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Screening of Brinjal (*Solanum melongena* L.) Varieties for Resistance to Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis* G.)

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ABSTRACT

Nine brinjal varieties, *i.e.*, Bemisal, Black Beauty, Black Pearl, Dilnasheen, Hybrid Shilpa, Hybrid 888, Hybrid 3715, Nirala and Round Black, were screened for resistance to brinjal shoot and fruit borer (BSFB) in a field study at Sahiwal, Pakistan on spring and fall sown crops in 2011 and 2012. The experiments were conducted in a Randomized Complete Block Design having nine treatments and four replications. The fall crop was transplanted in the field on March 11 in 2011 and 2012 and the spring crop on August 15 in 2011 and 2012. Each plot had four rows, spaced 50 cm apart. Plant to plant spacing was 30 cm. Data on shoot infestation were recorded from April 5 to May 5 and September 10 to October 11 for spring and fall sown crops, respectively in both years. Healthy and infested shoots were counted on 10 randomly selected plants from the middle two rows of each plot. For fruit infestation data all the marketable fruit was plucked from plants in the middle two rows of each plot. Data were recorded from May 5 to September 15 and from September 30 to December 30 for the spring and fall sown crops, respectively in both years. Data were recorded at 15 day intervals for both shoot and fruit infestation. Fruit firmness of twenty fruit from randomly selected plants from the middle two rows of each plot was recorded using a penetrometer. The results of this two years' study showed that shoot infestation was lowest on the varieties Hybrid Shilpa (5.6%), Nirala (6.0%) and Hybrid 3715 (6.4%) and fruit infestation was lowest on Hybrid Shilpa (22.6%) and Nirala (24.0%). BSFB incidence was higher on the spring sown crop as compared that on the fall sown crop in both years. However, the incidence was not significantly different between the two years. The highest fruit firmness was recorded for Nirala (11.8 Kg). There was a significant positive relationship between fruit firmness and percent BSFB infestation.

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Authors' Contribution
QY and M. Aslam planted the crop, recorded and analyzed the data. All the authors took part in designing the study and writing of manuscript.

Key words
Brinjal, Egg plant, *Leucinodes orbonalis* , varietal screening,

INTRODUCTION

Eggplant (*Solanum melongena* L.) is a popular vegetable grown in areas having hot-wet climates (Hanson *et al*., 2006) like that occurring in South-East Asia (Thapa, 2010) where it is the most commonly grown solanaceous vegetable (Kantharajha and Golegaonkar, 2004). Its worldwide production is 50 million Mt from an area of about 1.6 million ha (FAO, 2012). In Pakistan its annual production is 87,000 million MT obtained from an area of nine thousand hectare (FAO, 2014). It is a good source of minerals, antioxidants, vitamins, fibers and proteins (Obho *et al*., 2005). Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* (G.) is the most important insect pest of this crop (Latif *et al*., 2010; Chakraborti and Sarkar, 2011; Saimandir and Gopal, 2012) and is predominant in brinjal producing countries all over the world (Dutta *et al*., 2011). Production losses due to this pest are very high in South Asia (Thapa, 2010) and range from 85 to 90 percent (Misra, 2008; Jagginavar *et al*., 2009). It feeds internally on fruit and its excretion inside it make the fruit unfit for human consumption (Baral *et al*., 2006).

Since brinjal is attacked by many insect pests and pesticides are used extensively to reduce economic losses caused by these pests. The use of these chemicals results in many ecological hazards like environmental contamination, bioaccumulation and bio-magnification (Dadmal *et al*., 2004). The indiscriminate and continuous use of insecticides also leads to insecticide resistance in insect pests (Harish *et al*., 2011). The most important problem with chemical use is the retention and persistence of insecticide residues on the surface of vegetables. When these vegetables are eaten by human beings, traces of the insecticides enter their bodies and may cause serious health problems. To avoid these hazards, alternate control measures for these pests are needed. The use of resistant varieties is one of these alternate methods (Hossain *et al*., 2002). The screening of different brinjal varieties for resistance has been carried out by many workers. Different varieties have been field tested in different countries around the world. Pusa

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Purple Cluster was graded as a highly resistant variety in a field screening trial in India (Lal, 1991). The variety, Nayankajal was found resistant to BSFB in Bangladesh (Hossain *et al*., 2002). A hybrid variety, Sweta, was found most resistant to multiple insect pests of brinjal, including *L. orbonalis*, spotted leaf beetle, mealybug aphid, leafhopper and whitefly (Elanchezhyan *et al*., 2008). The use of resistant varieties is the safest control measure which can be integrated with other control methods. Selected resistant brinjal varieties can be used in combination with other control methods to manage this insect pest economically and in an environmentally safer way (Lit, 2009). It is not necessary that the varieties be highly resistant. Even a very low level of resistance can play a vital role in managing an insect pest when it is combined with other control methods that result in a reduced use of insecticides (Srivastava, 1993). Host plant resistance can be affected by many different factors, so it is important to study local and available varieties for resistance to BSFB under local conditions. This study was carried out to screen different brinjal varieties to identify varieties resistant to BSFB.

MATERIALS AND METHODS

Field screening

The experiments were carried out in a field at The COMSATS Institute of Information Technology, Sahiwal (30°39′52″N 73°6′30″E), Pakistan during 2011 and 2012. In each year the crop was planted in spring and fall. Seeds of five brinjal varieties were obtained from Ayyub Agricultural Research Institute, Faisalabad and four varieties were obtained from seed dealers in Faisalabad. The nursery was sown in 12 earthen pots of 30 cm diameter on February 10, 2011 and 2012 for the spring crop and on July 05, 2011 and 2012 for the fall (autumn) crop. The experiment was conducted in a Randomized Complete Block Design having nine treatments (varieties) and four replications. Brinjal varieties Bemisal, Black Beauty, Black Pearl, Dilnasheen, Hybrid Shilpa, Hybrid 888, Hybrid 3715, Nirala and Round Black were screened for resistance to BFSB. Planting was done, just after irrigation, on one side of ridges 50 cm apart. Each variety was planted in four rows 5.0 m in length in each plot. Plots and replications were separated by one and two meter non-cropped areas, respectively. The seedlings were transplanted by handin the field on March 11, in 2011 and 2012 for the spring crop and on August 15, 2011 and 2012 for the fall (autumn) crop. Furrows were irrigated one day before transplanting. Seedlings were transplanted on ridges at a plant to plant distance of 30.0 cm. Fertilizer was applied @ 10:75:100 NPK kg/ha. A light irrigation was made right after transplanting and subsequent irrigations were made at two to three day intervals until the plants were established.

Data recording

Data on shoot infestation were recorded from April 5 to May 5 and September 10 to October 11 for the spring and fall sown crops, respectively, in both years. Healthy and infested shoots were counted on 10 randomly selected plants from the middle two rows of each plot. The infested shoots from selected plants were marked by tying a ribbon around the shoot to avoid recounting during the next data recording. Percent shoot infestation was calculated by using the following formula:

$$\% \text{ infestation} = \frac{\text{Number of shoots infested}}{\text{Total no. of shoots}} \times 100$$

For fruit infestation data recording, all marketable fruit from plants in the middle two rows of each plot was plucked to count the number of infested (having entry or exit holes) and healthy fruit per plot every 15 days from May 5 to September 15 for the spring sown crop and from September 30 to December 30 for the fall (autumn) sown crop in both years. Percent fruit infestation was calculated using the following formula:

$$\% \text{ infestation} = \frac{\text{Number of fruits infested}}{\text{Total no. of fruits}} \times 100$$

Data were recorded in a similar manner for the crops planted in both seasons and both years. Fruit firmness for the screened varieties was recorded by using a penetrometer, model F327 (FACCHINI Srl, Italy). Twenty fruits of marketable quality from each variety were taken randomly from ten randomly selected plants in the middle two rows of each plot. Fruit was peeled using a manual peeler. The knob of the penetrometer was inserted gently in the fruit pulp to the point marked on the knob. The data for all the varieties were recorded.

