The Bioscan 11(4): 2721-2726, 2016 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

ROLE OF ABIOTIC FACTORS IN THE INCIDENCE OF FRUIT AND SHOOT BORER (*LEUCINODES ORBONALIS)* GUENEE IN EGGPLANT (*SOLANUM MELONGENA* L.)

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KEYWORDS
Brinjal
Screening
Resistance breeding
Abiotic factor

Received on :
08.10.2016

Accepted on :
13.11.2016

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ABSTRACT

Eggplant (*Solanum melongena* L.) is an important vegetable crop grown in various tropical and temperate parts of the world. Cultivated varieties of eggplant are susceptible to a wide array of biotic and abiotic stress conditions. Fruit and shoot borer (FSB) is the most serious pest leading the yield loses to the tune of 70-80%. Non availability of resistant source in the cultivated germplasm is major bottleneck in the resistance breeding programme for FSB. Keeping this in view 22 indigenous genotypes acquired from NBPGR were screened for FSB resistance and it was observed that none of the genotypes were resistant to FSB infestation. Maximum fruit infestation (78.45%) was recorded in 25th July, 2013 with 33.6°C temperature and 85% Relative Humidity. While, minimum infestation was recorded in 27th June, 2013 *i.e.* 36.84% with 34.9°C temperature and 74% Relative Humidity. Maximum fruit borer incidence was observed in case of genotype IC 099736 with fruit borer infestation of 74.87% and minimum fruit borer infestation 36.34% was observed in case of genotyope IC 099680. Correlation between meteorological parameters and FSB infection revealed their positive correlation with Minimum temperature (r = 0.57) and maximum temperature (r = 0.49) and rainfall (0.56).

INTRODUCTION

Eggplant (*Solanum melongena* L.) is an important vegetable crop grown in various tropical and temperate parts of the world. Brinjal (*Solanum melongena* Linn.) is one of the most popular vegetable crops grown round the year in most of the parts of India and finds its place as the poor man's vegetable in Indian curries. India produces almost thirteen per cent of world's vegetable output occupying second position in brinjal production. There is a wide genetic diversity in the cultivated as well as the wild species of eggplant. Cultivated varieties of eggplant are susceptible to a wide array of pests and pathogens as well as to various abiotic stress conditions. In contrast, the majority of wild species are resistant to nearly all known pests and pathogens of eggplant and thereby are a source of desirable traits for crop improvement. Among the biotic stress factors that hamper the production of brinjal, the shoot and fruit borer (Leucinodes orbonalis Guen.) is the most serious one, which occurs throughout the year at all the stages of crop growth. The percentage of fruit damage due to this pest was reported to vary from 25.82 to as high as 92.50 (Atwal and Verma, 1972; Gangwar and Sachan, 1981) and yield reduction was as high as 20.70 per cent (Peswani and Lal, 1964). Varieties or hybrids that are inherently resistant to shoot and fruit borer has the potential to improve the marketable yield and enhance economic returns of the poor farmers. The major bottleneck in the resistance breeding programme for shoot and fruit borer is the lack of resistant source in the cultivated germplasm. This has necessitated brinjal breeders to look for the resistance sources. Pest abundance and distribution changes with abiotic factors and therefore meteorological parameters play a pivotal role in the biology of any pest. Temperature is the most crucial abiotic factor influencing the rate of growth and development of insect and is especially important for insect as pests control measures must be timed carefully to be effective. However, relative humidity, rainfall, wind speed and temperature are the chief weather parameters that largely direct the activity of a given insect. The interaction between pest activity and abiotic factors helps in deriving at predictive models that aids in forecast of pest incidence (Mathur *et al.*, 2012). Keeping in view the importance of insect and its interaction with abiotic factors, the present investigation was planned.

