STABILITY ANALYSIS AND MOLECULAR CHARACTERIZATION OF F_1 HYBRIDS IN BRINJAL (*Solanum melongena* L.)

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"STABILITY ANALYSIS AND MOLECULAR CHARACTERIZATION OF F_1 HYBRIDS IN BRINJAL (*Solanum melongena* L.)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVIATIONS

%	-	per cent
µ	-	Mean
µl	-	Micro litre
µM	-	Micro molar
^{0} C	-	Degree Celsius
ANOVA	-	Analysis of Variance
b_i	-	Regression coefficient
bp	-	base pairs
cm	-	centimeter
CTAB,	-	cetyl trimethylammonium bromide
d.f	-	degrees of freedom
DAS	-	Days after sowing
DAT		Days after transplanting
EDTA	-	Ethyl diamino tetra acetic acid
et al.	-	and co-workers/co-authors
F_1	-	First filial generation
F_2		Second filial generation
Fig.	-	Figure
g		gram
GOT		Grow out test
ha	-	hectare
i.e.	-	that is
ISSR	-	Inter-simple sequence repeats
kg	-	kilogram
m	-	meter
M	-	Molar
mg	-	milligram
min	-	minutes

mM	-	Milli molar
Nacl	-	Sodium chloride
ng	-	Nanogram
PCR	-	polymerase chain reaction
PVP	-	Polyvinyl pyrollidone
RAPD	-	random amplified polymorphic marker
RBD		Randomized block design
rpm	-	revolutions per minute
S.E(m)	-	Standard Error Mean
S^2_{di}	-	Deviation from regression
SE	-	Standard Error
spp.	-	Species
SSR	-	simple sequence repeat
t	-	tons
v/v	-	Volume/ volume
viz.	-	namely
w/v	-	weight/volume

Introduction

1. INTRODUCTION

Eggplant or brinjal, *Solanum melongena* L., is an ancient crop in Eastern countries. Domestication of eggplant took place in the area between northeastern India and southwestern China long ago, where the greatest diversity is found. The name 'brinjal' is popular in Indian subcontinent and is derived from Arabic and Sanskrit whereas the name 'eggplant' has been derived from the shape of the fruit of some varieties, which are white and resemble the shape of hen's eggs. It is called 'aubergine' (French word) in Europe. This popular crop is cultivated worldwide. Brinjal is widely grown in temperate and tropical Asian countries. It is an important vegetable crop of India adapted to different agro-climatic regions and can be grown throughout the year. It is used primarily as a cooked vegetable and known to have medicinal properties, beneficial for patients suffering from liver complaints and diabetes (Shukla and Naik, 1993).

Brinjal is usually self-pollinated, but the extent of cross-pollination has been reported to be as high as 48% and hence it is classified as often cross-pollinated crop (Agrawal, 1980). *S. melongena* belongs to the Solanaceae family, and to the tribe Solaneae, which comprises several cultivated species including chilli (*Capsicum* sp.), tomato (*Solanum* section *Lycopersicon* sp.), potato (tuberous *Solanum* sp.), *Physalis* and *Cyphomandra* species (Daunay *et al*., 2001). Eggplant is a diploid species, with a chromosome number 2n = 24 and a genome size of approximately 956 Mbp (Bennett and Leitch, 2004). Nutritionally it is a good source of minerals and vitamins. Furthermore, the fruit contains mostly water, fibre, phenolic compounds, alkaloids, some protein and carbohydrates (Cao *et al*., 1996; Stommel and Whitaker, 2003; Aubert *et al*., 1989a,b).

Brinjal is a major vegetable crop of our country since ancient times and the human society has social and economic relationship with this crop. India ranks second after China in area and production of brinjal. The cultivated area of brinjal in India is 6.64 lakh hectares with a production of 125.52 lakh tonnes and productivity is of 18.9 tonnes per hectare (FAO, 2017). West Bengal is the leading state with an area of 1.61 lakh hectares and annual production of 29.85 lakh tonnes (NHB, 2015).

The low productivity of the crop is mainly ascribed to poor genetic stock, incidence of pests and diseases and environmental conditions which vary from year to year. Fruit and shoot borer (*Leucinodes orbonalis* Guen.) is the most extensive pest which reduces the crop yield upto 60-70% (Singh and Nath, 2010). Thus, the major breeding goal is to produce high yielding, pest and disease resistant cultivars which should be stable and adaptable over different locations and seasons. The phenotype of an individual is a mixture of both genotype and environment. This has led to a greater emphasis to study the effect of genotype × environment interactions of various breeding lines or varieties across different environments (Kang, 2004). In India, attempts were made to harness hybrid vigour in brinjal as early as 1934 (Rao, 1934). Majority of the hybrids were found to exhibit heterosis with respect to seed germination, plant height, plant spread, number of branches, early flowering, number of fruits per plant, fruit size and fruit yield (Pal and Singh, 1946). Vegetable hybrid technology is one of the most potential technologies in Indian agricultural production system to harvest full potential of hybrids and meet the future demands of the population.

A number of promising varieties have been released in the country but very little efforts have been made to know the stability of varieties in different environments. As India comprises a wide range of weather conditions across a large geographic scale and varied topography, it is of utmost importance to develop a stable genotype across wide range of environments besides high yield. The study on yield stability or genotype × environment interaction is necessary to evaluate the consistency of crop yield and, for plant breeders it becomes increasingly significant in terms of the effectiveness of selection and recommendation of cultivars for different regions (Huehn, 1990). Stability analysis provides a general solution for the response of the genotypes to environmental change. Stability analysis is a good technique for measuring the adaptability of different crop varieties to varying environments (Morales *et al*., 1991). For this purpose, various biometrical techniques are available for estimating stability parameters. Yates and Cochran (1938) proposed linear regression analysis, which has been widely used and later modified by Finlay and Wilkinson (1963) and Eberhart and Russell (1966). This analysis involves regressing the average of the genotypes on an environmental index, providing a stability index.

In brinjal, hybrid seeds are produced using hand emasculation and pollination technique. The chance for the presence of selfed admixtures in the produced seed is high. Hence, to safeguard the farmer's interests and ensure that the farmers obtain true value for the money spent on purchase of seeds, it is necessary to confirm the identity and purity of the hybrid seeds before it reaches the farmer's fields. Considering this fact, genetic purity testing through grow out test (GOT) was made mandatory for seed certification of brinjal hybrid seeds in India (Tunwar and Singh, 1988). GOT involves the comparison of phenotypic characters of plants raised from seeds of test sample, with that of authentic samples throughout the crop's growing season. It is time consuming, cumbersome and costly. An easy and reliable alternative is the DNA marker based assays, which detect the level of admixtures in a seed lot based on the established variations between the cultivars at the level of nucleotide sequences. A variety of DNA markers are now available in brinjal for phylogenetic interpretations, fingerprinting of cultivars and marker assisted selection (Doganlar *et al.,* 2002; Tiwari *et al.,* 2009; Barchi *et al.,* 2011; Verma *et al.,* 2012). Among these, the Simple Sequence Repeat (SSR) markers are popularly used for assessing hybrid purity because of the comparative simplicity, rapidness, reproducibility and cost effectiveness. The co-dominant nature of SSR markers make them an effective tool for testing hybrid purity against the admixture of selfed seeds as well as off types. Considering this view, the present study was undertaken with the following objectives.

- To study the performance of superior hybrids over different locations and seasons from heterotic crosses of brinjal
- To confirm the hybridity using SSR markers

Review of Literature

2. REVIEW OF LITERATURE

Global warming and climatic changes have resulted in reducing the productivity of many crops around the world. The expression of yield or productivity of any variety is the result of interplay of the genotype with the environment. Considerable attention should be given to the effect of genotype × environment interaction in plant breeding programs in order to meet the future demand, to accomplish the objectives of food and national security at individual level. The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions (Ali *et al.*, 2003). Some genotypes may perform well in certain environments, but fail in several others. Genotype × environment (G × E) interactions are extremely important in the development and evaluation of plant varieties because they reduce the genotypic stability values under diverse environments (Akcura *et al.*, 2005). Yield is a complex character which is dependent on a number of other characters and is highly influenced by many genetic factors as well as environmental fluctuation. Genotypes which can adjust its phenotypic state in response to environmental fluctuations in such a way that it gives maximum stable economic return can be termed as well "buffered" or stable (Allard and Bradshaw, 1964). In a static mean of stability (Becker and Leon, 1988), a stable genotype is the one possessing a constant performance irrespective of any changes in environmental conditions. In this context, the present investigation is aimed at studying the stability of brinjal hybrids for yield characters during *kharif* and summer season and also to confirm the hybridity.

Relevant literature pertaining to the objective of study is reviewed under the following headings.

2.1 STABILITY ANALYSIS

Yield stability of a genotype at a wide range of environments has always been a priority to the plant breeders. On the other hand farmers arise a question: How broadly can a variety be adapted with a small genotype x environment interaction in a given location? The phenotype of an individual is a mixture of both genotype and environment. The level of performance of any character is a result of the genotype of the cultivar, the environment in which it is grown, and the interaction between genotype × environment. The G×E study is especially important in countries with various agro-ecologies. G×E interactions greatly affect the phenotype of a variety, so stability analysis is required to characterize the performance of varieties in different environments, to help plant breeders in selecting varieties. A genotype is regarded as stable if it has a low contribution to the G×E interaction (Comstock and Moll, 1963). Generally, the term stability refers to the ability of the genotypes to be consistent, both with high or low yield levels in various environments. On the other hand, adaptability refers to the adjustment of an organism to its environment, e.g., a genotype that produces high yields in specific environmental conditions and poor yields in another environment (Balzarini *et al.*, 2005).

The concept of stability has been defined and assessed in several ways and several biometrical methods including univariate and multivariate analyses (Lin *et al.*, 1986; Becker and Leon 1988; Crossa, 1990). The most widely used is the regression method, based on regressing the mean value of each genotype on the environmental index or marginal means of environments (Romagosa and Fox, 1993). A good method to measure stability was proposed by Finlay and Wilkinson (1963) and was later improved by Eberhart and Russell (1966). According to Eberhart and Russell model to assess the stability of genotype, regression coefficient (bi) is considered as a parameter of response of a particular genotype and deviation from regression (S^2di) as a parameter of stability. The genotypes with regression coefficient (bi) near to unity (1) and non-significant deviation from regression (S^2di) were considered as stable genotypes as their performance can be predicated over the environments.

Vegetables play an important role in human nutrition. Brinjal known as "King of vegetables" is nutritionally rich in vitamins, minerals, and dietary fibre. In India, it is grown in almost all parts of the country and is available throughout the year. The primary goal of a plant breeder is to develop a high yielding variety with stability and adaptability across different environments. There has been increasing concern among the farmers on the cultivation of hybrids, because under optimum crop production and protection management, crop raised from the seeds of F_1 hybrid has several advantages like better yield, adaptability and uniformity under unfavourable environments, they were found to fail.

Singh *et al.* (1985) during 1979-81 evaluated twelve *Solanum melongena* genotypes at Hissar for yield stability. Differences among genotypes and environments, and genotype × environment interactions, were highly significant. Although PH4 had the highest mean yield (68.345 t/ha), it had low stability. PBr91-2 and Azad Kranti were stable and produced 51.00 and 47.45 t/ha, respectively. PH4, ARU2C, PBr.129.5 and BR112 gave good yields under unfavourable conditions (1979-80) while Vijai was the best under favourable conditions (1980-81).

Eleven eggplant (*Solanum melongena*) varieties were grown at Hissar during 1982-84 which revealed differential responses among varieties to environment and significant genotype-environment interaction. Significant differences existed among varieties for yield and stability parameters. Khurana *et al.* (1987) concluded that the variety H4 gave the highest yields (40.9-65.4 t/ha) and was the most stable among 11 varieties.

In a study to find phenotypic stability for fruit yield in brinjal Khurana *et al.* (1987) found differential responses among varieties to environment and significant genotype-environment interactions. Significant differences existed among varieties for yield and stability parameters.

Sidhu *et al.* (1989) evaluated fifteen varieties of brinjal over four years (*Kharif* 1980, 1981, 1982 and 1983) and analysed stability parameters and yield. Significant genotype x year interactions were recorded. S-16 produced the highest yield (28.69 t/ha) and had the best stability, followed by P-8 and Annamalai.

Ten promising accessions of eggplant for fruit yield in bimonthly staggered sowing during 1987-88 was studied by Vadivel and Bapu (1989). The genotype x environment interaction was significant indicating differential response of genotypes. The genotypes Ep-65 and Annamalai were the most stable and gave the highest fruit yield over all environments. Co-2 performed well in favourable environments and Co-1 and Ep-44 performed well in less favourable environment.

Balakrishnan *et al.* (1993) conducted an experiment to study the stability for yield in five hybrids at six sites during 1989-91. They concluded that Pusa Hybrid 6 gave the highest mean yield, but proved suitable only for conditions of high soil fertility. Azad and NDBH1 showed general adaptation.

The F_3 generations of six brinjal (*Solanum melongena*) crosses and their 6 parents were grown under three environments (normal sowing and spacing, and late sowing combined with either normal or wide spacing) and evaluated by Chowdhury and Talukdar (1997) for nine traits, *viz*., days to 50% flowering, days to 75% fruit setting, plant height, primary branches, fruit length, fruit girth, fruit number/plant, average fruit weight and fruit yield/plant. The pooled analysis of variance revealed significant differences among the genotypes. The linear component of genotype (GE) environment interaction was not significant, but the non-linear component was found to be significant for all traits except days to 50% flowering, days to 75% fruit setting and number of primary branches. Amongst the parents, MHB1, RU2C and Lota gave stable performance for fruit yield/plant and some component traits. Most of the crosses showed fairly stable performance for yield/plant and average fruit weight.

Srivastava *et al.* (1997) tested twelve genotypes of brinjal for stability for fruit yield during *Kharif* 1994-98 and observed significant differences in fruit yield between genotypes and in genotype x environment interactions. KS-351 gave the best fruit yield followed by KS-331-5. Furthermore, these were free from linear and non-linear components of interaction and as such were regarded as most desirable for cultivation.

In an evaluation with ten varieties of brinjal (*Solanum melongena*) for three years for fruit yield and its components Mishra *et al.* (1998) reported that the varieties showed significant differences for all characters. Highly significant differences were recorded between genotypes and environments. Environment II gave the highest yield. Brinjal BB 49, BB 7, BB 1 and BB 2 gave high mean yield and stability. Brinjal BB 49 was identified as a high yielding and stable genotype. Therefore, these varieties can be considered to be stable for the environments representing Ghumsar Udayagiri.

Mohanty and Prusuti (2000) studied genotype × environment interaction and stability parameters in fifteen genotypes of brinjal over three years during 1994-96 with respect to yield components. Wide differences among genotypes, environments and genotype × environment interaction were observed for all the traits. Significant linear and nonlinear components of genotype-environment interaction was recorded for yield and number of fruits/plant, while the predictable portion alone was significant for average fruit weight. Adaptability of brinjal genotypes for general cultivation and high-yielding environments were studied. Significant positive correlations were noticed between mean performance, regression coefficient and deviation from regression for yield and number of fruits/plant and for average fruit weight.

The height, fruit weight and yield of seven brinjal [aubergines] (*Solanum melongena*) hybrids, *viz*., Neembkar, BH-1, BH-2, ARBH-216, ARBH-242, Pusa Hybrid-6 and Pusa Hybrid-9, were evaluated by Rai *et al.* (2000) during 1994-98 in Madhya Pradesh, India. The stability analysis revealed that the mean squares for environment as well as hybrid × environment were highly significant for all the characters under study, indicating different responses of the hybrids. ARBH-216, ARBH-242 and Pusa Hybrid-6 were the tallest plants (93.1, 92.5 and 91.1 cm, respectively). Based on regression coefficient values, BH-2 and Pusa Hybrid-6 were found to be stable in plant height under varying environments, while the rest were stable either in good or poor environments only. Pusa Hybrid-6 had the heaviest average fruit weight (194.6 g), while BH-1 was the only hybrid stable in fruit weight under varying environments. ARBH-242 had the highest yield (626.84 q/ha), followed by Pusa Hybrid-6 (512.00 q/ha) and Pusa Hybrid-9 (504.90 q/ha). Neembkar, ARBH-216 and ARBH-242 had significant negative regression coefficients in yield, indicating that these hybrids may be cultivated under poor environments.

Sarma *et al.* (2000) studied genotype × environment interaction in brinjal (*Solanum melongena*) by growing fifteen genotypes in four environments (2 plant densities, 2 sowing dates) in rabi 1995-96 at Jorhat. Significant genotype and genotype × environment interaction effects were observed for yield and 7 yield-related characters. Stability parameters indicated that JC2 had average stability for yield per plant, earliness of flowering, tallness, fruit circumference and average fruit weight. Genotypes with a high degree of stability were identified for the different characters for use in breeding programmes. It was observed that stability of fruit circumference and average fruit weight and plasticity in other yield components led to the stability in yield per plant.

Rai *et al.* (2000) evaluated nine long fruited brinjal hybrids (HOE-404, ARBH-258, HOE-414, Pusa hybrid-5, ARBH-527, ARBH-541, PBH-1, PBH-6 and ARBH-201) for yield and its contributing attributes in a field experiment conducted in Raipur, Madhya Pradesh, India for four years (1995-99). The stability analysis revealed that the mean squares for hybrid × environment (linear) were highly significant for all the characters under study, indicating different response of hybrids. The hybrid PBH-6 was found to be the most stable for yield and its contributing characters in Chhattisgarh region of Madhya Pradesh.

Rai *et al.* (2001) studied eleven cultivars of aubergine having long-shaped fruits (Punjab Sadabahar, PB-33, PB-30, KS-331, KS-352, NDB-26-1, NDB-28-2, JB-15, BB-46, BB-13-1 and Purple Long) in Madhya Pradesh, India for stability parameters with respect to yield and its contributing characters (plant height, fruit weight, and longitudinal and equatorial fruit lengths) over four environments (1995-99). Variations among cultivars for all the characters under study, except plant height, were significant. Genotype × environment interactions for different characters were also significant, indicating different response of cultivars among different environments. However, the linear effect and the linear interaction with genotype were both non-significant for all characters under study. Pooled deviations from regression for all characters were highly significant. This meant that the environmental interaction with cultivars were, in general, non-linear in nature. For the characters plant height and equatorial and longitudinal fruit lengths, all cultivars were stable. As regard fruit weight, all cultivars, except PB-33 and BB-13-1, were either stable or linearly predictable. As for yield, PB-30 and JB-15 were stable as well as linearly predictable. PB-30 had the second highest yield (472.53 q/ha). Pusa Purple Long was also stable in yield, however, it performed well under poor environments only.

Thirty tomato genotypes were evaluated by Upadhyay *et al.* (2001) for stability under diverse environmental conditions during 1996-97 in Pantnagar, Uttaranchal, India. The different environments were created using different N:P:K rates (E1, 0:0:0 kg/ha; E2, 100:60:60 kg/ha; E3, 200:120:120 kg/ha; and E4, 300:180:180 kg/ha). Pooled analysis of variance exhibited significant mean of squares due to the genotypes for all the traits studied: number of days to first harvest after transplanting, number of primary branches per plant, plant height, number of locules/plant, number of marketable fruits per plant, marketable fruit yield per plant, number of unmarketable fruits per plant and unmarketable fruit yield per plant. Significant variation due to the environments were observed for all characters, except number of primary branches per plant, number of locules per fruit and number of days to first harvest after transplanting. E3 was superior over the environments for all traits. Significant mean squares due to genotype environment interaction were observed for all traits except number of marketable fruits/plant and marketable fruit yield per plant. Cultivars Rupali and Pant T-3 were the only stable genotypes for marketable fruit yield per plant.

Prasad *et al.* (2002) evaluated forty-five aubergine inbred lines in three environments for yield attributes. Genotypes had divergent linear response to environmental change and significant pooled deviation suggested that deviation from linear regression also contributed substantially towards the differences in the stability of genotype. Further, linear and non-linear components contributed significantly to the differences in stability among the genotypes tested. Environmental indices revealed that El is the most favourable environment as the least number of attributes recorded negative trend in their expression. The inbred line CH 303 (xi=1.71 kg, bi=1.60 and s^2di=0.01) showed supremacy in yield and stability for favourable environments followed by CH 309, CH 267 and CH 250. The inbred line CH-309, a high yielder with unit value of regression coefficient coupled with low degree of deviation from regressions and highly suitable for unfavourable environments and can be commercially exploited as it produces attractive purple long fruits and is highly resistant to bacterial wilt disease.

Fifteen brinjal genotypes/lines were evaluated for yield and its components for five consecutive years from 1993-94 to 1997-98 by Chaurasia *et al.* (2005). G x E interactions were significant for all the characters under study *viz*., plant height, fruit length, fruit diameter, fruit size, number of fruits per plant and 10 fruit weight. KS-224 was the highest yielder followed by KS-331 and H-7. These lines can be recommended for general cultivation and can also be utilized in breeding programmes to incorporate stability.

An experiment was conducted by Kanwar *et al.* (2005) to study the stability of six cultivars (Punjab Barsati, Punjab Sadabahar, Punjab Bahar, Punjab Neelam, Punjab Jamuni Gola and Punjab Moti) of aubergine grown under four environments in Ludhiana, Punjab, India, during the winter, spring, summer and rainy seasons of 1999-

2000. Parameters included in the study were: number of fruits per plant, fruit weight at harvest, seed weight per fruit and seed yield. Punjab Moti was the best for number of fruits per plant and seed yield per hectare, while Punjab Jamuni Gola was the best for fruit weight at harvest and seed weight per fruit.

Greenhouse experiments were conducted by Shoba *et al.* (2006) to determine the heat tolerance and stability for yield of sixty tomato F_1 hybrids and their 11 parents under different environments. Based on the stability analysis, the genotypes were grouped as group A (suitable for both normal and stress environments), group B (suitable for normal environment only) and group C (suitable for stress environment only).

Stability analysis of aubergine genotypes (KS 224, JB 64-1-2, AB 98-10, AB 98-13, PLR 1, Gandhinagar Local, Bombay Gulabi, Morvi-4-2, Surati Ravaiya and JBPR 1; and the control, GBH 1) conducted by Suneetha *et al.* (2006a) in Gujarat, India revealed significant mean squares due to seasons, indicating variable expression of the traits in the different seasons. The results on environmental indices revealed rainy season to be beneficial for fruit yield per plant, days to first picking, plant height and majority of the fruit characters, while summer season was observed to be ideal for fruits per plant, and late summer for primary branches per plant. Further, the partitioning of season + (season × genotype) mean squares revealed higher magnitudes of season (linear), compared to genotype × season (linear), indicating that predictable component accounted for the major part of total variation observed for fruit yield per plant. However, mean squares due to pooled deviations were observed to be significant for fruit yield per plant and the other yield attributes except fruit diameter, indicating the role of both predictable and unpredictable components in the differential response of the genotypes for stability of these traits. Studies on the stability of genotypes also indicated greater number of genotypes with predictable response for fruit yield per plant and majority of the yield component characters studied. Further, among the genotypes with predictable response, genotypes exhibiting stability for specific environments were observed to be higher in number, compared to the genotypes exhibiting stability for wider environments. The parents, PLR 1 and JBPR 1 were observed to be stable for fruit yield and few yield contributing characters, while the hybrids, PLR 1 × JBPR 1, Morvi 42 × JBPR 1 and Surati Ravaiya × JBPR 1 were identified as high yielding and stable hybrids suitable for cultivation during all the seasons studied.

Vadodaria *et al.* (2009b) evaluated forty eight brinjal hybrids along with their sixteen parents and a check variety (GBH 1) for fruit borer infestation and fruit yield per plant during three consecutive seasons (2003-2004). Stability analysis indicated significant G x E interactions for both the attributes. Linear and non-linear components contributed significantly to the differences in stability among the genotypes tested. From the point of view of yield and resistance to fruit borer infestation, six hybrids *viz.*, JBSR 98-2 x Pant Rituraj, ABL 98- 1 x Pant Rituraj, ABL 98-1 x GBL 1, Morvi 4-2 x GBL 1 Morvi 4-2 x PLR 1 and Green Round x GBL 1 with good adaptability were identified. These hybrids were suitable either for resistance breeding or for commercial exploitation of hybrid vigour.

Mheta *et al.* (2011) evaluated seven open pollinated genotypes of long brinjal in three environments under rainy season and irrigated situations for Chhattisgarh plains. Data indicated highly significant mean squares for genotypes and genotype x environment interaction. IBWl-2007-1 was the most stable genotype under irrigated condition of Chhattisgarh plains for *kharif* planting situations. A local genotype was the most suitable for fruit yield under rainfed environment.

Bora *et al.* (2011b) evaluated seventeen genotypes of brinjal for two consecutive seasons (autumn winter, 2008 and spring summer,2009) under two treatments (recommended NPK as per package and vermicompost) for stability in performance. Significant G x E interaction was observed for most of the yield attributing characters studied except for total number of fruits per plant. In general, all genotypes gave higher yields in autumn winter with recommended NPK. PB67 was the top performing genotype in all four environments. PB60, PB66, PB4 and Punjab Sadabahar also showed commendable stability in yield across the environments.

Chaudhari *et al.* (2015) reported stability performance over three locations for fruit yield and its components in fifty-one genotypes (36 hybrids+15 parents) of brinjal using Line × Tester mating design. The analysis further revealed that components of G × E interactions were significant for plant height, days to 50 per cent flowering, average fruit weight, number of fruits per plant, fruit yield per plant and ascorbic acid indicating that linear as well as non-linear components were important. Parents showed average stability for fruit yield per plant and its component characters while only one cross, JBL-08-08 × NSR-1 exhibited average stability for fruit yield per plant.

Field experiments were carried out to evaluate seventeen hybrids of tomato (*Solanum lycopersicum* Mill.) for their stability at three locations in Kashmir valley during *kharif* 2011 and 2012 by Ummyiah *et al.* (2015). Significant differences were observed among all the hybrids for eight quantitative characters. The pooled analysis of variance for stability of the hybrids revealed significant differences among the genotypes and environments for all the traits studied. The interaction component genotype × environment was also significant for all the traits. The hybrids stable for yield and most of the traits were TO-687, Indam-531, Rambo, PS-255, Maharaja and Swaraj-1516. This implied that these hybrids contributed less to the genotype × environment interaction and hence were recommended.

Shalini (2016) conducted stability analysis in tomato (*Solanum lycopersicum* L.) involving 23 genotypes during 2004-2006. On the basis of stability parameters, the genotype H-24 was found to be stable across the seasons as indicated by higher mean values for total yield per plant, number of fruits per plant and average fruit weight coupled with regression coefficient nearer to unity and non-significant S^2d_1.

Bhushan and Samnotra (2017b) assessed the performance of twenty five brinjal genotypes in terms of yield as well as quality across six seasons and six environments through phenotypic stability studies subjected to Eberhart and Russel regression model at Vegetable Experimental Farm, Division of Vegetable Science & Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha during 2013-14 and 2014-15.The portioning of environments + (genotypes x environments) mean squares showed that environments (linear) differed significantly and were quite diverse with regards to their effect on the performance of the genotypes for fruit yield and quality traits. A perusal of stability parameters indicated only one genotype PPL-74 as average responsive and thus adapted to all types of environments for total phenol content whereas for ascorbic acid content, only two genotypes *viz*., Sandhya and Chhaya were stable. However, two genotypes *viz*., Shamli and Punjab Sadabahar were identified as stable for fruit yield per plant whereas, genotype PPL-74 was found stable for average fruit weight and fruit yield per hectare.

Dhaka *et al.* (2017) investigated the magnitude of influence of variable environments on numerous genotypes of brinjal for growth and flowering. The cultivars were investigated during four successive environments at two different locations in Rajasthan with contrasting environmental components such as soil and climate. The phenotypic response of the genotypes was followed with a focus on the size of the growth and the direction of flowering within the group of genotypes as a result of each factor: season, location of growing, genotype and their complex interactions. The collected data were analyzed and provided sufficient information on the genotype × environment interaction. Significant differences were found among the investigated genotypes for growth and earliness traits regardless of their specific response to the year conditions and the location. The genotype × environment interaction was significantly high and non-linear. This means that under changeable environments the different cultivars react differently and can, therefore, be grouped according to the growth and earliness stability. Seven genotypes were found to be stable across the environments for days to anthesis of first flower, eight genotypes were found stable for days to 50 per cent flowering and ten genotypes were found stable for days to first fruit picking. Among the genotypes, Pusa Upkar and Punjab Sadabahar × Pusa Upkar were stable for all the earliness traits.

