island Belt Fault (IBF) that lies buried under the rann sediments further north[10]. Geomorphic studies show a strong control of structural set-up on the landscape of these islands, and active titling in the recent past based on the raised notches and other marine erosional features at the base of the escarpments has been suggested[11]. The raised rann sediments occur all around the fringes of the islands and gradually slope away from the islands to imperceptibly merge with the rann surface. However, incised vertical cliffs comprising these sediments are