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Review Article

Evaluation of Resistance in Brinjal (*Solanum melongena* L.) against Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis* Guen.) Infestation: A Review

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Abstract

Brinjal or eggplant (*Solanum melongena L.)* is widely grown vegetable in South and South-East Asian countries. There are various factors that limits the production of brinjal among which brinjal shoot and fruit borer *(Leucinodes orbonalis* Guen) is the most common one which occurs during the time at all the phases of the crop development. The damage caused by shoot and fruit borer *(Leucinodes orbonalis* L.*)* in brinjal begins immediately after transplantation of crop and growers will have to harvest an immature crop. The life cycle of BSFB completes in 19-28 days. It is estimated by various specialists that increase in the number of shoots per plant will lower the attack rate of the pest. Round shape fruits are more susceptible compared to long bodied fruits. It is also examined that total sugar contents increase the attack while total phenol contents produce resistance to pest. The information of nature and relative extent of gene exploit (additive and non-additive) is of key importance in scheming appropriate and well-organized breeding plan for enhancement of resistance and crop yield. Physical and chemical features, for example, plant structure, fruit form, spines of leaves, branches, petioles, calyx of fruits, fruit skin thickness and shoot thickness, synthetic traits, for example, ash, crude fibre, silica, sugars, mineral ingredients, total phenol contents of fruit and shoot of brinjal are examined to be included towards the shoot and fruit borer resistance in brinjal.

Keywords: Eggplant; Brinjal Shoot and Fruit Borer; Resistant genotypes; Various traits producing resistance.

Introduction

Brinjal or eggplant (*Solanum melongena* L.*)* is widely cultivated and broadly developed in all South East Asian nations. It is protruding vegetable crop developed all through the tropical and sub-tropical locales of the world. A few biotic and abiotic factors are accounted for poor production of brinjal. Among the biotic factors that hinder the creation of brinjal, the shoot and fruit borer (*Leucinodes orbonalis* Guen.) is the most open one which arises during the time at all the phases of the crop development. The damage caused by this harmful pest was described to be about 30-70 per cent by different specialists.

Management of this pest by utilization of chemicals may diminish the pest assault to a higher level, however it causes unfriendly impacts on environment and human wellbeing. The production of brinjal in India is as low as 16.9 t/ha when

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compared with various countries. The basic reason behind high profit in various countries is the utilization of F1 hybrids. The hybrid power will be the most elevated in F1 crossovers which performs to build yield. Fusing high return and resistance/tolerance to shoot and fruit borer would be an appreciated tactic. Before starting any breeding program, one must have sufficiently inside data about the ways and means by which the resistance can be exploited. Though numerous researchers have announced screening of different germplasm of brinjal for resistance from shoot and fruit borer alongside the physical and chemical characters capable to borer assault; small work has been done to understand the heritable characteristics. A little contribution is made to search out the best mechanisms causing resistance to BSFB for protection of crops and gaining good yields.

Mode of Injury

The destruction caused by shoot and fruit borer *(Leucinodes orbonalis* G.*)* in brinjal begins soon after transplanting. The attack of the pest may occur at every stage and every part of the plant. The life cycle of this pest is 19-28 days. The eggs are laid separately on ventral surface of leaves, on flowering buds and infrequently on early fruits. In young plants, the caterpillars drill into petioles, midrib of leaves, early shoots and forage, subsequently, the influenced leaves dry furthermore, drop off. In some cases, the developing point is executed and plant will no longer continue the growth and development.

In later phase of crop development, the caterpillar drills into flower buds and fruits, making them completely unfit for utilization (Lal and Ahmed, 1965). Since the insect behaves as shoot borer in beginning times and fruit borer in later stages, higher occurrence of shoot infestation would typically prompt higher frequency of fruit invasion. (Panda *et al.*, 1971) watched comparative pattern in most 13 varieties screened. The infestation of *Leucinodes* was expected on aubergine in Bihar, India, during Kharif 1990-91. A larval population excreta, on products of various cultivars have seen from the fourth week of October to second week of December, still larval population on fruits were related with the most extreme and least temperature (Shah *et al*., 1995).