2.2 RESPONSE OF GENOTYPES TO ENVIRONMENTS FOR QUALITATIVE TRAITS.

Eggplant or brinjal (*Solanum melongena* L.) fruit is important as a vegetable because of its high moisture content and low calorific value. The presence of good fibre and various vitamins and minerals in the fruit is beneficial to human health. Furthermore, the fruit contains phenolic compounds such as anthocyanins and phenolic acids which have antioxidant properties (Cao *et al.,* 1996; Stommel and Whitaker, 2003) as well as alkaloids (Aubert *et al.* 1989a), which have several beneficial biological and pharmaceutical properties. Phenols and ascorbic acids are important determinants of brinjal fruit flavour (Stommel and Whitaker, 2003). Higher ascorbic acid content in brinjal fruit is associated with increased nutritive value of the fruits which would help better retention of colour and flavour (Kumar and Arumugam, 2013). The proximate compositions of fruits estimated *viz.,* moisture, crude protein, total sugar and total phenol contents not only determine fruit quality but also are associated with the tolerance attribute of the genotype against biotic stresses (Karak *et al.*, 2012). The available literature concerning the qualitative traits of brinjal is reviewed as under:

Prohens *et al.* (2007) investigated the relationship among, as well as the variation and heritability of, the content of phenolics, ascorbic acid, and soluble solids, pH, and the degree of browning and color difference of the cut surface of the fruit flesh in a collection of 69 eggplant varieties. These included landraces from different origins, commercial varieties, experimental hybrids, and four accessions of the related *S. aethiopicum* L. *and S. macrocarpon* L. species. Analyses of variance revealed significant differences among the materials studied for all traits considered. The concentration of phenolics in *S. melongena* spanned a threefold range, although the highest (1122 mg_kg^{-1}) and lowest (134 mg_kg^{-1}) concentrations of phenolics were found in *S. macrocarpon and S. aethiopicum* respectively. Concentrations of ascorbic acid were very low, a mean 27 times lower than those of phenolics, and soluble solids content ranged from 3.60% to 6.60% with a pH that ranged from 5.01 to 5.93. Commercial varieties had, as a mean, a 20% lower concentration of phenolics than landraces, as well as a lower degree of browning and color difference. Positive correlations existed between phenolic concentration and degree of browning (r = 0.388) and color difference (0.477), although only 15.1% and 22.8% of the total variation in degree of browning and color difference, respectively, could be attributed to variation in phenolics. Ascorbic acid, soluble solids content, and pH were not correlated to either degree of browning or color difference. The heritability was moderate for phenolic concentration (0.50) and high for degree of browning (0.71) and color difference (0.82). The results illustrated that there are opportunities for the development of new varieties with a high concentration of phenolics and low or moderate browning.

Okmen *et al.* (2009) studied total water soluble antioxidant activity and phenolic content of 26 eggplant (*Solanum melongena* L.) cultivars. Total water soluble antioxidant activity of the cultivars varied from 2664 to 8247 mmolTrolox/kg, which is a 3.1-fold difference. Cultivars also showed significant variation for total phenolic contents ranging from 615 to 1376 mg/kg, a 2.2-fold difference. The two traits were significantly correlated. Results of this study suggest that breeders can use the information to develop eggplant cultivars with high antioxidant activity.

The effect of temperature on polyphenolic contents and antioxidant capacity of different parts (whole fruit, pulp and peel) of dark purple and white eggplant variety cultivated in different regions of Algeria was evaluated. High phenol content was recorded for peel of dark purple variety in the following order; fresh (548.77 mg GA/g) > frozen (106.11) > dry (93.48). The antioxident capacity, measured as ascorbic acid equivalent antioxidant capacity assay, is in the following order; peel of fresh dark purple eggplant (324.34 mg AA/g) > whole fruit of frozen dark purple eggplant (182.69 mg/g) > peel of fresh white eggplant (89.52 mg/g) (Boubekri *et al.,* 2013).

Kumar and Arumugam, (2013) evaluated 33 indigenous brinjal genotypes collected from in and around Tamilnadu for quantitative and qualitative traits at ACRI, Madhurai and reported ascorbic acid content varying from 7.38 mg/100g (EP 30) to 13.47mg/100g (Keerikai).

Shaheen *et al.* (2013) estimated the total phenol content of five cultivars (BARI-Begun-1, BARI-Begun-5, BARI-Begun-6, BARI-Begun-8 and White Begun) at University of Dhaka and their findings reflect that among the five cultivars studied, BARI-Begun-8 contained the highest (39.3±1.6 and 7.86±0.33mg/GAE/g) and BARI-Begun-5 contained the lowest TPC (16.32±0.22 and 3.16±0.04mg/GAE/g) on dry as well as fresh weight basis, respectively.

Jose *et al.* (2014) studied proximate composition, carbohydrates, total phenols and vitamin C of eggplant fruits of three Spanish land races, three commercial hybrids and three hybrids between landraces cultivated across two environment conditions (open field and greenhouse for up to four seasons). The results indicated that season (S) had a larger effect than the genotype (G) for composition traits, except for total phenols. G X S interaction was generally of low relative magnitude. Orthogonal decomposition of the season effect showed that differences within OF or GH environments were in many instances greater than those between OF and GH. Spanish landraces presented, on an average lower contents of total carbohydrates and starch and higher contents of total vitamin C, ascorbic acid and total phenolics than commercial hybrids. Hybrids among landraces presented variable levels of heterosis for composition traits. They concluded that cultivation environment has a major role in determining the composition of eggplant traits. Environment and genotypic differences can be exploited to obtain high quality eggplant fruits.

Biochemical analysis of six long fruited (NB-2, NDBH-2, ND-3, PPL, Pant Samrat and Pusa Kranti) and six round fruited varieties (NB-1, NDBH-1, NDBH-3, Pant Rituraj, Punjab Bahar and PPR) for total phenols was conducted. Results indicated that PPR (103.42 mg/100g) contained significantly highest total phenol content followed by Pant Rituraj (99.64 mg/100g) whereas amongst all the varieties, Punjab Bahar showed lowest total phenol content (79.33 mg/100g) (Tripathi *et al.,* 2014).

Somavathi *et al.* (2014) conducted a study to determine the antioxidant activity and total phenol content of five different skin colours/patterns i.e. purple with no lines, light purple with lines, dark purple with lines, pink coloured and purple with green lines. The results revealed significant differences in antioxidant activity and total phenol content (TPC) in different skin colours with maximum TPC in dark purple with lines (60.94 ± 0.52) and minimum in light purple with lines (48.67 ± 0.26).

Guillermo *et al.* (2014) characterized and compared the ascorbic acid and total soluble phenols in five eggplant types i.e. Chinese, Philippine, American, Hindu and Thai. Of all the types, significantly highest ascorbic acid content (22.0±4.1 mg/100g fresh sample) was observed in Hindu type whereas significantly highest values for total soluble phenols was recorded in Thai type (2049.8±77.8 mg/100g).

Fifty genotypes of brinjal having fruits of different colours were evaluated for dry matter, total soluble sugars, total phenols, ortho-dihydroxy phenols (ODHs) and flavonols in two years i.e 2012 and 2013. It was found that brinjal has low sugar content and it is a rich source of phenolic compounds. Highest total phenol content was found in genotype G-415 (green) in 2012 and 2013. G-418 (green) and P-71 (purple) showed ODH content in the maximum range (80-100 mg/100g). The maximum flavonol content was found in BLEND-11-WR-2 which was having white coloured fruits (Kumari *et al.,* 2014).

Kandoliya *et al.* (2015) conducted an experiment to study the nutritional quality along with various parameters contributing antioxidant activity to brinjal fruits of local varieties. The findings from all the varieties studied showed 25.17-40.35% radical scavenging activity (DPPH), comparable amount of flavanoids (7.42-13.25 mg. $100g^{-1}$) and anthocyanine content along with total phenol (32.89-39.12 mg.$100g^{-1}$), ascorbic acid (9.43-16.75 mg.$100g^{-1}$), protein (0.92-1.39 %) and titrable acidity (0.20-0.32 %) in the pulp of brinjal fruits. The activity value for polyphenol oxidase (PPO), the enzyme responsible for the browning reaction ranged from 0.66 to 1.39 OD. min^{-1}. g^{-1} in fresh pulp of brinjal. These results reveal that a particular variety is nutritionally considered better due to its higher antioxidant property, proteins and sugar content.

Nayanathara *et al.* (2016) evaluated five eggplant genotypes (violet nadan, long green, small round green, violet suphol and violet with white stripes) for total phenolic activity, total flavonoid activity and anthocyanin activity. The results showed that the total phenolic and flavonoid values of eggplant varieties extract varied from 856.76 to 386.75 gallic acid equivalents mg/100 g extract and total flavonoid content from 102.01 to 22.62 catechin equivalents mg/100 g extract. Violet suphol which contained high total phenolic and flavonoid content had better anthocyanin value as compared (129.29 mg/gm) to other varieties.

2.3 RESPONSE OF GENOTYPES TO ENVIRONMENTS FOR BIOTIC TRAITS.

Vegetable crops are exposed to a wide range of potential parasites, therefore, are more prone to various biotic and abiotic stresses. Among biotic stresses, frequent occurrence of fungal, bacterial and viral diseases are the major cause of reduced productivity and quality of vegetables. Cultivation of resistant or tolerant cultivars is one of the best options to minimize the losses due to disease occurrence. The production of brinjal suffers immensely due to the attack of disease and insect pests. Among them shoot and fruit borer *(Leucinodes orbonalis* Guen) and bacterial wilt *(Ralstonia solanacearum)* are the major constraints for yield loss.

2.3.1 Screening for shoot and fruit borer resistance:

The most extensive pest of this vegetable is brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) which reduces the yield and inflicts colossal loss in production. The losses caused by pest vary from season to season because moderate temperature and high humidity favour the population build-up of brinjal shoot and fruit borer (Shukla and Khatri, 2010; Bhushan *et al.,* 2011). This pest may reduce the crop yield upto 60-70% (Singh and Nath, 2010). Screening of brinjal cultivars against *L. orbonalis* has been attempted by several workers as follows:-

An experiment was conducted with twenty brinjal varieties/lines at Mymensingh, Bangladesh during 2007 to 2008 to identify their characteristics and susceptibility/resistance against brinjal shoot and fruit borer infestation. In case of shoot infestation, the varieties/lines Katabegun WS and Marich Begun S were found to be tolerant while the varieties/lines Amjuri, Borka, Dharola, Deembegun, ISD 006, Kajla, Khatkhatia BAU, Laffa S, Singnath, Thamba and Uttara were found to be moderately tolerant; BL-118, Eye Red, Islampuri BADC, Irribegun and Nayantara were found to be susceptible; Bijoy and Kaikka N were found to be highly susceptible. In case of fruit infestation, the varieties/lines Thamba and Katabegun WS were found to be tolerant while the varieties/lines Amjuri, BL-118, ISD 006, Islampuri BADC, Irribegun, Marich begun S, Kajla, Khatkhatia BAU, Laffa S and Singnath were found to be moderately tolerant; Borka, Dharola, Deembegun, Eye Red, Kaikka N, Nayantara and Uttara were found to be susceptible and the variety Bijoy was found to be highly susceptible (Ahmad *et al.,* 2008).

Malik and Rishi Pal (2013) evaluated 40 germplasm lines of brinjal for their reaction to shoot and fruit borer. The infestation of shoot borer appeared in 3 rd week (18-24 October). The shoot infestation mean varied between 0 to 20%. Shoot infestation was correlated with weather parameters prevailing during the crop season. Maximum temperature played positive role (r=0.34 to 0.928) in multiplication of shoot borer while minimum temperature was negatively correlated (r=-0.5 to -0.819). Relative humidity exhibited a negative influence on pest multiplication. Wind velocity and rainfall showed no significance in multiplication of this pest, while evaporation rate showed significant positive effect (r=0.249 to 0.959) on the multiplication of infesting shoot. General equilibrium position of fruit borer varied between 14.18 to 53.19% fruit infestation on different genotypes. HMB10 showed minimum fruit infestation of 14.18%, followed by 18.54, 24.01, 24.07 and 24.29% fruit infestation on SM 195, Long Green Mysore, Pant Samrat and S-15-1 genotypes, respectively. Maximum infestation of 53.19% was noticed on H-129. As regard the impact of weather parameters on fruit infestation temperature (maximum r=0.029 to 0.769), minimum (r=0.038 to -0.0678) had negative impact on the pest infestation, while relative humidity showed its positive significance. Likewise for shoot infestation, wind velocity and rainfall did not show any significance, while sunshine hours played significant negative role (r=0.03 to -0.682) in infestation of this pest.

Kumar and Singh (2013) investigated incidence of shoot and fruit borer, *Leucinodes orbonalis* Guen. (on shoot) during vegetative phase of the crop upto the 3rd week of September. On initiation of fruiting stage there was a continuous decline in the infestation on shoots and it disappeared during fruiting stage of the crop towards the end of October, as the borer infestation shifted to the fruits in the 2nd week of October. It gradually declined with the advent of winter season and was completely wiped out by the end of November. The role of temperature, rainfall and relative humidity (morning) in increasing infestation and intensity on shoot and fruits was very conducive but RH (%) (evening) responded negatively. The economic injury level of shoot and fruit borer on brinjal shoots was recorded as 0.96 & 0.90 per cent during 1st and 2nd year respectively and on brinjal fruits as 0.81 & 0.72 per cent during 1st and 2nd year.

Response of different brinjal genotypes to brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) was evaluated by Khan and Singh (2014) at Pantnagar, Uttarakhand during *kharif* (rainy season) 2011- 2012. 192 eggplant entries/accessions were evaluated for resistance to shoot and fruit borer. Minimum mean infestation in fruits was found in genotype EC305163 (0.0%) and IC090132 (0.0%) while maximum mean infestation in fruits was recorded in IC261792 (100%) and IC420406 (100%). Among the 192 genotypes of brinjal tested, EC305163 and IC090132 were found to be immune to shoot and fruit borer, three genotypes namely IC545256, IC433625 and IC264470 were found to be resistant, 21 fairly resistant, 38 tolerant, 52 susceptible and the rest (76 genotypes) were found to be highly susceptible to brinjal shoot and fruit borer.

Eighteen eggplant entries/accessions were evaluated for resistance to shoot and fruit borer at Indira Gandhi Krishi Viswavidyalaya, Raipur (Chhattisgarh) in *Rabi* (summer) season 2013. Minimum mean infestation in fruits was found in genotype Punjab Sadabahar, 2010/BRLVAR-3, 2010/BRLVAR-1 and 2010/BRLVAR-4 while maximum mean infestation in fruits was recorded in Swarnamani. Calyx diameter and fruit diameter showed significantly positive association with fruit infestation. Greenish purple coloured variety was least preferred by fruit borers with fruit damage of 5.21 per cent and highest fruit damage (28.27%) was noticed in variety dark purple coloured (Devi *et al.,* 2015).

Mannan *et al.* (2015) studied infestation of brinjal shoot and fruit borer (BFSB) in relation to plant age and season. The peak shoot infestation was 8.56% in the 10^{th} week of transplanting. No infestation of BSFB was found up to 5 weeks of transplanting. The shoot infestation was initiated in the 6^{th} week of transplanting which increased to a little higher level in the next week. Then it showed an exponential increase upto 10^{th} week after which it declined steadily. Flowering and fruit setting started in the 9^{th} week of transplanting. Infestation of brinjal shoot and fruit borer (BSFB) shifted to fruits from shoots causing a steady decline in the trend of shoot infestation. Plant age had significant effect (r^2=0.87) on fruit infestation. Fruit infestation reached the highest level (38.56%) in 14th week of transplanting. However, the level of infestation at different ages of the plant may vary depending on the location, temperature, variety etc. The shoots and fruits of brinjal plant were found to be infested by BSFB throughout the year, although the level of infestation varied. Maximum shoot and fruit infestation was found in the month of September.

Singh *et al.* (2016) carried out an investigation to identify promising genotypes that could withstand brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee.) infestation in *Rabi* season 2013-14 and 2014-15. Thirty eggplant accessions were evaluated for resistance to shoot and fruit borer. Minimum mean infestation in shoot and fruits was found in the genotypes Punjab Sadabahar, PLR-1, DBR-31, NURBEE, NDB-3, PUSA PURPLE LONG, NDHB-2 and NDHB-3 while maximum mean infestation in fruits was recorded in Swarnamani and BR-112.

Vethamoni and Praneetha (2016) carried out an experiment with twenty lines and three testers to develop green fruited brinjal F_1 hybrids with cluster bearing habit, striped fruit, shoot and fruit borer resistance and high yield. The lines and testers were raised in the crossing block and crossing was carried out in L × T mating design and hybrid seeds were obtained. Among the sixty hybrids developed, six hybrids with high yield and shoot and fruit borer resistance were identified and raised in the field and their growth, yield and shoot and fruit borer resistance were studied. Based on mean performance, the parent L15 was found to be the best for plant height, number of fruits, fruit yield and marketable yield with less borer infestation. Among the hybrids, the maximum number of fruits (54.8) was recorded in the hybrid L15 × T2 followed by L2 × T2 (43.4) and L16 × T2 (42.2) respectively. The maximum per plant yield of 4.2 kg/plant was recorded by the hybrid L15 × T2. The hybrid L2 × T2 stood second, recording 3.6 kg and L16 × T2 was in the third position with a yield of 3.4 kg. Minimum borer infestation of shoot (12.0%) was recorded in the hybrid L15 × T2 followed by L2 × T2 (12.4%) and L12 × T2 (12.9%). Minimum borer infestation of fruit (13.0%) was recorded in the hybrid L15 × T2 followed by the hybrid L12 × T2

(13.8%). Among the F_1 hybrids, the performance of L15 × T2 was superior for growth and yield characters. Shoot and fruit borer damages were also low level in this hybrid.

2.3.2 Screening for bacterial wilt resistance:

Ralstonia solanacearum (Smith, 1896; Yabuuchi *et al*., 1996) is one of the most destructive soil borne vascular pathogens of Solanaceous vegetables and several other crops grown in the tropical, subtropical as well as temperate regions of the world (Ghosh and Dutta, 2014). It invades the plant vessels and provokes complete wilting of the plant followed by its death that sometimes leads to complete yield loss. Screening of brinjal cultivars against bacterial wilt has been attempted by several workers as follows:-

Fifteen brinjal accessions were screened in the sick bed preinoculated with *Ralstonia solanacearum*. The population of *R. solanacearum* in the sick bed soil was 2.1 ′ 107 cfu/g soil. The accession EG 203 was resistant against the bacterium with lowest wilt incidence. The accession EG 193 was moderately susceptible. Rest of the accessions were susceptible. Resistant and moderately susceptible accessions showed longer incubation period (Hussain *et al.,* 2005).

Rahman *et al.* (2011) conducted an experiment in Dhaka to screen out the resistant cultivars of eggplant against wilt disease. Eight cultivars *viz*. Nayantara, Singhnath, Dhundul, Kazla, Marich Begun Luffa, Kata Begun and Uttara were used as treatments. At 55 days after transplanting (DAT) the cultivar Luffa exhibited the highest bacterial wilt incidence (80%) and the lowest wilt incidence was recorded in the cultivar Kata Begun (30%). At 90 DAT the highest Fusarium and Nemic wilt incidence was recorded in the cultivar Luffa and the lowest wilt incidences were recorded in the cultivar Kata Begun. The highest shoot height was recorded in the cultivar Kata Begun and the lowest shoot height was recorded in the cultivar Singhnath. The highest gall number was recorded in Luffa and the lowest gall number was recorded in Kata Begun. The highest yield per hectare (29.84 t/ha) was recorded in the cultivar Nayantara and the lowest yield (10.50 t/ha) was recorded in Dhundhul. Among the cultivars Kata Begun was graded as resistant to bacterial, fungal and nemic wilt.

Bora *et al.* (2011a) tested a total of 14 brinjal (*Solanum melongena* L.) genotypes during rabi season of 2007-08 and 2009-10 at Assam Agricultural University, Jorhat for resistance to bacterial wilt and performance of yield and its component characters. Promising varieties were tested in Lower Brahmaputra Valley Zone (LBVZ), North Bank Plain Zone (NBPZ) and Hill Zone (HZ) of Assam. Pooled data of 3 years trial conducted at Jorhat revealed that 'Utsav' exhibited lowest bacterial wilt incidence of 2.23% as against 65.8% in the susceptible check PPL. The yield of 'Utsav' was the highest (168.6 q ha^{-1}) which was 43.4% higher than the best check SM 6-6. The yield of 'Utsav' was 124.8, 8.6 and 14% higher in LBVZ, NBPZ and HZ, respectively. The duration of the crop as revealed from flowering and first harvesting was also shorter than the check varieties. 'Utsav' showed highest benefit:cost ratio of 3.64 as against 2.54 in SM 6-6. Hence, 'Utsav' was recommended for both plain and hill areas of Assam and North Eastern region.

Kumar *et al.* (2014) studied bacterial wilt resistance in brinjal. Nine accessions were evaluated in IET (Initial Evaluation Trial) and 8 accessions in AVT (Advance Varietal Trial) during 2010- 2012 in the wilt sick plot of ICAR Research Complex for Eastern Region, Research Centre, Ranchi. Among the accessions of brinjal, evaluated Arka Nidhi was found most resistant in IET. In AVT, two entries BEBWRES-05 and Arka Nidhi were highly resistant with maximum wilt percent of 7 and 19 respectively at 120 days interval whereas BEBWRES-2, BEBWRES-4 and SM 6-6 (C) with less than 40 % wilt at 120 days interval were found moderately resistant to bacterial wilt.

Forty-one eggplant accessions were screened in a sick plot for bacterial wilt resistance at Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru. Nine accessions, *viz.*, IIHR-322, AVT-IIRES-1, AVT-IIRES-2, AVT-IIRES-4, AVT-IIRES-5, IIHR500-A, BPLH-1, IIHR-3 and IIHR-5 showed highly resistant reaction, with no wilting of plants; five accessions, *viz.,* RES-2, RES-5, RES-6, 37-36-4-4 and 36-37-13 showed resistance reaction with 3.33 -10.0 % wilt. Two accessions, *viz*., 36-37-3 and 37-4-20 showed moderately resistant reaction, with 11.0 and 12.0 % wilt incidence, respectively; while 22 accessions were 'moderately susceptible to highly susceptible', with wilt incidence ranging from 25.45 to 100.0% (Gopalakrishnan *et al.,* 2014).

One hundred germplasm lines of brinjal received from NBPGR, New Delhi were evaluated for bacterial wilt resistance. Highest yield was recorded in IC- 285126 (3.29 kg/plant; fruit weight 200.0 g; fruit length 11.40 cm and round green) followed by IC-809900 (1.81 kg/plant; fruit weight 200.0 g; fruit length 16.50 cm and long light purple). Eight lines found to be wilt resistant under natural field conditions were screened in rainy season. Out of these only two lines were found resistant at 90 DAT *viz*., IC-261786 (120.62 q/ha; fruit weight 118.0 g; fruit length 17.3 cm and long green) and IC-261793 (63.12q/ha; fruit weight 252.0 g; fruit length 7.7 cm and round green striped) with 84% plant survival against bacterial wilt. They concluded that germplasm IC-261786 and IC-261793 can further be utilized for pre-breeding aimed at developing wilt resistant high yielding varieties (Bhavana and Singh, 2016).

Yadav *et al.* (2017) selected eight parental lines of brinjal including one wild species (*Solanum gilo*) which were crossed in half diallel fashion for transfer of disease resistant trait from one variety to another. The eight parents and twenty eight F_1 hybrids were screened against bacterial wilt disease. Fifteen genotypes were found moderately resistant and thirteen genotypes namely (Swarna Pratibha, *Solanum gilo*, Swarna Pratibha × Pant Rituraj, Swarna Pratibha × Pusa Purple Long, Swarna Pratibha × BR-112, Swarna Pratibha × CHFB-6, Swarna Pratibha × CHFB-7, Pant Rituraj × CHFB-6, Pant Rituraj × CHFB-7, Pant Rituraj × *Solanum gilo*, BR-112 × CHFB-6, CHFB-6 × CHFB-7 and CHFB-7 × *Solanum gilo*) were found to be resistant to wilt. These sources of resistance were identified from present investigation can be exploited for future breeding programmes for the development of disease resistant commercial cultivars through heterosis breeding.

2.4 MOLECULAR CHARACTERIZATION OF HYBRIDS AND ITS PARENTS.

Eggplant hybrid seeds are produced by 'Hand Emasculation and Pollination' technique and so there is a high chance for the presence of selfed, admixtures or off-types. To safeguard the farmer's interests and to ensure that the farmers obtain true value for the money spent on purchase of hybrid seeds, it is necessary to confirm the identity and purity of the hybrid seeds before it reaches the farmer's fields. Hence, ensuring the genetic purity of certified seeds of brinjal hybrids is mandatory in India, which is done through field grow out test (GOT) based on the morphological characters of plants grown to maturity. GOT being land and labour intensive, time consuming and influenced by the environment, there is a need to identify rapid and reliable alternatives like molecular based assays.

Among molecular markers, simple sequence repeat (SSR) markers are reported to be the best for testing genetic identity and purity of seeds. Being co-dominant in nature, they can determine the heterozygosity of the hybrid by the presence of polymorphic parental alleles, which facilitates in testing the hybrid purity and identity. The available literature related to molecular characterization of hybrids and its parents in brinjal is reviewed as under:

Kumar *et al.* (2014) identified the SSR markers that could be used to test the genetic purity of three popular brinjal hybrids (*viz.*, PH-5, PH-9 and Kashi Komal). Among 30 SSR markers studied, six markers were found to be suitable for testing the purity of these hybrids. The analysis of plant-to-plant variation within the parental lines of all the hybrids, using the identified hybrid specific markers, showed highly homogenous SSR profile, which further indicated the scope of application of these markers in maintenance and purity testing of hybrids and parental lines. Multiplexing of 2 polymorphic markers differentiated all the hybrids from each other, which can be used as referral markers for unambiguous identification, seed purity testing and protection of the hybrids. The validation of the identified markers in commercial seed lots of hybrids PH-5 and PH-9 revealed admixture of selfed seeds, which was confirmed through GOT.

Reddy *et al.* (2015) assessed the purity of interspecific hybrids of *Solanum melongena* L. ('IIHR3', Arka Keshav ('AK'), '2BMG') and *Solanum macrocarpon* L. ('SM') using simple sequence repeats (SSR). Genomic DNA from parents and F_1 hybrids were subjected to SSR analysis to detect parental polymorphism. Among 119 SSRs screened, 5 SSRs were codominant. There were five unique microsatellite markers, two for 'IIHR3' × 'SM', emf 01C03 and emh 02E08; one for 'AK' × 'SM', emi 02 F16; and two for '2BMG' × 'SM', emb 01E 03 and emg 11I03, which were useful to detect purity of three interspecific eggplant hybrids.

Wang *et al.* (2015) screened 124 pairs of SSR primers to identify hybrid purity and to analyse genetic relationship of F_1 hybrids of *Solanum melongena* ×*Solanum melongena* reciprocal crossing combination and *S. integrifolium*× *S. melongena* combination. The results showed that 15 pairs of SSR primers could stably amplify clear differential bands between parents. As to 210 plants of F_1 hybrids, 208 plants were identified as true hybrid, with hybrid rate of 99.0%, and this result was consistent with investigation result of characters in the field. In addition, the F_1 hybrids of *S. melongena* × *S. melongena* reciprocal-crossing combination had closer genetic relationship with parents with subtle difference. However, the F_1 hybrids of *S. integrifolium* × *S. melongena* combination had rather distant genetic relationship with male parent, which preferred to maternal inheritance.

Mangal *et al.* (2016) investigated twenty genotypes of brinjal representing nine open pollinated varieties, four hybrids, seven parents of hybrids (one parent common for two hybrids) and three wild relatives namely *S. integrifolium, S. incanum* and *S. aethiopicum* using 47 microsatellite loci distributed uniformly throughout the genome.

These 47 simple sequence repeat (SSR) loci amplified a total of 135 alleles among the 23 genotypes with one to seven alleles per loci. The average number of alleles per loci was found to be 2.87. The highest polymorphism information content (PIC value) was observed to be 0.75 for the marker emf11F24 located on linkage group 11. Utilizing SSR marker technique they confirmed the hybridity of four IARI brinjal hybrids. Four markers *viz*., emg11104, eme08D09, ecm009, and emf11F24 confirmed the hybridity of three hybrids namely, PH-5, PH-6 and DBHL-20.