MATERIALS AND METHODS

The experiment was conducted in randomized block design using 22 indegenous genotyopes of brinjal *viz.*, IC 104101, IC 316232, , IC 249374, IC 343145, IC 354611, IC 261836, IC 099736, IC 203585, IC 261888, IC 090126, IC 099665, IC 099680, IC 354612, IC 261767, IC 261828, IC 249357, IC 316223, IC 310886, IC 261797, IC 261249, IC 305129 and IC 090958 with three replication at Vegetable Research Farm, SKUAST-Jammu, Chatha during the period of March, 2013 to August, 2013. The experimental farm is situated at 33º 552 N latitude and 74º 582 E longitude at an elevation of

332 m above mean sea level. The place experiences hot dry summers, hot and humid rainy season and cool winters. Agro climatically, the location represents zone V of Jammu and Kashmir and is characterized by subtropical climate. The seedlings were raised on raised seed bed. The sandy loam soil was ploughed twice, with the second plowing perpendicular to the first. Prior to planting, 20 Mt·ha-1 of cow manure was applied. At the time of transplanting plant establishment a combined N:P:K synthetic fertilizer (100:60: 50 kg·ha-1) was applied with one-third of the N and all the P and K applied at time of land preperation. The remaining N was applied in two top dressings at hoeings. The seedlings were transplanted on 15th March, 2013 with spacing of 60X 45 cm *i.e.* 60 cm line to line and 45 cm plant to plant. Irrigation and other cultural practices were followed as per package of practices to raise healthy plants. Infestation of FSB to the shoots and fruits was monitored weekly after establishment of the plant in the field and continued to the last harvest of the brinjal fruits. Shoot damage was recorded by counting the infested shoots from 5 randomly selected plants. Percentage of shoot damage was calculated from damaged and healthy shoots. The number of infested and healthy brinjal fruits per plot were recorded at each harvest. The percentage of infestation by number was calculated using the number of infested and total brinjal. At each count the affected shoots and fruits were removed and harvested. Incidence of BSFB in different months was calculated from the pooled weekly data. The correlations between seasonal incidence and environmental factors such as temperature, humidity and rainfall were determined. Similar method of calculation FSB incidence and its correlation with abiotic factors was done by earlier workers Mathur *et al.*, 2012; Mannan *et al.*, 2015. Grades (1- Immune - 0% fruit infestation; 2- Highly resistant - 1-10% fruit infestation; 3-Moderately resistant - 11-20; 4-Tolerant - 21-30; 5-Susceptible - 31-40; 6-Highly susceptible – above 40) were also assigned for the fruit damage based on the rating given by Mishra *et al.* (1988).The percentage infestation by number was calculated and the data were statistically analyzed and means were separated by Gomez and Gomez (1984). The Data related to meteorological parameters (minimum and maximum temperature, relative humidity and rainfall) during the period of experiment was obtained from Agro-meterological Department of SKUAST-Jammu Table 3. Simple correlation (r) between the meteorological parameters (minimum and maximum temperature, relative humidity and rainfall) and incidence of fruit infestation and shoot borer infestation were calculated.

RESULTS AND DISCUSSION

In the present study the 22 different indigenous lines were screened against fruit and shoot borer infestation and it was observed that none of the genotypes were resistant to fruit and shoot borer infestation. However, resistant to this pest has been reported either in wild species of brinjal like *Solanum khasianum* (Lal *et al.*, 1976) and *S. anomalum* and *S. incanum* (Behera *et al.*, 1999) or in the derivatives of wild species like Arka Mahima and Arka Sanjivans (Kale et *al.*,1986)

Fruit borer infestation

The data in (Table 1) depicted that infestation of brinjal fruit remained fluctuating through the period under study. However percent fruit infestation increased from 27th June, 2013 to 25th July, 2013 with a range of (36.84% to 78.45%)The maximum 78.45% fruit infestation was recorded in 25th July, 2013 with 33.6°C temprature and 85% Relative Humidity. Simmilarly, minimum infestation was recorded in 27th June, 2013 *i.e.* 36.84% with 34.9°C temprature and 74% Relative Humidity. Among genotypes maximum fruit borer incidence was observed in case of genotype IC 099736 with fruit borer infestation of 74.87% this was followed by genotype IC 354611 with fruit borer infestation of 70.10%. Minimum fruit borer infestation was observed in case of genotyope IC 099680 (34.53%) followed by genotype IC 261249 (36.34%). During

Table 1: Incidence of Fruit Borer Infestation among IC lines of Brinjal during 2013