A lot of damage occurs because of *Leucinodes orbonalis* shifts from year to year and area to area. It is accounted for to be higher in Kharif when contrasted with summer season (Pawar *et al*., 1987; Krishnaiah and Vijay, 1975). The yield misfortune announced due to these insects are 30 to 70 percent. (La, 1964; Singh and Kalda, 1997; Mishra and Mishra, 1996; Kumar and Shukla, 2002).

Different Sources of Resistance

The wild types of Solanum Viz. *Solanum incanum* and *Solanum integrifolium* which were used as resistant sources and have been accounted for to be resistant to shoot and fruit borer by lots of research specialists. (Lal *et al.*, 1976) revealed that five wild types of brinjal viz., *S. sisymbrifolium*, *S. xanthocarpum*, *S. nigrum*, *S. khasianum and S. integrifolium* were constantly discovered resistant from shoot and fruit borer attack while *Solanum incanum* had 5.3 to 8.6 percent infestation between various years. The percentage injury on fruit weight evidence was more than that of fruit number evidence. (Kale *et al.*, 1986) likewise revealed that the wild types of *Solanum* were resistant to shoot and fruit borer invasion. Punjab Barsati, an early development aubergine cultivar showed 1.4 percent damage to fruit borer which was 84.8, 47.8 and 32.2 percent not exactly in Punjab Chumkila, R 34 and PPL, separately (Chadha and Sindhu, 1987).

Observations on occurrence of *L. orbonalis* in aubergine demonstrated that out of 150 tried SM 17-4, PBR 129-5 and Punjab Barasati were the safest (Singh *et al*., 1991). Mote (1979) in a field trial directed in Maharashtra, announced a base fruit invasion of 11.51 percent in Arka Kusumkar. Safe cultivars to *L. orbonalis* were examined by numerous researchers, for example, Pusa Purple Long (*Patel et al*., 1995), Pusa Purple Cluster-2 (Dhankar *et al.*, 1977) Anamalai and S-8 (Dhooria and Chadha, 1981), in Assam, Kuchia (Isahque and Chowdhery, 1984) in Bagladesh, Singnath Long (Ahmed *et al.*, 1985) in Haryana, PPC-2 and Aushey (Dhankar *et al.*, 1977) in Andhra Pradesh, SM-204 (Raju *et al.*, 1987) in Orisa, Pusa Purple Cluster (Das and Singh, 1990) in Maharashtra, PBR-120-5 (Darekar *et al.*, 1991) in Bihar, MHR, Kachbachia and Annapurna (Shah *et al.*, 1995) in Bangalore, Arka shirish and Neelam (Shrinivas and Peter, 1995) in Gujarat, PPL, PPC, Pusa Kranti (Patel *et al.*, 1995) in Pantnagar (Singh and Kalda, 1997) in Palampur, Himachal Pradesh, Arka Keshva, Pusa Anupam, Punjab Barasati, SM-6-7, SM 141, CHES-243 and DBL-V-4 were recognized as fairly resistant (Sharma *et al*., 2001). Yadav *et al.*, (2003) revealed that the PPC, Pusa Kranti, PPL, Neelam long, Black Beauty and BR-112 were minimum destructed cultivars to this pest. However, thought the number of cultivars tolerant to fruit and shoot borer have seen announced yet there was no reliability.

Dhankar *et al.*, (1977) arranged *S. sisymbrifolium* as tolerant to shoot and fruit borer in typical and ratoon crops. Baksha and Iqbal (1979) announced field resistance in *S. incanum, S. khasianum*, *S. macranthum and S. mammosum*. Kale *et al.*, (1986) detailed *S. incanum*, *S. xanthocarpun*, *S. khasianum and S. sisymbrifolium* to be impenetrable to shoot and fruit borer. Gangopadhyay *et al.*, (1996) detailed that *S. incanum* was resistant to shoot and fruit borer when contrasted with different species. Tejavathu *et al.*, (1991) detailed *S. gilo* and *S. manomalum* as resistant to *L. orbonalis*. Singh and Kalda (1997) in an investigation led at IARI, New Delhi, India, detailed *S. gilo* and *S. manomalum* to indicate high level of resistance from *L. orbonalis*. Since

S. gilo is perfect with *S. melongena* it can be utilized as a part of reproducing aubergines resistant to *L. orbonalis*.