Four markers were reported to be polymorphic between parental lines of four respective hybrids (*viz.,* PH-5, PH-9, NDBHL-20 and Kashi Komal) and were found to be suitable for ensuring the genetic identity and purity of these hybrids. Among the identified markers, a set of three markers (emg01B17, emd05F05 and CSM31) could be used for ensuring the identity of the hybrids. Utility of SSR marker based DNA fingerprinting in ensuring the seed purity has been further demonstrated in comparison with that of field plot test (Jha *et al.*, 2016).

Commercial eggplant varieties Mara and Mistisa were crossed with drought-tolerant eggplant accessions PHL 2789 and PHL 4841, respectively. To confirm that the F1 progenies indeed came from the cross made between the two selected parents, analysis was done by Maravilla *et al.* (2017) at the molecular level using simple sequence repeat (SSR) markers. Out of 65 SSR markers screened for polymorphism, six markers (EM141, eme05B09, EM133, emh11O01, emf21I02 and EM117) were able to discriminate between Mistisa and PHL 4841 and four markers (CSM20, eme09E09, EM131 and EES063) were able to distinguish Mara from PHL 2789. These markers were used to determine the hybridity of the 30 progenies from each cross. Based on marker data, all progenies except for progeny number 13 were identified as hybrids for the cross Mistisa x PHL 4841 while all the 30 progenies from the cross Mara x PHL 2789 were confirmed as hybrids.

Zhang *et al.* (2017) selected forty-eight released SSR primers for polymorphism screening of parents of two eggplant hybrids 15-16 and 1-7. Combining field plant purity identification, the validity of purity identification by SSR molecular markers was verified. Among the 48 pairs of primers. 12 pairs showed polymorphism in parent of hybrid 15-16, in which polymorphic primers banding type of 8 pairs was complementary type (SM14, SM15, SM17, SM20, SM29, SM30, SM34 and SM45). Five pairs showed polymorphism in parent of hybrid 1-7, in which polymorphic primers banding type of four pairs was complementary type (SM15, SM20, SM24 and SM29). Two pairs of SSR primers which were complementary types to each other were selected for hybrid purity identification. The results indicated that the purity of hybrid 15-16 and hybrid 1-7 were 99% and 100% respectively, which were in line with field identification.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled "Stability analysis and molecular characterization of F_1 hybrids in brinjal (*Solanum melongena* L.)" was initiated to evaluate and screen superior hybrids for consistent performance over different locations and seasons from heterotic crosses of brinjal and to confirm the hybridity using SSR markers. Details pertaining to materials and methodology employed in the investigation are presented in this chapter.

3.1 MATERIALS

The experimental material comprised of ten hybrids identified as superior with respect to yield, combining ability and gene action from a previous post graduate research programme (Rajasekhar, 2014). The F_1 hybrid Neelima (KAU) was used as standard check in the above study. The seven parents were selfed to produce the selfed seeds and these were crossed directly to produce hybrids on the basis of the above mentioned post graduate research programme. The details of parental lines used is given below.

Table 1. List of parents in brinjal used for hybridization

SL. No.	Accession Number	Name of parents	Source
1.	SMV1	Local	Wardha, Maharashtra
2.	SMV2	Local	Palakurthi,Andhra Pradesh
3.	SMV3	Surya	KAU,Vellanikkara
4.	SMV4	NBR-38	Nagpur, Maharashtra
5.	SMV5	Swetha	KAU,Vellanikkara
6.	SMV6	Local	Vellayani, Kerala
7.	SMV7	Selection Pooja	Bharat Seed Company, Jodhpur

3.1.1 SELFING AND CROSSING TECHNIQUE

In brinjal anthesis occurs between 8 a.m. to 12 noon. Hence, well developed flower-buds likely to, open the next morning were selected and emasculated during evening hours and bagged for protection. On the next day between 7 and 10 a.m., emasculated buds were pollinated by the respective parents. The pollinated buds were again protected with paper bags and labeled. The mature fruits obtained after hybridization were harvested and the seeds were collected separately for each cross. For maintenance of individual parental lines, flower buds of the different parents were selfed by bagging the individual hermaphrodite flower buds which were properly tagged and later the seeds were collected from the mature fruits accordingly.

Table 2. List of brinjal hybrids used for evaluation

Sl.No.	Hybrids	Accession No.
1.	Wardha local x Palakurthi local	SMV1 x SMV2
2.	Wardha local x Surya	SMV1 x SMV3
3.	Wardha local x Swetha	SMV1 x SMV5
4.	Wardha local x Vellayani local	SMV1 x SMV6
5.	Palakurthi local x Vellayani local	SMV2 x SMV6
6.	Surya x NBR-38	SMV3 x SMV4
7.	Surya x Vellayani local	SMV3 x SMV6
8.	NBR-38 x Vellayani local	SMV4 x SMV6
9.	NBR-38 x Selection Pooja	SMV4 x SMV7
10.	Swetha x Vellayani local	SMV5 x SMV6
11.	Neelima	SMV8

3.2 EXPERIMENTAL SITE:

The present investigation was carried out in four locations during *kharif* and summer seasons.

Location I: College of Agriculture, Vellayani

Location II: Farmer's field, Thiruvalla.

Location III: Farmer's field, Sadanandapuram.

Location IV: Farmer's field, Kayamkulam.

3.3 EXPERIMENTAL DESIGN

The experiment was laid out in Randomized Block Design (RBD) with eleven treatments and four replications. The spacing of 60 cm x 75 cm (plot size of 9 m^2) was followed during *kharif* and summer seasons.

3.4 CULTURAL OPERATIONS

The field was prepared to fine tilth by ploughing, harrowing and clod crushing and levelled. Thirty days old seedlings having 8-10 cm height were transplanted into the main field at a spacing of 60 cm x 75 cm during both seasons. The crop was raised as per the Package of Practices Recommendations of Kerala Agricultural University (KAU, 2011).

3.5 RECORDING OF OBSERVATIONS

Five plants were randomly selected from each plot in all the four replications passing up the border plants. The tagging was done before flowering. Observations with respect to different characters were recorded on these plants and the mean of five plants were considered for statistical analysis. Observations for the following characters were recorded on the tagged plants.

A. Yield Characters

3.5.1 Days to First Flowering

Number of days from the date of transplanting to the opening of the first flower in observational plants was recorded.

3.5.2 Days to First Harvest

Number of days from the date of transplanting to harvesting of the first fruit in observational plants was recorded.

3.5.3 Number of Fruits Plant^{-1}

Total number of fruits produced per plant till last harvest was counted.

3.5.4 Fruit Weight

Five fruits were selected at random from the observational plants. The fruits were weighed separately and the weight was expressed in grams.

3.5.5 Fruit Length

Length of selected fruits was measured as the distance from peduncle attachment of the fruit to the apex using twine and scale and expressed in centimeters.

3.5.6 Fruit Girth

Girth of the fruits was taken at the broadest part using twine and scale and expressed in centimeters.

3.5.7 Calyx Length

Length of calyx was recorded using twine and scale for each selected fruit and expressed in centimeters.

3.5.8 Fruit Colour

Dominant pigmentation on fruits of each variety was observed visually and recorded.

3.5.9 Yield Plant^{-1}

Weight of all fruits harvested from selected plants was recorded and expressed in kilograms per plant.

3.5.10 Yield Plot^{-1}

Weight of all fruits harvested from each plot was recorded and expressed in kilograms per plot

3.5.11 Plant Height

Plant height was recorded from the ground level to the top-most bud leaf of the plants at the time of peak harvest and presented in centimeters.

B. Scoring for pests and diseases

3.5.12 Shoot Borer Infestation

The number of shoots affected by borer and total number of shoots per plant was recorded from five randomly selected plants and the per cent of shoot borer infestation was worked out. Observations were recorded at 20 days interval from 60 DAT upto 100 DAT and expressed in percentage.

$$\text{Percentage of shoots infested} = \frac{\text{Number of shoots showing damage symptoms}}{\text{Total number of shoots}} \times 100$$

3.5.13 Fruit Borer Infestation

The number of fruits affected by borer and total number of fruits harvested per plant was recorded from five randomly selected plants and the per cent of fruit borer infestation was worked out. Observations were taken at 20 days interval from 80 DAT upto 120 DAT and percentage of damaged fruits was worked out.

$$\text{Percentage of damaged fruit} = \frac{\text{Number of fruits with bore holes}}{\text{Total no. of fruits on sample plants}} \times 100$$

Scoring

Characterization of shoot and fruit borer incidence was done as suggested by Tewari and Krishnamoorthy (1985). The incidence of *Leucinodes orbonalis* G. on shoots was assessed in terms of the percentage of infested shoots out of the total number of shoots available in each plot. Incidence on fruits was assessed by calculating percentage of infested fruits at different pickings and the pooled data was subjected to statistical analysis. Ranking has been denoted from 0 to 5 based on the percentage of fruit and shoot borer infestation. Pest rating was done as per the following scale:

Table.3 Fruit and shoot borer infestation rating scale in brinjal (Mishra *et al.* 1988)

Percentage of infestation	Grade	Rank
0	Immune (I)	0
1-10	Highly resistant (HR)	1
11-20	Moderately resistant (MR)	2
21-30	Tolerant (T)	3
31-40	Susceptible (S)	4
>40	Highly Susceptible (HS)	5

3.5.14 Bacterial Wilt

3.5.14.1 Percentage of plants infested

Number of plants showing wilting symptoms were recorded and from this percentage of plants infested was calculated. The observations were recorded at ten days interval from 30 DAT (Days After Transplanting) up to 90 days.

$$\text{Percentage of plants infested} = \frac{\text{Number of plants showing wilting}}{\text{Total number of plants}} \times 100$$

Scoring

Reaction to the incidence of bacterial wilt was studied adopting spot planting technique as suggested by Narayankutty (1986). In this technique, a wilt susceptible variety was planted along with the line under test. The wilting of the susceptible line indicated presence of virulent inoculum in the soil. Wilt incidence was confirmed by

Sh

bacterial ooze test. Disease rating was done as per the following scale suggested. Ranking has been denoted from 0 to 5 based on the percentage of plants wilted.

Table. 4 Bacterial wilt disease rating scale in brinjal by Winstead and Kelman (1952)

Percentage of plants infested	Grade	Rank
Plants did not show any wilt symptom	Highly resistant (HR)	0
1-20% plants wilted	Resistant (R)	1
21-40% plants wilted	Moderately resistant (MR)	2
41-60% plants wilted	Moderately susceptible(MS)	3
61-80% plants wilted	Susceptible (S)	4
More than 80% plants wilted	Highly susceptible (HS)	5

C. Biochemical Characters

3.5.15 Total Phenols

Total phenol content of fruit was estimated by using Folin-Ciocalteau reagent (Sadasivam and Manickam, 1996).

Reagents

- 80% ethanol
- Folin-Ciocalteau Reagent
- Na_2CO_3 20%
- Standard (100 mg Catechol in 100 ml water)
- Dilute 10 times for a working standard.

Procedure:

Weigh exactly 0.5 to 1.0g of the sample and grind it with a pestle and mortar in 10-time volume of 80% ethanol. Centrifuge the homogenate at 10,000rpm for 20 min. Save the supernatant. Re-extract the residue with five times the volume of 80% ethanol, centrifuge and pool the supernatants. Evaporate the supernatant to dryness. Dissolve the residue in a known volume of distilled water (5 ml).

Pipette out different aliquots (0.2 to 2 ml) into test tubes. Make up the volume in each tube to 3ml with water. Add 0.5 ml of Folin-Ciocalteau reagent. After 3 minutes add 2 ml of 20 percent Na_2CO_3 solution to each test tube. Mix thoroughly; place the test tubes in boiling water for exactly one min. Cool and measure the absorbance at 650nm against a reagent blank. Prepare a standard curve using different concentrations of catechol.

Calculation**:** From the standard curve find out the concentration of phenols in the test sample and express as mg phenols/100 g material.

3.5.16 Total Sugars

Total sugar content in a fruit sample was estimated by using Anthrone method. (Sudharmai Devi, 2008)

Reagents

1. 2.5 N HCL
2. Anthrone reagent: Dissolve 200 mg anthrone reagent in 100 ml of ice cold 95% H_2SO_4. Prepare fresh before use.
3. Standard glucose: Dissolve 100 mg in 100 ml water.
4. Working standard: 10 ml of stock diluted to 100 ml distilled water. Store refrigerated after adding a few drops toluene.

Procedure

Weigh 100 mg of the sample into a boiling tube. Hydrolyse by keeping it in a boiling water bath for 3 hours with 5ml of 2.5 N HCL and cool to room temperature.

Neutralize it with sodium carbonate until the effervescence ceases. Make up the volume to 100 ml and centrifuge. Collect the supernant and take 0.5 and 1 ml aliquots for analysis.

Prepare the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard. 0 serves as blank. Make up the volume to 1 ml in all the tubes including the sample tubes by adding distilled water. Then add 4 ml anthrone reagent. Heat for 8 minutes in a boiling water bath. Cool rapidly and read the green to dark green colour at 630 nm. Draw a standard graph by plotting concentration of the standard on the X – axis versus absorbance on Y – axis. From the graph calculate the amount of total sugars present in the sample tube and expressed in g/100g.

3.5.17 Vitamin C

The ascorbic acid content in plants was estimated volumetrically by the method explained by Sadasivam and Manickam (1996). Working standard solution of 5ml containing 100µg/ml of ascorbic acid was pipetted out into a 100 ml conical flask. 4% oxalic acid was added to it and titrated against 2, 6- dichlorophenol indophenol dye (V_1 ml). End point was noted on appearance of pink colour which persisted for a few minutes. The sample (0.5g) was weighed and ground in a mortar with pestle using 15ml 4% oxalic acid.

The homogenate was filtered through a double layered cheese cloth. The filtrate was made up to a known volume and centrifuged at 10,000 rpm for 10 min. The supernatant was collected and made up to 25ml using oxalic acid. 5.0 ml aliquot was pipetted into a conical flask to which 10ml of 4% oxalic acid was added. This was titrated against dichlorophenol indophenol (DCPIP) solution, until the appearance of pink colour in tested sample (V_2 ml). The amount of ascorbic acid is calculated as follows:

$$\text{Ascorbic acid} = \frac{0.5\text{mg}}{V_1\text{ml}} \times \frac{V_2}{5\text{ml}} \times \frac{100}{\text{weight of sample}}$$

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3.6 EVALUATION OF SEGREGATING GENERATION (F_2 population)

The material for the study comprised of four F_2 populations which were obtained by selfing four superior F_1 hybrids selected on the basis of yield performance from the previous experiments and were evaluated in a field experiment. For selfing, mature flower buds that would open on the following day were covered with butter paper covers in the previous evening hours, labeled and the covers were retained till fruit set. The experiment was laid out in Randomized Block Design (RBD) with four treatments and four replications. The spacing of 60 cm x 75 cm (plot size of 9 m^2) was followed in the experiment.

The list of hybrids used for developing F_2 population are:

1. Wardha local × Palakurthi local
2. Wardha local × Swetha
3. Wardha local × Vellayani local
4. Swetha × Vellayani local

Yield and yield attributing characters were recorded for evaluation.

3.7 MOLECULAR CHARACTERIZATION OF HYBRIDS AND THEIR PARENTS

3.7.1 Genomic DNA extraction:

The following protocol reported by Doyle & Doyle (1987) using CTAB was employed with modifications.

Young, healthy leaves of brinjal plants were collected and 100 mg of leaf material (avoided midrib and took the tip of the leaf) was taken for DNA isolation. CTAB extraction buffer (Appendix I) was preheated to 60^0C by keeping in water bath. Samples were crushed to a fine powder in liquid nitrogen with a precooled mortar and pestle. The powder was transferred to 2ml eppendorf tubes and to this 1ml of warm CTAB extraction buffer was added and mixed gently by inverting the tubes. Samples were incubated for 30 to 45 minutes in water bath at 65°C and mixed periodically (every 5 to 10 minutes). The samples were centrifuged at 4°C for 8min at 10000 rpm. The supernatant was transferred to another tube to which equal volume of Chlorofom:Isoamyl alcohol (24:1) mixture was added and mixed gently by inverting tubes to form an emulsion. The samples were again centrifuged at 10000 rpm for 10 min and the aqueous phase was transferred to fresh tube (If supernatant was still cloudy again added equal volume Chlorofom:Isoamyl alcohol (24:1) and repeated this step). The aqueous phase was transferred to fresh tube and equal volume of 1.5M sodium acetate and Chlorofom:Isoamyl alcohol (24:1) was added and centrifuged at 10000 rpm for 10 min. The aqueous phase was transferred to new tube and 1ml of cold isopropanol added and kept at -20^{0}C overnight. The solution was centrifuged at 10000 rpm for 20 min at 4^{0}C and the aqueous phase was discarded without dislodging the pellet. The pellet was washed with 200µl of 70% ethanol two times by centrifuging at 10000 rpm for 5 min and the pellet was dried at 37^{0}C for 20 to 30min. The pellet was resuspended in 50µl TE buffer. 1µl of Rnase was added to the final concentration of 10µg/ml and incubated at 37^{0}C for 30 min for immediate analysis or stored at -20^{0}C.

3.7.2 DNA Quantification:

DNA quantification was done using spectrophotometric (Systronics) measurement of UV absorption at wavelengths 260 and 280 nm. The TE buffer in which the DNA was already dissolved was taken in cuvette to calibrate the spectrophotometer at 260 and 280 nm wavelengths. The optical density of the DNA samples dissolved in TE buffer was recorded both at 260 and 280 nm wavelengths. The quality of DNA could be judged from the ratio of the O.D. values recorded at 260 and 280 nm. A ratio between 1.8 and 2 indicates good quality DNA. The quantity of DNA in sample was estimated by using the following formula:

Concentration DNA (ng/µl) $=A_{260} \times 50 \times$ dilution factor

3.7.3 Agarose Gel Electrophoresis:

The most common method to assess the integrity of genomic DNA is to run a sample of DNA on agarose gel. Horizontal gel electrophoresis unit (BIORAD, USA) was used to run the samples on the gel. A sample of DNA (5µl) was loaded on agarose gel (2%) made in 1x TAE buffer (Appendix I). The gel was run at $5Vcm^{-1}$ until the dye migrated $3/4^{th}$ of the distance through the gel. The gel was visualised using gel documentation system (SynGene G Box).

3.7.4 PCR analysis of genomic DNA using SSR Primers

Four SSR primer pairs were randomly selected from the sequence information available in literature (Nunome *et al.* 2009; Vilanova *et al.* 2012). These primers have been reported by Jha *et al.* 2016 and Kumar *et al.* 2014 as suitable for effectively assessing the genetic purity of brinjal hybrids. The sequences of the primers are shown in Table 5.

Table 5. Sequence of the selected SSR primers.

	Marker	Forward	Reverse
1	emb01M15	GCA AGG CTC AAA GTC ACA AGT CAA	GGC TCT GCC CCT AAC ATC TAC AAA
2	eme08D09	ATG GAT TAG CAT GTG GAG GAC TGA A	GTT TCA TGG TAG GTG GAG ACA GAA CCA
3	CSM31	CAA CCG ATA TGC TCA GAT GC	GCC CTA TGG TCA TGT TTT GC
4	emd05F05	ACG GGG GTG TCT CAT TAC ACT ACT GG	GTT TAC CCG TTC CTC AGC TTA TAG ACC C

3.7.5 PCR amplification

Amplification reaction mixture was prepared in 0.2 ml thin walled flat cap PCR tubes. PCR reactions of 25µl contained 10 µl PCR master mix (GeNei^{TM}), 2 µl of each forward and reverse primer (10µM), 100 ng genomic DNA and 8 µl of double distilled water. Amplification (Eppendorf Master Cycler) was carried out with the programme as follows:

1. Initial denaturation at 94 °C for 4 minutes,
2. Denaturation at 94 °C for 30 seconds,
3. Annealing at Tm of the specific primer for 1 minute
4. Extension at 72 °C for2 minutes,
5. Steps are repeated for 35 cycles,
6. Extension at 72 °C for 5 minutes.

After amplification, 3 µl of loading buffer (Appendix I) was added to each amplified product and mixed thoroughly. PCR Products were separated by gel electrophoresis on 2% agarose gel in 1X TAE buffer and visualized under ultraviolet light and photographed using a gel documentation system.

3.8 STATISTICAL ANALYSIS

The data recorded on different traits were subjected to the following statistical analysis.

1. Analysis of variance
2. Stability Analysis.

3.8.1 Analysis of variance

3.8.1.1 Analysis in Randomized Block Design (RBD)

The adopted design was Randomized Block Design (RBD) with four replications. The analysis of variance was carried out as per the method outlined by Panse and Sukhatme (1985).

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Where,

Y_{ij}	=	Phenotypic observation of i^{th} genotype in j^{th} replication
μ	=	General mean
α_i	=	True effect of i^{th} genotype. Where i = 1, 2…..g
β_j	=	True effect of j^{th} replication. Where j = 1, 2…..r
e_{ij}	=	Random error associated with i^{th} genotype and j^{th} replication

Analysis of variance (ANOVA) was carried out for each character as indicated below:

Source of variation	d.f.	SS	MSS	F-ratio
Replications	r-1	RSS	M_r	M_r/M_e
Genotypes	g-1	TSS	M_g	M_g/M_e
Error	(r-1) (g-1)	ESS	M_e	
Total	rg-1			

Where,

r = Number of replications

g = Number of treatments (genotypes)

M_r = Mean sum of squares of replications

M_g = Mean sum of squares of treatments

M_e = Mean sum of squares of error

d.f = Degrees of freedom

The significance of mean sum of squares for each character was tested against the corresponding error degrees of freedom using 'F' test (Fisher and Yates, 1967).

$$\text{Standard Error Mean (SE(m))} = (M_e/r)^{1/2}$$

Where,

M_e = Error mean of squares

r = Number of replications

$$C.D = S.E\,(d) \times t$$

Where,

$S.E\,(d) = (2M_e/r)^{1/2}$

't' = t Table value at error degrees of freedom

$$C.V = (\sqrt{Me}/\overline{X}) \times 100$$

Where,

$\overline{X}$ = Population mean

3.8.2 Stability Analysis

3.8.2.1 Methods to Measure Stable Performance of Genotypes:

Analysis of variance of genotypic mean was computed for each agronomic variable in each environment. The data were pooled over environments as the coefficients of variation values in each environment were generally low.

3.8.2.1.1 Eberhart and Russell's model (1966)

Following the methodology of Eberhart and Russell's model (1966), three parameters namely (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated. Eberhart and Russell (1966) used to study the stability of genotypes under different environments.

$$Y_{ij} = m + B_i I_j + \delta_{ij} \qquad (i = 1, 2...., g \text{ and } j = 1, 2 ......, e)$$

Where,

Y_{ij} = mean of i^{th} genotype in j^{th} environment.

m = mean of all genotype over all the environments

B_i = regression coefficient of the i^{th} genotype on the environmental index which measures the response of this genotype to varying environments.

I_j = environmental index which is defined as the deviation of the mean of all the genotypes at a given location from overall mean

$$= \frac{\sum_i Y_{ij}}{t} - \frac{\sum_i \sum_j Y_{ij}}{ge}$$

With $\sum_j I_j = 0$

δ_{ij} = The deviation from regression of the i^{th} genotype at j^{th} environment

3.8.2.1.2 Analysis of variance for stability

The analysis of variance proposed by Eberhart and Russell (1966) is given below.

ANOVA to estimate stability parameters (Eberhart and Russell, 1966)

	Source	d. f	S. S	M.S.S
1.	Total	(ge -1)	$\sum\sum Y_{ij}^2 - CF$	
2.	Genotype	(g-1)	$\frac{\sum Y_i^2}{e} - CF$	MS_1
3.	Environment + (Genotype x Environment)	g(e-1)	$\sum_i\sum_j Y_{ij}^2 - \sum_i \frac{Y_i^2}{e}$	
4.	Environment (Linear)	1	$\left(\frac{1}{g}\right)\frac{\left(\sum_j Y_j I_j\right)^2}{\sum_j I_j^2}$	
5.	Genotype x Environment (Linear)	(g-1)	$\sum_j\left[\frac{\left(\sum_j Y_{ij} I_j\right)^2}{\sum_j I_j^2}\right] - \left(\frac{1}{g}\right)\frac{\left(\sum_j Y_j I_j\right)^2}{\sum_j I_j^2}$	MS_2
6.	Pooled deviation	g(e-2)	$\sum\sum \delta_{ij}^2$	MS_3
7.	Deviation due to Genotype 1 Genotype 2 Genotype g	(e-2)	$[\sum Y_{ij}^2 - \frac{Y_i^2}{e}] - [\frac{(\sum Y_i I_j)^2}{\sum I_j^2}]$	
8.	Pooled error	ge(r-1)		S_e^2

g = No. of genotypes = 11, r = No. of replications = 4

e = No. of environments = 4

3.8.2.2 Estimation of stability parameters

The two stability parameters, regression coefficient (b_i) and deviation from regression(S^2_{di}) were estimated as follows :

3.8.2.2.1 Computation of regression coefficient (b_i) for each genotype

$$b_i = \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}$$

Where,

b_i = regression coefficient of i^{th} genotype

$\sum I_j^2$ = The sum of squares of environmental indices (I_j) which are common to each value of bi.

$\sum_j Y_{ij} I_j$ = (for each genotype) = The sum of products of environmental index (Ij) and the corresponding means (X) of that genotypes at each environment (Y_{ij}).

3.8.2.2.2 Computation of mean square deviation S^2_{di} from linear regression:

In a regression analysis, it is possible to partition the variance of dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (variance due to regression) and the other which explains the variance due to deviations from linearity symbolically.

$\sigma_Y^2 = \sigma^2$ (regression) $+\sigma^2$ (deviation from regression)

Obviously, by subtracting the variance due to regression from σ^2 Y, the variance due to deviation from regression can be obtained which in turn can be used for

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estimating S^2_{di} values. The variance of means over different locations with regard to individual genotypes may be obtained in the following way.

$$\sigma^2_{vi} = \sum_j Y^2_{ij} - \left(\frac{Y^2_i}{g}\right)$$

Where, Y_{ij} and Y_i are the mean values of genotypes in each location and total value of a variety in all the locations respectively.

The variance due to deviations from regression $\left(\sum_j \delta^2_{ij}\right)$ for a genotype being:

$$\sum_j \delta^2_{ij} = \left[\sum_j Y^2_{ij} - \frac{Y^2_i}{g}\right] - \frac{\left(\sum_j Y_{ij} I_j\right)^2}{\sum_j I^2_j}$$

Where,

$\sum_i Y^2_{ij} - \left(\frac{Y^2_i}{g}\right)$ = The sum of squares variance due to dependent variable (Y) and

$\frac{\left(\sum Y_{ij} I_j\right)^2}{\sum_j I^2_j}$ = The sum of squares variance due to regression of dependent variable (Y) on I.

From which it can be obtained as

$$S^2 d_i = \left[\frac{\sum_j \delta^2_{ij}}{e-2}\right] - \left(\frac{S^2_e}{r}\right)$$ Where, S_e^2 = Pooled error.

3.8.2.2.3 Test of Significance

The mean sum of squares due to genotypes and environments were tested against pooled deviation. Whereas, mean sum of squares due to G x E interaction was tested against pooled error. Environment (linear) and G x E (linear) were tested against pooled deviation, if pooled deviation is non-significant both these linear components were tested against pooled error. Mean sum of squares due to pooled deviations were tested against pooled error.

The following tests of significance were carried out:

1. To test the significance of the difference among genotype means *i.e.,* $Ho = \mu_1 = \mu_2 = \mu_3 = \ldots\ \mu_g$

$$F = \frac{MS_1}{MS_3}$$

2. To test that the genotypes did not differ for their regression on environmental index, *i.e.*

$Ho = b_1 = b_2 = b_3 \ldots\ldots\ldots B_e$, the 'F' test used was

$$F = \frac{MS_2}{MS_3}$$

3. Individual deviation from linear regression was tested as follows:

$$F = [(\sum_j \delta_{ij}^2)/(e-2)] / \text{pooled error}$$

Against F table value at (e-2) (g-2), at 5% or 1% probability level.

3.8.2.2.4 Stable Genotype

A genotype with unit regression coefficient (b_i=1) and deviation not significantly different from zero (S^2_{di}=0) was taken to be a stable genotype with unit response.