Genotypes	6th June	13th June	20th June	27th June	4th July	11th July	18th July	25th July	1st August	8th August	15th August	22th August	29th August	Average
IC 099680	12.5	44.44	29.17	38.89	60	77.78	25	33.33	33.33	44.44	16.67	0	33.33	34.53
IC 090958	33.33	19.05	38.89	23.33	50	50	88.89	75	88.89	66.67	72.22	50	60	55.1
IC 261767	53.33	50	26.67	38.1	38.1	42.86	61.11	100	88.89	77.78	60	33.33	33.33	54.11
IC 249357	66.67	58.33	45.45	40.74	45.83	72.22	86.67	66.67	58.33	66.67	77.78	47.62	33.33	58.95
IC 316223	60	70.37	44.44	42.42	33.33	66.67	33.33	77.78	66.67	38.89	62.5	66.67	40	54.08
IC 310886	52.38	30	40	38.89	43.33	33.33	53.33	100	83.33	66.67	11.11	0	40	45.57
IC 261836	50	42.86	29.63	14.58	46.67	14.29	33.33	66.67	66.67	77.78	27.78	16.67	11.11	38.31
IC 104101	33.33	50	29.17	20.51	33.33	40	33.33	16.67	66.67	75	40	40	40	39.85
IC 099736	100	68.89	79.17	84.85	79.17	100	80	86.11	81.82	75	40	40	58.33	74.87
IC 203585	38.89	42.86	27.27	33.33	75	75	45.83	80	33.33	88.89	40	33.33	20	48.75
IC090126	38.1	55.56	26.67	19.05	52.38	53.33	28.57	100	66.67	77.78	16.67	38.89	20	45.67
IC099665	45.83	48.15	57.14	36.11	59.26	50	33.33	100	11.11	33.33	33.33	0	33.33	41.61
IC 354611	66.67	70.37	37.25	54.55	53.33	76.19	90.48	86.67	77.78	80	88.89	62.5	66.67	70.1
IC 316232	59.26	43.33	33.33	40	39.39	83.33	60	77.78	100	86.67	50	48.15	55.56	59.75
IC 261828	59.26	44.44	53.33	31.11	33.33	80	80	83.33	100	93.33	55.56	51.85	40.74	62.02
IC354612	29.63	25.64	44.44	55.56	40.48	66.67	75	75	75	72.22	50	83.33	33.33	55.87
IC 305129	33.33	33.33	33.33	52.38	22.22	66.67	77.78	87.5	77.78	66.67	66.67	74.07	50	57.06
IC 261249	13.33	18.18	23.33	14.29	51.85	44.44	33.33	100	50	33.33	44.44	33.33	12.5	36.34
IC 249374	36.11	44.44	33.33	30.3	45.83	80	50	88.89	73.33	66.67	66.67	50	40	54.28
IC 261797	22.22	33.33	36.67	33.33	42.86	66.67	88.89	85.71	75	100	62.96	85.71	50	60.26
IC 343145	27.27	36.67	30	38.89	53.33	52.38	100	88.89	50	66.67	50	25	22.22	49.33
IC 261888	23.33	23.33	50	29.17	33.33	100	100	50	33.33	33.33	33.33	0	22.22	40.88
Average	43.4	43.34	38.58	36.84	46.93	63.26	61.74	78.45	66.27	67.63	48.48	40.02	37.09	51.69

Table 2: Incidence of Shoot Borer Infestation among IC lines of Brinjal during 2013