Observations in Karnataka, India, affirmed resistance in *S. macrocarpum* with aubergine (Kumar and Sadashive, 1996). Behara and Singh (2002) revealed that interspecific hybrid can be used for exchange of shoot and fruit borer resistant genes and in addition other agronomically appealing attributes from the wild relatives to the cultivars of eggplant. Sharma *et al*., (2001) identified that the liens with $17F_1$ cross unaffectedly resistant to *L. orbonalis*. Shinde (2004) presumed that the cross *S. incanum* x Ruchira demonstrated guarantee for field resistance to shoot and fruit borer.

The susceptibility to shoot and fruit borer was devastating character in all F1's. The resistant genotypes had more number of fruits per plant, thicker fruit skin, little fruit shape, less fruit development, late fruiting and less shoot thickness when contrasted with susceptible genotypes in every one of the four crosses according to the mean implementation a character under examination. The resistant genotypes had brought down total sugars, nitrogen, potassium and zinc while higher total phenols, iron calcium, fibre, ash and silica in their fruits and shoots. These parameters may be in charge of producing resistance to shoot and fruit borer attack.

Hereditary Potentials of Different Characters

The information of nature and gene activity (additive and non-additive) is of prime significance in outlining proper and well-organized breeding programme for development of resistance and yield. The data on gene activity for shoot and fruit borer resistance in brinjal was exceptionally pitiful, in that capacity, a number of researchers have taken a shot at this angle and which is evaluated beneath.

Singh and Kalda (1997) announced that the frequency of infestation in brinjal varieties from 30.5 to 39.9 percent and in this way, reasoned susceptibility to *L. orbonalis* is a predominant character in brinjal. Dhankar *et al.,* (1979) assessed four hybrids and their six parents, which contrasted in resistance from *L. orbonalis* and yield potential, for 12 yield related characteristics and 9 susceptibility characters. The hybrids BR-103 x White long and BR-112 x Aushey gave positive heterosis for attractive yield and resistance. The weakness of hybrids acquired by intersection two tolerant composes (PPL and Aushey) recommended that more than one recessive gene was in charge of controlling resistance to *L. orbonalis*. Dahiya *et al.*, (1985) tested a best cross including 10 lines and 4 testers, the difference because of gca of females and males and sca of crosses were highly significance for character viz., loss of yield, damaged fruits, pervaded branches, dry tissues and total sugar contents of fruits. The parents of Annamalai and PPC-2 were best broad combiners for a large portion of the characters. The investigation of sca impacts has demonstrated that crosses with tolerant x tolerant and tolerant x susceptible parents will be better in the hybridization program for acquiring attractive isolates. Governance gene action has been accounted for to represent plant spread (Bajpai, 1977). Vijaygopal and Sethumadhavan (1973) announced that erect kind plants were devastating over spreading type and the plant spread is polygenetic controlled. Purple shading is predominant over green (Khand and Ramjan, 1954; Swamy, 1970; Choudhary, 1972; More and Patil, 1982; Gopinath *et al.*, (1986).

Articulation of fruit shading is monogenic (Choudhary, 1972; More and Patil, 1982; Patil and then some, 1983; Swamy, 1970) while Thakur *et al*., (1969) announced two genes in supplement activity to express fruit shading and Khapre *et al.*, (1985) announced that connection of 3 non-allelic genes are in charge of shading articulation. The inheritance of fruit shading was observed to be controlled by two prevailing complimentary variables P and D (Thakur *et al.*, 1968). Swamy (1970) announced that extended fruit shape was immense over oval.