Data analyses

Data were subjected to Analysis of Variance and mean separation was done by calculating Least Significant Difference using Statistix (2000) statistical software. Regression analysis was also performed using MINITAB software (MINITAB, 2013) to established the relationship between percent BSFB fruit infestation and fruit firmness

RESULTS AND DISCUSSION

Shoot infestation

BSFB incidence on spring sown crop during 2011

On April 5, the highest BSFB incidence on brinjal

shoots was recorded on the variety Bemisal (Table I). The varieties Nirala, Hybrid Shilpa and Hybrid 888 had the lowest level of incidence. Percent borer infestation was not significantly different between the varieties Dilnasheen and Round Black. Incidence on both of these varieties was significantly lower than that on the variety Bemisal and higher than that on other varieties screened. Highest borer incidence occurred on the variety Round Black on April 20, while the lowest occurred on the variety Nirala. Borer incidence on the variety Bemisal was significantly lower than that on the variety Round Black but higher than that on the other varieties screened. The rest of the varieties had an intermediate level of incidence which ranged from 8.26±1.3 to 12.50±1.3 percent. On May 5, varieties Nirala and Bemisal had the highest but not significantly different incidence whereas the lowest incidence was recorded on Hybrid Shilpa. Incidence on all other varieties was not significantly different but higher than that on Hybrid Shilpa and lower than that on Nirala and Bemisal. Incidence of BSFB on these varieties ranged from 3.55±0.4 to 4.85±1.9 percent.

None of the varieties screened had a consistently higher or lower incidence during the season on different sampling dates. However, the seasonal mean (total infestation on all sampling dates/ number of sampling dates) incidence gave a better indication about the response of varieties to borer infestation. Data of seasonal mean incidence indicated that the variety Round Black had a highestincidence, followed by that on the variety Bemisal, than that on all other varieties included in the trial (Table I). Lowest seasonal incidence was found on the variety Hybrid Shilpa. Incidence on variety Black Pearl was significantly lower than that on the variety Round Black and higher than that on Hybrid 888 and Hybrid Shilpa. Incidence on the variety Hybrid 888 was higher compared to that on the variety Hybrid Shilpa but lower than that on varieties Nirala and Hybrid 3715. Incidence was significantly lower on the variety Dilnasheen as compared to that on Round Black but higher than that on other varieties.

BSFB incidence on fall sown crop during 2011

On September 10, the highest borer incidence was recorded on the varieties Dilnasheen and Round Black (Table II). Incidence on the variety Black Pearl was lower when compared to these two varieties but higher than that on all other varieties tested. The difference in incidence was not significant among varieties Nirala and Bemisal. Both of these varieties had a significantly lower incidence than that on Dilnasheen and Round Black but higher than that on other varieties. On September 25, highest incidence was recorded on the variety Black Pearl and lowest on Hybrid Shilpa. Incidence on all other varieties screened was not significantly different and higher than that on Hybrid Shilpa and lower than that on Black Pearl. On October 11, highest borer incidence was noted on the variety Black Pearl whereas the lowest was recorded on varieties Nirala, Black Beauty and Hybrid 3715. Incidence on the rest of the varieties was not significantly different but higher than that on the varieties Nirala, Black Beauty and Hybrid Shilpa and lower than that on Black Pearl.

When seasonal mean incidence was compared among varieties the highest incidence was noted on the variety Black Pearl and lowest on Nirala and Hybrid Shilpa (Table II). Variety Round Black had a lower incidence than that on Black Pearl and higher than that on other varieties screened. Incidence on the variety Dilnasheen was lower than that on Black Pearl and Round Black but higher than that on other varieties. Incidence on the variety Bemisal was lower as compared to that on the varieties Black Pearl, Round Black and Dilnasheen but higher than that on other varieties. Incidence on the variety Black Beauty was higher than that on Hybrid Shilpa, Nirala, Hybrid 888 and Hybrid 3715 and lower than that on the rest of the varieties.

BSFB incidence on spring sown crop during 2012

On April 5, highest incidence was observed on the variety Round Black followed by that on the variety Black Pearl (Table III). Lowest incidence was noted on the variety Hybrid 3715. Borer incidence was not significantly different among the varieties, Nirala, Dilnasheen, Bemisal and Hybrid 888, which had a lower incidence than that on the varieties Black Pearl and Round Black but higher than that on all other varieties tested. On April 20, varieties Round Black and Black Pearl had the highest borer incidence followed by that on Black Beauty. Incidence on varieties Nirala, Dilnasheen, Bemisal, Hybrid 888 and Hybrid 3715 was not significantly different but higher than that on the variety Hybrid Shilpa and lower than that on other varieties. Variety Hybrid Shilpa had the lowest borer incidence. On May 5, the variety Black Beauty had the highest incidence followed by that on the variety Dilnasheen. The incidence on Hybrid 888 and Hybrid 3715 was not significantly different but lower as compared to that on Black Beauty and Dilnasheen and higher than that on other varieties tested. Difference in borer incidence was not significantly different among the varieties Round Black, Black Pearl and Bemisal, which had a higher incidence than that on Nirala and Hybrid Shilpa. Both of these varieties had the lowest level of borer incidence.

As in the 2011 crop season, none of the varieties had a consistently lower or higher borer incidence on

Table I.- Mean percent shoot infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during spring 2011.

Varieties	Mean percent BSFB shoot infestation[a]			Mean[b]
	Sampling dates			
	05-Apr	20-Apr	05-May	
Nirala	5.93±0.7c	7.58±0.3 e	5.41±1.9a	6.31±0.9cde
Dilnasheen	9.66±1.3ab	10.67±1.0bcde	3.97±0.9ab	8.10±0.8bcd
Round Black	9.08±1.1ab	17.70±1.7a	3.94±0.5ab	10.23±0.8a
Black Beauty	7.42±0.9abc	8.26±1.3de	3.62±0.8ab	6.43±0.7cde
Black Pearl	7.21±1.2bc	12.50±1.3bc	4.85±1.1ab	8.19±0.7bc
Bemisal	10.29±1.4a	13.65±2.7b	5.37±0.6a	9.77±0.7ab
Hybrid Shilpa	5.83±0.5c	9.80±0.7cde	2.55±0.6b	6.06±0.4e
Hybrid 888	5.77±0.2c	8.78±0.8de	4.04±0.3ab	6.20±0.3de
Hybrid 3715	7.21±1.0bc	11.51±0.4bcd	3.55±0.4ab	7.42±0.3cde
LSD	3.06	3.63	2.76	1.96

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05)
[b] Total infestation on all sampling dates/ number of sampling dates.

Table II.- Mean percent shoot infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during fall 2011.

Varieties	Mean percent BSFB shoot infestation[a]			Mean[b]
	Sampling dates			
	10 Sep	25-Sep	11-Oct	
Nirala	4.40±0.1bc	8.22±1.1ab	2.79±0.4b	5.14±0.4d
Dilnasheen	7.52±1.0a	8.26±0.6ab	3.94±1.2ab	6.57±0.7abc
Round Black	7.22±0.9a	9.28±1.8ab	4.27±0.6ab	6.93±0.2ab
Black Beauty	5.65±0.8abc	9.09±1.0ab	3.14±0.6b	5.96±0.3bcd
Black Pearl	6.45±0.9ab	10.67±1.5a	5.63±0.3a	7.59±0.8a
Bemisal	4.96±1.1bc	9.34±0.9ab	4.33±0.7ab	6.21±0.4abcd
Hybrid Shilpa	3.96±0.6c	6.8±0.8b	4.32±0.5ab	5.04±0.6d
Hybrid 888	3.59±0.1c	7.86±0.8ab	4.38±0.3ab	5.28±0.3cd
Hybrid 3715	5.32±0.6abc	7.85±0.3ab	3.21±0.4b	5.46±0.2cd
LSD	2.22	3.27	1.81	1.39

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

any sampling date. A comparison of seasonal mean incidence among varieties indicated that the varieties Round Black and Black Pearl had the highest, and statistically similar, incidence level (Table III). The variety Black Beauty had a lower incidence level than that on these two varieties but higher than that on other varieties. Variety Dilnasheen had a lower incidence than that on Round Black, Black Beauty and Black Pearl but had a significantly higher incidence than that on Hybrid Shilpa. Borer incidence was not significantly different among the varieties Hybrid 888, Hybrid 3715 and Nirala, which had a higher incidence than that on Bemisal and Hybrid Shilpa but lower than that on the rest of the varieties. Lowest incidence was recorded on variety Hybrid Shilpa.