shoot incidence	6th June	13th June	20th June	27th June	4th July	11th July	18th July	25th July	1st August	8th August	15th August	22th August	29th August	Average
IC 099680	46.67	46.67	60	13.33	20	0	0	20	20	20	13.33	20	6.67	22.05
IC 090958	60	26.67	0	20	40	26.67	40	60	60	60	60	20	20	37.95
IC 261767	66.67	60	46.67	40	80	26.67	40	40	53.33	46.67	40	20	13.33	44.1
IC 249357	80	53.33	46.67	80	40	66.67	20	40	80	66.67	73.33	66.67	33.33	57.44
IC 316223	86.67	46.67	40	20	53.33	6.67	40	60	80	46.67	60	6.67	13.33	43.08
IC 310886	46.67	40	40	0	20	26.67	20	0	0	0	0	0	0	14.87
IC 261836	73.33	46.67	60	46.67	40	20	60	80	53.33	40	20	20	6.67	43.59
IC 104101	46.67	46.67	60	20	46.67	40	40	66.67	53.33	53.33	40	60	60	48.72
IC 099736	100	73.33	53.33	80	40	33.33	66.67	60	40	40	40	53.33	26.67	54.36
IC 203585	53.33	60	80	60	26.67	20	13.33	0	40	26.67	13.33	20	0	31.79
IC090126	40	20	40	66.67	80	0	26.67	6.67	26.67	46.67	46.67	0	20	32.31
IC099665	60	60	60	73.33	66.67	40	33.33	60	33.33	40	0	26.67	20	44.1
IC 354611	60	60	20	60	0	40	60	40	20	40	46.67	40	6.67	37.95
IC 316232	46.67	26.67	13.33	0	26.67	20	0	20	6.67	40	40	20	13.33	21.03
IC 261828	53.33	46.67	53.33	60	60	40	73.33	46.67	40	73.33	53.33	66.67	80	57.44
IC354612	66.67	80	60	46.67	20	0	26.67	20	40	40	0	20	0	32.31
IC 305129	60	40	46.67	20	6.67	0	20	40	20	40	13.33	20	40	28.21
IC 261249	26.67	0	13.33	20	0	0	13.33	0	6.67	20	0	6.67	20	9.74
IC 249374	26.67	0	53.33	80	46.67	60	73.33	73.33	66.67	13.33	80	60	13.33	49.74
IC 261797	13.33	13.33	20	46.67	40	73.33	80	20	40	20	33.33	40	20	35.38
IC 343145	46.67	6.67	60	0	20	0	46.67	40	46.67	6.67	40	60	6.67	29.23
IC 261888	40	6.67	0	20	40	0	20	6.67	6.67	0	0	6.67	0	11.28
Average	54.55	39.09	42.12	39.7	36.97	24.55	36.97	36.36	37.88	35.45	32.42	29.7	19.09	35.76

Table 3: Meteorological parameters during 2013

Date & month	Rainfall (mm)	Rainy days	RH1 (Morning)	RH2 (Afternoon)	Maximum Temprature(⁰C)	Minimum Temprature(⁰C)	MeanEvapo-ration (mm)
28th May-3 June	12.0	1	58	27	37.9	21.5	8.0
4-10	0.0	0	59	32	41.1	25.0	8.7
11-17	95.2	3	77	55	33.9	23.3	6.2
18-24	2.6	1	63	41	38.3	25.8	9.6
25th June-1 July	31.6	3	74	53	34.9	24.4	7.3
2-8	76.2	2	84	58	35.2	25.1	7.1
9-15	47.2	6	89	64	33.4	23.9	7.0
16-22	35.8	2	84	66	33.1	25.9	6.4
23-29	30.6	3	85	67	33.6	26.1	6.9
30th July-5th August	112.5	5	88	73	33.0	24.5	6.1
6-12	45.2	2	91	75	31.1	25.6	5.3
13-19	309.4	6	96	87	28.0	23.6	1.4
20-26	15.6	1	85	62	34.7	25.6	5.5
27th August-2 September	76.4	3	87	65	33.5	23.8	6.5

Table 4: Correlation between the abiotic factors and Fruit Borer infestation

	Fruit Infestation	Maximum temperature	Minimum temperature	Relative humidity	Rain fall
Fruit Infestation	1				
Maximum temperature	0.49**	1			
Minimum temperature	0.57**	0.08880	1		
Relative humidity	0.38	0.76**	-0.24719	1	
Rain fall	0.56**	0.23	0.59**	0.16	1

the standard week of maximum fruit infestation *i.e.* 25th July, 2013 the genotype IC 261767, IC 310886, IC090126, IC 099665 and IC 261249 showed 100% fruit infestation. However genotype *viz*., IC 099736 showed 86.11% fruit infestation and genotype IC 354611 showed 86.67% fruit borer infestation. During the standard week of minimum fruit borer infestation genotype IC 261249 showed minimum fruit borer infestation of 14.29% followed by genotype IC 090126.

