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A review on the diversity of brinjal fruit and shoot borer, *Leucinodes orbonalis*

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Abstract
Brinjal, *Solanum melongena* L. of the family, Solanaceae is grown twice to thrice a year. It can give a good handsome amount of produce. It has good nutritious value and even used in traditional medicine. Several biotic and abiotic factors destroyed the plants and fruits of brinjal, thus, reducing a great size in yield. The diseases which affect the yield and destroy the brinjal are Cercospora leaf spot, Colletotrichum fruit rot, Damping off, Early blight, Phomopsis fruit rot and Powdery mildew. And the major insect pests which destroy the brinjal yields and plants are Shoot and fruit borer, Whitefly, Leafhopper, Stem borer, Brinjal hadda beetle, Brinjal lace wing bug, Stem borer, Aphid Brown leaf hopper and Ash weevils. Brinjal shoot and fruit borer, *Leucinodes orbonalis* is the most harmful and destructive pest for brinjal. Many strategies have been put forward for the management of Brinjal fruit and shoot borer. The several control measures include the use of chemical or bio control agents or conventional physical method (removal of affected terminal shoot and fruits, avoiding continuous cropping of brinjal). Another method is growing the varieties with long and narrow fruits in endemic areas. Installation of pheromone traps. However, in current context the problem is insecticides resistant Fruit and shoot borer (*Leucinodes orbonalis*) are existed. So, it is very important to study and analyze the genetic variability among different fruit and shoot borer populations. Various molecular markers are deployed to study the genetic diversity of *Leucinodes orbonalis*. Many studies revealed that there is significant variation among the *Leucinodes orbonalis* populations collected from different locations.

Keywords: brinjal, poor man's vegetable, *Leucinodes orbonalis*, low yield, genetic diversity, management

Introduction

Brinjal or eggplant (*Solanum melongena* L.) originated from India and it is one the popular vegetable crop in India. It belongs to the family, Solanaceae, it's plant is a bushy foliage and retains a height of about 60 to 95 cm. This vegetable is grown in various parts of the world; the tropical, sub-tropical, and warm temperate areas. In south Asian countires like Bangladesh, India and Pakistan, it is usually known as *brinjal*. In Europe, it is known as *aubergine*, in West Indies as *melongene*, in America as *guinea squash* and in Turkey, it is known *patlican* (Naeem and Ugur 2019) [16]. During 300 B.C. to 300 A.D. for the first time brinjal was recorded in India. Brinjal is being cultivated greatly in China, Bangladesh, India, Philippines and Pakistan. China is world largest producer of brinjal and India stands second (Vethamonai and Ravikesavan 2020) [20]. The annual production of brinjal in India is 13.55 million tones occupying an area of 0.71 million hectares which gives a productivity of 19.1 tons per hectare at an average (NHB, 2017). Brinjal is often term as poor man's vegetable due to high potential of productivity and it is available throughout the year and mostly grown and harvested twice or thrice a year. Brinjal is very nutritious in nature having rich source of minerals and it is used in the preparation of traditional medicine also.

Eggplant is one of top ten vegetables. It is one amongst the healthy food, it is low calorie food and has high phenolic content and with antioxidant activity. Brinjal contains calcium, iron, magnesium, minerals, vitamins and other phenolic components. Delphinidin-3-(coumaroyl-rutinoside)- 5-glucoside (or Nasrin) is present in eggplant peel (Matsuzoe *et al*. 1999) [14]. However, many biotic and abiotic factors are there which affect the yields of the brinjal and even cause the death of the plants. Some of the common diseases and their causal agents which affect the yield and destroy the brinjal are Cercospora leaf spot caused by *Cercospora melongenae*, Colletotrichum fruit rot caused by *Colletotrichum melongena*, Damping off caused by *Fusarium*, *Pythium spp*., *Rhizoctonia spp*., Early blight by *Alternaria tomatophilia*, Phomopsis fruit rot by *Phomopsis vexans*, Powdery mildew by *Leveillula taurica*, Verticillium wilt caused by *Verticillium* spp. and *Phytophthora blight* by *Phytophthora capsia* ((Anon n.d.-a)eggplant diseases and pests, plant village).