Mean and standard error of 'b'

$$\text{Mean of b} = \bar{b} = \sum_i \frac{b_i}{v}$$

$$\text{S.E.}(b) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\sum_j \text{Ij}^2}}$$

$$\text{SE bi} = \sqrt{\sum_j \delta^2 \text{ij} / (e-2) / \sum_j \text{Ij}^2}$$

3.8.2.2.5 Population Mean

Population mean (μ) and standard error was calculated as

Population mean (μ) = Grand total / No. of observations

$$\text{S.E.}(\text{mean}) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\text{Number of environments} - 1}}$$

Results

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4. RESULTS

The experimental results obtained after statistical analysis of data recorded for various parameters in the present investigation entitled "Stability analysis and molecular characterization of F_1 hybrids in brinjal (*Solanum melongena* L.)" carried out during 2015-16 and 2016-17 under four locations *viz*., Vellayani, Thiruvalla, Sadanandapuram and Kayamkulam in Kerala for assessing stability performance of ten brinjal hybrids and one check for yield attributes during *kharif* and summer season have been presented under the following headings :

1. Analysis of variance
2. Mean performance
3. Stability analysis for yield and its attributing traits (Eberhart and Russell, 1966 model)
4. Evaluation of segregating generations (F_2 population)
5. Molecular characterization of hybrids and their parents

4.1 EVALUATION OF F_1 HYBRIDS DURING *KHARIF* SEASON

4.1.1 Analysis of Variance:

Analysis of variance showed significant differences among the genotypes for all the characters studied in all the environments indicating presence of sufficient amount of genetic variability in all the characters. (Table 6.1 to 6.4).

4.1.2 Mean Performance:

4.1.2.1 Performance of brinjal hybrids at COA, Vellayani:

The mean performances of eleven genotypes for different characters are given in Table 7. Neelima is used as check.

4.1.2.1.1 Days to First Flowering:

The number of days to first flowering in the hybrids ranged from 40.15 to 46.35 days. Hybrid SMV1×SMV5 was the earliest flowering type which took 40.15

Table 6. Analysis of variance (mean square) for individual locations during *kharif* season.

Table 6.1. Location-I (Vellayani)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	0.36	1.01	0.49	17.39	1.53	0.45	0.09	0.004	7.61	1.81	0.31	0.01	3.41
Treatment	10	12.68**	35.82**	164.37**	574.46**	8.57**	13.46**	0.13**	1.62**	627.41**	143.54**	67.41**	2.20**	20.40**
Error	30	0.28	1.61	0.24	15.67	0.58	0.27	0.02	0.002	6.47	2.51	0.40	0.01	4.03

Table 6.2. Location - II (Thiruvalla)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	1.73	3.35	0.49	3.10	0.49	1.21	0.03	0.003	8.73	0.39	0.18	0.02	19.32
Treatment	10	21.22**	48.98**	205.09**	464.14**	7.02**	11.56**	0.09**	1.76**	663.50**	143.28**	71.70**	2.07**	43.27**
Error	30	1.25	2.39	0.82	2.15	0.30	0.29	0.02	0.01	3.39	1.16	0.41	0.02	5.46

**Significant at 1 % level

Table 6.3. Location - III (Sadanandapuram)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	2.50	0.42	0.08	18.65	1.07	0.37	0.01	0.002	3.22	0.29	0.21	0.06	20.27
Treatment	10	33.84**	20.68**	210.00**	1578.88**	7.64**	21.49**	0.11**	2.28**	748.28**	355.10**	85.60**	2.35**	33.55**
Error	30	1.13	0.96	0.98	6.84	0.33	0.28	0.01	0.01	3.86	1.25	0.35	0.02	5.37

Table 6.4. Location - IV (Kayamkulam)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	0.50	0.54	0.36	88.09	0.92	0.49	0.07	0.004	21.81	9.37	0.35	0.02	10.75
Treatment	10	19.22**	59.94**	155.59**	668.95**	9.00**	29.43**	0.07**	1.75**	676.48**	130.46**	74.01**	1.85**	28.84**
Error	30	0.45	0.33	0.56	59.27	0.37	0.26	0.01	0.01	5.69	4.85	0.38	0.02	4.29

**Significant at 1 % level

days. SMV8 and SMV5×SMV6 took maximum days to flower i.e 46.35 days and 45.95 days respectively.

4.1.2.1.2 Days to First Harvest:

Hybrid SMV3×SMV6 (61.65) took the minimum number of days to first harvest and SMV8 (69.80) took maximum days to first harvest while SMV4×SMV7 (69.75), SMV1×SMV2 (68.90) and SMV5×SMV6 (68.15) were on par with the maximum number of days to first harvest.

4.1.2.1.3 Number of Fruits Plant $^{-1}$:

Number of fruits plant^{-1} varied from a minimum of 17.95 (SMV2×SMV6) to a maximum of 38.70 (SMV1×SMV2) and the difference was significant. SMV3×SMV4 and SMV3×SMV6 were on par with the lowest value.

4.1.2.1.4 Fruit Weight:

Maximum individual fruit weight was recorded in SMV8 (102.45 g) and minimum in SMV1×SMV3 (71.45 g). Hybrids SMV1×SMV5 and SMV2×SMV6 were on par with SMV1×SMV3.

4.1.2.1.5 Fruit Length:

The hybrids differed significantly with respect to fruit length which ranged from 10.33 cm (SMV1×SMV3) to 14.99 cm (SMV4×SMV7). The hybrid SMV4×SMV7 produced the longest fruit, which was on par with SMV1×SMV6 and SMV2×SMV6.

4.1.2.1.6 Fruit Girth:

Girth of fruit ranged from 11.48 cm (SMV1×SMV3) to 17.98 cm (SMV1×SMV3). Hybrid SMV1×SMV2 was on par with the lowest value.

4.1.2.1.7 Calyx Length:

Calyx length varied from 2.67 cm (SMV2×SMV6) to 3.16 cm (SMV8). SMV8 was on par with SMV1×SMV2 and SMV4×SMV7.

Table 7. Mean performance of brinjal hybrids at Vellayani during *kharif* season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	44.55	68.90	38.70	78.20	12.37	11.85	3.15	3.33	58.00	100.15	12.15	2.19	12.50
SMV1 × SMV3	45.30	64.55	28.40	71.45	10.33	13.63	2.89	1.90	33.55	87.70	10.70	3.77	10.63
SMV1 × SMV5	40.15	65.05	30.10	72.20	13.56	12.31	3.08	2.57	47.40	95.50	13.83	4.18	10.00
SMV1 × SMV6	43.75	62.90	27.55	97.85	14.26	14.05	3.01	2.68	47.78	93.65	16.20	2.63	13.75
SMV2 × SMV6	42.50	62.80	17.95	73.10	14.14	11.48	2.67	1.33	24.17	93.10	13.65	3.17	12.50
SMV3 × SMV4	42.45	67.10	18.90	97.30	11.68	15.73	2.91	1.86	29.53	100.70	21.23	1.72	13.13
SMV3 × SMV6	43.70	61.65	18.65	82.85	10.95	13.18	2.79	1.57	28.97	101.30	16.48	2.79	14.38
SMV4 × SMV6	44.50	63.70	28.05	93.10	12.93	13.72	2.74	2.63	44.42	102.85	10.62	2.95	9.38
SMV4× SMV7	44.70	69.75	23.05	93.15	14.99	13.94	3.13	2.16	32.75	92.40	15.00	3.91	8.75
SMV5× SMV6	45.95	68.15	32.15	99.30	13.89	14.55	2.78	3.19	62.33	100.00	23.61	2.57	15.00
SMV8	46.35	69.80	23.80	102.45	12.71	17.98	3.16	2.55	47.81	109.05	17.48	3.03	15.00
C.D. (5%)	0.77	1.84	0.71	5.74	1.10	0.76	0.22	0.07	3.69	2.30	0.91	0.17	2.92
SE(m)	0.27	0.63	0.24	1.98	0.38	0.26	0.08	0.02	1.27	0.79	0.31	0.06	1.00
C.V.	1.21	1.93	1.87	4.53	5.89	3.77	5.27	1.94	6.13	1.62	4.04	3.86	16.37

4.1.2.1.8 Yield Plant^{-1}:

The minimum yield plant^{-1} was recorded in SMV2×SMV6 (1.33 kg) while maximum yield plant^{-1} was attained by SMV1×SMV2 (3.33 kg) followed by SMV5×SMV6 (3.19 kg).

4.1.2.1.9 Yield Plot^{-1}:

Yield plot^{-1} recorded significant differences among the eleven hybrids. The yield plot^{-1} ranged from 24.17 kg (SMV2×SMV6) to 62.33 kg (SMV5×SMV6).

4.1.2.1.10 Plant Height:

Plant height ranged from 87.70 cm to 109.05 cm among the hybrids. SMV8 was the tallest hybrid and SMV1×SMV3 was the shortest hybrid.

4.1.2.1.11 Total Phenols:

Highest total phenol content was recorded in SMV5×SMV6 (23.61 mg/100g) and lowest was found in SMV4×SMV6 (10.62 mg/100g) which was on par with SMV1×SMV3 (10.70 mg/100g).

4.1.2.1.12 Total Sugars:

Total sugars varied from 1.72 g/100g to 4.18 g/100g among the eleven hybrids. SMV1×SMV5 recorded the highest total sugar content and SMV3×SMV4 recorded the lowest.

4.1.2.1.13 Vitamin C:

Vitamin C was higher in SMV 8 (15 mg/100g) homogenous to SMV5×SMV6 while, SMV4×SMV7 recorded the least Vitamin C content (8.75 mg/100g).

4.1.2.1.14 Shoot and Fruit Borer Infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis.

Table 8. Pest and disease scoring of brinjal hybrids at Vellayani during *kharif* season.

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	17.50 (2)	22.50 (3)	18.17 (2)	19.39	7	MR	21.67 (3)	30.67 (3)	29.50 (3)	27.28	9	T	12.50 (1)	R
SMV1 × SMV3	35.00 (4)	27.92 (3)	28.00 (3)	30.31	10	T	34.58 (4)	38.75 (4)	35.75 (4)	36.36	12	S	27.50 (2)	MR
SMV1 × SMV5	27.50 (3)	23.08 (3)	24.00 (3)	24.86	9	T	31.16 (4)	33.08 (4)	32.58 (4)	32.27	12	S	22.50 (2)	MR
SMV1 × SMV6	32.50 (4)	28.75 (3)	25.67 (3)	28.97	10	T	37.33 (4)	37.24 (4)	32.00 (4)	35.52	12	S	20.00 (1)	R
SMV2 × SMV6	42.50 (5)	28.75 (3)	23.00 (3)	31.42	11	S	33.33 (4)	31.16 (4)	29.66 (3)	31.38	11	S	20.00 (1)	R
SMV3 × SMV4	37.50 (4)	29.17 (3)	29.00 (3)	31.89	10	S	36.65 (4)	35.17 (4)	32.08 (4)	34.63	12	S	42.50 (3)	MS
SMV3 × SMV6	27.50 (3)	27.50 (3)	25.00 (3)	26.67	9	T	34.58 (4)	35.00 (4)	37.50 (4)	35.69	12	S	15.00 (1)	R
SMV4 × SMV6	40.00 (4)	34.74 (4)	29.00 (3)	34.58	11	S	33.32 (4)	31.42 (4)	29.16 (3)	31.30	11	S	32.50 (2)	MR
SMV4× SMV7	42.50 (5)	26.66 (3)	28.00 (3)	32.39	11	S	42.49 (5)	44.83 (5)	39.91 (4)	42.41	14	HS	50.00 (3)	MS
SMV5× SMV6	12.50 (2)	20.41 (2)	15.00 (2)	15.97	6	MR	22.08 (3)	25.83 (3)	23.75 (3)	23.89	9	T	7.50 (1)	R
SMV8	15.00 (2)	19.16 (2)	17.00 (2)	17.05	6	MR	24.99 (3)	23.75 (3)	23.83 (3)	24.19	9	T	7.50 (1)	R
Grand Mean	30.00	26.24	23.80	26.68			32.01	33.35	31.43	32.26			23.41	
C.D (5%)	8.18	6.24	5.66				7.27	5.65	6.26				10.05	

Shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

4.1.2.1.14 .1 Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and is furnished in Table 8. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (12.50, 20.41, 15.00) followed by SMV8 (15.00, 19.16, 17.00) SMV1×SMV2 (17.50, 22.50, 18.17), SMV1×SMV5 (27.50, 23.08, 24.00), SMV3×SMV6 (27.50, 27.50, 25.00), and SMV1×SMV3 (35.00, 27.92, 28.00) at all 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV4×SMV6 (40.00, 34.74, 29.00) followed by SMV4×SMV7 (42.50, 26.66, 28.00), SMV3×SMV4 (37.50, 29.17, 29.00) and SMV2×SMV6 (42.50, 28.75, 23.00) at all 60 DAT, 80 DAT and 100 DAT respectively.

4.1.2.1.14 .2 Fruit Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and is furnished in Table 8.

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (22.08, 25.83, 23.75) followed by SMV8 (24.99, 23.75, 23.83) and SMV1×SMV2 (21.67, 30.67, 29.50) at all 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (42.49, 44.83, 39.91) followed by SMV1×SMV3 (34.58, 38.75, 35.75), SMV3×SMV6 (34.58, 35.00, 37.50), SMV1×SMV6 (37.33. 37.24, 32.00), SMV3×SMV4 (36.65, 35.17, 32.08), SMV1×SMV5 (31.16, 33.08, 32.58),

Plate 1. General view of experimental plot at Vellayani during *kharif* season

Plate 2. General view of experimental plot at Thiruvalla during *kharif* season

SMV2×SMV6 (33.33, 31.16, 29.66) and SMV4×SMV6 (33.32, 31.42, 29.16) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation, genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 8.

4.1.2.1.15 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from the field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (7.50) and SMV8 (7.50) were uniform in nature with less percentage of plants wilted and SMV4×SMV7 (50.00) recorded higher wilting percentage of plants followed by SMV3×SMV4 (42.50).

Based on percentage of wilted plants genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 8.

4.1.2.2 Performance of brinjal hybrids at Farmer's field, Thiruvalla:

The mean performance of eleven hybrids for various yield components are presented in Table 9.

4.1.2.2.1 Days to First Flowering:

The overall mean value for days to first flowering averaged to 45.47 days with a lower range of 42.50 days and higher range of 49.90 days. SMV1×SMV6 was the earliest flowering type in agreement with SMV4×SMV6. SMV1×SMV3 took the maximum days to flower.

4.1.2.2.2 Days to First Harvest:

Table 9. Mean performance of brinjal hybrids at Thiruvalla during *kharif* season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	46.55	73.95	35.70	77.05	13.25	10.30	3.26	2.85	51.04	92.80	11.92	1.90	13.13
SMV1 × SMV3	49.90	69.05	21.40	68.35	9.57	12.58	3.25	1.48	26.39	85.30	10.12	3.52	10.63
SMV1 × SMV5	45.00	65.90	28.85	70.10	13.68	11.59	3.15	2.03	37.61	86.20	14.60	3.93	11.88
SMV1 × SMV6	42.50	60.75	26.25	81.50	13.64	12.66	2.79	1.91	35.23	91.15	17.21	2.86	13.75
SMV2 × SMV6	48.35	65.55	14.30	73.50	13.68	10.36	2.94	0.91	16.00	87.20	13.10	2.98	14.38
SMV3 × SMV4	43.45	68.95	14.35	79.55	11.26	14.94	3.11	1.02	18.47	87.45	20.95	1.80	9.38
SMV3 × SMV6	44.10	64.70	15.00	86.95	11.69	13.68	3.09	1.23	22.60	88.30	15.78	2.78	11.25
SMV4 × SMV6	42.80	65.70	22.60	86.70	12.53	12.87	2.86	1.72	30.61	88.45	10.51	3.12	7.50
SMV4× SMV7	46.75	69.05	16.00	85.75	13.22	13.82	3.00	1.38	22.59	92.90	16.13	4.12	6.25
SMV5× SMV6	45.10	67.70	29.40	102.30	13.10	12.57	3.01	2.89	55.60	95.40	23.81	2.82	14.38
SMV8	45.70	70.80	20.50	98.20	11.38	15.76	2.99	2.03	39.02	106.35	17.47	3.04	17.50
C.D.(5%)	1.62	2.24	1.32	2.13	0.79	0.78	0.19	0.11	2.67	1.57	0.93	0.19	3.39
SE(m)	0.56	0.77	0.45	0.73	0.27	0.27	0.07	0.04	0.92	0.54	0.32	0.07	1.17
C.V.	2.46	2.29	4.08	1.77	4.39	4.20	4.34	4.18	5.70	1.19	4.13	4.43	19.78

Among hybrids the earliest harvest was registered in SMV1×SMV6 (60.75 days) and the latest harvest was observed in SMV1×SMV2 (73.95 days).

4.1.2.2.3 Number of Fruits Plant^{-1}:

Number of fruits plant^{-1} among the hybrids ranged from 14.30 to 35.70. SMV1×SMV2 was the top hybrid followed by SMV5×SMV6 (29.40) and SMV1×SMV5 (28.85) with respect to number of fruits plant^{-1}. SMV2×SMV6 produced the least number of fruits plant^{-1} complementary to SMV3×SMV4.

4.1.2.2.4 Fruit Weight:

The hybrids showed a variation from 68.35 g (SMV1×SMV3) to 102.30 g (SMV5×SMV6). The hybrid check Neelima (SMV8) recorded average fruit weight of 98.20 g.

4.1.2.2.5 Fruit Length:

The longest fruits were produced by SMV1×SMV5 and SMV2×SMV6 each 13.68 cm and was followed by SMV1×SMV6 (13.64 cm), SMV1×SMV2 (13.25 cm) and SMV4×SMV7 (13.22 cm). The shortest fruit was produced by SMV1×SMV3 (9.57 cm).

4.1.2.2.6 Fruit Girth:

Fruit girth ranged from 10.30 cm (SMV1×SMV2) to 15.76 cm (SMV8).

4.1.2.2.7 Calyx Length:

Calyx length varied from 2.79 cm (SMV1×SMV6) to 3.26 cm (SMV1×SMV2). SMV1×SMV3 and SMV1×SMV5 were found to be comparable to SMV1×SMV2.

4.1.2.2.8 Yield Plant^{-1}:

The variation in fruit yield among the hybrids was commendable. Fruit yield plant^{-1} ranged from 0.91 kg to 2.89 kg. SMV5×SMV6 was the highest yielder followed by SMV1×SMV2 (2.85 kg).

4.1.2.2.9 Yield Plot^{-1}:

The hybrid SMV5×SMV6 had significantly highest yield plot^{-1} (55.60) followed by SMV1×SMV2 (51.04 kg). The lowest yield (16 kg) was for the hybrid SMV2×SMV6.

4.1.2.2.10 Plant Height:

Plant height was maximum for the hybrid SMV8 (106.35 cm) and SMV1×SMV3 hybrid recorded the minimum plant height (85.30 cm).

4.1.2.2.11 Total Phenol:

A higher level of total phenols was observed in SMV5×SMV6 (23.81 mg/100g) and the lowest was found in SMV1×SMV3 (10.12 mg/100g) on par with SMV4×SMV6 (10.51 mg/100g).

4.1.2.2.12 Total Sugars:

The overall mean value for total sugars averaged 2.99 g/100g with a lower range of 1.80 g/100g and higher range of 4.12 g/100g. SMV4×SMV7 recorded the highest amount of total sugars, while SMV3×SMV4 showed the lowest, on par with SMV1×SMV2 (1.90 g/100g).

4.1.2.2.13 Vitamin C:

Vitamin C content varied from 6.25 mg/100g to 14.38 mg/100g among the hybrids. SMV2×SMV6 and SMV5×SMV6 were the topmost and equal in vitamin C content. SMV4×SMV7 registered the lowest content.

4.1.2.2.14 Shoot and Fruit Borer Infestation:

Screening of hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

Table 10. Pest and disease scoring of brinjal hybrids at Thiruvalla during *kharif* season

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	22.50 (3)	29.33 (3)	22.00 (3)	24.61	9	T	26.50 (3)	33.50 (4)	31.75 (4)	30.58	11	S	12.50 (1)	R
SMV1 × SMV3	35.00 (4)	27.50 (3)	25.00 (3)	29.17	10	T	39.99 (4)	36.92 (4)	38.58 (4)	38.49	12	S	22.50 (2)	MR
SMV1 × SMV5	40.00 (4)	25.83 (3)	26.00 (3)	30.61	10	T	32.50 (4)	32.32 (4)	37.17 (4)	34.00	12	S	22.50 (2)	MR
SMV1 × SMV6	40.00 (4)	25.41 (3)	24.00 (3)	29.80	10	T	35.66 (4)	37.24 (4)	34.00 (4)	35.63	12	S	10.00 (1)	R
SMV2 × SMV6	37.50 (4)	31.23 (4)	31.00 (4)	33.24	12	S	32.50 (4)	32.08 (4)	31.24 (4)	31.94	12	S	17.50 (1)	R
SMV3 × SMV4	45.00 (5)	27.91 (3)	27.00 (3)	33.30	11	S	31.65 (4)	35.58 (4)	46.65 (5)	37.96	13	S	27.50 (2)	MR
SMV3 × SMV6	45.00 (5)	30.83 (3)	23.00 (3)	32.94	11	S	37.49 (4)	35.40 (4)	39.58 (4)	37.49	12	S	15.00 (1)	R
SMV4 × SMV6	42.50 (5)	38.74 (4)	25.50 (3)	35.58	12	S	40.82 (5)	41.57 (5)	39.56 (4)	40.65	14	HS	40.00 (2)	MR
SMV4× SMV7	42.50 (5)	31.24 (4)	28.00 (3)	33.91	12	S	48.32 (5)	37.83 (4)	39.15 (4)	41.77	13	HS	42.50 (3)	MS
SMV5× SMV6	12.50 (2)	22.07 (3)	21.00 (3)	18.52	8	MR	24.58 (3)	27.50 (3)	27.08 (3)	26.38	9	T	10.00 (1)	R
SMV8	17.50 (2)	22.50 (3)	22.00 (3)	20.67	8	MR	25.83 (3)	28.00 (3)	25.33 (3)	26.39	9	T	7.50 (1)	R
Grand Mean	34.55	28.41	24.95	29.30			34.17	34.36	35.46	34.66			20.68	
C.D.(5%)	7.81	6.37	5.06				5.19	5.75	7.11				11.35	

4.1.2.2.14 .1 Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval. The details are furnished in Table 10.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (12.50, 22.07, 21.00) followed by SMV8 (17.50, 22.50, 22.00) SMV1×SMV2 (22.50, 29.33, 22.00), SMV1×SMV3 (35.00, 27.50, 25.00), SMV1×SMV6 (40.00, 25.41, 24.00), and SMV1×SMV5 (40.00, 25.83, 26.00) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV4×SMV6 (42.50, 38.74, 25.50) followed by SMV4×SMV7 (42.50, 31.24, 28.00), SMV3×SMV4 (45.00, 27.91, 27.00) and SMV2×SMV6 (37.50, 31.23, 31.00) at 60 DAT, 80 DAT and 100 DAT respectively.

4.1.2.2.14 .2 Fruit Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and the details are furnished in Table 10.

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (24.58, 27.50, 27.08) followed by SMV8 (25.83, 28.00, 25.33) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (48.32, 37.83, 39.15) followed by SMV4×SMV6 (40.82, 41.57, 39.56), SMV1×SMV3 (39.99, 36.92, 38.49), SMV3×SMV4 (31.65, 35.58, 46.65), SMV3×SMV6 (37.49, 35.40, 39.58), SMV1×SMV6 (35.66, 37.24, 34.00), SMV1×SMV5 (32.50, 32.32, 37.17), SMV2×SMV6 (32.50, 32.08, 31.24) and SMV1×SMV2 (26.50, 33.50, 31.75) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on pooled mean percentage of shoot and fruit infestation genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The classification is furnished in Table10.

4.1.2.2.15 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data of number of plants wilted at 90 DAT was collected from the field experiment and subjected to statistical analysis.

Among the hybrids, SMV8 (7.50) recorded the least percentage of plants wilted followed by SMV5×SMV6 (10.00) and SMV4×SMV7 (42.50) recorded higher wilting percentage of plants followed by SMV4×SMV6 (40.00).

Based on mean percentage of wilted plants genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS) and the details are furnished in Table 10.

4.1.2.3 Performance of brinjal hybrids at Farmer's field, Sadanandapuram:

The mean performances of eleven genotypes for different characters are given in Table 11. Neelima is used as check.

4.1.2.3.1 Days to First Flowering:

The number of days to first flowering in the hybrids ranged from 38.00 to 46.80 days. SMV3×SMV4 was the earliest and SMV1×SMV3 and SMV4×SMV6 were the late ones to flower. SMV1×SMV3 was statistically on par with SMV4×SMV6 in days to first flowering. Another early flowering hybrid was SMV1×SMV6.

4.1.2.3.2 Days to First Harvest:

Hybrid SMV1×SMV6 (61.65) took the minimum number of days to first harvest and SMV8 (68.50) took maximum days to first harvest with SMV1×SMV5 (68.35) on par.

Table 11. Mean performance of brinjal hybrids at Sadanandapuram during *kharif* season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	43.95	65.50	38.20	89.15	14.29	12.17	3.05	3.36	60.06	95.55	14.72	2.02	11.88
SMV1 × SMV3	46.50	66.50	23.75	68.80	10.22	14.14	2.75	1.67	29.29	82.30	10.56	3.62	10.00
SMV1 × SMV5	41.95	68.35	30.65	88.35	13.86	12.11	2.99	2.72	48.99	85.15	12.29	4.24	11.88
SMV1 × SMV6	38.45	61.65	26.15	111.90	15.41	13.39	2.63	2.87	51.19	90.60	17.73	2.67	14.38
SMV2 × SMV6	40.00	65.90	17.35	69.60	13.91	12.42	2.52	1.22	23.01	82.70	11.50	3.00	14.38
SMV3 × SMV4	38.00	62.85	18.25	118.55	12.75	16.27	2.99	2.19	37.91	92.80	21.26	1.74	12.50
SMV3 × SMV6	43.35	66.05	16.75	116.65	13.44	15.78	2.78	2.08	35.79	111.00	16.66	2.77	13.75
SMV4 × SMV6	46.80	63.05	22.90	117.50	14.05	15.68	2.69	2.67	45.36	107.20	10.28	2.65	10.00
SMV4× SMV7	44.55	63.60	17.50	97.90	14.13	19.02	2.88	1.74	28.16	95.15	17.32	4.05	8.13
SMV5× SMV6	42.55	63.50	33.55	117.60	15.20	14.17	2.80	3.77	67.11	89.75	25.01	2.89	16.88
SMV8	42.60	68.50	20.80	120.95	13.32	17.86	2.75	2.53	45.04	100.85	17.45	3.06	17.50
C.D. (5%)	1.54	1.42	1.44	3.80	0.83	0.76	0.10	0.15	2.85	1.63	0.86	0.21	3.36
SE(m)	0.53	0.49	0.50	1.31	0.29	0.26	0.04	0.05	0.98	0.56	0.30	0.07	1.16
C.V.	2.49	1.51	4.10	2.58	4.19	3.55	2.57	4.28	4.58	1.19	3.72	4.78	18.05

4.1.2.3.3 Number of Fruits Plant^{-1}:

Among the hybrids, number of fruits plant^{-1} varied from 16.75 to 38.20. The hybrid SMV1×SMV2 was out-standing with respect to number of fruits plant^{-1} followed by SMV5×SMV6 (33.55) and SMV1×SMV5 (30.65). Minimum number of fruits plant^{-1} was recorded by SMV3×SMV6, SMV2×SMV6 and SMV4×SMV7.

4.1.2.3.4 Fruit Weight:

Individual fruit weight ranged from 68.80 g (SMV1×SMV3) to 120.95 g (SMV8). Hybrids SMV3×SMV4, SMV5×SMV6 and SMV4×SMV6 was on par with SMV8.

4.1.2.3.5 Fruit Length:

The longest fruit was produced by SMV1×SMV6 (15.41 cm) which was statistically superior to other hybrids, while SMV5×SMV6 was on par with SMV1×SMV6. The shortest fruits were produced by SMV1×SMV3 (10.22 cm).

4.1.2.3.6 Fruit Girth:

Fruit girth was highest for the hybrid SMV4×SMV7 (19.02 cm). The lowest fruit girth was recorded for SMV1×SMV5 (12.11) which was on par with SMV1×SMV2 (12.17 cm) and SMV2×SMV6 (12.42 cm).

4.1.2.3.7 Calyx Length:

The shortest calyx length was recorded for SMV2×SMV6 (2.52 cm) and SMV1×SMV2 (3.05 cm) registered the lengthiest calyx.

4.1.2.3.8 Yield Plant^{-1}:

The fruit yield plant^{-1} among the hybrids ranged from 1.22 kg to 3.77 kg. SMV5×SMV6 was the highest yielder. The hybrid SMV1×SMV2 (3.36 kg) recorded on par yield with SMV5×SMV6. The lowest yield was recorded for SMV2×SMV6 (1.22 kg).