BSFB incidence on fall sown crop during 2012

On September 10, incidence of borer was highest on varieties Black Beauty and Black Pearl followed by Bemisal, Round Black and Dilnasheen (Table IV). The level of incidence on other varieties was significantly lower than that on Black Beauty and Black Pearl. On September 25, highest incidence was recorded on varieties Black Beauty, Black Pearl and Bemisal followed by the

Table III.- Mean percent shoot infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during spring 2012.

Varieties	Mean percent BSFB shoot infestation[a]			Mean[b]
	Sampling dates			
	10 Sep	25-Sep	11-Oct	
Nirala	6.03±0.9b	6.50±1.3bc	3.17±0.6d	5.23±0.7c
Dilnasheen	6.40±0.8ab	8.40±0.3ab	5.46±0.7abc	6.75±0.3ab
Round Black	6.44±0.4ab	6.60±0.6bc	3.97±0.2cd	5.67±0.1bc
Black Beauty	9.00±1.3a	9.61±0.7a	4.67±0.8abcd	7.76±0.5a
Black Pearl	8.85±1.6a	9.13±0.7a	5.77±1.1ab	7.92±1.0a
Bemisal	7.35±1.1ab	8.94±0.7a	6.18±0.2a	7.49±0.6a
Hybrid Shilpa	4.70±0.3b	4.83±1.0cd	4.48±0.3bcd	4.67±0.4c
Hybrid 888	5.25±0.5b	6.09±0.7cd	5.01±0.7abc	5.45±0.4bc
Hybrid 3715	4.80±0.8b	4.22±0.3d	4.99±0.8abc	4.67±0.4c
LSD	2.72	2.16	1.67	1.50

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

Table IV.- Mean percent shoot infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during fall 2012.

Varieties	Mean percent BSFB shoot infestation[a]			Mean[b]
	Sampling dates			
	5 Apr	20-Apr	5 May	
Nirala	7.92±1.2abc	9.51±1.2bc	4.55±0.7c	7.32±0.7bcd
Dilnasheen	8.85±0.3abc	10.41±0.9bc	7.56±0.7ab	8.94±0.4abc
Round Black	11.24±2.7a	16.77±2.0a	5.16±0.1bc	11.06±1.5a
Black Beauty	7.28±1.0bc	12.41±0.7b	8.63±1.7a	9.44±0.4ab
Black Pearl	10.70±1.4ab	16.03±1.6a	5.02±0.8bc	10.58±0.7a
Bemisal	7.57±0.2abc	9.04±0.6bc	5.00±0.3bc	7.21±0.1cd
Hybrid Shilpa	7.22±0.7bc	8.88±0.5c	4.22±0.4c	6.77±0.2d
Hybrid 888	9.08±0.6abc	9.73±0.8bc	6.02±1.0abc	8.30±0.5bcd
Hybrid 3715	6.26±0.6c	11.42±1.1bc	6.38±1.1abc	8.02±0.6bcd
LSD	3.67	3.43	2.62	2.13

[a]Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b]Total infestation on all sampling dates/ number of sampling dates.

variety Dilnasheen. Borer incidence was not significantly different between varieties Hybrid 888 and Hybrid Shilpa, which had a higher incidence than that on Hybrid 3715 but lower than that on all other varieties. Incidence on varieties Nirala and Round Black was not significantly different but significantly lower than that on the varieties Black Beauty, Black Pearl and Bemisal and higher than that on all other varieties. Lowest incidence was recorded on Hybrid 3715. On October 11, highest and lowest borer incidence was recorded on varieties Bemisal and Nirala, respectively. The variety Black Pearl had a lower incidence than that on the variety Bemisal but higher than that on all other varieties. Incidence was not significantly different among the varieties Dilnasheen, Hybrid 888 and Hybrid 3715. These three varieties had a higher incidence than that on the varieties Round Black and Nirala but lower than that on other varieties.

The trend of borer incidence was again not consistent on different sampling dates during the season. However, seasonal mean incidence was highest on the varieties Black Beauty, Black Pearl and Bemisal followed by that on the variety Dilnasheen (Table IV). Lowest borer incidence was noted on the varieties Nirala, Hybrid Shilpa and Hybrid 3715. Borer incidence on varieties

Round Black and Hybrid 888 was not significantly different. However, incidence on these two varieties was lower than that on varietiesBlack Pearl, Black Beauty, Bemisal and Dilnasheen and higher than that on varieties Nirala, Hybrid Shilpa and Hybrid 3715.

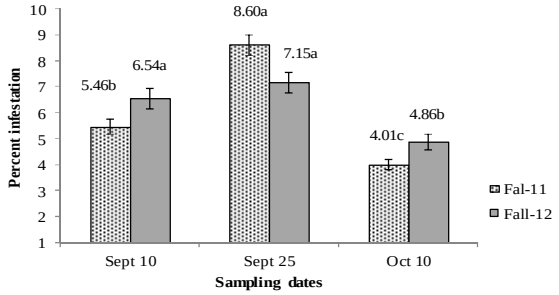

Fig. 1. Mean shoot infestation of BSFB (*L. orbonalis*) on different sampling dates (averaged over varieties) of spring 2011 and 2012 on different brinjal varieties.

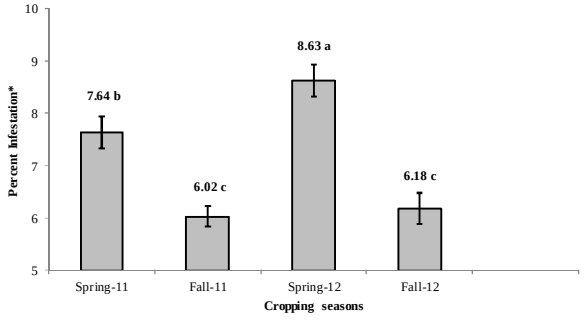

Fig. 2. Mean shoot infestation of BSFB (*L. orbonalis*) on different sampling dates (averaged over varieties) of fall 2011 and 2012 on different brinjal varieties

Mean shoot incidence between sampling dates (averaged over varieties) was compared for different crop seasons during 2011 and 2012. In the spring of 2011 and 2012, incidence was significantly higher on April 20, followed by that on April 5 (Fig. 1). Lowest incidence was recorded on May 5. In the fall 2011 sown crop, incidence was significantly different among sampling dates, being highest on September 25 and lowest on October 10. During 2012, no significant difference in borer incidence was noted between the September 10 and 25 sampling dates, which had a higher incidence than that on October 10 when the lowest incidence was recorded (Fig. 2). When incidence among sowing seasons of the crop (averaged over varieties and sampling dates) was compared, it was significantly higher on the spring sown crop during 2012. Incidence on the spring sown crop during 2011 was significantly lower than that on the spring sown crop during 2012, but higher than that on fall sown crop during 2011 and 2012. The incidence in the fall sown crop during 2011 and 2012 was not significantly different (Fig. 3). Incidence between years (averaged over seasons, sampling dates and varieties) was not significantly different (Fig. 4).