And some of the major insect pests which destroy the brinjal yields and plants are Shoot and fruit borer (*Leucinodes orbonalis*), Whitefly (*Bemisia tabaci*), Leafhopper, (*Amrasca devastans*), Stem borer (*Euzophera perticella*), Brinjal hadda beetle (*Epilachna vigintiocto punctata*), Brinjal lace wing bug (*Urentius hystricellus*), Stem borer (*Euzophera perticella*), Aphid (*Aphis gossypii*), Brown leaf hopper (*Cestius phycitis*), Ash weevils (*Myllocerus subfasciatus*, *Myllocerus discolor* and *Myllocerus viridanus*) and Brown leaf hopper (*Cestius phycitis*) (Anon n.d.-b; Devi 2021) [6]. Shoot and fruit borer pest, *Leucinodes orbonalis* (Lepidoptera: Pyralidae) is one of the most dangerous pest of brinjal destroying the plants and fruits. In the review paper, the damaged caused by Fruit and shoot borer to brinjal, Life cycle of *Leucinodes orbonalis* and its management are highlighted. There may be variations in the insect genome among the populations of different places. Different geographic populations have different activities against the insecticides and there arise different activities of resistant toward insecticides. Using of molecular marker in

analyzing the variation in genome and also for characterizing the resistant population has remained an effective technique. Kariyana *et al*. reported diversity within *Leucinodes. orbonalis* populations from diverse geographic locations across the world (Kariyanna *et al*. 2022) [10]. They reported no significant molecular diversity however there is a difference in the amino acid composition (Kariyanna *et al*. 2022) [10]. The present review paper presented the studies on Nutrient content and health benefits of brinjal and mainly focused on the study of genetic diversity of *Leucinodes orbonalis* using molecular markers.

Nutrient contents and Health Benefits of brinjal

Brinjal are rich in nutrients with dietary fiber and protein, minerals such as calcium, iron magnesium, manganese, and phosphorous and vitamins such as Vit. A,Vit. B complex, ascorbic acid, vit. E and vit K (Naeem and Ugur 2019) [16]. Eggplant has the complete set of vitamins, minerals, nutritional fiber, protein, bioactive compounds and good anti-oxidant activity (Noda *et al*. 2000; Whitaker and Stommel 2003) [17, 21]. A widely present compound in peel of eggplant is Nasrin or delphinidin- 3-(coumaroyl-rutinoside)-5-glucoside (Cassidy *et al*. 2013; Kwon, Apostolidis, and Shetty 2008; Matsubara *et al*. 2005; Matsuzoe *et al*. 1999) [5, 11, 13, 14]. The main phytochemicals present in brinjal are the phenolic components such as chlorogenic acid and caffeine, flavonoids (nasunin), glucoside and delphinidin (Cassidy *et al*. 2013; Kwon *et al*. 2008; Matsubara *et al*. 2005) [5, 11, 13]

The extracts of brinjal showed effects on the healing of burns, inflammatory infections, gastritis, warts, arthritis and stomatitis (Im *et al*. 2016) [7]. Various secondary metabolites are produced by brinjal which have significant qualities for good health. Some of them are chlorogenic acid (5-O-caffeoyl-quinic acid; CGA) and acts as an anti-inflammatory, anti-obesity, and anti-diabetic agent (J. Prohens *et al*. 2013; Plazas *et al*. 2013) [8, 18]. Chlorogenic acid has also reported to have cardio-protective functions (Plazas *et al*. 2013) [18] and showed anticarcinogenic functions by making apoptosis in leukemia and lung cancer cells (Tajik *et al*. 2017) [19]. Chlorogenic acid is reported to have antimicrobial activity against pathogenic bacteria such as *Bacillus subtilis, Bacillus cereus, Escherichia coli, Vibrio cholerae, Pseudomonas sp. and Staphylococcus aureus*, (Ahmed, Mubassara, and Sultana 2016) [2]. The brinjal extracts have also proved to have a extra toxic result on cancer cells other than the normal cells (Afshari *et al*. 2018) [1].