Patil and More (1983) detailed three genes while Nimbalkar and More (1980) watched four for fruit shape. Dharmagowda (1979) revealed over predominance gene activity for typical fruit weight. Nagai and Kida (1926) revealed predominance of spines on fruit stalks of brinjal. Rangaswamy and Sundaran (1973) announced that appearance of spines is monogenic as additionally detailed by (Khan and Ramzan, 1954) while Sinha *et al.,* (1966) watched that inheritance of spines was digenic and clarified it based on duplicate of predominant gene activity.

Additive gene activity represented the appearance of fruit weight (Peter and Singh, 1973; Singh *et al.*, 1979; Sindhu *et al.*, 1980; Dixit *et al*., 1984; Singh and Mittal, 1988). Fruit diameter was administered by both additive and non-additive gene activity (Singh and Mittal, 1988) fruit border has been accounted for to be represented by the added gene activity (Dixit *et al.,* 1984). Ingale and Patil (1997) announced non-grouped fruiting to be prevailing over bunched fruiting and proposed that the four correlative genes were included. They additionally revealed that purple pigmentation and occurrence of pubescence were prevailing over green shading and absence of pubescence. Isolation investigation showed that the purple colouring was measured by four genes and occurrence of pubescence on the pedicel was controlled by three and four integral genes in the fruit and flower, respectively. Inheritance of yield in *S. melongena* was planned where in fruit yield and fruits/plant indicated negative dominance impacts. Duplicate epistasis was noted for these characters (Chadha and Sharma, 1989).

Most characters were administered by both additive and non-additive gene impacts, proposing that a breeding technique including biparental mating and reciprocal recurrent selection would be the most reasonable (Chadha and Sharma, 1991). Additive gene activity has been accounted for to administer inheritance of yield contributing characters in brinjal (Gill *et al*., 1976; Sharma, 1985; Madalageri *et al.,* 1986; Naulsri *et al.,* 1986; Ranhawa, 1987; Kumar and Ram, 1997). Non-additive gene activity has been observed by Padmanabham and (Jagadish 1996). Additive gene activity administered the normal fruit weight (Singh *et al*., 1982; Dixit *et al.*, 1984; Mittal *et al*., 1976; Peter and Singh, 1973; Salehuzzaman and Alam, 1983) while Dharmagowda (1979) announced both additive and prevailing gene activity for the normal fruit weight. Kathiria *et al.* (1998) discovered both additive and non-additive segments were vital for fruit weight. Additive gene activity has been examined to supervise number of fruits per plant (Gill *et al.*, 1976; Singh *et al.*, 1979; Salehuzzaman and Alam, 1983; Randhawa, 1987; Singh and Mittal, 1988; Chadha and Sharma, 1991). Dixit *et al.* (1984) detailed inheritance of number of fruits per plant to be represented by both additive and non-additive gene activity. Shinde (2006) announced that the epistatic parts were engaged with the occurrence of the majority of the chemical characters in brinjal fruits. Both additive and non-additive gene impacts ought to be exploited by utilizing various breeding tactics and back crosses with the genotypes having low sugars, phenols, nitrogen and silica levels in brinjal fruits.

Shinde (2007) detailed that the additive, predominance epistasis and gene impacts was vital for the vast majority of the characters in brinjal shoots. It should require to be explored these genetic impacts through various breeding tactics and back intersection with the genotypes having higher crude fibre, ash and silica levels in brinjal shoots.

Shinde *et al.* (2009) expected the nature and scale of gene activity in six progenies mean for resistance from shoot and fruit borer related characters in four crosses in brinjal. Study showed that extent of predominance affected was higher for all the characters with the exception of percent infected shoots, fruit length, pedicel length, days to 50 percent blooming and fruit skin thickness. Epistatic part additive x additive, and predominance x predominance was engaged with the occurrence of the majority of the characters. Replacement form of epistasis was watched for most the crosses.