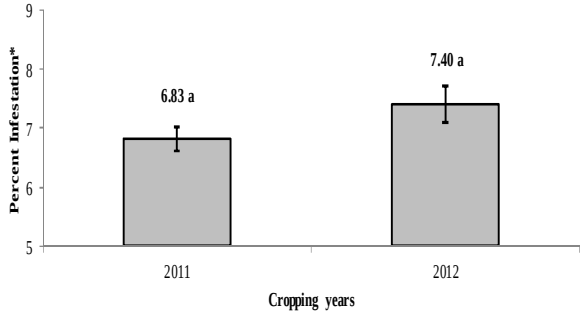

Fig. 3. Mean shoot infestation of BSFB (*L. orbonalis*) in different crop seasons (averaged over varieties and sampling dates) at Sahiwal during 2011 and 2012.

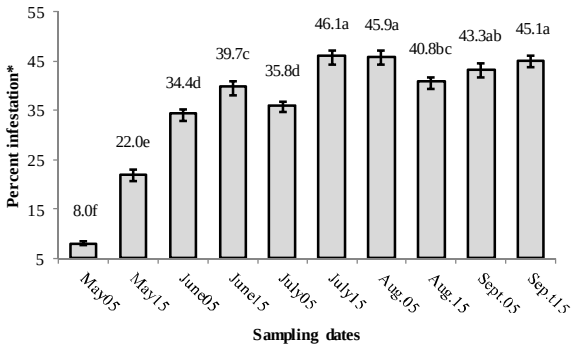

Fig. 4. Mean shoot infestation of BSFB (*L. orbonalis*) in different years (averaged over crop seasons, sampling dates and varieties at Sahiwal during 2011 and 2012.

Fruit infestation

BSFB incidence on spring sown crop during 2011

On May 5, highest BSFB incidence was recorded on the variety Black Pearl followed by that on Black Beauty and Hybrid 3715, which did not differ significantly from each other (Table V). Lowest incidence was noted on the variety Nirala. Incidence on varieties Round Black and Hybrid Shilpa was not significantly different but higher than that on the variety Nirala and lower than that on the

Table V.- Mean percent fruit infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during spring 2011.

Varieties	Percent BSFB fruit infestation Sampling dates									
	5-May	15-May	5-Jun	15-Jun	5-Jul	15-Jul	5-Aug	15-Aug	5-Sep	15-Sep	Mean[b]
Nirala	5.2±0.7e	17.5±1.5c	31.0±1.8cd	31.2±0.7e	28.2±1.2d	44.0±2.1bc	38.2±1.8de	33.5±1.8.e	32.2±2.0f	40.7±1.7e	30.2±0.7f
Dilnasheen	8.2±1.0bcd	21.5±1.9c	34.0±1.3bc	35.7±2.7cde	33.5±1.5c	46.0±1.7bc	45.7±2.3bc	37.0±2.6de	40.2±2.3cde	47.0±0.9abcd	34.9±0.4de
Round Black	6.2±0.7de	20.5±1.5c	33.7.±1.5bcd	38.7±1.5bc	35.5±1.8c	41.2±2.6c	43.0±1.8cd	40.5±1.7bcd	38.5±2.2def	44.2±0.9cde	34.2±0.8e
Black Beauty	9.7±0.5ab	22.2±2.9bc	33.5±2.0cd	39.7±3.6bc	34.7±1.4c	43.0±4.8c	50.7±2.2ab	46.2.5±3.1a	48.7±3.2ab	47.7±3.6abc	37.6±0.7c
Black Pearl	10.7±0.7a	33.7±2.1a	44.2±1.1a	49.7±0.8a	45.7±0.5a	56.0±2.9a	53.5±1.8a	44.0±1.6abc	52.2±1.1a	49.7±2.0ab	44.0.±0.5a
Bemisal	6.7±0.8cde	21.7±1.5c	33.0±1.6cd	33.0±1.4de	34.5±1.0c	44.2±0.7bc	44.5±1.8c	36.2±1.5de	45.5±3.5abc	42.5±1.5efg	34.2±0.8e
Hybrid Shilpa	6.2±0.6de	18.0±1.3c	29.5±1.8d	37.2±1.6cd	32.7±1.6bc	44.5±2.3bc	36.2±1.5e	39.5±1.3cd	35.0±1.6ef	40.0±2.1e	31.9±0.8f
Hybrid 888	8.7±0.8abc	27.0±1.6b	38.0±1.5b	49.5±1.3a	41.7±0.7b	51.7±2.7ab	54.7±1.3a	46.0±1.5ab	51.5±1.9ab	50.7±1.1a	42.0±0.6b
Hybrid 3715	9.7±0.7ab	22.2±1.0bc	32.7±1.1cd	43.7±0.7b	34.5±1.0b	44.7±3.3bc	46.2±1.4bc	41.5±1.9abcd	45.5±0.9bcd	45.7±2.2bcd	36.6.±0.6cd
LSD	2.34	5.10	4.36	5.62	3.95	8.10	5.17	5.66	6.81	4.86	1.88

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

other varieties. On May 15, highest incidence was recorded on variety Black Pearl. Incidence on Hybrid 888 was significantly lower than that on Black Pearl and higher than that on other varieties. Borer infestation on the varieties Hybrid 3715 and Black Beauty was significantly lower than that on Black Pearl and Hybrid 888 but higher than that on other varieties. On June 5, the highest incidence was recorded on the variety Black Pearl followed by that on Hybrid 888. Lowest incidence was noted on the variety Hybrid Shilpa. Variety Dilnasheen had a significantly lower incidence than that on the variety Black Pearl and not significantly different from that on Hybrid 888, but higher than that on other varieties screened. On June 15, highest borer incidence was recorded on the varieties Black Pearl and Hybrid 888. Incidence on variety Hybrid 3715 was significantly lower than that on these two varieties, but higher than that on all other varieties. Lowest incidence was recorded on the variety Nirala. On July 5, maximum incidence was noted on the variety Black Pearl followed by that on Hybrid 888 and Hybrid 3715. Incidence on the varieties Dilnasheen, Round Black, Black Beauty and Bemisal was not significantly different. Incidence on these varieties was significantly lower than that on Black Pearl, Hybrid Shilpa, Hybrid 3715 and Hybrid 888 but higher than that on Nirala. Borer incidence on Hybrid Shilpa was significantly higher than that on the variety Nirala and significantly lower than that on the rest of the varieties. Variety Nirala had the lowest percent borer incidence. On July 15, incidence was highest on the variety Black Pearl followed by that on Hybrid 888, whereas incidence was lowest on the varieties Round Black and Black Beauty. Borer incidence was not significantly different among the varieties Dilnasheen, Bemisal and Hybrid Shilpa, which had a lower incidence than that on Hybrid 888 and Black Pearl but higher than that on the other varieties tested. On August 5, maximum borer incidence was recorded on varieties Black Pearl and Hybrid 888 followed by that on Black Beauty. Borer incidence on varieties Dilnasheen and Hybrid 3715 was not significantly different from each other but was lower as compared to that on Black Pearl, Hybrid 888 and Black Beauty. Lowest incidence was noted on the variety Hybrid Shilpa. On August 15, variety Black Beauty had the highest incidence followed by that on Hybrid 888. Lowest incidence was recorded on the variety Nirala. Incidence on the varieties Dilnasheen and Bemisal was not significantly different and was lower than that on Black Beauty and Hybrid 888 but higher than that on the other varieties. On September 5, the highest incidence level was noted on the variety Black Pearl followed by that on Hybrid 3715 and Black Beauty whereas lowest incidence was recorded on the variety Nirala. On September 15, highest incidence was

found on the variety Hybrid 888 followed by that on Black Pearl. Lowest incidence was recorded on the varieties Nirala and Hybrid Shilpa. Borer incidence among other varieties ranged from 40.0±2.1 to 50.7±1.1 percent and was higher than that on the varieties Nirala and Hybrid Shilpa but lower than that on Black Pearl and Hybrid 888.