4.1.2.3.9 Yield Plot^{-1}:

The hybrid SMV5×SMV6 had significantly highest yield plot^{-1} (67.11 kg), followed by SMV1×SMV2 (60.06 kg). The lowest yield (23.01 kg) was for the genotype SMV2×SMV6.

4.1.2.3.10 Plant Height:

Plant height was maximum for SMV3×SMV6 (111.00 cm) and it was statistically on par with SMV4×SMV6 (107.20 cm). SMV1×SMV3 recorded the minimum plant height (82.30 cm) and it was proportionate to SMV2×SMV6 (82.70 cm).

4.1.2.3.11 Total Phenols:

Among the hybrids, total phenols varied from 10.28 to 25.01 mg/100g. SMV5×SMV6 was noted with the highest level of total phenolic content, followed by SMV3×SMV4 (21.26 mg/100g). SMV4×SMV6 registered the lowest (10.28 mg/100g) total phenol content which was on par with SMV1×SMV3 (10.56 mg/100g).

4.1.2.3.12 Total Sugars:

Hybrid SMV3×SMV4 recorded the least (1.74 g/100g) total sugar content and SMV1×SMV5 was the uppermost with 4.24 g/100g total sugars.

4.1.2.3.13 Vitamin C:

The highest vitamin C content was found in SMV8 (17.50 mg/100g) and the lowest in SMV4×SMV7 (8.13 mg/100g).

4.1.2.3.14 Shoot and Fruit Borer Infestation:

Screening of genotypes for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

Table 12. Pest and disease scoring of brinjal hybrids at Sadanandapuram during *kharif* season.

Genotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	15.00 (2)	24.58 (3)	23.00 (3)	20.86	8	MR	30.75 (3)	35.08 (4)	30.75 (3)	32.19	10	S	17.50 (1)	R
SMV1 × SMV3	37.50 (4)	32.08 (4)	26.00 (3)	31.86	11	S	32.91 (4)	37.25 (4)	36.58 (4)	35.58	12	S	25.00 (2)	MR
SMV1 × SMV5	37.50 (4)	27.49 (3)	27.50 (3)	30.83	10	T	28.00 (3)	29.99 (3)	28.41 (3)	28.80	9	T	12.50 (1)	R
SMV1 × SMV6	32.50 (4)	34.33 (4)	27.00 (3)	31.28	11	S	37.33 (4)	40.07 (5)	34.75 (4)	37.38	13	S	15.00 (1)	R
SMV2 × SMV6	35.00 (4)	28.75 (3)	27.00 (3)	30.25	10	T	37.25 (4)	39.24 (4)	38.98 (4)	38.49	12	S	15.00 (1)	R
SMV3 × SMV4	40.00 (4)	33.32 (4)	27.50 (3)	33.61	11	S	40.81 (5)	42.83 (5)	44.98 (5)	42.87	15	H	30.00 (2)	MR
SMV3 × SMV6	42.50 (5)	33.07 (4)	21.00 (2)	32.19	11	S	35.83 (4)	34.15 (4)	42.99 (5)	37.66	13	S	25.00 (2)	MR
SMV4 × SMV6	42.50 (5)	32.07 (4)	32.50 (4)	35.69	13	S	38.32 (4)	35.66 (4)	35.82 (4)	36.60	12	S	30.00 (2)	MR
SMV4× SMV7	37.50 (4)	36.66 (4)	28.50 (3)	34.22	11	S	51.66 (5)	47.08 (5)	42.48 (5)	47.07	15	H	47.50 (3)	MS
SMV5× SMV6	15.00 (2)	25.42 (3)	23.00 (3)	21.14	8	T	26.33 (3)	27.50 (3)	26.33 (3)	26.72	9	T	5.00 (1)	R
SMV8	22.50 (3)	26.66 (3)	23.00 (3)	24.05	9	T	27.16 (3)	24.17 (3)	24.67 (3)	25.33	9	T	5.00 (1)	R
Grand Mean	32.50	30.40	26.00	29.63			35.12	35.73	35.16	35.33			20.68	
C.D.(5%)	8.71	5.62	5.12				6.55	7.16	6.33				10.24	

4.1.2.3.14 .1 Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and is furnished in Table 12.

The minimum percentage of shoot infestation was recorded in the hybrids SMV1×SMV2 (15.00, 24.58, 23.00) followed by SMV5×SMV6 (15.00, 25.42, 23.00), SMV8 (22.50, 26.66, 23.00), SMV2×SMV6 (35.00, 28.75, 27.00) and SMV1×SMV5 (37.50, 27.49, 27.50) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV4×SMV6 (42.50, 32.07, 32.50) followed by SMV4×SMV7 (37.50, 36.66, 28.50), SMV3×SMV4 (40.00, 33.32, 27.50), SMV3×SMV6 (42.50, 33.07, 21.00), SMV1×SMV3 (37.50, 32.08, 26.00) and SMV1×SMV6 (32.50, 34.33, 27.00) at 60 DAT, 80 DAT and 100 DAT respectively.

4.1.2.3.14. 2 Fruit Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and is furnished in Table 12.

The minimum percentage of fruit infestation was recorded in the hybrids SMV8 (27.16, 24.17, 24.67) followed by SMV5×SMV6 (26.33, 27.50, 26.33) and SMV1×SMV5 (28.00, 29.99, 28.14) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (51.66, 47.08, 42.48) followed by SMV3×SMV4 (40.81, 42.83, 44.98), SMV2×SMV6 (37.25, 39.24, 38.98), SMV3×SMV6 (35.83, 34.15, 42.99), SMV1×SMV6 (37.33, 40.07, 34.75), SMV4×SMV6 (38.32, 35.66, 35.82), SMV1×SMV3 (32.91, 37.25, 36.58) and SMV1×SMV2 (30.75, 35.08, 30.75) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation the genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR),

Plate 3. General view of experimental plot at Sadanandapuram during *kharif* season

Plate 4. General view of experimental plot at Kayamkulam during *kharif* season

Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 12.

4.1.2.3.15 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from the field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (5.00) and SMV8 (5.00) were uniform in nature with less percentage of plants wilted and SMV4×SMV7 (47.50) recorded higher percentage of plants wilted followed by SMV3×SMV4 (30.00) and SMV4×SMV6 (30.00).

Based on percentage of wilted plants genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS) and the details are furnished in the Table 12.

4.1.2.4 Performance of brinjal hybrids at Farmer's field, Kayamkulam:

The mean performance of genotypes for various yield and its component traits are furnished in Table 13.

4.1.2.4.1 Days to First Flowering:

The days taken for first flowering varied among the genotypes. SMV1×SMV6 took the minimum days for first flowering (39.85 days). The hybrid SMV5×SMV6 recorded delayed flowering (47.85 days) and was preceded by SMV1×SMV3 (47 days).

4.1.2.4.2 Days to First Harvest:

Hybrid SMV2×SMV6 took less number of days to first harvest (68.90) and SMV4×SMV6 took more number of days to first harvest (79.05), followed by SMV3×SMV6 and SMV1×SMV3.

Table 13. Mean performance of brinjal hybrids at Kayamkulam during *kharif* season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	44.10	76.55	36.50	89.30	14.00	12.70	3.07	3.31	61.55	100.95	12.57	2.06	11.88
SMV1 × SMV3	47.00	78.60	27.15	82.45	10.41	13.14	2.71	2.05	37.96	90.90	11.16	3.23	11.25
SMV1 × SMV5	44.60	75.80	28.15	87.05	15.57	12.54	2.99	2.48	44.75	91.55	12.70	3.97	9.38
SMV1 × SMV6	39.85	70.10	24.25	108.75	15.74	15.19	2.88	2.63	49.24	98.30	16.56	2.85	13.13
SMV2 × SMV6	43.35	68.90	16.65	85.10	14.50	10.34	2.94	1.40	28.42	92.70	12.01	2.52	13.75
SMV3 × SMV4	44.10	73.05	18.70	115.50	14.07	19.74	2.98	2.49	39.90	97.75	21.64	1.87	9.38
SMV3 × SMV6	43.60	78.95	18.90	90.80	12.48	15.87	2.76	1.58	29.83	88.55	16.79	2.98	12.50
SMV4 × SMV6	46.70	79.05	23.00	84.00	13.84	14.88	3.13	2.08	35.45	98.95	10.49	2.49	12.50
SMV4× SMV7	44.75	70.20	21.25	89.90	13.49	16.89	3.00	1.91	32.47	91.30	14.14	4.02	7.50
SMV5× SMV6	47.85	75.75	32.10	104.95	14.27	14.87	2.90	3.57	69.60	108.10	23.61	2.79	15.00
SMV8	45.95	70.75	19.15	116.35	12.55	18.20	3.05	2.35	46.01	98.00	17.60	2.89	16.88
C.D. (5%)	0.97	0.84	1.09	11.17	0.88	0.74	0.15	0.11	3.46	3.20	0.90	0.21	3.01
SE(m)	0.33	0.29	0.37	3.85	0.30	0.26	0.05	0.04	1.19	1.10	0.31	0.07	1.04
C.V.	1.50	0.78	3.10	8.03	4.43	3.41	3.61	3.23	5.52	2.29	4.01	4.91	17.11

4.1.2.4.3 Number of Fruits Plant^{-1}:

Among the hybrids SMV1×SMV2 recorded significantly highest number of fruits plant^{-1} (36.50) and was followed by SMV5×SMV6 (32.10). SMV2×SMV6 was the lowest yielder with least number of fruits plant^{-1} (16.65).

4.1.2.4.4 Fruit Weight:

There was significant variation among the genotypes with respect to fruit weight. Significantly highest fruit weight of 116.35 g was recorded in SMV8 followed by SMV3×SMV4 (115.50). SMV1×SMV3 recorded the lightest fruits with a weight of 82.45 g.

4.1.2.4.5 Fruit Length:

The genotypes differed significantly with respect to fruit length and SMV1×SMV6 recorded the highest fruit length of 15.74 cm which was on par with SMV1×SMV5 (15.57 cm). The lowest fruit length was recorded in SMV1×SMV3 (10.41 cm).

4.1.2.4.6 Fruit Girth:

Hybrid SMV3×SMV4 was significantly superior with respect to fruit girth (19.74 cm) and was on par with SMV8, whereas the least fruit girth (10.34 cm) was noted in the genotype SMV2×SMV6.

4.1.2.4.7 Calyx Length:

The hybrid SMV1×SMV3 registered the shortest calyx length of 2.71 cm and SMV4×SMV6 noted the topmost calyx length of 3.13 cm.

4.1.2.4.8 Yield Plant^{-1}:

Fruit yield plant^{-1} varied significantly among the genotypes. SMV5×SMV6 recorded the highest fruit yield of 3.57 kg plant^{-1} followed by SMV1×SMV2 (3.31 kg). SMV2×SMV6 recorded lowest plant yield of 1.40 kg, SMV3×SMV6 was on par with it.

4.1.2.4.9 Yield Plot^{-1}:

There was significant variation for fruit yield plot^{-1} among the genotypes. Significantly highest fruit yield plot^{-1} (69.60 kg) was recorded in SMV5×SMV6 followed by SMV1×SMV2 (61.55 kg) whereas, the minimum yield plot^{-1} was recorded in SMV2×SMV6 (28.42 kg).

4.1.2.4.10 Plant Height:

The significant highest plant height of 108.10 cm was recorded in SMV5×SMV6 and lowest plant height of 88.55 cm was observed in SMV3×SMV6 genotype.

4.1.2.4.11 Total Phenols:

Higher level of total phenols was noted in SMV5×SMV6 (23.61 mg/100g) and lower level of total phenols was recorded in SMV4×SMV6 (10.49 mg/100g).

4.1.2.4.12 Total Sugars:

Total sugars ranged from 1.87 to 4.02 g/100g. SMV4×SMV7 was the uppermost with respect to total sugars level and SMV3×SMV4 was the lowermost.

4.1.2.4.13 Vitamin C:

Vitamin C content was high in SMV8 (16.88 mg/100g) followed by SMV5×SMV6 (15.00 mg/100g) and least in SMV4×SMV7 (7.50 mg/100g).

4.1.2.4.14 Shoot and Fruit Borer Infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

4.1.2.4.14 .1 Shoot Infestation Percentage:

Table 14. Pest and disease scoring of brinjal hybrids at Kayamkulam during *kharif* season.

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	20.00 (2)	26.00 (3)	22.50 (3)	22.83	8	T	31.50 (4)	38.33 (4)	30.75 (3)	33.53	11	S	7.50 (1)	R
SMV1 × SMV3	35.00 (4)	30.41 (3)	23.00 (3)	29.47	10	T	33.33 (4)	36.00 (4)	34.58 (4)	34.63	12	S	15.00 (1)	R
SMV1 × SMV5	35.00 (4)	28.33 (3)	25.00 (3)	29.44	10	T	29.25 (3)	29.16 (3)	31.49 (4)	29.97	10	T	17.50 (1)	R
SMV1 × SMV6	32.50 (4)	27.75 (3)	22.00 (3)	27.42	10	T	41.16 (5)	37.24 (4)	32.00 (4)	36.80	13	S	10.00 (1)	R
SMV2 × SMV6	45.00 (5)	27.25 (3)	25.00 (3)	32.42	11	S	33.50 (4)	33.33 (4)	32.49 (4)	33.10	12	S	12.50 (1)	R
SMV3 × SMV4	47.50 (5)	33.66 (4)	34.00 (4)	38.39	13	S	39.15 (4)	35.58 (4)	46.65 (5)	40.46	13	HS	35.00 (2)	MR
SMV3 × SMV6	32.50 (4)	36.41 (4)	27.00 (3)	31.97	11	S	37.49 (4)	35.40 (4)	41.08 (5)	37.99	13	S	10.00 (1)	R
SMV4 × SMV6	40.00 (4)	33.91 (4)	27.00 (3)	33.64	11	S	38.32 (4)	34.41 (4)	34.15 (4)	35.62	12	S	32.50 (2)	MR
SMV4× SMV7	40.00 (4)	30.99 (3)	28.00 (3)	33.00	10	S	51.66 (5)	39.08 (4)	37.07 (4)	42.60	13	HS	37.50 (2)	MR
SMV5× SMV6	10.00 (1)	22.83 (3)	18.00 (2)	16.94	6	MR	22.08 (3)	27.25 (3)	28.83 (3)	26.05	9	T	2.50 (1)	R
SMV8	15.00 (2)	22.16 (3)	24.00 (3)	20.39	8	MR	24.16 (3)	25.50 (3)	20.67 (3)	23.44	9	T	5.00 (1)	R
Grand Mean	32.05	29.06	25.05	28.72			34.69	33.75	33.61	34.02			16.82	
C.D.(5%)	8.78	4.27	6.30				4.91	5.49	4.70				10.71	

Shoot and fruit borer infestation was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval. The details are furnished in Table 14. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (10.00, 22.83, 18.00) followed by SMV8 (15.00, 22.16, 24.00) SMV1×SMV2 (20.00, 26.00, 22.50), SMV1×SMV6 (32.50, 27.74, 22.00), SMV1×SMV5 (35.00, 28.33, 25.00), and SMV1×SMV3 (35.00, 30.41, 23.00) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV3×SMV4 (47.50, 33.66, 34.00) followed by SMV4×SMV6 (40.00, 33.91, 27.00), SMV4×SMV7 (40.00, 30.99, 28.00), SMV2×SMV6 (45.00, 27.25, 25.00) and SMV3×SMV6 (32.50, 36.41, 27.00) at 60 DAT, 80 DAT and 100 DAT respectively.

4.1.2.4.14 .2 Fruit Infestation Percentage:

Shoot and fruit borer infestation was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and is furnished in Table 14.

The minimum percentage of fruit infestation was recorded in the hybrids SMV8 (24.16, 25.50, 20.67) followed by SMV5×SMV6 (22.08, 27.25, 28.83) and SMV1×SMV5 (29.25, 29.16, 31.49) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (51.66, 39.08, 37.07) followed by SMV3×SMV4 (39.15, 35.58, 46.65), SMV3×SMV6 (37.49, 35.40, 41.08), SMV1×SMV6 (41.16, 37.24, 32.00), SMV4×SMV6 (38.32, 34.41, 34.15), SMV1×SMV3 (33.33, 36.00, 34.58), SMV1×SMV2 (31.50, 38.33, 30.75) and SMV2×SMV6 (33.50, 33.33, 32.49) at 80 DAT, 100 DAT and 120 DAT respectively.

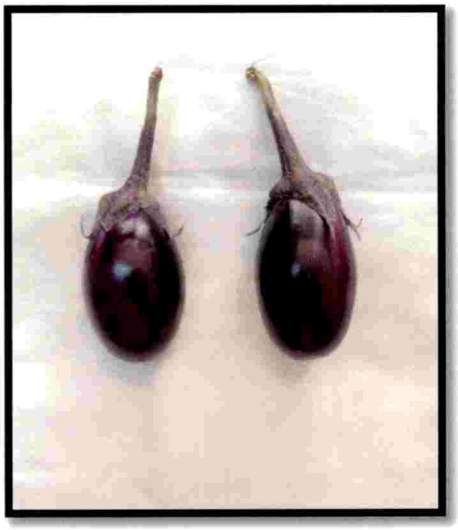
Based on percentage of shoot and fruit infestation, genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T),

Table 15. Expression of fruit colour.

Sl no.	Hybrids	Fruit colour
1	Wardha local × Palakurthi local	Purple
2	Wardha local × Surya	Deep purple
3	Wardha local × Swetha	Light pink
4	Wardha local × Vellayani local	Dark purple
5	Palakurthi local × Vellayani local	Light pink
6	Surya × NBR-38	Green with violet patches
7	Surya × Vellayani local	Olive with violet shades
8	NBR-38 × Vellayani local	Light green with patches
9	NBR-38 × Selection Pooja	Light green
10	Swetha × Vellayani local	Dark green with stripes
11	Neelima	Violet

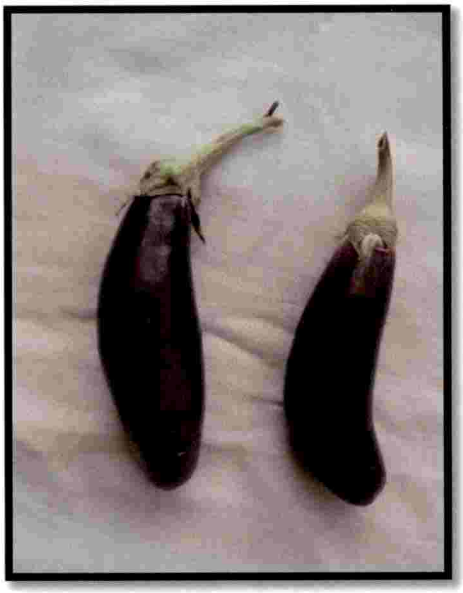
Plate 10. Variability of brinjal fruits in hybrids

Wardha local × Palakurthi local



Wardha local × Surya

Wardha local × Swetha



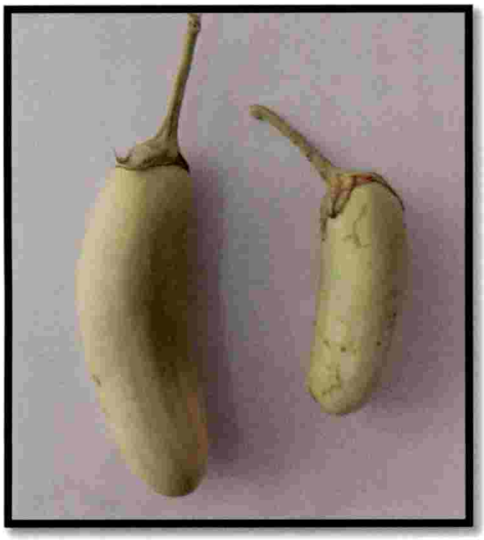
Wardha local × Vellayani local

Palakurthi local × Vellayani local

Surya × NBR-38

Surya × Vellayani local

NBR-38 × Vellayani local



NBR-38 × Selection Pooja

Swetha × Vellayani local

Neelima

Susceptible (S), and Highly Susceptible (HS) and the details are furnished in the Table 14.

4.1.2.4.15 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (2.50) recorded the lowest percentage of plants wilted and SMV4×SMV7 (37.50) recorded the highest percentage of plants wilted followed by SMV3×SMV4 (35.00).

Based on percentage of wilted plants, genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 14.

4.1.3 STABILITY ANALYSIS

For studying the stability of hybrids across four locations, phenotypic mean values were estimated for all the ten characters. According to Eberhart and Russell's Model, two parameters were estimated:

(i) Linear sensitivity coefficient (b_i) i.e. the regression coefficient of an individual mean on environment index to evaluate cultivars response.

(ii) Non-linear sensitivity coefficient (S^2_{di}) i.e. the mean square deviation from the linear regression to measure cultivars stability. Character wise results for mean performance and stability parameters have been presented in are described as follows:

4.1.3.1 Pooled analysis of variance

Eleven genotypes comprising of ten hybrids and one check were subjected to pooled analysis of variance for all the ten traits mentioned in the Table 16 across four locations. The analysis revealed presence of wide genetic variability among

Table 16. Pooled Analysis of Variance (mean square) for different quantitative traits over four locations during *kharif* season.

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
Genotypes	10	47.93**	64.18**	708.38**	2524.79**	27.58**	64.17**	0.20**	6.88**	2587.80**	412.20**
Environments	3	65.39**	787.55**	111.80**	3127.57**	17.00**	42.54**	0.41**	4.18**	1179.62**	379.42**
Gen. × Env. Interaction	30	13.01**	33.75**	8.89**	253.88**	1.55**	3.92**	0.06**	0.18**	42.62**	120.06**
Error	132	0.82	1.32	0.62	21.97	0.45	0.31	0.02	0.01	5.35	2.49

Table 17. Analysis of variance (mean square) for mean data of different quantitative traits over four locations during *kharif* season.

Source of Variation	Df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
Genotypes	10	11.98**	16.05**	177.09**	631.20**	6.89**	16.04**	0.05**	1.72**	646.95**	103.05**
Environments	3	16.35**	196.89**	27.95**	781.89**	4.25**	10.64**	0.10**	1.04**	294.91**	94.86**
Gen. × Env.	30	3.25**	8.44**	2.22**	63.47**	0.39**	0.98**	0.02**	0.04**	10.66**	30.02**
Env. + (Gen. × Env.)	33	4.44	25.57**	4.56**	128.78**	0.74	1.86**	0.02	0.14**	36.50**	35.91
Environment (Linear)	1	49.04**	590.66**	83.85**	2345.68**	12.75**	31.91**	0.31**	3.13**	884.72**	284.57**
Gen. × Env. (Linear)	10	4.02	13.93**	1.93	79.15	0.32	0.85	0.01	0.04	8.43	11.55
Pooled Deviation	22	2.61**	5.17**	2.15**	50.57**	0.38**	0.95**	0.02**	0.04**	10.70**	35.68**
Pooled Error	132	0.21	0.33	0.16	5.49	0.11	0.08	0.004	0.001	1.34	0.62
Total	43	6.20	23.35	44.68	245.62	2.17	5.16	0.03	0.50	178.46	51.52

**Significant at 1 % level

Table 18. Estimates of environmental indices (I_j) for each character under different locations during *kharif* season

Sl.No.	Characters	Vellayani	Thiruvalla	Sadanandapuram	Kayamkulam
1	Days to first flowering	-0.20	0.51	1.27	-1.58
2	Days to first harvest	-2.33	6.16	-0.70	-3.13
3	Number of fruits per plant	3.13	1.36	-3.68	-0.81
4	Fruit weight (g)	1.95	-0.002	-1.95	0.002
5	Fruit length (cm)	-0.29	0.53	-0.74	0.50
6	Fruit girth (cm)	-0.25	0.83	-1.28	0.70
7	Calyx length (cm)	0.01	0.02	0.11	-0.13
8	Yield per plant (kg)	0.11	0.12	-0.45	0.22
9	Yield per plot (kg)	1.54	3.23	-7.69	2.92
10	Plant height (cm)	-4.50	3.96	-9.14	9.68

the genotypes and among testing environments for all the ten characters. The Genotype × Environment interactions (G × E) were also significant for all the characters that indicated the substantial interaction between genotype and environment which implies differential response of genotypes across the environments for all the traits. Thus allowed further analysis to test the stability of the genotypes.

The mean squares due to Environments + (Genotype x Environment) were significant for the characters *viz.*, days to first harvest, number of fruits plant^{-1}, fruit weight, fruit girth, yield plant^{-1} and yield plot^{-1}. Sum of squares due to E + (G x E) was further partitioned into that of Environment (linear), Genotype x Environment (linear) and pooled deviation. Mean squares showed that environment (linear) differed significantly and were quite diverse in their effects on the performance of the genotypes. Variance of Genotype x Environment (linear) when tested against pooled deviation was significant for days to first harvest however found to be non-significant for rest of the traits. Pooled deviation (non-linear component) variances were significant for all characters suggesting importance of both linear and non-linear components (Table 17).

4.1.3.2 Environmental indices

The estimates of environmental indices (I_j) (Table 18) indicated that Thiruvalla location was highly favourable for all the characters except fruit weight. However, Kayamkulam location was favourable for fruit weight, fruit length, fruit girth, yield plant^{-1}, yield plot^{-1} and plant height. The Vellayani location was most favourable for number of fruits plant^{-1} and Sadanandapuram location was poor for all the characters except days to first flowering and calyx length.

4.1.3.3 Stability parameters

According to the Eberhart and Russell (1966) the ideal genotype would be the one which has high mean value, unit regression coefficient (b_i = 1) and minimum deviation from regression (S^2_{di} = 0). The linear regression (b_i) is treated as a measure of response of a genotype and deviation from regression (S^2_{di}) is

Table 19. Mean performance and stability parameters for yield and its component traits in brinjal during *kharif* season.

Genotype	Days to first flowering			Days to first harvest			Number of fruits per plant		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	44.79	0.73	0.762	71.23	1.01	9.277**	37.28	0.77	0.575
SMV1 × SMV3	47.18	1.09	2.877**	69.68	1.44	2.225**	25.18	1.79	2.899**
SMV1 × SMV5	42.93	1.26	4.118**	68.78	1.03	7.008**	29.44	0.32	1.408**
SMV1 × SMV6	41.14	1.08	5.990**	63.85	0.93	3.768**	26.05	0.33	2.190**
SMV2 × SMV6	43.55	2.66	2.376**	65.79	0.48	2.745**	16.56	0.94	0.348
SMV3 × SMV4	42.00	2.06	1.673**	67.99	0.91	4.479**	17.55	1.17	1.607**
SMV3 × SMV6	43.69	0.23	-0.175	67.84	1.69	10.494**	17.33	0.93	1.504**
SMV4 × SMV6	45.20	-1.05	2.865**	67.88	1.77	0.387	24.14	1.40	2.667**
SMV4× SMV7	45.19	0.65	0.503	68.15	0.42	9.080**	19.45	1.80	3.387**
SMV5× SMV6	45.36	1.19	3.906**	68.78	1.15	3.203**	31.80	0.70	2.469**
SMV8	45.15	1.10	1.526**	69.96	0.17	0.622	21.06	0.85	2.887**
Grand Mean	44.20			68.17			24.17		

**Significant at 1 % level

considered as a measure of stability. In the present study regression coefficient (b_i) values, b_i=1 are treated as unity. Deviation from regression (S^2_{di}) values, if found non-significant, are considered to be within the "minimum deviation" *i.e.*, zero. Hence, the genotypes are considered to be stable. Along with the stability parameters the genotype means decide the best stable genotype. On the basis of the three characteristic features *viz*., mean (μ), regression coefficient (b_i) and deviation from regression (S^2_{di}) were considered to assess the stability of a genotype. In addition to this if a genotype has greater mean (μ), bi = 1 and S^2_{di} = non-significant then it is stable and widely adapted for all environment, if a genotype has greater/ smaller mean (μ), bi > 1 and S^2_{di} = non-significant then it is above average stable and adapted to rich environment, if a genotype has greater/ smaller mean (μ), bi < 1 and S^2_{di} = non-significant then it is stable and adapted to poor environment and if a genotype has greater mean (μ), bi = 1 and S^2_{di} = significant then it is unstable. The estimation of stability parameters i.e., mean (μ), regression coefficient (b_i) and deviation from regression (S^2_{di}) for ten characters are furnished below character-wise.