Physical and Chemical Traits Accountable for Resistance

Physical and chemical ingredients of the plants are known to imply resistance against pests and diseases. Physical and chemical characteristics, for example, plant structure, fruit shape, spines of leaves, branches, petioles, calyx of fruits, fruit skin thickness and shoot thickness, synthetic traits, for example, ash, rough fibre, silica, sugars, mineral substance, overall phenol contents of fruits and shoots of brinjal are accounted for to be included towards the shoot and fruit borer resistance in brinjal. Krishnaiah and Vijay (1975) revealed that the lower susceptibility of cultivars to borer injury was may be because of hardness of the fruit skin. Lal *et al.,* (1976) inferred that the resistant varieties had firmly settled seeds in the mesocarp of the fruit. Kale *et al.*, (1986) revealed that wild sorts and resistant cultivars were of thick pubescent write, having relatively more number of trichomes. These cultivars had pretty much tight calyx, however fruit skin, more seediness and highly organized seeds in mesocarp of the fruits. Comparative discoveries were likewise announced by (Sharma *et al.,* 2001).

Bhutani *et al*. (1977) & Isahaque and Choudhary, (1984) suggested that the plants with better spread, more stature, long and slim fruits were less vulnerable to *L. orbonalis* than those with less spread and dwarf structure. The number of shoots per plant assumed a criticalness part in diminishing percent shoot damage. Pradhan (1966) watched that long thin fruited brinjal cultivars were less damaged than circular fruited as the larvae bore more effectively in round fruits than long fruits. Grewal *et al.,* (1995) credited resistance of cv. SM-17-4, PPC and brinjal green long to long or additional more extended fruits with thin pericarp. Mote (1979) recorded fruit skin thickness in some chose varieties alongside prone check yet couldn't build up any association with larval access, anyhow, Patil and Ajri (1993) watched that tough brinjal were less prone to *L. orbonalis*, as it limits the larval passage. Singh *et al*., (1991) announced that resistance of SM- 17-4, PBR 129-5 and Punjab Barasati was credited to little estimated fruits per plant with shorter inter or intra-cluster distance. Kumar and Ram (1998) subsequent to screening 40 brinjal accessions for resistance from shoot and fruit borer, announced that fruit diameter and fruit volume were suitable criteria for selection of resistance/tolerance of aubergines to *L. orbonalis*.

Panda (1999) detailed that outbreak of *L. orbonalis* on brinjal fruits was limited by firmly pressed seeds in the mesocarp. He additionally found that cultivars having fruits with loose calyx were more prone to fruit borer than those having fruits with tight calyx. Dahiya *et al.*, (1985) credited the tolerance of PPC-2 to thistles on plant or little and hard fruits while Annamalai to thickly pubescent leaves. Gangopadhyay *et al.* (1996) separated 27 germplasms and two wild types of brinjal and detailed that resistance was not given by any single character like spineless, shape and size of fruits or settlement of seeds. Panda *et al*., (1971) detailed that resistant varieties like H. 408, Black Pendy and Thorn Pendy recorded higher yield than susceptible cultivars and displayed higher yield potential than susceptible cultivars.

Singh *et al.* (1991) revealed that the resistance was credited to a considerable number of little diameter fruits per plant with shorter inter-cluster distance, late bear fruit and longer fruiting period. The shoot injury was additionally managed by the number of shoots per plant. In the event that there were considerable number of shoots at that point there was less damage. Sridhar *et al.* (2001) announced that three wild types of brinjal viz., *S. khasianum, S. viarum and S. incanum* were observed to be resistant to fruit invasion (0.5 to 10.0 %). More, it was watched that in genotypes with comparatively long fruits and firmly arranged seeds, the incidence of this pest was less. Among the cultured lines, CHB-103, CHB-187 and 259 were distinguished as genuinely safe cultivars under Bhubaneshwar (Orrisa) conditions. Ghosh and Senapati (2001) reasoned that the PK-123 and Pant cultivars of brinjal were slightest susceptible to *L. orbonalis* because of their generally intense skin, hard to semi-hard mash and tight to semi-tight settlement of seeds, though Pusa Purple Long and Pundiburi were most susceptible cultivars because of their thin, long fruits, delicate fruit skin and mash and inexactly composed seeds.