The variety Black Pearl had the highest level of incidence on all sampling dates, except on August 15 and September 15. The variety Nirala had lowest incidence on nine out of 10 sampling dates. When seasonal mean incidence was calculated the variety Black Pearl had the highest incidence level followed by that on Hybrid 888. Lowest incidence was recorded on Nirala and Hybrid Shilpa. The incidence on varieties Round Black and Bemisal was significantly higher than that on Nirala and Hybrid Shilpa but lower than that on the other varieties.

BSFB incidence on fall sown crop in 2011

On September 30, highest incidence of BSFB was recorded on varieties Black Beauty, Black Pearl and Hybrid 888, whereas lowest incidence was noted on the variety Bemisal (Table VI). BSFB incidence among all other varieties tested was not significantly different. On October 15, maximum borer incidence was noted on the variety Black Pearl. Variety Round Black had a lower incidence than that on the variety Black Pearl and higher than that on the rest of the varieties. Hybrid Shilpa had the lowest incidence. On October 30, the highest incidence was recorded on the variety Round Black followed by that on Black Pearl. BSFB incidence on varieties Nirala, Dilnasheen, Black Beauty and Hybrid 3715 was not significantly different and was lower than that on Round Black and Black Beauty but higher than that on the rest of the varieties. Minimum incidence was recorded on the varieties Bemisal, Hybrid Shilpa and Hybrid 888. On November 15, highest incidence was observed on variety Black Beauty followed by that on variety Dilnasheen. Varieties Nirala, Round Black and Black Pearl were not significantly different in borer incidence, which was lower than that on the varieties Black Beauty and Dilnasheen but higher than that on other varieties. Variety Hybrid 3715 had a higher borer incidence than that on the varieties Bemisal, Hybrid Shilpa and Hybrid 888 and lower than that on other varieties. On November 30, highest incidence was recorded on the variety Black Pearl. Incidence on the variety Round Black was lower than that on Black Pearl and higher than that on other varieties. The varieties Dilnasheen and Black Beauty had a statistically similar and significantly lower level of incidence than that on the variety Black Pearl but higher than that on other varieties except Round Black. Lowest incidence was recorded on

Table VI.- Mean percent fruit infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during fall 2011.

Varieties	Percent BSFB infestation[a]						Mean
	Sampling dates						
	30-Sep	15-Oct	30-Oct	15-Nov	30-Nov	15-Dec	30-Dec	
Nirala	7.0±0.8ab	26.7±2.3de	31.5±4.6bc	29.0±2.8abc	18.7±2.5cd	18.7±1.3bc	4.0±0.7e	19.3±1.5de
Dilnasheen	7.5±0.9ab	26.0±2.3de	31.5±1.9bc	38.0±2.2ab	24.0±2.7bc	19.7±1.1ab	6.0±0.4bcde	21.8±0.4cd
Round Black	8.2±1.1ab	34.0±1.9ab	44.5±4.0a	31.5±5.2abc	30.2±2.3ab	23.2±1.1a	7.5±1.5abcde	25.6±1.1ab
Black Beauty	9.5±0.6a	28.5±1.3bcd	32.2±2.1bc	39.2±3.4a	22.5±1.4bc	19.7±0.9ab	8.5±0.6abc	22.8±0.8bc
Black Pearl	9.2±1.0a	36.0±3.1a	40.5±2.2ab	35.0±1.6abc	33.0±2.3a	23.2±1.5a	7.7±0.9abcd	26.4±0.9a
Bemisal	5.5±1.3b	23.7±2.0de	25.2±1.6c	26.0±3.7c	13.5±1.3d	15.7±1.3c	4.7±0.6de	16.3±1.2e
Hybrid Shilpa	6.7±1.4ab	21.5±2.0e	29.7±6.8c	25.7±3.6c	18.0±4.6cd	16.0±1.3c	5.0±1.1cde	17.5±2.2e
Hybrid 888	9.7±0.6a	27.5±1.5cde	30.7±1.4c	23.2±6.8c	14.5±1.7d	17.2±1.1bc	10.5±2.3a	19.0±1.1de
Hybrid 3715	7.5±1.5ab	33.2±0.9abc	32.7±3.0bc	26.7±4.4bc	20.5±2.7cd	22.7±1.6a	9.2±1.5ab	21.8±0.4cd
LSD	3.31	6.20	9.53	11.83	7.91	3.74	3.74	3.47

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

variety Hybrid 888. On December 15, highest incidence was observed on varieties Round Black, Black Pearl and Hybrid 3715. BSFB incidence on varieties Dilnasheen and Black Beauty was not significantly different and was lower than that on Round Black, Black Pearl and Hybrid 3715 and higher than that on the other varieties. Varieties Nirala and Hybrid 888 had a similar level of incidence which was higher than that on varieties Bemisal and Hybrid Shilpa. Varieties Bemisal and Hybrid Shilpa had the lowest level of incidence. On December 30, incidence was highest on variety Hybrid 888 and lowest on Nirala. All other varieties had different incidence level, which ranged from 9.2±1.5 to 4.7±0.6 percent. The incidence on these varieties was lower than that on Hybrid 888 and higher than that on Nirala.

None of the varieties had a consistently highest or lowest level of incidence on different sampling dates during the season. When seasonal mean incidence was calculated, the variety Black Pearl had the highest incidence level followed by Round Black (Table VI). The lowest level of infestation occurred on varieties Bemisal and Hybrid Shilpa which were not significantly different.

BSFB incidence on spring sown crop during 2012

Incidence on May 5 was highest on the variety Black Pearl and lowest on varieties Nirala and Hybrid Shilpa (Table VII). Incidence on variety Black Beauty was lower when compared to Black Pearl but significantly higher than that on Nirala and Hybrid Shilpa. Incidence was not significantly different among other varieties tested. On May 15, again the highest incidence was recorded on the variety Black Pearl followed by the varieties Round Black and Bemisal. Borer incidence on these two varieties was not significantly different but was significantly lower than that on Black Pearl. The variety Hybrid Shilpa had the lowest incidence among all the varieties. Borer incidence on the rest of the varities ranged from 19.7±2.7 to 25.2±2.4 percent, which was higher than that on the variety Hybrid Shilpa and lower than that on Black Pearl, Round Black and Bemisal. On June 5, maximum incidence was noted on the variety Black Pearl. The varieties Dilnasheen, Round Black, Black Beauty, Bemisal and Hybrid 888 had a statistically similar level of incidence, which was significantly lower than that on Black Pearl and higher than that on other varieties. On June 15, borer incidence on varieties Black Beauty and Black Pearl was highest and not significantly different. Incidence on variety Hybrid 888 was significantly lower than that on varieties Black Beauty and Black Pearl but significantly higher than that on most of the other varieties tested. Incidence on varieties Nirala, Hybrid Shilpa and Hybrid 3715 was not significantly different.

Table VII.- Mean percent fruit infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during spring 2012.