4.1.3.3.1 Days to First Flowering:

Among the hybrids SMV1×SMV2 (μ=44.79, b_i=0.73, S^2_{di}=0.76), SMV4×SMV7 (μ=45.19, b_i=0.65, S^2_{di}=0.50) and SMV3×SMV6 (μ=43.69, b_i=0.23, S^2_{di}=-17) were identified as stable one's having regression coefficient near to 'unity' and non-significant deviation from regression. The hybrids SMV1×SMV2, SMV4×SMV7 and SMV3×SMV6 exhibited less than one b_i value, hence it is adaptable to poor environment. In case of other hybrids the performance has been found to be highly unpredictable because of their significant deviation from regression values (Table 19).

4.1.3.3.2 Days to First Harvest:

Hybrids SMV4×SMV6 and SMV8 were stable among the eleven hybrids with respect to days to first harvest. The hybrid SMV4×SMV6 exhibited more than one bi value (1.77) and minimum deviation from regression (0.387), hence it is adaptable to favourable environment. SMV8 exhibited less than one bi value (0.17) and minimum deviation from regression (0.622), hence it is adaptable to unfavourable environment (Table 19).

4.1.3.3.3 Number of Fruits Plant^{-1}:

The number of fruit plant^{-1} of the genotypes across four environments indicated that, SMV1×SMV2 has highest number of fruits plant^{-1} (37.28), while lowest numbers of fruits plant^{-1} were recorded by SMV2×SMV6 (16.56).

Among the hybrids, two hybrids *viz*., SMV1×SMV2 (μ=37.28, b_i=0.77, S^2_{di}=0.575) and SMV2×SMV6 (μ=16.56, b_i=0.94, S^2_{di}=0.348) recorded regression coefficient values near to 'unity' and minimum deviation from regression, hence they are stable and adaptable to all environment (Table 19). In case of other genotypes the performance has been found to be highly unpredictable because of their significant deviation from regression values.

4.1.3.3.4 Fruit Weight:

Fruit weight varied from 109.49 g (SMV1×SMV2) to 72.76 g (SMV1×SMV2) with overall mean of 91.86 g across the four environments. The deviations from regression were non-significant for four genotypes indicating the stability of these genotypes across the environments.

Hybrids SMV1×SMV2 (μ=83.43, b_i=0.75, S^2_{di}=1.705) and SMV1×SMV5 (μ=79.43, b_i=1.10, S^2_{di}=4.144) expressed regression coefficient near to 'unity' and deviation from regression near to zero were finally considered as stable ones for this trait. The genotype SMV8 which exhibited high mean, regression coefficient more than 'unity' and non-significant deviation from regression is recommended for cultivation in rich environments. Whereas, SMV4×SMV7 is suitable for poor environments (Table 19).

4.1.3.3.5 Fruit Length:

Table 19. (Continued…)

Genotype	Fruit weight (g)			Fruit length (cm)			Fruit girth (cm)		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	83.43	0.75	1.705	13.48	1.02	0.389	11.76	1.01	0.050
SMV1 × SMV3	72.76	0.22	54.844**	10.13	0.47	-0.021	13.37	0.45	0.297**
SMV1 × SMV5	79.43	1.10	4.144	14.17	0.97	0.667**	12.14	0.33	0.004
SMV1 × SMV6	100.00	1.54	23.739**	14.76	1.56	-0.092	13.82	0.78	0.769**
SMV2 × SMV6	75.33	0.05	62.574**	14.06	0.35	-0.001	11.15	0.40	1.187**
SMV3 × SMV4	102.73	2.06	30.403**	12.44	1.82	0.322	16.67	1.63	2.807**
SMV3 × SMV6	94.31	1.51	101.110**	12.14	1.31	0.614**	14.63	1.19	0.826**
SMV4 × SMV6	95.33	1.21	187.471**	13.34	1.15	-0.094	14.29	1.19	0.193
SMV4× SMV7	91.68	0.47	10.317	13.95	0.06	0.820**	15.92	2.14	2.731**
SMV5× SMV6	106.04	0.81	22.186**	14.11	1.24	0.136	14.04	0.87	0.375**
SMV8	109.49	1.28	-2.580	12.49	1.03	0.253	17.45	1.01	0.364**
Grand Mean	91.86			13.19			14.11		

**Significant at 1 % level

The overall fruit length of hybrids across the four environments indicated that SMV1×SMV2 had maximum fruit length (14.76 cm), while lowest fruit length was recorded by SMV1×SMV2 (10.13 cm) as depicted in table .

The hybrids with high mean, regression coefficient equal to 'unity' and non-significant deviation from regression *viz.,* SMV1×SMV2 (μ=13.48, b_i=1.02, S^2_{di} =0.389) and SMV8 (μ=12.49, b_i=1.03, S^2_{di}= 0.253) were finally considered as stable and widely adapted to all environments for this trait. The genotypes which exhibited high mean, regression coefficient more than 'unity' and non–significant deviation from regression were SMV1×SMV6 (μ=14.76, b_i=1.56, S^2_{di}=-0.092), SMV3×SMV4 (μ=12.44, bi=1.82, S^2_{di}=0.322), SMV4×SMV6 (μ=13.34, b_i=1.15, S^2_{di}=-0.094) and SMV5×SMV6 (μ=14.11, b_i=1.24, S^2_{di}=0.136) suitable for favourable environments. Whereas, the hybrids SMV1×SMV3 and SMV2×SMV6 exhibited better fruit length in unfavourable environment (Table 19).

4.1.3.3.6 Fruit Girth:

The mean values for this trait ranged from 11.76 cm (SMV1×SMV2) to 17.45 cm (SMV8). Most of the genotypes, exhibited significant S^2_{di} values whose performance cannot be predicted. Among the hybrids, SMV4×SMV6 (μ=14.29, b_i=1.19, S^2_{di}=0.193) was considered as stable because of high mean, regression coefficient around 'unity' and non–significant deviation from regression. Although SMV1×SMV2 expressed lower mean (11.76 cm) but was found stable because its regression coefficient (bi=1.01) is near to 'unity' and deviation from regression near to zero (0.050) (Table 19).

Further, the hybrid, SMV1×SMV5 was observed to be suitable for un-favourable environment as they recorded mean (12.14 cm) with lesser than 'unit' regression (0.33) and non–significant (0.004) deviation from linearity. The rest of genotypes which exhibited significant deviation from regression were considered as unstable.

4.1.3.3.7 Calyx Length:

Table 19. (Continued…)

Genotype	Calyx length (cm)			Yield per plant (kg)			Yield per plot (kg)			Plant height (cm)		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	3.13	0.81	-0.0004	3.21	0.78	-0.001	57.66	0.88	-0.236	97.36	1.23	2.082
SMV1 × SMV3	2.90	1.90	0.0347**	1.77	0.58	0.047**	31.80	0.71	16.916**	86.55	0.68	13.320**
SMV1 × SMV5	3.05	0.63	-0.0010	2.45	0.95	0.005	44.68	0.89	4.957	89.60	1.44	7.535**
SMV1 × SMV6	2.82	0.79	0.0241**	2.52	1.36	0.002	45.86	1.38	0.099	93.43	0.70	11.568**
SMV2 × SMV6	2.77	1.84	0.0125	1.22	0.62	0.014**	22.90	0.91	5.278**	88.93	1.15	19.104**
SMV3 × SMV4	3.00	0.42	0.0033	1.89	1.88	0.102**	31.45	1.78	14.244**	94.68	1.98	-0.505
SMV3 × SMV6	2.85	1.16	0.0129	1.61	0.93	0.058**	29.30	0.89	10.415**	97.29	0.87	170.195**
SMV4 × SMV6	2.85	0.91	0.0421**	2.27	1.25	0.092**	38.96	1.00	35.231**	99.36	1.71	58.136**
SMV4× SMV7	3.00	0.55	0.0070	1.80	0.83	0.061**	28.99	0.79	7.328**	92.94	-0.22	2.708**
SMV5× SMV6	2.87	0.84	0.0018	3.35	1.09	0.063**	63.66	1.11	6.223**	98.31	1.41	64.048**
SMV8	2.99	1.15	0.0218**	2.36	0.74	0.010**	44.47	0.67	2.517	103.56	0.06	37.425**
Grand Mean	2.93			2.22			39.98			94.73		

**Significant at 1 % level

Calyx length ranged from 2.77 cm (SMV2×SMV6) to 3.13 cm (SMV1×SMV2) across four locations. Seven genotypes expressed least non-significant deviation from regression and therefore, were stable across the four environments.

SMV1×SMV2 and SMV5×SMV6 showed regression coefficient approximately to unity (0.81, 0.84) and non-significant deviation from regression (-0.0004, 0.0018) hence, they are stable and widely adaptable for all environments. The genotypes which revealed high mean, regression coefficient less than one and non-significant deviation from regression were SMV1×SMV5, SMV3×SMV4 and SMV4×SMV7. Whereas, SMV2×SMV6 and SMV3×SMV6 were suitable for rich environments (Table 19).

4.1.3.3.8 Yield Plant^{-1}:

The overall fruit yield of hybrids in all the four environments indicated that SMV5×SMV6 has the highest mean fruit yield (3.35 kg) followed by SMV1×SMV2 (3.21 kg), while lowest yield was recorded by SMV2×SMV6 (1.22 kg).

Among the different hybrids, three hybrids expressed non-significant S^2_{di} values whose performance could be well predicted. The hybrid, SMV1×SMV2 (μ=3.21, b_i=0.78, S^2_{di}=-0.001) and SMV1×SMV5 (μ=2.45, b_i=0.95, S^2_{di}=0.005) with high mean, regression coefficient near to 'unity' and minimum deviation from regression were stable (Table 19).

With respect to poor environment, the hybrid SMV1×SMV6 (μ=2.52, b_i=1.36, S^2_{di}=0.002) which recorded high mean with more than 'unity' regression coefficient and non–significant deviation from linearity were considered as suitable for cultivation in unfavourable environments.

4.1.3.3.9 Yield Plot^{-1}:

The yield plot^{-1} of hybrids over all the four environments indicated that, SMV5×SMV6 has highest yield plot^{-1} (63.66 kg) followed by SMV1×SMV2 (57.66 kg), while lowest yield plot^{-1} was recorded by SMV2×SMV6 (22.90 kg).

The hybrids SMV1×SMV2 (μ=57.66, b_i=0.88, S^2_{di}=-0.236) and SMV1×SMV5 (μ=44.68, b_i=0.89, S^2_{di}=4.957) recorded high mean regression coefficient near 'unity' and non–significant deviation from regression were considered as stable genotype (Table 19.). With respect to poor environment, the hybrid SMV8 (μ=3.21, b_i=0.78, S^2_{di}=-0.001) recorded regression coefficient less than 'unity' and non–significant deviation from linearity and SMV1×SMV6 (μ=45.86, b_i=1.38, S^2_{di}=-0.099) exhibited regression coefficient more than 'unity' and non–significant deviation from linearity.

4.1.3.3.10 Plant Height:

Two hybrids exhibited predictable performance with non-significant S^2_{di} values. The hybrid, SMV1×SMV2 (μ=97.36, b_i=1.23, S^2_{di}=2.082) and SMV3×SMV4 (μ=94.68, b_i=1.98, S^2_{di}=-0.505) was considered as stable and adaptable to favourable environment because of regression coefficient more than 'unity' and non–significant deviation from regression (Table 19).

4.2 EVALUATION OF F1 HYBRIDS DURING SUMMER SEASON

4.2.1 Analysis of Variance:

Analysis of variance showed significant differences among the genotypes for all the characters studied in all the environments (Table 20.1 to 20.4).

4.2.2 Mean performance:

4.2.2.1 Performance of brinjal hybrids at COA, Vellayani:

Mean values for yield and yield contributing characters of brinjal genotypes are furnished in Table 21.

4.2.2.1.1 Morphological Characters:

Hybrid SMV1×SMV5 was the earliest to flower (42.20), while SMV4×SMV7 took the maximum duration to flowering (46.85). Hybrids SMV4×SMV6, SMV8 and SMV5×SMV6 were late bloomers.

Table 20. Analysis of variance (mean square) for individual locations during summer season.

Table 20.1. Location-I (Vellayani)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	0.278	0.323	0.398	1.732	1.307	0.259	0.032	0.004	5.141	42.133	1.933	0.082	13.400
Treatment	10	5.871**	8.671**	145.113**	993.581**	13.260**	17.475**	0.075**	1.515**	711.038**	142.639**	74.695**	2.500**	22.528**
Error	30	0.283	0.243	0.260	0.724	0.342	0.274	0.011	0.008	1.611	10.359	1.095	0.049	3.400

Table 20.2. Location - II (Thiruvalla)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	1.691	0.700	0.016	30.941	0.161	0.073	0.002	0.006	12.423	8.201	0.297	0.024	10.748
Treatment	10	29.745**	31.140**	91.338**	685.608**	7.022**	16.584**	0.058**	0.909**	387.984**	87.221**	76.928**	2.082**	27.301**
Error	30	0.695	0.436	0.243	14.548	0.127	0.130	0.002	0.004	4.456	3.638	0.754	0.013	4.915

**Significant at 1 % level

Table 20.3. Location - III (Sadanandapuram)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	0.559	0.615	0.208	31.129	0.033	0.041	0.013	0.0003	11.040	22.523	0.434	0.042	5.824
Treatment	10	16.326**	9.832**	130.087**	545.154**	5.704**	13.598**	0.164**	1.085**	564.035**	311.557**	74.230**	2.291**	24.205**
Error	30	0.724	0.691	0.323	8.676	0.167	0.253	0.007	0.004	4.628	10.989	0.686	0.029	4.886

Table 20.4. Location - IV (Kayamkulam)

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
Replication	3	1.188	1.988	0.390	1.508	0.095	0.091	0.002	0.001	6.546	10.417	0.925	0.025	14.157
Treatment	10	20.615**	20.823**	73.826**	550.192**	10.506**	13.371**	0.056**	1.307**	544.241**	67.091**	85.630**	1.924**	23.523**
Error	30	0.660	0.987	0.306	3.833	0.191	0.308	0.005	0.003	3.048	3.154	0.506	0.021	4.886

**Significant at 1 % level

Table 21. Mean performance of brinjal hybrids at Vellayani during summer season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	44.15	68.80	35.00	80.15	13.16	12.39	2.69	3.02	53.34	108.20	12.65	2.26	14.38
SMV1 × SMV3	45.15	70.55	22.20	57.65	9.87	14.04	2.78	1.50	22.48	94.50	10.99	3.71	9.38
SMV1 × SMV5	42.20	69.25	33.45	86.40	14.80	12.27	2.99	2.87	51.73	101.60	13.82	4.27	11.88
SMV1 × SMV6	44.60	67.50	30.50	103.05	15.91	13.92	2.90	3.05	53.94	96.70	16.83	2.67	11.25
SMV2 × SMV6	45.20	67.65	21.25	56.55	15.60	12.19	2.77	1.29	20.75	95.60	12.76	3.21	11.88
SMV3 × SMV4	44.95	72.25	19.05	84.80	12.75	17.68	3.04	1.82	25.99	107.40	21.08	1.47	10.63
SMV3 × SMV6	44.80	69.55	21.05	90.40	11.37	14.29	2.94	2.10	33.09	106.85	16.30	2.60	15.63
SMV4 × SMV6	46.45	70.20	24.75	95.40	13.19	14.12	2.89	2.37	37.04	107.00	10.25	3.13	8.75
SMV4× SMV7	46.85	71.55	22.30	98.15	13.21	17.63	2.56	2.10	31.04	96.95	14.41	3.97	11.88
SMV5× SMV6	45.35	69.00	33.80	95.00	13.68	14.70	2.84	2.93	56.61	107.40	24.65	3.07	14.38
SMV8	45.45	70.15	21.50	98.25	11.59	17.39	2.89	2.30	39.48	110.40	16.90	3.04	15.63
C.D.(5%)	0.77	0.72	0.74	1.23	0.85	0.76	0.15	0.13	1.84	4.67	1.52	0.32	2.68
SE(m)	0.27	0.25	0.26	0.43	0.29	0.26	0.05	0.05	0.64	1.61	0.52	0.11	0.92
C.V.	1.18	0.71	1.97	0.99	4.43	3.59	3.64	3.96	3.28	3.13	6.74	7.31	14.95

SMV1×SMV6 took minimum days to first harvest (67.50), while SMV3×SMV4 took maximum days to first harvest (72.25) followed by SMV4×SMV7 (71.55).

For the trait number of fruits plant^{-1} SMV1×SMV2 (35.00) recorded the maximum followed by SMV5×SMV6 (33.80) and SMV1×SMV5 (33.45) while, SMV3×SMV4 (19.05) recorded the lowest number of fruits plant^{-1}.

The variation for fruit weight ranged from 56.55 g to 103.05 g among the hybrids. Maximum fruit weight was observed in SMV1×SMV6 (103.05 g) and minimum value was recorded for SMV2×SMV6 (56.55 g).

Fruit length and girth also have recorded considerable variation among the genotypes. The longest fruits were recorded in SMV1×SMV6 (15.91 cm) and the shortest fruits were observed in SMV1×SMV3 (9.87 cm). SMV2×SMV6 had the lowest fruit girth (12.19 cm) and SMV3×SMV4 recorded the greater size for fruit girth (17.68 cm).

Calyx length varied from 2.56 to 3.04 cm among the hybrids. SMV3×SMV4 registered the ultimate calyx length (3.04 cm) among the hybrids and SMV4×SMV7 recorded the shortest calyx length (2.56 cm).

Hybrids SMV1×SMV6 (3.05 kg) SMV1×SMV2 (3.02 kg) and SMV5×SMV6 (2.93 kg) recorded the maximum values for yield plant^{-1}. The lowest yield plant^{-1} was observed in SMV2×SMV6 (1.29 kg) and SMV1×SMV3 was on par with it.

There was a significant difference with respect to yield plot^{-1}. The highest yield plot^{-1} was recorded by SMV5×SMV6 (56.61 kg) followed by SMV1×SMV6 (53.94 kg) and SMV1×SMV2 (53.34 kg). The lowest yield plot^{-1} was recorded in SMV2×SMV6 (20.75 kg).

The tallest hybrid was SMV8 (110.40 cm) and SMV1×SMV2 was on par with it. The shortest hybrid was SMV1×SMV3 (94.50 cm).

4.2.2.1.2 Biochemical Characters:

The hybrid SMV5×SMV6 recorded the highest value for total phenols (24.65 mg/100g) and SMV4×SMV6 recorded the minimal value (10.24 mg/100g) for total phenols as well as vitamin C (8.75 mg/100g). SMV8 registered 15.63 mg/100g of vitamin C content which was the highest among the genotypes. Total sugars level was low in SMV3×SMV4 (1.47 g/100g) and high in SMV1×SMV5 (4.27 g/100g).

4.2.2.1.3 Pest and Disease incidence:

4.2.2.1.3.1 ***Shoot and Fruit Borer Infestation:***

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and the results are furnished in Table 22. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (12.50, 20.00, 18.00) followed by SMV1×SMV2 (15.00, 21.42, 18.67), SMV8 (15.00, 21.25, 20.00) SMV1×SMV5 (30.00, 23.50, 24.00), SMV1×SMV6 (35.00, 29.17, 20.67), and SMV3×SMV6 (32.50, 29.58, 28.00) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV3×SMV4 (42.50, 42.08, 37.00) followed by SMV4×SMV7 (42.50, 31.66, 31.00), SMV2×SMV6 (42.50, 33.75, 27.00) and SMV4×SMV6 (37.50, 33.08, 29.00) at 60 DAT, 80 DAT and 100 DAT respectively.

Table 22. Pest and disease scoring of brinjal hybrids at Vellayani during summer season.

Geonotype	Shoot infestation (%)						Fruit infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	15.00 (2)	21.42 (3)	18.67 (2)	18.36	7	MR	26.00 (3)	32.50 (4)	30.41 (3)	29.64	10	T	15.00 (1)	R
SMV1 × SMV3	37.50 (4)	31.66 (4)	30.00 (3)	33.05	11	S	32.91 (4)	36.25 (4)	33.75 (4)	34.30	12	S	27.50 (2)	MR
SMV1 × SMV5	30.00 (3)	23.50 (2)	24.00 (2)	25.83	7	T	26.99 (3)	30.66 (3)	30.08 (3)	29.24	9	T	17.50 (1)	R
SMV1 × SMV6	35.00 (4)	29.17 (2)	20.67 (2)	28.28	8	T	35.66 (4)	36.66 (4)	32.50 (4)	34.94	12	S	10.00 (1)	R
SMV2 × SMV6	42.50 (5)	33.75 (4)	27.00 (3)	34.42	12	S	35.41 (4)	29.91 (3)	27.08 (3)	30.80	10	T	15.00 (1)	R
SMV3 × SMV4	42.50 (5)	42.08 (5)	37.00 (4)	40.53	14	S	37.90 (4)	35.42 (4)	32.32 (4)	35.21	12	S	35.00 (2)	MR
SMV3 × SMV6	32.50 (4)	29.58 (3)	28.00 (3)	30.03	10	T	32.08 (4)	34.16 (4)	35.42 (4)	33.88	12	S	20.00 (1)	R
SMV4 × SMV6	37.50 (4)	33.08 (4)	29.00 (3)	33.19	11	S	33.32 (4)	31.42 (4)	29.91 (3)	31.55	11	S	40.00 (2)	MR
SMV4× SMV7	42.50 (5)	31.66 (4)	31.00 (4)	35.05	13	S	42.08 (5)	44.83 (5)	40.58 (5)	42.50	15	HS	42.50 (3)	MS
SMV5× SMV6	12.50 (2)	20.00 (2)	18.00 (2)	16.83	6	MR	16.92 (2)	17.21 (2)	19.25 (2)	17.79	6	MR	5.00 (1)	R
SMV8	15.00 (2)	21.25 (3)	20.00 (2)	18.75	7	MR	19.16 (2)	18.08 (2)	20.92 (2)	19.38	6	MR	10.00 (1)	R
Grand Mean	31.14	28.83	25.76	28.57			30.76	31.55	30.20	30.84			21.59	
C.D.(5%)	7.20	3.79	4.87				3.92	2.62	4.80				10.36	

Fruit Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and the details are furnished in Table 22.

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (16.92, 17.21, 19.25) followed by SMV8 (19.16, 18.08, 20.92), SMV1×SMV5 (26.99, 30.66, 30.08), SMV1×SMV2 (26.00, 32.50, 30.41), SMV2×SMV6 (35.41, 29.91, 31.55) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (42.08, 44.83, 40.58) followed by SMV3×SMV4 (37.90, 35.42, 32.32), SMV1×SMV6 (35.66, 36.66, 32.50), SMV1×SMV3 (32.91, 36.25, 33.75), SMV3×SMV6 (32.08, 34.16, 36.42) and SMV4×SMV6 (33.32, 31.42, 29.91) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation, the genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS) and the results are furnished in the Table 22.

4.2.2.1.3.2 Bacterial Wilt Incidence:

Screening of 11 F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (5.00) recorded the least percentage of plants wilted followed by SMV8 (10.00) and SMV4×SMV7 (42.50) recorded the highest percentage of plants wilted followed by SMV4×SMV6 (40.00).

Based on percentage of wilted plants, the genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 22.

Table 23. Mean performance of brinjal hybrids at Thiruvalla during summer season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	41.65	65.50	36.35	89.45	14.24	11.72	2.89	3.26	58.86	112.95	12.24	2.04	10.63
SMV1 × SMV3	38.60	65.95	25.60	76.65	11.33	13.20	2.87	1.94	35.50	95.90	10.14	3.49	10.00
SMV1 × SMV5	41.05	66.65	31.55	88.45	15.93	11.85	2.64	2.79	51.70	100.15	14.11	3.89	10.63
SMV1 × SMV6	45.85	65.05	28.50	106.50	16.01	14.41	3.03	3.04	55.67	96.80	16.22	2.97	13.13
SMV2 × SMV6	40.15	63.00	25.00	78.00	15.13	11.37	2.84	2.10	39.22	99.90	12.70	2.98	11.25
SMV3 × SMV4	46.20	72.30	22.70	101.05	13.82	16.44	3.03	2.24	38.71	101.60	21.02	1.64	10.00
SMV3 × SMV6	39.85	64.90	21.50	90.70	13.91	13.70	2.93	1.96	36.39	97.40	15.45	2.87	14.38
SMV4 × SMV6	41.55	65.40	24.10	111.45	14.58	13.98	3.05	2.66	49.30	103.35	9.49	3.11	6.88
SMV4× SMV7	45.85	70.55	22.70	89.15	13.25	15.13	2.87	2.30	37.22	97.60	15.92	4.17	10.00
SMV5× SMV6	39.50	64.65	31.80	107.80	14.87	15.72	2.93	3.17	62.90	101.05	24.08	2.95	13.75
SMV8	42.00	68.75	23.15	114.10	13.51	17.71	3.03	2.55	49.11	100.05	17.12	3.01	16.25
C.D.(5%)	1.21	0.96	0.72	5.54	0.52	0.52	0.06	0.09	3.06	2.77	1.26	0.17	3.22
SE(m)	0.42	0.33	0.25	1.91	0.18	0.18	0.02	0.03	1.06	0.95	0.43	0.06	1.11
C.V.	1.98	0.99	1.85	3.98	2.51	2.55	1.41	2.52	4.51	1.90	5.67	3.82	19.22

Plate 5. General view of experimental plot at Vellayani during summer season

Plate 6. General view of experimental plot at Thiruvalla during summer season

4.2.2.2 *Performance of brinjal hybrids at Farmer's field, Thiruvalla:*

The mean performance of genotypes with respect to various characters is furnished in Table 23.

4.2.2.2.1 *Morphological Characters:*

Earliness in flowering and days to first harvest was noticed in SMV1×SMV3 (38.60) and SMV2×SMV6 (63.00) respectively. The hybrid SMV3×SMV4 took the longest duration to flower (46.20) as well as to the first harvest (72.30).

The hybrid SMV1×SMV2 produced the largest number of fruits plant^{-1} (36.35) whereas SMV3×SMV6 produced the least number (21.50) and SMV3×SMV4 and SMV4×SMV7 were on par with it.

Individual fruit weight ranged from 76.65 g (SMV1×SMV3) to 114.10 g (SMV8). SMV4×SMV6 was on par with the hybrid SMV8.

The longest fruit was produced by SMV1×SMV6 (16.01 cm) and was on par with SMV1×SMV5 and SMV2×SMV6. The shortest one was produced by SMV1×SMV3 (11.33 cm).

The hybrid SMV8 showed the maximum fruit girth (17.71 cm) and was on par with SMV3×SMV4. Fruit girth was minimum in SMV1×SMV2 (11.72 cm). Calyx length ranged from 2.64 cm (SMV1×SMV5) to 3.05 cm (SMV4×SMV6).

SMV1×SMV2 recorded the highest yield plant^{-1} (3.26 kg) as well as plant height (112.95 cm) and SMV5×SMV6 (62.90 kg) recorded the highest yield plot^{-1}. The hybrid SMV1×SMV3 recorded lowest yield plant^{-1} (1.94 kg), yield plot^{-1} (35.50 kg) and plant height (95.90 cm).

4.2.2.2.2 *Biochemical Characters:*

Higher level of total phenols, total sugars and vitamin C content was recorded in SMV5×SMV6 (24.08 mg/100g), SMV4×SMV7 (4.17 g/100g) and SMV8 (16.25 mg/100g) respectively. SMV4×SMV6 noted lower level of total

Table 24. Pest and disease scoring of brinjal hybrids at Thiruvalla during summer season

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	25.00 (3)	28.50 (3)	24.00 (3)	25.83	9	T	24.75 (3)	31.33 (4)	32.75 (4)	29.61	11	T	10.00 (1)	R
SMV1 × SMV3	35.00 (4)	31.33 (4)	24.00 (3)	30.11	11	T	38.32 (4)	37.25 (4)	38.17 (4)	37.91	12	S	15.00 (1)	R
SMV1 × SMV5	25.00 (3)	28.74 (3)	27.00 (3)	26.91	9	T	30.33 (3)	33.24 (4)	32.33 (4)	31.97	11	S	22.50 (2)	MR
SMV1 × SMV6	30.00 (3)	30.41 (3)	23.00 (3)	27.80	9	T	37.75 (4)	36.24 (4)	29.50 (3)	34.50	11	S	17.50 (1)	R
SMV2 × SMV6	37.50 (4)	31.39 (4)	31.00 (4)	33.30	12	S	32.50 (4)	34.99 (4)	30.40 (3)	32.63	11	S	12.50 (1)	R
SMV3 × SMV4	47.50 (5)	27.49 (3)	28.00 (3)	34.33	11	S	35.81 (4)	37.41 (4)	47.90 (5)	40.37	13	HS	27.50 (2)	MR
SMV3 × SMV6	32.50 (4)	32.91 (4)	26.00 (3)	30.47	11	T	35.82 (4)	35.40 (4)	36.25 (4)	35.82	12	S	12.50 (1)	R
SMV4 × SMV6	42.50 (5)	31.24 (4)	25.00 (3)	32.91	12	S	39.56 (4)	39.41 (4)	37.07 (4)	38.68	12	S	27.50 (2)	MR
SMV4× SMV7	45.00 (5)	36.23 (4)	34.00 (4)	38.41	13	S	48.32 (5)	37.83 (4)	39.15 (4)	41.77	13	HS	40.00 (2)	MR
SMV5× SMV6	17.50 (2)	21.66 (3)	19.00 (2)	19.39	7	MR	18.25 (2)	19.00 (2)	21.33 (3)	19.53	7	MR	7.50 (1)	R
SMV8	20.00 (2)	19.16 (2)	20.00 (2)	19.72	6	MR	19.41 (2)	21.00 (3)	19.42 (2)	19.94	7	MR	10.00 (1)	R
Grand Mean	32.50	29.00	25.55	29.02			32.80	33.01	33.11	32.97			18.41	
C.D.(5%)	8.58	3.95	4.91				4.33	4.13	4.87				11.18	

phenols (9.49 mg/100g) and vitamin C (6.88 mg/100g) content. Total sugars was lowest in SMV3×SMV4 (1.64 g/100g).