Sharma *et al.* (2001) detailed that Arka Keshva was discovered resistant to this pest. It was watched that incidence of *L. orbonalis* was moderately less in the genotype having less fruits with firmly arranged seeds in the mesocarp. Shinde *et al.* (2009) announced that the relationship ponders with physical character uncovered that the percent invaded fruits had remarkable positive relationship with percent damaged fruit weight, mean fruit weight, fruit length, calyx length and fruit development. The percent pervaded shoots had critical positive relationship with shoot thickness.

Scientists have since quite a while ago perceived the specificity of insects for plants, various types of insects react differentially to different supplementary chemicals happening in plants. Of the expression of plant resistance that are chemicals, the supposed auxiliary plant chemicals have all the earmarks of being prevailing. Normally they alter or control insect development, improvement and propagation, yet others, for example, anti-feedants change behaviour. As hereditary examinations turn out to be more refined, the biosynthesis of resistance metabolites will be speed up (Heden, 1982).

Panda and Das (1975) watched that higher silica and crude fibre in the shoots of resistant varieties. They additionally watched that higher ash and less sugars in resistant varieties. Resistant cultivars had around 20 percent ash in fruits while susceptible cultivars recorded 11.8 percent. Darekar *et al.* (1991) and Isahaque and Chodhary (1984) detailed lower contents of tatal sugars in resistant brinjal varieties when contrasted with vulnerable assortments. Raju *et al.* (1987) discovered less protein content determined as total nitrogen in fruits of modestly resistant cultivar SM 204 than in the susceptible check SM-82. They additionally watched that low N, K and Zn and high measures of P, Ca, Fe, Mn, Cu and phenols were involved with the modest resistance of assortments to the shoot and fruit borer. They likewise watched higher zinc content in susceptible varieties.

Bajaj *et al.* (1989) revealed that phenolic composites might be in charge of resistance from assault by *L. orbonalis* in brinjal cultivar SM-17-4. Panda and Das (1975) revealed that higher silica content presented resistance in plants against *L. orbonalis*. Panda (1999) exposed that little potassium and high phosphorus content contributed towards resistance response. He likewise detailed that low level of nitrogen limits the incidance of *L. orbonalis*. Darekar *et al.* (1991) announced lower polyphenol content in susceptible cultivars and higher content in resistant ones. Jat and Pareek (2003) detailed that the biochemical characters, for example, total sugars, free amino acids and protein were absolutely revised with fruit borer pervasion while total phenols and negative correlation. Shinde *et al.* (2009) revealed in relationship get ahead that the percent fruit invasion had huge positive relationship with total sugars, potassium where as critical positive relationship with total sugars, potassium whereas remarkable negative connection with total phenols, copper, manganese, calcium and ash. The per cent shoot pervasion had huge positive correlation with phosphorus, iron, magnesium, calcium crude fibre, ash and silica.

Conclusion

Apart from chemicals and other unsafe methods which were utilized for the prevention and control of *Leucinodes orbonelis*, it is necessary to use pest resistant cultivars which are screened by many scientists, researchers, organisations and institutions for the management of pest attack. Many other tactics can also be enhancing like cultural control, physical traps, and natural enemies are the best and environment friendly sources of pest control. It is recommended while choosing genotypes for shoot and fruit borer, aside from their execution in light of per cent, heterosis and relationship of morphological, physical characters due thought may likewise be given on content of each biochemical parameters in fruits and shoots of brinjal. These characters might be well-thought-out while choosing the genotypes for facilitate change in brinjal in connection to resistance from *Leucinodes orbonalis* Guen. While selecting the cultivars for sowing, above mentioned traits and genotypes of brinjal should be kept in mind.

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