Varieties	Percent BSFB fruit infestation										
	Sampling dates										
	5-May	15-May	5-Jun	15-Jun	5-Jul	15-Jul	5-Aug	15-Aug	5-Sep	15-Sep	Mean[b]
Nirala	6.7±0.7c	19.7±2.7cd	28.5±1.5bc	24.7±2.2d	29.0±2.0c	40.0±4.1bc	28.0±2.7d	35.0±1.8d	49.0±3.3bc	27.5±1.0g	28.8±0.8e
Dilnasheen	8.0±1.1bc	25.2±1.7bc	32.5±0.9b	26.2±3.3cd	32.0±2.2c	37.0±2.8bcd	38.5±1.3bc	40.2±2.7cd	34.0±2.3d	36.0±2.3ef	31.00.9de
Round Black	7.0±0.9bc	26.7±1.3b	32.0±0.7b	34.0±3.3bc	31.2±1.1c	46.7±4.1ab	45.5±2.4ab	44.7±3.2bc	49.5±1.7abc	46.2±1.7bc	36.4±0.6c
Black Beauty	10.2±1.4ab	23.0±1.9bc	32.5±3.8b	47.0±2.1a	41.7±3.8ab	52.5±3.1a	49.7±3.1a	51.5±1.5ab	51.0±5.1abc	47.2±1.8b	40.6±0.4b
Black Pearl	11.5±1.4a	41.5±1.3a	49.2±4.5a	47.7±4.8a	45.0±5.1a	46.0±3.2ab	52.7±2.7a	49.5±1.7ab	59.0±3.4a	53.2±2.8a	45.5±1.5a
Bemisal	8.0±0.9bc	26.2±1.2b	33.7±3.0b	29.5±1.5cd	33.2±2.9bc	33.0±5.7cd	42.0±2.3b	36.7±4.6cd	43.0±2.3cd	41.5±1.2cd	32.6±0.8d
Hybrid Shilpa	5.2±1.1c	15.0±1.2d	23.0±1.8c	26.0±1.8d	29.5±0.64c	29.0±3.3d	31.7±1.2cd	34.5±2.8d	33.5±1.8d	30.7±1.7fg	25.8±0.9f
Hybrid 888	7.7±1.1bc	25.2±2.4bc	34.5±1.6b	37.7±3.0b	44.7±2.2a	52.7±2.2a	51.7±2.4a	55.7±2.4a	55.0±1.0ab	50.5±0.9ab	41.6±0.8b
Hybrid 3715	8.5±1.0abc	24.2±3.1bc	30.0±2.1bc	25.5±1.0d	31.7±3.4c	37.0±2.2bcd	38.2±3.6bc	38.5±4.6cd	39.0±5.4d	38.5±1.7de	31.1±1.0de
LSD	**3.30**	**6.14**	**7.86**	**3.88**	**8.86**	**10.17**	**7.71**	**8.30**	**9.95**	**5.30**	**2.77**

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

Borer incidence was lowest on these varieties. On July 5, highest borer incidence was recorded on varieties Black Pearl and Hybrid 888 followed by that on Black Beauty. The level of borer incidence was not significantly different among all the other varieties but significantly higher than that on Black Pearl, Hybrid 888 and Black Beauty. On July 15, maximum incidence was found on the varieties Black Beauty and Hybrid 888. Borer incidence on varieties Round Black and Black Pearl was not significantly different and lower than that on the varieties Black Beauty and Hybrid 888 and higher than that on other varieties. Lowest incidence was noted on the variety Hybrid Shilpa. On August 5, incidence was highest on the varieties Black Beauty, Black Pearl and Hybrid 888 followed by that on Round Black. Incidence on variety Bemisal was significantly lower than that on Black Beauty, Black Pearl and Hybrid 888. Lowest incidence was recorded on the variety Nirala. On August 15, highest incidence was noted on the variety Hybrid 888. Incidence on varieties Black Beauty and Black Pearl was not significantly different and both had a lower incidence than that on variety Hybrid 888 and higher than that on the rest of the varieties. Incidence was not significantly different on varieties Bemisal, Black Pearl and Hybrid 3715. These varieties had a higher incidence than that on the variety Nirala and lower than that on the other varieties. Incidence was lowest on variety Nirala. On September 5, the highest incidence was recorded on variety Black Pearl followed by that on variety Hybrid 888. Incidence was not significantly different between varieties Round Black and Black Beauty, which had a lower incidence than that on Black Pearl and Hybrid 888 and higher than that on other varieties. Incidence on Bemisal was higher than that on the varieties Dilnasheen, Hybrid Shilpa and Hybrid 3715, on which incidence was lowest and not significantly different. On September 15, the highest incidence was recorded on variety Black Pearl followed by that on Black Beauty and Round Black. Lowest incidence was noted on the variety Nirala. All other varieties had different levels of incidence, which ranged from 30.7±1.7 to 50.5±0.9 percent.

None of the varieties had a consistently higher or lower incidence on different sampling dates throughout the season. When seasonal mean incidence was calculated the highest level of BSFB incidence was found on the variety Black Pearl (45.5±1.5 %) and lowest on Hybrid Shilpa (25.8±0.9 %). Borer incidence was not significantly different on the varieties Black Beauty and Hybrid 888, which had a lower incidence than that on Black Pearl, and higher than that on other varieties. Borer incidence was similar on the varieties Dilnasheen and Hybrid 3715, which had a higher incidence than that on the varieties Nirala and Hybrid Shilpa and lower than that on other varieties. Incidence on the variety Round Black was significantly lower than that on Black Pearl, Hybrid 888 and Black Beauty and higher than that on other varieties. The incidence on the variety Bemisal was significantly lower than that on Black Pearl, Hybrid 888, Black Beauty and Round Black but higher than that on other varieties. Variety Hybrid Shilpa had the lowest (25.8±0.8) borer incidence.

BSFB incidence on fall sown crop in 2012

On September 30, the highest incidence occurred on variety Black Pearl and lowest on variety Nirala (Table VIII). Incidence on the remainder of the varieties was not significantly different. However, the incidence level on these varieties was higher than that on the varieties Nirala and Bemisal and lower than that on the variety Black Pearl. On October 15, the highest incidence was recorded on the varieties Round Black, Black Pearl, Bemisal and Hybrid 888. Infestation on Dilnasheen and Black Beauty was not significantly different but was higher than that on Hybrid Shilpa and lower than that on the other varieties tested. Lowest incidence was recorded on the variety Hybrid Shilpa. On October 30, the highest incidence occurred on the varieties Round Black and Black Pearl. Incidence on Hybrid 3715 was significantly lower than that on these two varieties, but higher than that on all other varieties. Incidence was not significantly different on the varieties Dilnasheen, Black Beauty, Round Black and Bemisal, which had a lower incidence than that on the varieties Black Pearl and Hybrid 3715, but higher than that on the other varieties screened. Lowest and not significantly different incidence was recorded on the varieties Nirala, Hybrid Shilpa and Hybrid 888.

On November 15, borer incidence was again highest on the variety Black Pearl. Incidence was significantly lower on the variety Bemisal as compared to that on Black Pearl but higher than that on the rest of the varieties. The level of incidence was lower on the variety Round Black than that on Black Pearl and Bemisal but higher than that on several other varieties. Variety Nirala had a significantly higher incidence than that on Hybrid Shilpa and lower than that on all other varieties. The lowest level of incidence was recorded on the variety Hybrid Shilpa. On November 30, the highest incidence level was noted on the variety Round Black and lowest on the variety Hybrid Shilpa. Incidence on variety Black Pearl was significantly lower than that on the variety Round Black and significantly higher than that on the rest of the varieties tested. Incidence was not significantly different on varieties Bemisal and Hybrid 888. These varieties had a higher incidence than that on varieties Nirala, Dilnasheen, Black Beauty, Hybrid Shilpa and Hybrid 3715 and lower than that on other varieties. On December 15, incidence

Table VIII.- Men percent fruit infestation of BSFB (*L. orbonalis*) on different varieties of brinjal (*S. melongena*) at Sahiwal during fall 2012.