4.2.2.2.3 Pest and Disease incidence:

4.2.2.2.3.1 Shoot and Fruit Borer Infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval. The details are furnished in Table 24. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (17.50, 21.66, 19.00) followed by SMV8 (20.00, 19.16, 20.00) SMV1×SMV2 (25.00, 28.50, 24.00), SMV1×SMV5 (25.00, 28.74, 27.00), SMV1×SMV6 (30.00, 30.41, 23.00), SMV1×SMV3 (35.00, 31.33, 24.00) and SMV3×SMV6 (32.50, 32.91, 26.00) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV4×SMV7 (45.00, 36.23, 34.00) followed by SMV3×SMV4 (47.50, 27.49, 28.00), SMV2×SMV6 (37.50, 31.39, 31.00) and SMV4×SMV6 (42.50, 31.24, 25.00) at 60 DAT, 80 DAT and 100 DAT respectively.

Fruit Infestation Percentage:

Shoot and fruit borer was screened for all 11 F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval. Details are furnished in Table 24.

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (18.25, 19.00, 21.33) followed by SMV8 (19.41, 21.00, 19.42) and SMV1×SMV2 (24.75, 31.33, 32.75) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (48.32, 37.83, 39.15) followed by SMV3×SMV4 (35.81, 37.41, 47.90), SMV4×SMV6 (39.56, 39.41, 37.07), SMV1×SMV3 (38.32, 37.25, 38.17), SMV3×SMV6 (35.82, 35.40, 36.25), SMV1×SMV6 (37.75, 36.24, 29.50), SMV2×SMV6 (32.50, 34.99, 30.40) and SMV1×SMV5 (30.33, 33.24, 32.33) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation the genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 24.

4.2.2.2.3.3 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (7.50) recorded the lowest percentage of plants wilted and SMV4×SMV7 (40.00) recorded the highest percentage of plants wilted.

Based on percentage of wilted plants, genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS) and results are furnished in the Table 24.

4.2.2.3 Performance of brinjal hybrids at Farmer's field, Sadanandapuram:

The mean performance of eleven genotypes for different characters related to yield parameters and quality traits are given in Table 25.

Table 25. Mean performance of brinjal hybrids at Sadanandapuram during summer season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	45.15	68.90	35.20	76.15	12.97	10.81	2.61	2.85	53.02	105.15	13.74	2.23	14.38
SMV1 × SMV3	46.95	66.65	27.45	55.65	10.61	11.03	2.33	1.88	36.30	83.35	11.13	3.70	12.50
SMV1 × SMV5	44.65	68.65	32.55	84.50	14.15	11.21	2.75	2.65	50.62	92.10	12.88	4.32	11.88
SMV1 × SMV6	48.05	68.35	31.00	84.35	14.88	12.42	2.95	2.45	51.04	87.75	17.17	2.63	14.38
SMV2 × SMV6	49.75	68.10	23.60	70.65	14.75	10.32	2.82	1.56	25.58	91.30	10.92	3.21	16.88
SMV3 × SMV4	46.50	72.15	18.75	77.45	12.62	14.56	2.58	1.44	22.98	82.30	20.34	1.66	11.88
SMV3 × SMV6	44.35	68.45	23.00	71.05	13.33	11.37	2.47	1.55	30.16	111.00	16.97	2.71	16.25
SMV4 × SMV6	46.10	69.90	22.25	86.05	13.72	12.55	2.92	1.90	32.90	94.80	10.29	2.82	11.25
SMV4× SMV7	48.95	70.60	19.55	79.50	14.12	15.15	2.45	1.63	26.58	92.10	15.18	3.90	9.38
SMV5× SMV6	43.15	66.95	31.05	92.80	14.01	13.16	2.80	2.73	53.78	96.10	24.30	2.85	16.25
SMV8	45.55	69.15	21.30	98.50	13.00	15.60	2.73	2.11	41.02	101.60	17.12	3.07	15.63
C.D.(5%)	1.24	1.21	0.82	4.27	0.59	0.73	0.12	0.10	3.12	4.81	1.20	0.25	3.21
SE(m)	0.43	0.42	0.28	1.47	0.21	0.25	0.04	0.03	1.08	1.66	0.41	0.09	1.11
C.V.	1.84	1.21	2.19	3.70	3.04	4.01	3.03	3.16	5.58	3.51	5.36	5.67	16.14

4.2.2.3.1 Morphological Characters:

Days to first flowering ranged from 43.15 to 49.75 days. SMV5×SMV6 was the earliest to bloom and SMV2×SMV6 was the last to bloom, followed by SMV4×SMV7 (48.95) and SMV1×SMV6 (48.05).

Hybrid SMV1×SMV3 recorded early fruiting (66.65), while SMV3×SMV4 was observed to be lagging behind (72.15) among the genotypes.

The hybrids differed significantly with respect to number of fruits plant^{-1} which varied from 18.75 (SMV3×SMV4) to 35.20 (SMV1×SMV2). SMV1×SMV5 was on par with SMV1×SMV2.

The overall mean for fruit weight was 79.70 g. Maximum fruit weight was recorded in SMV8 (98.50 g) and the lowest fruit weight was recorded in SMV1×SMV3 (55.65 g).

Fruit length exhibited significant variation among the genotypes with a range of 10.61 to 14.88 cm. The longest fruits were produced by SMV1×SMV6 (14.88 cm) and was statistically on par with SMV2×SMV6 (14.75 cm), whereas SMV1×SMV3 had the shortest fruits (10.61 cm). Fruit girth with higher expansion was noted in SMV8 (15.60cm) followed by SMV4×SMV7 (15.15 cm). SMV2×SMV6 registered the lowest fruit girth (10.32 cm). Calyx length ranged from 2.33 cm (SMV1×SMV3) to 2.95 cm (SMV1×SMV6).

Significant variations were noticed for yield plant^{-1}, yield plot^{-1} and plant height among the hybrids. SMV1×SMV2 was topmost with respect to yield plant^{-1} (2.85 kg) and yield plot^{-1} (53.02 kg) and was equivalent to SMV5×SMV6. Hybrid SMV3×SMV6 was the tallest among the hybrids (111.00 cm). SMV3×SMV4 performed poorly among the hybrids with respect to yield plant^{-1} (1.44 kg), yield plot^{-1} (22.98 kg) and plant height (82.30 cm).

4.2.2.3.2 Biochemical Characters:

Total phenols was noted high in SMV5×SMV6 (24.30 mg/100g) and low in SMV4×SMV6 (10.29 mg/100g). Total sugars varied from 1.66 g/100g

Table 26. Pest and disease scoring of brinjal hybrids at Sadanandapuram during summer season

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT	Grading
SMV1 × SMV2	22.50 (3)	28.33 (3)	25.00 (3)	25.28	9	T	27.75 (3)	32.16 (4)	33.75 (4)	31.22	11	S	15.00 (1)	R
SMV1 × SMV3	42.50 (5)	32.90 (4)	24.00 (3)	33.13	12	S	32.49 (4)	34.33 (4)	36.00 (4)	34.27	12	S	17.50 (1)	R
SMV1 × SMV5	35.00 (4)	28.32 (3)	25.50 (3)	29.61	10	T	30.08 (3)	29.16 (3)	28.66 (3)	29.30	9	T	12.50 (1)	R
SMV1 × SMV6	30.00 (3)	31.66 (4)	27.00 (3)	29.55	10	T	40.57 (5)	42.90 (5)	37.00 (4)	40.16	14	HS	7.50 (1)	R
SMV2 × SMV6	35.00 (4)	27.49 (3)	23.00 (3)	28.50	10	T	33.50 (4)	33.83 (4)	34.98 (4)	34.10	12	S	20.00 (1)	R
SMV3 × SMV4	42.50 (5)	36.74 (4)	30.00 (3)	36.41	12	S	42.48 (5)	42.17 (5)	45.81 (5)	43.49	15	HS	37.50 (2)	MR
SMV3 × SMV6	37.50 (4)	35.16 (4)	23.00 (3)	31.89	11	S	35.41 (4)	35.40 (4)	32.49 (4)	34.43	12	S	22.50 (2)	MR
SMV4 × SMV6	37.50 (4)	34.99 (4)	32.00 (4)	34.83	12	S	32.07 (4)	35.82 (4)	37.48 (4)	35.12	12	S	30.00 (2)	MR
SMV4× SMV7	37.50 (4)	37.48 (4)	25.00 (3)	33.33	11	S	49.57 (5)	44.83 (5)	39.15 (4)	44.52	14	HS	42.50 (3)	MS
SMV5× SMV6	17.50 (2)	19.75 (2)	20.00 (2)	19.08	6	MR	19.58 (2)	20.33 (2)	19.33 (2)	19.75	6	MR	10.00 (1)	R
SMV8	20.00 (2)	24.57 (3)	23.00 (3)	22.52	8	T	19.58 (2)	24.08 (3)	23.75 (3)	22.47	8	T	5.00 (1)	R
Grand Mean	32.50	30.67	25.23	29.47			33.01	34.09	33.49	33.53			20.00	
C.D.(5%)	8.74	5.40	4.80				4.01	3.52	4.12				10.59	

(SMV3×SMV4) to 4.32 g/100g (SMV1×SMV5). Vitamin C content was recorded highest in SMV2×SMV6 (16.88 mg/100g) which was on par with SMV3×SMV6 and SMV5×SMV6.

4.2.2.3.3 Pest and Disease incidence:

4.2.2.3.3.1 Shoot and Fruit Borer Infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings.

Shoot Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and is furnished in Table 26. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (17.50, 19.75, 20.00) followed by SMV8 (20.00, 24.57, 23.00) SMV1×SMV2 (22.50, 28.33, 25.00), SMV2×SMV6 (35.00, 27.49, 23.00), SMV1×SMV6 (30.00, 31.66, 27.00), and SMV1×SMV5 (35.00, 28.32, 25.50) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV3×SMV4 (42.50, 36.74, 30.00) followed by SMV4×SMV6 (37.50, 34.99, 32.00), SMV4×SMV7 (37.50, 37.48, 25.00), SMV1×SMV3 (42.50, 32.90, 24.00) and SMV3×SMV6 (37.50, 35.16, 23.00) at 60 DAT, 80 DAT and 100 DAT respectively.

Fruit Infestation Percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval. The details are furnished in the Table 26.

Plate 7. General view of experimental plot at Sadanandapuram during summer

Plate 8. General view of experimental plot at Kayamkulam during summer season

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (19.58, 20.33, 19.33) followed by SMV8 (19.58, 24.08, 23.75) and SMV1×SMV5 (30.08, 29.16, 28.66) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (49.57, 44.83, 39.15) followed by SMV3×SMV4 (42.48, 42.17, 45.81), SMV1×SMV6 (40.57, 42.90, 37.00), SMV4×SMV6 (32.07, 35.82, 37.48), SMV3×SMV6 (35.41, 35.40, 32.49), SMV1×SMV3 (32.49, 34.33, 36.00), SMV2×SMV6 (33.50, 33.83, 34.98) and SMV1×SMV2 (27.75, 32.16, 33.75) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation, the genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 26.

4.2.2.3.3.2 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from the field experiment and subjected to statistical analysis.

Among the hybrids, SMV8 (5.00) recorded with lowest percentage of plants wilted followed by SMV5×SMV6 (10.00). SMV4×SMV7 (42.50) recorded higher percentage of plants wilted followed by SMV3×SMV4 (37.50).

Based on percentage of wilted plants, the genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS) and the details are furnished in the Table 26.

4.2.2.4 Performance of brinjal hybrids at Farmer's field, Kayamkulam:

The performance of genotypes evaluated for various yield characters are presented in Table 27.

4.2.2.4.1 Morphological Characters:

Table 27. Mean performance of brinjal hybrids at Kayamkulam during summer season.

Genotype	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)	Total phenols (mg/100g)	Total sugars (g/100g)	Vitamin C (mg/100g)
SMV1 × SMV2	42.65	70.15	33.60	86.85	13.69	12.50	2.82	3.10	57.80	97.10	11.82	1.85	13.13
SMV1 × SMV3	41.00	67.15	23.20	73.30	10.21	14.45	3.02	1.75	31.96	89.05	10.59	3.33	10.00
SMV1 × SMV5	39.00	71.00	27.95	92.60	15.80	11.97	2.91	2.79	51.35	94.60	12.50	4.04	11.88
SMV1 × SMV6	45.75	69.45	25.15	97.95	14.65	13.67	3.27	2.69	48.31	99.85	16.62	2.95	13.75
SMV2 × SMV6	41.65	70.70	22.85	81.40	13.73	11.02	3.07	1.61	31.86	94.60	12.88	2.68	15.63
SMV3 × SMV4	43.80	70.20	21.50	80.75	10.89	14.30	3.01	1.74	27.42	90.05	21.19	2.02	10.63
SMV3 × SMV6	44.30	70.55	19.60	73.05	12.75	13.86	2.97	1.58	25.90	88.55	17.56	2.78	14.38
SMV4 × SMV6	47.15	73.95	24.45	86.50	14.45	13.18	3.08	2.39	38.74	99.50	9.91	2.60	10.00
SMV4× SMV7	43.85	74.95	21.10	99.30	13.33	16.12	2.92	1.97	31.09	97.75	14.04	4.04	10.63
SMV5× SMV6	43.10	71.35	29.10	104.05	14.11	13.46	3.10	3.02	56.03	97.40	24.74	2.94	16.88
SMV8	44.80	74.05	20.10	106.70	12.83	17.56	3.04	2.34	44.70	97.10	17.49	2.91	15.00
C.D.(5%)	1.18	1.44	0.80	2.84	0.63	0.81	0.10	0.08	2.53	2.58	1.03	0.21	3.21
SE(m)	0.41	0.50	0.28	0.98	0.22	0.28	0.04	0.03	0.87	0.89	0.36	0.07	1.11
C.V.	1.87	1.40	2.27	2.19	3.28	4.01	2.30	2.53	4.31	1.87	4.62	5.01	17.14

Days to first flowering was lowest in SMV1×SMV5 (39 days). It was highest in SMV4×SMV6 (47.15 days). SMV1×SMV3 took the minimum days to first harvest (67.15) and SMV4×SMV7 took the maximum days to first harvest (74.95).

Average number of fruits plant^{-1} was minimum in SMV3×SMV6 (19.60) which was on par with SMV8, SMV3×SMV4 and SMV4×SMV7. Maximum number of fruits plant^{-1} was noted in SMV1×SMV2 (33.60).

Average individual fruit weight was minimum in SMV3×SMV6 (73.05 g) and maximum in SMV8 (106.70 g) which was on par with SMV5×SMV6 (104.05 g).

For the traits fruit length and fruit girth, significant differences were observed among the hybrids. Longest fruits were produced by SMV1×SMV5 (15.80 cm) and shortest were produced by SMV1×SMV3 (10.21 cm). Fruit girth varied from 11.02 cm (SMV2×SMV6) to 17.56 cm (SMV8).

Calyx length ranged from 2.82 cm to 3.27 cm. SMV1×SMV6 recorded the longest calyx (3.27 cm).

Wide variation was observed for the traits yield plant^{-1}, yield plot^{-1} and plant height among the hybrids. SMV1×SMV2 was ultimate with respect to yield plant^{-1} (3.1 kg) and yield plot^{-1} (57.8 kg) and SMV1×SMV6 (99.85 cm) was the tallest among the hybrids. SMV3×SMV6 showed poor performance with respect to yield plant^{-1} (1.58 kg), yield plot^{-1} (25.90 kg) and plant height (88.55 cm).

4.2.2.4.2 Biochemical Characters:

SMV5×SMV6 recorded higher level of total phenols (24.74 mg/100g) and vitamin C (16.88 mg/100g). SMV4×SMV6 recorded lower level of total phenols (9.91 mg/100g) and vitamin C (10.00 mg/100g), while SMV1×SMV3 was equal to SMV4×SMV6 with respect to vitamin C content.

Table 28. Pest and disease scoring of brinjal hybrids at Kayamkulam during summer season

Geonotype	Shoot borer infestation (%)						Fruit borer infestation (%)						Wilt (%)	
	60 DAT (Rank)	80 DAT (Rank)	100 DAT (Rank)	Pooled mean	Total rank	Grading	80 DAT (Rank)	100 DAT (Rank)	120 DAT (Rank)	Pooled mean	Total rank	Grading	90 DAT (Rank)	Grading
SMV1 × SMV2	15.00 (2)	24.50 (3)	21.00 (3)	20.17	8	MR	22.83 (3)	24.49 (3)	26.00 (3)	24.44	9	T	10.00 (1)	R
SMV1 × SMV3	32.50 (4)	30.83 (3)	24.75 (3)	29.36	10	T	34.16 (4)	34.75 (4)	30.83 (3)	33.24	11	S	20.00 (1)	R
SMV1 × SMV5	32.50 (4)	28.75 (3)	25.00 (3)	28.75	10	T	30.33 (3)	27.66 (3)	30.24 (3)	29.41	9	T	15.00 (1)	R
SMV1 × SMV6	37.50 (4)	27.91 (3)	22.00 (3)	29.14	10	T	37.07 (4)	34.99 (4)	30.75 (3)	34.27	11	S	7.50 (1)	R
SMV2 × SMV6	35.00 (4)	28.42 (3)	24.00 (3)	29.14	10	T	31.00 (4)	30.33 (3)	30.41 (3)	30.58	10	T	17.50 (1)	R
SMV3 × SMV4	42.50 (5)	33.74 (4)	33.00 (4)	36.41	13	S	37.06 (4)	34.16 (4)	46.23 (5)	39.15	13	S	40.00 (2)	MR
SMV3 × SMV6	27.50 (3)	34.32 (4)	25.00 (3)	28.94	10	T	36.66 (4)	35.40 (4)	42.41 (5)	38.15	13	S	15.00 (1)	R
SMV4 × SMV6	40.00 (4)	34.99 (4)	28.00 (3)	34.33	11	S	38.73 (4)	35.32 (4)	37.48 (4)	37.18	12	S	37.50 (2)	MR
SMV4× SMV7	42.50 (5)	38.07 (4)	31.00 (4)	37.19	13	S	51.66 (5)	40.25 (5)	41.74 (5)	44.55	15	HS	40.00 (2)	MR
SMV5× SMV6	12.50 (2)	19.16 (2)	18.00 (2)	16.55	6	MR	16.66 (2)	17.92 (2)	22.67 (3)	19.08	7	MR	7.50 (1)	R
SMV8	20.00 (2)	18.50 (2)	19.00 (2)	19.17	6	MR	18.66 (2)	20.92 (2)	21.17 (3)	20.25	7	MR	7.50 (1)	R
Grand Mean	30.68	29.02	24.61	28.10			32.26	30.56	32.72	31.84			19.77	
C.D.(5%)	8.74	3.86	4.53				3.60	2.92	3.87				12.12	

Total sugars ranged from 1.85 g/100g to 4.04 g/100g. SMV1×SMV5 registered higher content of total sugars (4.04 g/100g) and was on par with SMV4×SMV7 and SMV1×SMV2 recorded the lowest value for total sugars.

4.2.2.4.3 Pest and Disease incidence:

4.2.2.4.3.1 Shoot and Fruit Borer Infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The data on damage parameters collected from field experiment were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings:

Shoot infestation percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and is furnished in Table 28. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids.

The minimum percentage of shoot infestation was recorded in the hybrids SMV5×SMV6 (12.50, 19.16, 18.00) followed by SMV8 (20.00, 18.50, 19.00) SMV1×SMV2 (15.00, 24.50, 21.00), SMV1×SMV5 (32.50, 28.75, 25.00), SMV3×SMV6 (42.50, 33.74, 33.00), SMV2×SMV6 (35.00, 28.42, 24.00), SMV1×SMV6 (37.50, 27.91, 22.00) and SMV1×SMV3 (32.50, 30.83, 24.75) at 60 DAT, 80 DAT and 100 DAT respectively. The maximum percentage of shoot infestation was recorded in the hybrids SMV4×SMV7 (42.50, 38.07, 31.00) followed by SMV3×SMV4 (42.50, 33.74, 33.00) and SMV4×SM6 (40.00, 34.99, 28.00) at 60 DAT, 80 DAT and 100 DAT respectively.

Fruit Infestation Percentage:

Shoot and fruit borer was screened for all 11 F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and is furnished in Table 28.

The minimum percentage of fruit infestation was recorded in the hybrids SMV5×SMV6 (16.66, 17.92, 22.67) followed by SMV8 (18.66, 20.92, 21.17), SMV1×SMV2 (22.83, 24.49, 26.00), SMV1×SMV5 (30.33, 27.66, 30.24) and SMV2×SMV6 (31.00, 30.33, 30.41) at 80 DAT, 100 DAT and 120 DAT respectively. The maximum percentage of fruit infestation was recorded in the hybrids SMV4×SMV7 (51.66, 40.25, 41.74) followed by SMV3×SMV4 (37.06, 34.16, 46.23), SMV3×SMV6 (36.66, 35.40, 42.41), SMV4×SMV6 (38.73, 35.32, 37.48), SMV1×SMV6 (37.07, 34.99, 30.75) and SMV1×SMV3 (34.16, 34.75, 30.83) at 80 DAT, 100 DAT and 120 DAT respectively.

Based on percentage of shoot and fruit infestation, the genotypes were classified as Immune (I), Highly resistant (HR), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 28.

4.2.2.4.3.2 Bacterial Wilt Incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiment and subjected to statistical analysis.

Among the hybrids, SMV5×SMV6 (7.50) recorded the lowest percentage of plants wilted which was similar to SMV8. SMV4×SMV7 (40.00) and SMV3×SMV4 (40.00) recorded higher percentage of plants wilted followed by SMV4×SMV6 (37.50).

Based on percentage of wilted plants, the genotypes were classified as resistant (R), Moderately Resistant (MR), Tolerant (T), Susceptible (S), and Highly Susceptible (HS). The details are furnished in the Table 28.

4.2.3. STABILITY ANALYSIS

The stability analysis analysis (Eberhart and Russell's, 1966) was carried out by using the phenotypic mean values of eleven F_1 hybrids across the four environments for all the ten characters. Character wise results for mean

Table 29. Pooled Analysis of Variance (mean square) for different quantitative traits over four locations during summer season.

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
Genotypes	10	35.25**	43.92**	408.17**	2239.91**	31.30**	55.37**	0.17**	4.48**	2054.36**	293.60**
Environments	3	153.18**	162.87**	38.43**	1972.72**	9.64**	33.37**	0.93**	1.71**	660.70**	784.20**
Gen. × Env. Interaction	30	12.44**	8.84**	10.73**	178.20**	1.73**	1.89**	0.060**	0.11**	50.98**	104.96**
Error	132	0.62	0.62	0.28	7.80	0.22	0.23	0.007	0.005	3.92	8.29

Table 30. Analysis of variance (mean square) for mean data of different quantitative traits over four locations during summer season.

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
Genotypes	10	8.81**	10.98**	102.04**	559.98**	7.83**	13.84**	0.04**	1.12**	513.59**	73.40**
Environments	3	38.30**	40.72**	9.61**	493.18**	2.41**	8.34**	0.23**	0.43**	165.18**	196.05**
Gen. × Env.	30	3.11**	2.21**	2.68**	44.55**	0.43**	0.47**	0.01**	0.03**	12.75**	26.24**
Env. + (Gen. × Env.)	33	6.31**	5.71**	3.31	85.33	0.61	1.19**	0.03**	0.06**	26.60	41.68
Environment (Linear)	1	114.89**	122.15**	28.82**	1479.54**	7.23**	25.03**	0.70**	1.28**	495.53**	588.15**
Gen. × Env. (Linear)	10	4.02	4.00**	1.43	17.44	0.23	0.23	0.02	0.03	15.24	21.49
Pooled Deviation	22	2.41**	1.20**	3.01**	52.82**	0.49**	0.54**	0.01**	0.03**	10.45**	26.01**
Pooled Error	132	0.16	0.15	0.07	1.95	0.06	0.06	0.002	0.001	0.98	2.07
Total	43	6.89	6.94	26.27	195.72	2.29	4.13	0.04	0.31	139.86	49.06

**Significant at 1 % level

performance and stability parameters have been presented in are described as follows:

4.2.3.1 Pooled analysis of variance

Eleven hybrids were subjected to pooled analysis of variance for ten characters *viz*., days to first flowering, days to first harvest, number of fruits plant^{-1}, fruit weight, fruit length, fruit girth, calyx length, yield plant^{-1}, yield plot^{-1} and plant height over four locations. The pooled analysis of variance revealed that highly significant differences existed among the genotypes (G) for all traits. Highly significant differences were observed for environments for all the traits indicated the divergence among growing environments. The high significant effect of genotype x environment for all the characters indicated differential response of genotype to various environments (Table 29). Therefore, further analysis of stability was carried out for these characters.

The mean squares due to Environments + (Genotype x Environment) were significant for the characters *viz*., days to first flowering, days to first harvest, fruit girth, calyx length and yield plant^{-1} reemphasizing the existence of G×E interactions. Sum of squares due to E + (G x E) was further partitioned into that of Environment (linear), Genotype x Environment (linear) and pooled deviation. The linear contribution of the environmental effects on the performance of genotype were reflected by highly significant mean square due to environment for all the traits. The mean square due to G x E interaction (linear) was also significant for days to first harvest indicated that a considerable proportion of genotypes x environment interaction were contributed by the linear component (Table 30). Pooled deviation (non-linear component) variances were significant for all characters suggesting importance of both linear and non-linear components.

4.2.3.2 Environmental indices

Environmental indices of ten characters were presented in the Table 31. It was observed that Sadanandapuram location was found most favourable for most

Table 31. Estimates of environmental indices (I_j) for each character under different locations during summer season

Sl.No.	Characters	Vellayani	Thiruvalla	Sadanandapuram	Kayamkulam
1	Days to first flowering	0.84	-0.80	-2.15	2.11
2	Days to first harvest	0.57	2.13	-2.49	-0.21
3	Number of fruits per plant	0.17	-1.31	0.90	0.24
4	Fruit weight (g)	-1.70	1.63	8.07	-7.99
5	Fruit length (cm)	-0.36	-0.24	0.68	-0.08
6	Fruit girth (cm)	0.83	0.05	0.34	-1.21
7	Calyx length (cm)	-0.02	0.15	0.05	-0.19
8	Yield per plant (kg)	0.01	-0.03	0.25	-0.23
9	Yield per plot (kg)	-2.44	-0.65	5.66	-2.58
10	Plant height (cm)	4.73	-3.19	2.38	-3.91

of the characters except days to first flowering and days to first harvest, while Kayamkulam location was poor for all the characters except days to first flowering and number of fruits $plant^{-1}$.

4.2.3.3 Stability parameters:

The estimation of stability parameters i.e., mean (μ), regression coefficient (b_i) and deviation from regression (S^2_{di}) for ten characters are furnished below.

4.2.3.3.1 Days to First Flowering:

The mean values for days to first flowering varied from 41.73 (SMV1×SMV5) to 46.38 (SMV4×SMV7) days. The stability parameters bi=1, S^2_{di}= 0 and high mean or around overall mean in respect of this trait indicated two hybrids SMV1×SMV2 (μ=43.40, b_i=0.83, S^2_{di}=-0.150) and SMV1×SMV3 (μ=42.93, b_i=2.03, S^2_{di}=0.057) were stable with regression approximate or more than unity and minimum deviation from regression (Table 32).