In general, genotypes showing fruit borer infestation below 50% were IC 099680, IC 310886, IC 261836, IC 104101, IC 203585, IC 090126, IC 099665, IC 261249, IC 343145, IC 261888. These genotypes can be considered as tolerant to fruit borer infestation. In earlier studies Mannan *et al*. (2003), carried out screening for resistance against fruit and shoot borer and reported that the lines Jumki-1 and Jumki-2 were highly resistance. Sharma *et al*. (2001) reported fruit damage by fruit borer ranging from 2.75-10.0%. Ahmed *et al*. (1983) observed percentage fruit infestation to the tune of 23.47, 23.11, 23.83 and 31.66 in Singhnath Long, Khotkotia Round, Khotkotia Long, Islampuri, respectively.

Shoot borer infestation

The data in (Table 2) depicted that infestation of brinjal shoot

Table 5: Correlation between the abiotic factors and Shoot Borer infestation

	Shoot Infestation	Maximum temperature	Minimum temperature	Relative humidity	Rain fall
Shoot Infestation	1				
Maximum temperature	0.50**	1			
Minimum temperature	0.77**	0.11	1		
Relative humidity	0.35	0.73**	-0.27	1	
Rain fall	0.55**	0.21	0.61**	0.11	1

remained fluctuating through the period under study. However it showed a decreasing trend with the age of the plants. Hossain *et al.*,2002 also reported the similar results, they observed that plant age had significant effect on the incidence of brinjal shoot and fruit borer. Maximum shoot infestation was observed in the standard week of 6th June, 2013 *i.e.* 54.55% and it was reported minimum *i.e.* 19.09% in the standard week of 29th August, 2015 when the maximum temprature was 41.1°C and relative humidity 59% and 33.5°C and relative humidity 87%, respectively. Genotypes IC 249357 and IC 261828 showed maximum shoot borer infestations with shoot borer incidence of 57.44%, these were followed by genotype IC 099736 with shoot incidence of 54.36%. All other genotypes showed shoot borer infestation below 50%. Minimum shoot borer infestation to the tune of 9.74% was shown by IC 261249, this was followed genotype IC 261888 with shoot borer infestation of 11.28% and IC 310886 with shoot borer infestation of 14.87%. IC 099736 showed 100% shoot borer infestation during the standard week of maximum infestation *i.e.* 6th July, 2014, where as genotype IC 261797 showed minimum fruit borer infestation to the tune of 13.33%. The genotypes which showed no shoot borer infestation during the standard week of minimum infestation i.e 29th August, 2015 were IC 310886, IC 203585, IC 354612, IC 261888. All the genotypes except IC 249357, IC 099736, IC 261828 showed shoot borer infestation below 50%, thus can be considered as tolerant to shoot borer infestation.

The variation in infestation could be due to their ability to resist the pathogen. The result of present study are in agreement with Kabir *et al.* (1994) who mentioned that brinjal fruit and shoot borer, damaged 10-20% brinjal fruits and sometimes it reached upto 40%, Mukhopadhyay and Mandal (1994) mentioned the infestation to fruit borer in brinjal varied from variety to variety. Kumar and Sadashiva (1996) stated that brinjal fruit and shoot borer is a serious pest and even a ready brinjal can rot due to it (10-50% infestation), if it is not managed properly. Mall *et al.* (1996) considered brinjal fruit and shoot borer to be deleterios pest and reported fruit and shoot borer damage to the tune of 20 -25% as compared to 10 to 23 % in control. Screening of brinjal germplasm for fruit and shoot borer resistance was also been made by other researchers in India, who used few dozens of eggplant accessions as planting material and they revealed a few or none as resistant to EFSB (Darekar *et al.*, 1991; Singh and Kalda, 1997; Behera *et al.*, 1999; Doshi *et al.*, 2002). Some of the wild *Solanum* species such as *Solanum gilo*, *Solanum incanum*, *Solanum indicum*, *Solanum integriifolium*, *Solanum khasianum*, *Solanum sisymbriifolium*, *Solanum xanthocarpum*, etc were reported to possess high resistance to EFSB (Khan *et al.*, 1978; Sharma *et al.*, 1980; Chelliah and Srinivasan, 1983; Singh and Kalda, 1997; AVRDC, 1999; Behera *et al.*, 1999; Behera and Singh, 2002). However, the resistance in these wild species should carefully be evaluated and confirmed before attempting to transfer the resistance to cultivated eggplant, because *S. indicum* had been reported as an alternate host to EFSB (Isahaque and Chaudhuri, 1983), although it was reported as a resistant source in other reports. In addition, the crossability and hybridization of cultivated eggplant with its wild relatives generally pose difficulties due to breeding incompatibilities (Dhankhar *et al.*, 1982), and in several cases, crosses were only successful if in vitro embryo rescue was employed (Kashyap *et al.*, 2003; Rattan *et al.*, 2014).