Varieties	Percent BSFB infestation[a]						
	Sampling dates						
	30-Sep	15-Oct	30-Oct	15-Nov	30-Nov	15-Dec	30-Dec	Mean
Nirala	6.2±0.6b	19.2±3.1b	22.0±2.2c	23.5±2.5d	29.7±1.7c	21.2±1.7cd	5.0±1.3c	18.0±1.1d
Dilnasheen	7.7±0.8ab	18.2±0.9bc	25.7±1.5bc	27.7±1.1bcd	23.5±1.4e	20.2±1.1cd	9.5±1.3ab	19.0±0.8cd
Round Black	8.5±0.6ab	25.5±2.4a	32.0±2.0a	30.5±1.8bc	41.5±1.5a	27.5±1.0ab	4.2±0.4c	24.0±0.4b
Black Beauty	7.7±0.5ab	17.0±0.8bc	24.7±1.5bc	25.7±1.8cd	26.7±0.8cde	24.0±1.3bc	11.5±1.0a	19.7±0.7cd
Black Pearl	9.5±0.6a	29.0±1.8a	32.5±0.9a	39.0±1.5a	37.5±0.9b	29.2±1.1a	9.0±0.4ab	26.7±0.5a
Bemisal	7.2±1.4ab	29.0±1.4a	23.2±1.0bc	32.7±0.8b	29.2±0.6cd	18.7±1.0d	5.0±1.3c	20.7±0.6c
Hybrid Shilpa	8.0±0.7ab	13.2±1.1c	22.5±1.3c	16.2±1.2e	19.0±0.9f	19.7±0.8cd	6.2±1.2bc	15.2±0.8e
Hybrid 888	7.7±0.8ab	25.5±2.7a	22.5±0.9c	28.7±3.1bcd	28.7±1.4cd	19.0±1.1d	9.2±0.5ab	20.2±1.1cd
Hybrid 3715	8.2±1.2ab	19.0±1.1b	27.0±1.6b	25.7±0.5cd	25.7±2.0de	19.7±3.1cd	10.7±1.7a	19.5±1.2cd
LSD	2.41	5.58	4.36	5.35	3.93	4.57	3.45	2.59

[a] Means followed by the same letter in columns are not significantly different (LSD at P=0.05).
[b] Total infestation on all sampling dates/ number of sampling dates.

was highest on the variety Black Pearl, followed by that on Round Black. Incidence on variety Black Beauty was significantly lower than that on the variety Black Pearl and higher than that on other varieties. No significant difference occurred on the varieties Nirala, Dilnasheen, Hybrid Shilpa and Hybrid 3715, all of which had a significantly lower incidence than that on Black Pearl and Round Black and higher than that on the other varieties. Incidence on Bemisal and Hybrid 888 was not significantly different and was the lowest. On December 30, highest incidence was recorded on the varieties Black Beauty and Hybrid 3715. Incidence was not significantly different on the varieties Dilnasheen, Black Pearl and Hybrid 888, which had a lower incidence as compared to that on Black Beauty and Hybrid 3715 and higher than that on the other varieties. Variety Hybrid Shilpa had a higher incidence than that on the varieties Nirala and Round Black and lower than that on other varieties. Varieties Nirala and Round Black had the lowest incidence level.

No clear trend of incidence was noted on different sampling dates on any variety. During the season variety Black Pearl had the highest incidence while variety Hybrid Shilpa had the lowest incidence on most sampling dates. When seasonal mean incidence was compared, it was clear that variety Black Pearl had the highest and Hybrid Shilpa the lowest incidence. The remainder of the varieties were not significantly different in their incidence level, which was significantly lower than that on the variety Black Pearl and higher than that on Hybrid Shilpa. Among the brinjal varieties screened for the incidence of BSFB, three long-fruited varieties, *i.e.*, Nirala, Hybrid Shilpa and Hybrid 888, had a lower BSFB incidence level than that on other varieties.

The present results are similar to those of Mishra *et al*. (1987), who tested 46 brinjal varieties against BSFB infestation and reported that Katrain-4 (long-fruited) was highly resistant. It was similar to other long fruited varieties. In another study, Lal (1991) found that all long- and medium-fruited varieties ranged from resistant to tolerant, while round-fruited varieties were highly susceptible. Ali *et al.* (1994) studied the effects of morphological characters of 28 brinjal varieties on BSFB infestations. They found that varieties with small sized, oval, slightly long, intermediate long and long fruit with a purple or greenish color were less infested than those with large sized, round and purple black color fruit. Pusa Purple Cluster and Doli-5 were found resistant to BSFB infestation by Jyani *et al.* (1995). Sharma *et al*. (1985) reported that round shaped brinjal fruit are more susceptible to BSFB infestation than long shaped ones. In another screening of brinjal varieties Krishna *et al.* (2001) recorded the lowest BSFB infestation on the variety Pusa Purple Long and the highest on variety

Ramy Round Purple. Our studies also support the findings of Javed (2012), who reported that the variety Nirala was highly resistant to BSFB among 13 brinjal varieties tested. Jat *et al.* (2003) reported Nirala as moderately susceptible to BSFB infestation. This difference may be due to different environmental and soil conditions at different experimental localities.

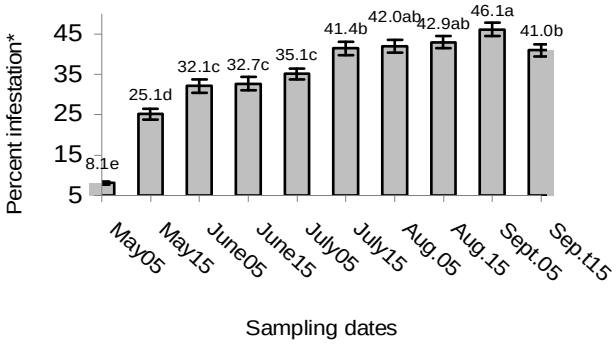

Fig. 5. Mean infestation of BSFB (*L. orbonalis*) on different sampling dates (averaged over varieties) in spring sown crop at Sahiwal during 2011.

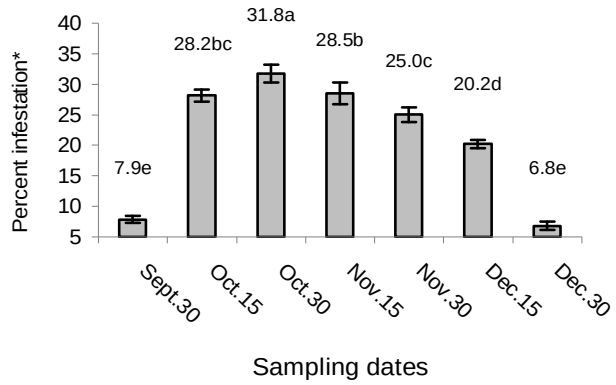

Fig. 6. Mean infestation of BSFB (*L. orbonalis*) on different sampling dates (Averaged over varieties) in spring sown crop at Sahiwal during 2012.

BSFB incidence on fruit on different sampling dates (averaged over varieties) within sowing seasons was also compared. On the spring 2011 sown crop, highest incidence was noted on July 15, August 5 and September 15 followed by that on September 5 (Fig. 5). Lowest incidence was recorded on May 5. On other sampling dates which had a significantly different borer infestation, it ranged between 22.0 and 40.8 percent. On the 2012 spring sown crop, incidence was highest on September 5 followed by that on August 5 and 15 (Fig. 6). Lowest incidence was recorded on May 5. On the rest of the sampling dates, incidence was between 25.1 and 41.0 percent. During 2011 on the fall sown crop, highest incidence was recorded on October 30, followed by that on November 15 (Fig. 7). Lowest incidence was noted on September 30 and December 30. On the rest of the sampling dates, incidence was between 20.2 and 28.2 percent. These results support observations recorded by Singh *et al.* (2000), Naqvi *et al*. (2009) and Kumar and Dharmendra (2013). They found that BSFB infestation on brinjal began in August and reached its peak in October and then started declining. On the fall sown crop during 2012, highest incidence was noted on October 30, November 15 and November 30 (Fig. 8). On October 15 and December 15, incidence was not significantly different and higher than that on September 30 and December 30, which had the lowest BSFB incidence.