Fruit and shoot borer (*Leucinodes orbonalis*)

Fruit and shoot borer is caused by *Leucinodes orbonalis* (Lepidoptera: Pyralidae). The fruit and shoot borer is amongst the discussed disease of brinjal. It is one of most dangerous brinjal pests in South and Southeast Asia. It can reduce the yield of brinjal up to 70% in the Asian tropics (Devi 2021) [6]. The Shoot and fruit borer damaged the shoots of brinjal by about 16% and brinjal fruits by about 70% (Kar *et al*. 2021) [9].

Nature of damage caused by *Leucinodes orbonalis*

The newly hatched larva attacks the brinjal. Firstly, larva starts to drill on growing stage, flower buds or fruits. In the early vegetative phase of crop development, the larva eats tender shoots. The larva made an entry hole when it attacked and drilled the fruits. Then the hole is filled with excreta shortly. The larva makes tunnel in the shoot and feeds on the inner material. And then the larva excretes into the feeding tunnels, resulting in the withering of the plant (Devi 2021) [6].

Life cycle of *Leucinodes orbonalis*

Adult females lay eggs under the leaf tender shoots, flower buds or the base of developing fruits. The eggs are of about 200 creamy white eggs. Often the eggs are either singly or in groups of two to five. The eggs become red until hatching. Cycle of the egg cycle is 3 to 4 days. The larvae are creamy white to pink in color in their early stages. When matured, larvae have a blackish or dark brown head. The larva often has five instars and sometimes six. The period of larva is about 2 weeks in summer and in winter it is 3 weeks. The larva becomes pupa on the plant parts or plant debris on the soil surface (Devi 2021) [6]. The pupa has tough dark brown silken cocoons. The dorsum of the thorax and abdomen of the moth is pale brown or white along with black spots. The female has a bulged abdomen. They are usually bigger than males and live longer than males also. The abdomen of female moth curls upwards. The life span of adult moth is about a week and there are 5 overlapping generations in a year (Devi 2021) [6].

Management of *Leucinodes orbonalis*

There are several control measures for the management of fruit and shoot borer. They may be of chemical control or biocontrol or conventional physical method. Such as removal of affected terminal shoot and fruits showing boreholes and continuous cropping of brinjal crop should be avoided. Another method is growing the varieties with long and narrow fruits in endemic areas. Installation of pheromone traps at the rate of 12/hectares (Devi 2021) [6]. Activity of larval parasitoids (*Pristomerus testaceus*, *Cremastus flavoorbitalis*) should be encouraged (Devi 2021) [6]. By avoiding the application of synthetic pyrethroids and insecticides at the time of fruit maturation and harvest. Spraying of chemical insecticides (azadirachtin, chlorpyrifos, dimethoate, emamectin benzoate, flubendiamide, phosalone and quinalphos) starting from one month after planting at 15 days interval is also another control measure (Devi 2021) [6].

Diversity of Brinjal Fruit and shoot borer

Murarli *et al*. characterized the populations of *Leucinodes orbonalis* and investigated the genetic diversity in the entire region of Tamil Nadu, South India (Murali *et al*. 2021) [15]. During the study, 60 RAPD ten-mer primers were used and among them 10 ten primers generated reproducible and scorable banding profile. The primers (OPG 7, OPG 8, OPS 2 and OPS 7) delivered the highest genetic variation producing over 80% genetic polymorphism. Phylogenetic analysis showed eighteen clusters; 8 major and 10 minor clusters. Significant genetic variation among the populations was observed. This was confirmed by the results of analysis of molecular variance, cluster analysis, population structure and statistical fitness. During the RAPD analysis, a trait specific marker was obtained. The obtained molecular marker was cloned and sequenced, thus, developed a stable diagnostic SCAR marker. The SCAR marker so developed can be used for DNA fingerprinting to differentiate the populations.