Correlation between meteorological parameters and fruit and shoot borer infection

As evident from Table (4) incidence of fruit infestation was positively correlated with Minimum temperature (r = 0.57) and maximum temperature (r = 0.49). Thus it clearly indicates that there is great influence of temperature on the development of pests. The magnitude of correlation of fruit infestation with minimum temperature is more than that with maximum temperature. This indicates that temperature plays an important role in fruit borer infestation and as the maximum temperature increases the infestation also increases. This is in line with the findings of Shukla and Khatri (2010), who also reported a positive correlation of temperature and fruit infestation. A positive and significant correlation between minimum temperature and fruit infestation, with higher magnitude than correlation between maximum temperature and fruit infestation indicates that minimum temperature plays an important role in the building up of the pest. Simmilar findings were reported by Shukla and Khatri (2010), who reported a positive correlation between minimum temperature and fruit infestation, with higher magnitude than correlation between maximum temperature and fruit infestation. Many workers also observed maximum population increase of moth between 22 to 35°C. Lal (1975) observed this borer throughout the year except during severe winter. Mehto *et al.* (1980) also observed this pest round the year on brinjal crop. Pawar *et al.* (1986) reported incidence of this pest during kharif crop and summer seasons. The borer infestation was found to be very low during the winter months (December-February) which increased markedly in the summer months which was supported by Alam *et al.* (2006). Rashid *et al.* (2003) observed difficulty in controlling *L. orbonalis* infestation under the open field during summer time.In the present study, the fruit infestation revealed a positive and significant correlation with rainfall (r= 0.56), which indicates that population of the pest increases with the rainfall. These findings are in line with the findings of Shukla and Khatri (2010) and Shukla (1989) who observed a positive correlation between fruit infestation and rainfall. Atwal and Verma (1972) also reported the abundance of *Leucinodes orbonalis* Guenee during monsoon period. Fruit borer had positive but non significant (r = 0.38) correlation with relative humidity. A non significant correlation depicts no influence of relative humidity and fruit infestation. Earlier researchers Shukla and Khatri (2010) also observed non significant correlation between fruit borer population and relative humidity. However a positive and significant correlation between fruit infestation and reltive humidity has also been reported by many researchers like, Patel *et al*. (1988) and Dhamdhere *et al*. (1995). They found high humidity favoured the population build up of *Leucinodes orbonalis* Guenee during the summer. Shoot borer infestation showed a similar trend as that of fruit borer incidence (Table 5). The present experiment provides a basic study to find the resistance source of Fruit shoot borer and to observe the correlation between abiotic factors and the said insect infestation. It can be concluded that infestation of the said pest on brinjal crop is greatly influenced by abiotic factors.

ACKNOWLEDGMENT

The authors are thankful to Govt. of India, Ministry of Science and Technology, Department of Biotechnology, New Delhi, India for funding and to carry out the research project 'Androgenesis mediated introgression of fruit and shoot borer (Leucinodes orbonalis) resistant genes into cultivated eggplant (Solanum melongena)'' under the Bio-CARe scheme for women. The authors are also thankful to NBPGR, New Delhi for supplying germplasm for the present study.

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