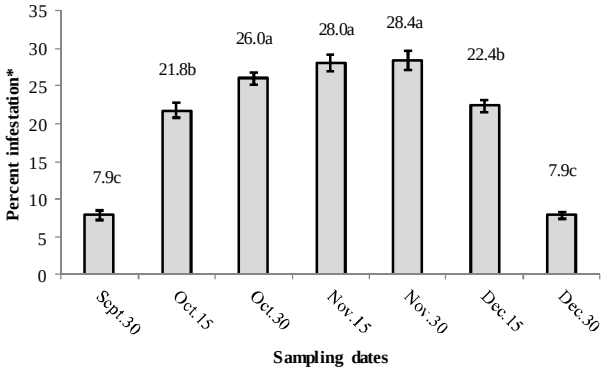

Fig. 7. Mean infestation of BSFB (*L. orbonalis*) on different sampling dates (Averaged over varieties) in fall sown crop at Sahiwal during 2011.

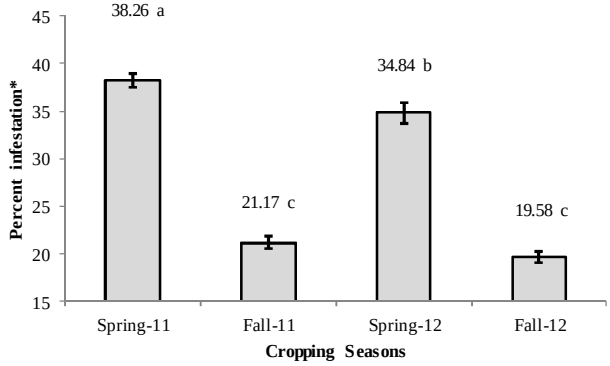

Fig. 8. Mean infestation of BSFB (*L. orbonalis*) on different sampling dates (Averaged over varieties) in fall sown crop at Sahiwal during 2012.

These results support field studies conducted for the incidence on BSFB on brinjal by Ghosh and Senapati (2009). They found that this pest causes the most damage

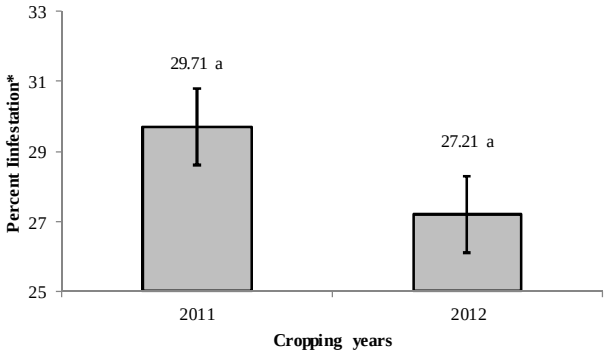

Fig. 9. Mean fruit infestation of BSFB (*L. orbonalis*) in different crop seasons (averaged over varieties and sampling dates) at Sahiwal during 2011 and 2012.

and is most active during the summer months, *i.e.*, from May to August. It becomes less active during the winter months, particularly in December and January. Our conclusions are different from those of Varma *et al.* (2009), who studied the incidence and abundance of BSFB in Allahabad, India and observed the highest incidence on brinjal in December. A comparison of incidence between seasons (averaged over varieties and sampling dates) is presented in Figure 9. The highest incidence occurred on the spring sown crop in 2011 followed by that on the spring sown crop in 2012. Incidence on the autumn sown crop in 2011 and 2012 was not significantly different and was the lowest incidence level. This seasonal fluctuation in the incidence of this pest was similar to the results of previous studies. Patel *et al.* (1988) found shoot and fruit damage in brinjal by BSFB was higher in May transplanted (spring) crops than that in July and September transplanted (fall) crops. When incidence between years (averaged over varieties, planting dates and seasons) was compared, the incidence was not significantly different (Fig. 10).

After two years of research on the incidence of BSFB on brinjal varieties, we concluded that long-fruited brinjal varieties, *i.e.*, Nirala and Hybrid Shilpa, sustained less BSFB damage as compared to that on round fruited varieties. These findings agree with the studies of other scientists (Hossain *et al.*, 2002; Thangamani *et al.*, 2011). The spring sown crop had a higher borer incidence than the fall sown crop and was a little higher in 2011 than in 2012.

Fruit firmness

Fruit firmness was highest (11.8 kg) in Nirala followed by that in Hybrid Shilpa (10.65 kg). Firmness in varieties Hybrid 888 (7.17 kg) and Black Pearl (6.37 kg) was the lowest and not significantly different. Fruit firmness in the varieties Hybrid 3715 (7.17 kg) and Black beauty (7.27 kg) was also not significantly different but significantly different from all other varieties (Table IX).

The regression between fruit firmness (independent variable) and percent BSFB fruit infestation (dependent variable) revealed a positive relationship (R^2= 75.5%) between fruit firmness and fruit infestation (Fig 10).

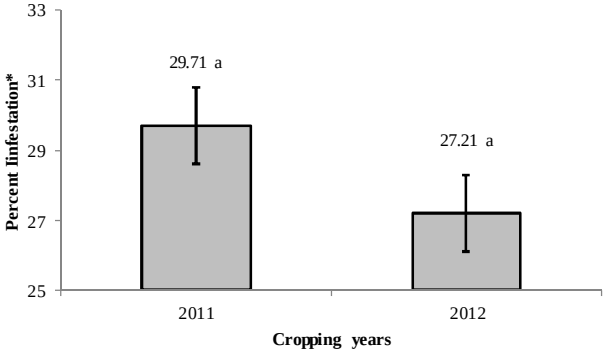

Fig. 10. Mean fruit infestation of BSFB (*L. orbonalis*) in different years (averaged over crop seasons, sampling dates and varieties) at Sahiwal during 2011 and 2012.

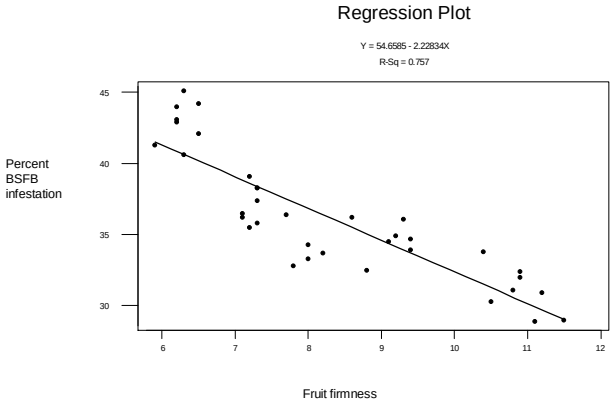

Fig. 11. Regression plot between brinjal fruit firmness and percent BSFB (*L. orbonalis*) infestation.

Javed (2012) studied the effect of brinjal morphological characters on fruit and shoot infestation by *L. orbonalis.* They found a strong negative correlation

between fruit infestation and number of leaf trichomes, fruit infestation and stem thickness and fruit infestation and stem hair density. A significantly negative correlation was found between fruit infestation and crown hair density. They noted that the variety Nirala had the lowest BSFB infestation among thirteen varieties. In our study, Nirala and Hybrid Shilpa, both with long fruits, were found to have the lowest BSFB infestation among nine brinjal varieties. In addition to the morphological characters, Javed (2012) we detected a positive relation between fruit firmness and percent BSFB fruit infestation so fruit firmness could be a contributory factor for resistance in brinjal. In another study by Yousafi *et al*. (2013) Nirala showed good performance against jassid infestation also. These findings indicate that Nirala is a tolerant variety against major insect pests of brinjal.

Table IX.- Mean (± SE) Fruit firmness of brinjal varieties sown in Sahiwal during Spring 2011.

Varieties	Fruit firmness* (Kg)
Nirala	11.8±0.76a
Dilnasheen	9.32±0.45c
Round black	8.67±0.78d
Black beauty	7.27±0.71f
Black pearl	6.37±0.63g
Bemisal	7.87±0.79e
Hybrid Shilpa	10.65±0.77b
Hybrid 888	6.15±0.61g
Hybrid 3715	7.17±0.61f
LSD	0.29

Statement of conflict of interest

Authors have declared no conflict of interest.

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