The genetic variability among geographically confined populations of Fruit and shoot borer from 30 locations of Odisha was analysed using RAPD (Kar *et al*. 2021) [9]. They used Brinjal Fruit and shoot borer of thirty populations and twenty random RAPD primers were used for amplification. The PCR amplification obtained 118 bands by 10 primers and 116 were found to be polymorphic of which 13 were unique bands. Genetic similarity ranges from 0.37 to 0.93 among Fruit and shoot borer populations. With a mean of 0.65 specifying which indicated a significant genetic differentiation among the populations (Kar *et al*. 2021) [9].

Cytochrome C oxidase (COI) is widely used for the determination of genetic variations among populations of *Leucinodes orbonalis* of brinjal. Genetic diversity among the *Leucinodes orbonalis* populations from different geographic locations across the world was reported by Kariyanna *et al*. (Kariyanna *et al*. 2022) [10] No significant diversity within *Leucinodes orbonalis* populations was found but a difference in the amino acid composition was obtained. The phylogenetic tree from a maximum likelihood tree suggested different haplotypes cluster in a single clade of *Leucinodes orbonalis* populations collected from India and other countries of Southeast Asia.

The genetic diversity of *Leucinodes orbonalis* population was investigated to have a better understanding of pest management (Marimuthu *et al*. 2009) [12]. Different populations of *Leucinodes orbonalis* from different field locations of Tamilnadu, India were collected. During the study, out of the 17 RAPD primers used 11 primers delivered polymorphic bands. Two major clusters were obtained with no variation among population.

Discussion

Brinjal is an important vegetable crop which is agronomically and economically important. Many studies showed that brinjal has significant amount of vitamins, minerals, dietary fibers, protein and several bioactive compounds as well they have antioxidant activity and with pharmaceuticals and nutraceuticals compounds. The extracts of brinjal showed effects on the healing of burns and inflammatory infections (Im *et al*. 2016) [7]. Chlorogenic acid, a phytochemical from brinjal was found to have anti-inflammatory, anti-obesity, and anti-diabetic activitie (J. Prohens *et al*. 2013; Plazas *et al*. 2013) [8, 18]. Chlorogenic acid has also been reported to be have anticancer properties (Afshari *et al*. 2018; Tajik *et al*. 2017) [1, 19] and antibacterial activity also (Ahmed *et al*. 2016) [2].

Many insect pests destroyed the brinjal field causing a certain downfall in the yield. One such important pest which damaged the brinjal is Fruit and shoot borer, *Leucinodes orbonalis*. Several control strategies have been deployed for the management of Fruit and shoot borer, chemical insecticides as well as biocontrol agents. But there are cases that insecticides resistant Fruit and shoot borer existed. Therefore, various studies have reported on the genetic variability of Fruit and shoot borer population of different locations, these studies made a better understanding in the management of Fruit and shoot borer of brinjal. Significant genetic variation among the *Leucinodes orbonalis* populations was observed (Kar *et al*. 2021; Murali *et al*. 2021) [9, 15]. A difference in the amino acid composition was obtained within *Leucinodes orbonalis* populations (Kariyanna *et al*. 2022) [10]. A wide range of molecular variations in the genome of *Leucinodes orbonalis* from different geographic populations has been obtained. And also several insecticidal activities against insecticides are also observed not only this, case of resistant against several insecticides has been arisen. Thus, adoption of molecular marker method has been an effective tool in studying the genetic diversity of *Leucinodes orbonalis* of different populations and also for identifying and characterizing the insecticides resistant *Leucinodes orbonalis*.

Conclusion

Brinjal is of high productivity and known as poor man's vegetable. It contains minerals, vitamins, dietary fibre and other useful phytochemical. Many more studies are needed to be studied on brinjal regarding its phytochemicals analysis and their applications in pharmaceutical and food industries. However, the insect pest, Shoot and fruit borer is a constraint in production. Various studies on the molecular diversity on *Leucinodes orbonalis* populations grown in different locations are also required, which would help in establishing the management strategies of Fruit and shoot borer of brinjal.

Conflict of Interest

The authors declare no conflict of interest.

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