4.2.3.3.2 Days to First Harvest:

Among the eleven genotypes, seven hybrids expressed non-significant deviation for this trait. The hybrids SMV1×SMV2 (μ=68.34, b_i=1, S^2_{di}=0.256), SMV1×SMV5 (μ=68.89, b_i=0.93, S^2_{di}=-0.126) and SMV1×SMV6 (μ=67.59, b_i=0.91, S^2_{di}=0.523) recorded regression coefficient around unity and non-significant deviation from linearity hence, they are stable.

While, SMV3×SMV6 (μ=68.36, b_i=1.26, S^2_{di}=0.185), SMV4×SMV6 (μ=69.86, b_i=1.80, S^2_{di}=0.208) and SMV5×SMV6 (μ=67.99, b_i=1.46, S^2_{di}=0.211) recorded regression coefficient greater than unity and non-significant deviations from regression. But hybrid SMV3×SMV4 (μ=71.73, b_i=-0.40, S^2_{di}=0.506) response was negative for regression coefficient and non-significant deviation from linearity (Table 32).

4.2.3.3.3 Number of Fruits $Plant^{-1}$:

Table 32. Mean performance and stability parameters for yield and its component traits in brinjal during summer season.

Genotype	Days to first flowering			Days to first harvest			Number of fruits per plant		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	43.40	0.83	-0.150	68.34	1.00	0.256	35.04	1.18	0.002
SMV1 × SMV3	42.93	2.03	0.057	67.58	0.45	4.961**	24.61	1.16	6.596**
SMV1 × SMV5	41.73	0.98	3.170**	68.89	0.93	-0.126	31.38	2.01	3.336**
SMV1 × SMV6	46.06	0.35	2.313**	67.59	0.91	0.523	28.79	2.04	5.075**
SMV2 × SMV6	44.19	2.23	1.140**	67.36	1.62	0.686**	23.18	0.71	2.933**
SMV3 × SMV4	45.36	0.14	2.038**	71.73	-0.40	0.506	20.50	0.00	5.433**
SMV3 × SMV6	43.33	0.97	3.094**	68.36	1.26	0.185	21.29	1.06	1.394**
SMV4 × SMV6	45.31	0.88	5.488**	69.86	1.80	0.208	23.89	-0.31	1.701**
SMV4× SMV7	46.38	0.86	2.719**	71.91	0.89	1.888**	21.41	0.48	2.630**
SMV5× SMV6	42.78	0.93	4.107**	67.99	1.46	0.211	31.44	1.41	2.995**
SMV8	44.45	0.78	0.831**	70.53	1.08	2.182**	21.51	1.25	0.243
Grand Mean	44.17			69.10			25.73		

**Significant at 1 % level

Number of fruits plant^{-1} ranged from 35.04 (SMV1×SMV2) to 20.50 (SMV3×SMV4) in the present study across four locations. Hybrid SMV1×SMV2 (μ=35.04, b_i=1.18, S^2_{di}=0.002) is considered as stable genotype because it recorded high mean, regression coefficient around unity and non-significant deviation from regression and SMV8 expressed lower mean (21.51), regression coefficient more than one (1.25) and non-significant deviation from linearity (0.243) suitable for good environment (Table 32.). The other nine genotypes were found to be significant deviations from regression exhibited unpredictable performance.

4.2.3.3.4 Fruit Weight:

The mean character for this trait varied from 65.81 g (SMV1×SMV3) to 104.39 g (SMV8). Hybrid SMV5×SMV6 (μ=99.91, b_i=1.01, S^2_{di}=6.744) is considered as stable genotype because it recorded high mean, regression coefficient around unity and non-significant deviation from regression. SMV1×SMV2 recorded regression coefficient near to one (0.88) and non-significant deviation from regression (2.067) (Table 32).

4.2.3.3.5 Fruit Length:

The mean value for this trait ranged from 10.50 cm to 15.36 cm. Among the eleven genotypes, three hybrids recorded non-significant deviation from regression (S^2_{di}) values *i.e.* their performance could be predicted. Table 32 depicted that the hybrids SMV1×SMV2 (μ=13.51, b_i=0.95, S^2_{di}=0.134) and SMV5×SMV6 (μ=14.17, b_i=1.03, S^2_{di}=-0.028) recorded regression coefficient values of unity and non-significant deviation from regression. The hybrid SMV1×SMV3 exhibited more than unit value of regression (1.30) and non-significant deviation from regression (-0.016), while other genotypes gave unpredictable performance with significant deviations from regression.

4.2.3.3.6 Fruit Girth:

The mean values for this trait ranged from 11.22 cm (SMV2×SMV6) to 17.06 cm (SMV8). Most of the hybrids exhibited significant S^2_{di} values for this trait. Among the hybrids, SMV1×SMV6 (μ=13.60, b_i=0.87, S^2_{di}=0.166) was

Table 32. (Continued…)

Genotype	Fruit weight (g)			Fruit length (cm)			Fruit girth (cm)		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	83.15	0.88	2.067	13.51	0.95	0.134	11.85	0.75	0.213
SMV1 × SMV3	65.81	1.45	28.777**	10.50	1.30	-0.016	13.18	1.49	0.901**
SMV1 × SMV5	87.99	0.31	9.638**	15.17	0.89	0.760**	11.82	0.50	-0.039
SMV1 × SMV6	97.96	1.26	33.957**	15.36	0.69	0.516**	13.60	0.87	0.166
SMV2 × SMV6	71.65	0.75	142.456**	14.80	0.31	0.863**	11.22	0.85	0.026
SMV3 × SMV4	86.01	1.36	37.522**	12.52	1.80	1.078**	15.74	1.41	1.557**
SMV3 × SMV6	81.30	0.96	108.518**	12.84	1.88	0.562**	13.30	1.46	0.103
SMV4 × SMV6	94.85	1.41	75.752**	13.98	0.92	0.306**	13.46	0.80	0.027
SMV4× SMV7	91.53	0.58	102.558**	13.48	-0.12	0.219**	16.00	0.92	1.054**
SMV5× SMV6	99.91	1.01	6.744	14.17	1.03	-0.028	14.26	0.95	1.018**
SMV8	104.39	1.04	11.577**	12.73	1.36	0.330**	17.06	1.01	0.244**
Grand Mean	87.69			13.55			13.77		

**Significant at 1 % level

considered stable because of desirable mean, regression coefficient around 'unity' and non–significant deviation from regression (Table 32.). Further, the hybrids SMV1×SMV2, SMV1×SMV5, SMV2×SMV6 and SMV4×SMV6 were observed with less than 'unity' regression (0.75, 0.50, 0.85 and 0.80) and non–significant deviation from linearity. SMV3×SMV6 was the only hybrid which expressed regression coefficient greater than one (1.46) and non-significant deviation from linearity (0.103) suitable for favourable environment.

4.2.3.3.7 Calyx Length:

Five hybrids *viz.*, SMV1×SMV2, SMV1×SMV3, SMV4×SMV6, SMV5×SMV6 and SMV8 recorded non-significant deviation from regression (S^2_{di}) values *i.e.* their performance could be predicted. SMV5×SMV6 and SMV8 were stable genotypes with regression coefficient around unity (0.83, 0.97) and non-significant deviations from linearity (0.0036, 0.0007). SMV1×SMV3 is suitable for rich environment as its regression coefficient is more than one (2.02) while SMV1×SMV2 and SMV4×SMV6 is suitable for poor environment as its regression coefficient is less than unity (0.75, 0.50) (Table 32.).

4.2.3.3.8 Yield Plant^{-1}:

High fruit yield is the ultimate objective for any breeder. Among the hybrids studied, four genotypes revealed non-significant deviations from the regression (S^2_{di}) values, which implies that the hybrids were within the range of minimum deviation from regression, their performance could be predicted. The hybrids *viz.*, SMV1×SMV2 (μ=3.06, b_i=0.84, S^2_{di}=0.002), SMV5×SMV6 (μ=2.96, b_i=0.88, S^2_{di}=0.003) and SMV8 (μ=2.33, b_i=0.90, S^2_{di}=0.0001) were considered stable as they recorded high mean with regression coefficient near 'unity' and non–significant deviation from regression (Table 32.). The hybrid SMV3×SMV4 (μ=1.81, b_i=1.67, S^2_{di}=-0.001) exhibited lower mean with regression coefficient more than 'unity' and non–significant deviation from regression were found suitable for rich environment (Table 32.). The hybrids showing unpredictable performance with highly significant deviation from regression were unstable.

Table 32. (Continued…)

Genotype	Calyx length (cm)			Yield per plant (kg)			Yield per plot (kg)			Plant height (cm)		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
SMV1 × SMV2	2.75	0.72	0.0056	3.06	0.84	0.002	55.76	0.65	3.150	105.85	1.10	32.299**
SMV1 × SMV3	2.75	2.02	0.0021	1.77	0.15	0.054**	31.56	0.71	47.940**	90.70	1.20	8.319**
SMV1 × SMV5	2.82	0.23	0.0351**	2.78	0.29	0.006**	51.35	0.07	-0.674	97.11	1.05	-1.057
SMV1 × SMV6	3.04	0.86	0.0153**	2.81	1.26	0.036**	52.24	0.47	9.962**	95.28	0.47	32.930**
SMV2 × SMV6	2.87	0.64	0.0112**	1.64	1.13	0.097**	29.35	1.88	14.948**	95.35	0.57	8.242**
SMV3 × SMV4	2.91	1.28	0.0196**	1.81	1.67	-0.001	28.77	1.75	0.974	95.34	2.61	6.539
SMV3 × SMV6	2.83	1.47	0.0144**	1.80	0.91	0.063**	31.38	0.69	18.205**	100.95	0.37	145.412**
SMV4 × SMV6	2.98	0.50	0.0033	2.33	1.56	0.009**	39.50	1.75	2.913	101.16	1.18	1.873
SMV4× SMV7	2.70	1.49	0.0089**	2.00	1.40	0.006**	31.48	1.03	3.729**	96.10	0.34	5.752
SMV5× SMV6	2.92	0.83	0.0036	2.96	0.88	0.003	57.33	0.96	1.147	100.49	1.14	1.546
SMV8	2.92	0.97	0.0007	2.33	0.90	0.000	43.58	1.05	1.924	102.29	0.98	21.498**
Grand Mean	2.86			2.30			41.12			98.24		

**Significant at 1 % level

Plate 12. Variability in brinjal hybrids

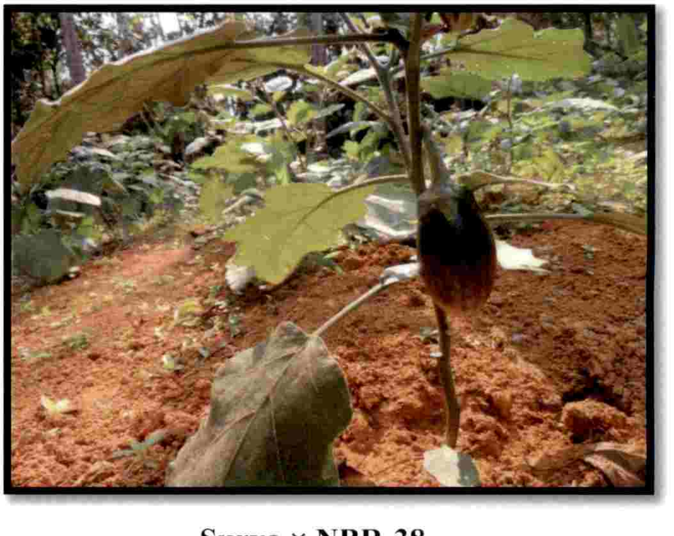
Wardha local × Palakurthi local

Wardha local × Vellayani local

Wardha local × Surya

Wardha local × Swetha

Palakurthi local × Vellayani local



Surya × NBR-38

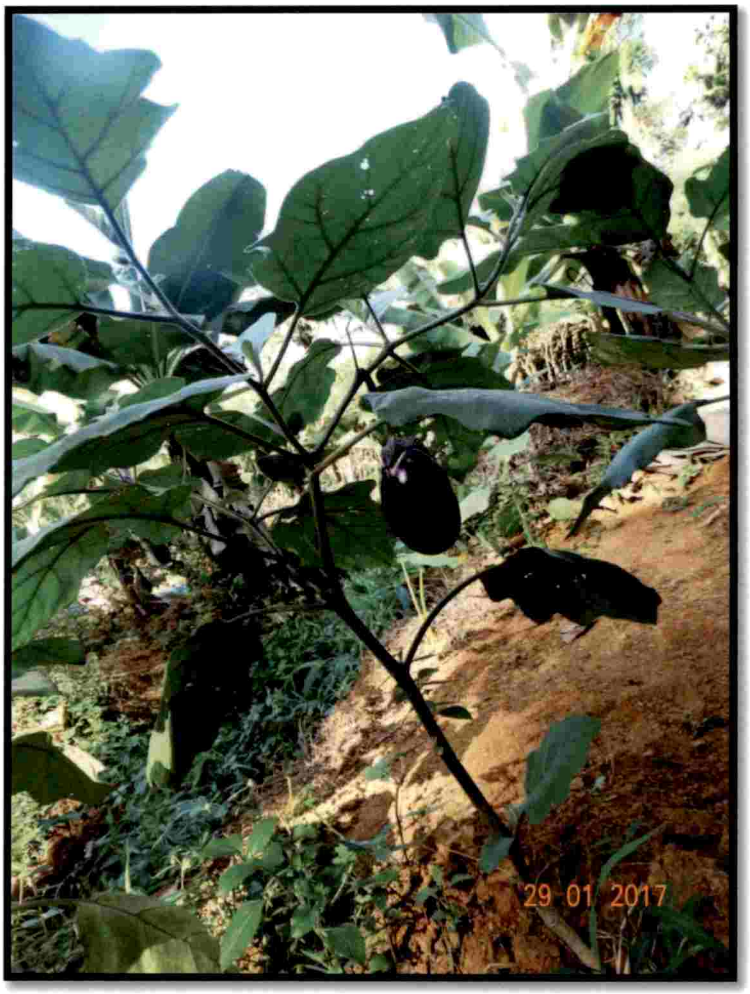
Surya × Vellayani local

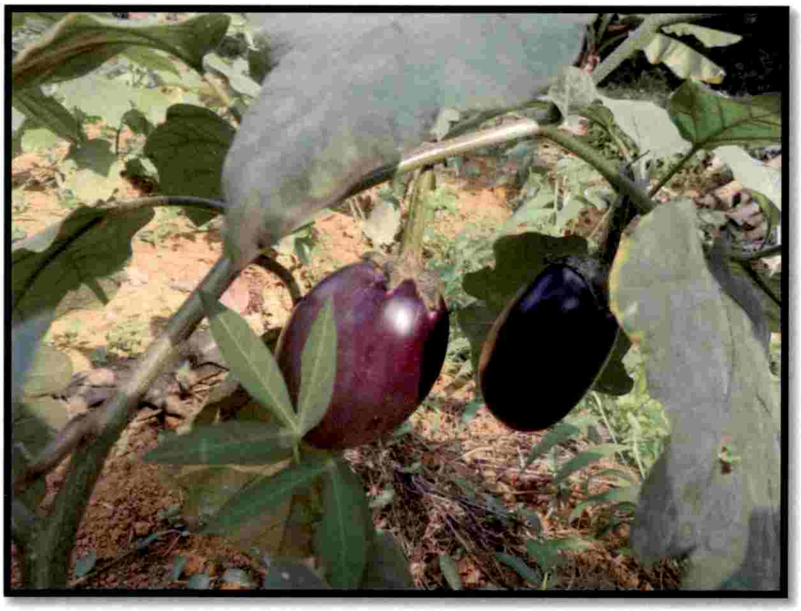
NBR-38 × Vellayani local

NBR-38 × Selection Pooja

Swetha × Vellayani local

Neelima





4.2.3.3.9 Yield Plot^{-1}:

The yield plot^{-1} ranged from 28.77 kg (SMV3×SMV4) to 57.33 kg (SMV5×SMV6) across the four environments. The hybrids with high mean, regression coefficient near 'unity' and non-significant deviation from regression *viz.,* SMV5×SMV6 (μ=57.33, b_i=0.96, S^2_{di}=1.147) and SMV8 (μ=43.58, b_i=1.05, S^2_{di}=1.924) were finally considered as stable ones for this trait. The hybrid SMV3×SMV4 with regression coefficient (1.75) higher than 'unity' and non–significant (0.974) deviation from regression were suitable for favourable environment (Table 32). With respect to poor environment, the hybrid SMV1×SMV2 (μ=55.76, b_i=0.65, S^2_{di}=3.150) and SMV1×SMV5 (μ=51.35, b_i=0.07, S^2_{di}=-0.674) which recorded high mean with less than 'unity' regression coefficient and non–significant deviation from linearity were suitable.

4.2.3.3.10 Plant Height:

The mean values for plant height ranged from 90.70 cm (SMV1×SMV3) to 105.85 cm (SMV1×SMV2). Hybrid SMV1×SMV5 (μ=97.11, b_i =1.05, S^2_{di}=-1.057), with regression coefficient near to 'unity' and non–significant deviation from regression was stable genotype (Table). For better environment, the variety, SMV5×SMV6 (μ=100.49, b_i =1.14, S^2_{di}=1.546) and SMV4×SMV6 (μ=101.16, b_i =1.18, S^2_{di}=1.873) with regression coefficient greater than 'unity' was suitable and for poor environment, only one hybrid *viz.,* SMV4×SMV7 (μ=96.10, b_i=0.34, S^2_{di}=5.752) was better, as it recorded regression coefficient less than 'unity'. In case of other hybrids the performance has been found to be highly unpredictable because of their significant deviation from regression values (Table 32).

4.3 EVALUATION OF SEGREGATING GENERATION (F_2)

4.3.1 Analysis of Variance:

Analysis of variance showed significant differences among the segregating population for all the characters studied at COA, Vellayani indicating presence of sufficient amount of genetic variability in all the characters. (Table 33).

Table 33. Analysis of variance (mean square) of F_2 populations (segregants) at Vellayani.

Source of Variation	df	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
Replication	2	0.02	0.18	0.10	3.16	0.01	0.35	0.003	0.004	3.62	1.04
Treatment	3	9.45**	25.48**	70.46**	224.91**	6.01**	7.72**	0.09**	0.01**	23.93**	243.49**
Error	6	0.15	0.21	0.24	6.32	0.12	0.12	0.01	0.002	3.77	2.06

Table 34. Mean performance of F_2 populations (segregants) at Vellayani.

F_2 genotypes	Days to first flowering	Days to first harvest	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Calyx length (cm)	Yield per plant (kg)	Yield per plot (kg)	Plant height (cm)
SMV1 × SMV2	38.20	65.27	28.00	67.00	12.06	9.36	3.02	1.83	29.23	106.80
SMV1 × SMV5	40.53	62.13	18.60	60.20	14.67	11.73	2.84	1.73	24.63	98.07
SMV1 × SMV6	40.67	67.80	20.13	66.87	12.98	12.81	3.22	1.86	22.47	94.00
SMV5 × SMV6	37.07	61.53	17.13	80.80	15.06	12.71	3.19	1.80	25.20	114.13
Mean	39.12	64.18	20.97	68.72	13.69	11.65	3.07	1.81	25.38	103.25
C.D.(5%)	0.80	0.93	1.00	5.12	0.70	0.69	0.21	0.09	3.96	2.92
SE(m)	0.23	0.26	0.28	1.45	0.20	0.20	0.06	0.03	1.12	0.83
C.V.	1.00	0.71	2.34	3.66	2.51	2.91	3.29	2.39	7.65	1.39

**Significant at 1 % level

Plate 9. Evaluation of Segregating generations (F_2 population) at Vellayani

Wardha local × Palakurthi local

Wardha local × Swetha

Wardha local × Vellayani local

Swetha × Vellayani local

Plate 11. Variability of brinjal fruits in F_2 populations

4.3.2 Mean performance:

4.3.2.1 Performance of segregating population (F_2) at COA, Vellayani:

The mean performance of four selected F_2 populations have been evaluated for different characters, the details being given in Table 34.

4.3.2.1.1 Days to First Flowering:

SMV5×SMV6 (F_2) was the earliest flowering type taking 37.07 days to flower. SMV1×SMV6 (F_2) took maximum days to flower being 40.67 days.

4.3.2.1.2 Days to First Harvest:

SMV5×SMV6 (F_2) took the minimum number of days (61.53) to first harvest and SMV1×SMV6 (F_2) took maximum number of days (67.80) to first harvest.

4.3.2.1.3 Number of Fruits Plant^{-1}:

Number of fruits plant^{-1} varied from a minimum of 17.13 (SMV5×SMV6) to a maximum of 28.00 (SMV1×SMV2) and the difference was significant in F_2 population.

4.3.2.1.4 Fruit Weight:

Maximum individual fruit weight within F_2 population was recorded in SMV5×SMV6 (80.80 g) and minimum in SMV1×SMV5 (60.20 g).

4.3.2.1.5 Fruit Length:

The F_2 populations differed significantly with respect to fruit length which ranged from (12.06 cm) SMV1×SMV2 to (15.06 cm) SMV5×SMV6.

4.3.2.1.6 Fruit Girth:

Girth of fruit ranged from 9.36 cm (SMV1×SMV2) to 12.81 cm (SMV1×SMV6) in F_2 population. SMV5×SMV6 (F_2) was on par with the highest value.

Table 35. Quality and quantity of genomic DNA

Sl.No	Plant	A260	A280	O.D. Ratio (A260:A280)	Quantity of DNA (ng/µl)
1	Wardha local	0.012	0.006	2.00	600
2	Palakurthi local	0.009	0.005	1.80	450
3	Surya	0.018	0.010	1.80	900
4	NBR-38	0.030	0.014	2.14	1500
5	Swetha	0.012	0.007	1.71	600
6	Selection Pooja	0.019	0.011	1.73	950
7	Vellayani local	0.029	0.012	2.42	1450
8	Wardha local × Palakurthi local	0.069	0.033	2.09	3450
9	Wardha local × Surya	0.008	0.004	2.00	400
10	Wardha local × Swetha	0.012	0.007	1.71	600
11	Wardha local × Vellayani local	0.013	0.006	2.17	650
12	Palakurthi local × Vellayani local	0.030	0.014	2.14	1500
13	Surya × NBR-38	0.033	0.016	2.06	1650
14	Surya × Vellayani local	0.019	0.009	2.11	950
15	NBR-38 × Vellayani local	0.029	0.012	2.42	1450
16	NBR-38 × Selection Pooja	0.007	0.004	1.75	350
17	Swetha × Vellayani local	0.038	0.020	1.90	1900

4.3.2.1.7 Calyx Length:

Calyx length varied from SMV1×SMV5 (2.84 cm) to SMV5×SMV6 (3.22 cm) in segregating generation (F_2).

4.3.2.1.8 Yield Plant^{-1}:

The minimum yield plant^{-1} was recorded in SMV1×SMV5 (1.73 kg) while maximum yield plant^{-1} was attained by SMV1×SMV6 (1.86 kg) followed by SMV1×SMV2 (1.83 kg) among segregating individuals.

4.3.2.1.9 Yield Plot^{-1}:

Yield plot^{-1} recorded significant difference among the four F_2 families. The yield plot^{-1} ranged from 22.47 kg (SMV1×SMV6) to 29.23 kg (SMV1×SMV2).

4.3.2.1.10 Plant Height:

SMV5×SMV6 was the tallest (114.13 cm) segregant among the F_2 families and SMV1×SMV6 (94.00 cm) was the shortest in plant height.

4.4 MOLECULAR CHARACTERIZATION OF HYBRIDS AND THEIR PARENTS

4.4.1 Quality and quantity of genomic DNA

The genomic DNA isolated from parents and hybrids yielded good quality DNA. All the samples showed O.D ratio of A260 and A280 ranging from 1.71 to 2.42 (Table 35). The electrophoresis of genomic DNA on 2 % agarose gel showed a single band without any smear indicating good quality un sheared DNA

4.4.2 Amplification of genomic DNA of hybrids and their parents with SSR primers

Genomic DNA isolated from parents and hybrids were amplified using four SSR primers. Three markers (*viz.* emb01M15, eme08D09 and CSM31) were found to be polymorphic in nature among the parental lines of respective hybrids (SMV3×SMV4 SMV3×SMV6, SMV4×SMV7, SMV5×SMV6, SMV1×SMV5,

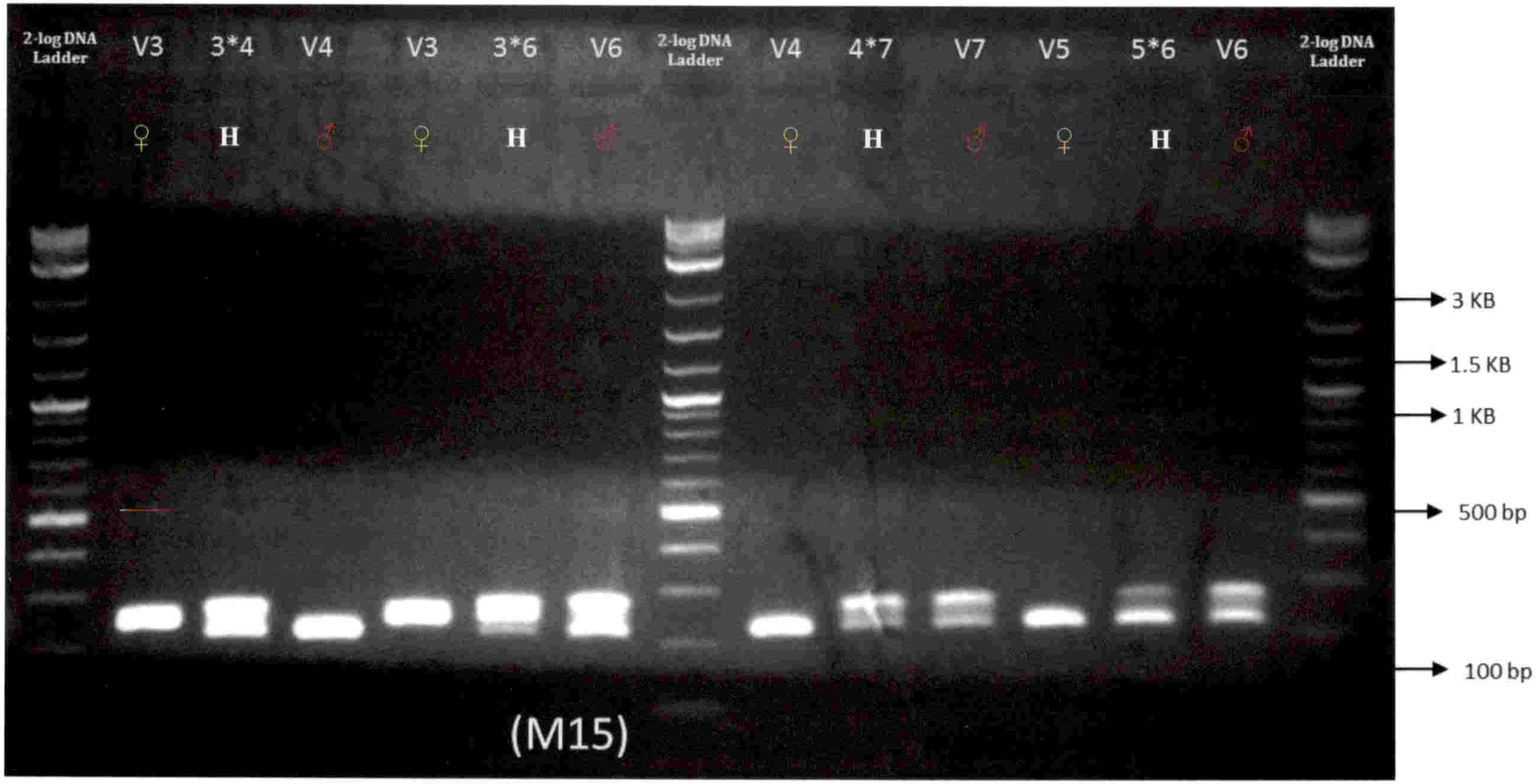


Plate 13. Simple sequence repeat (SSR) profiles of four brinjal hybrids (F_1) and respective parental lines (♀ and ♂) obtained from marker emb01M15.

V3= Surya
V5= Swetha
V7= Selection Pooja
V4= NB4-38
V6= Vellayani local
♀= Female
♂= Male
H= Hybrid
3*4= Surya × NBR-38
3*6= Surya × Vellayani local
4*7= NBR-38 × Selection Pooja
5*6= Swetha × Vellayani local

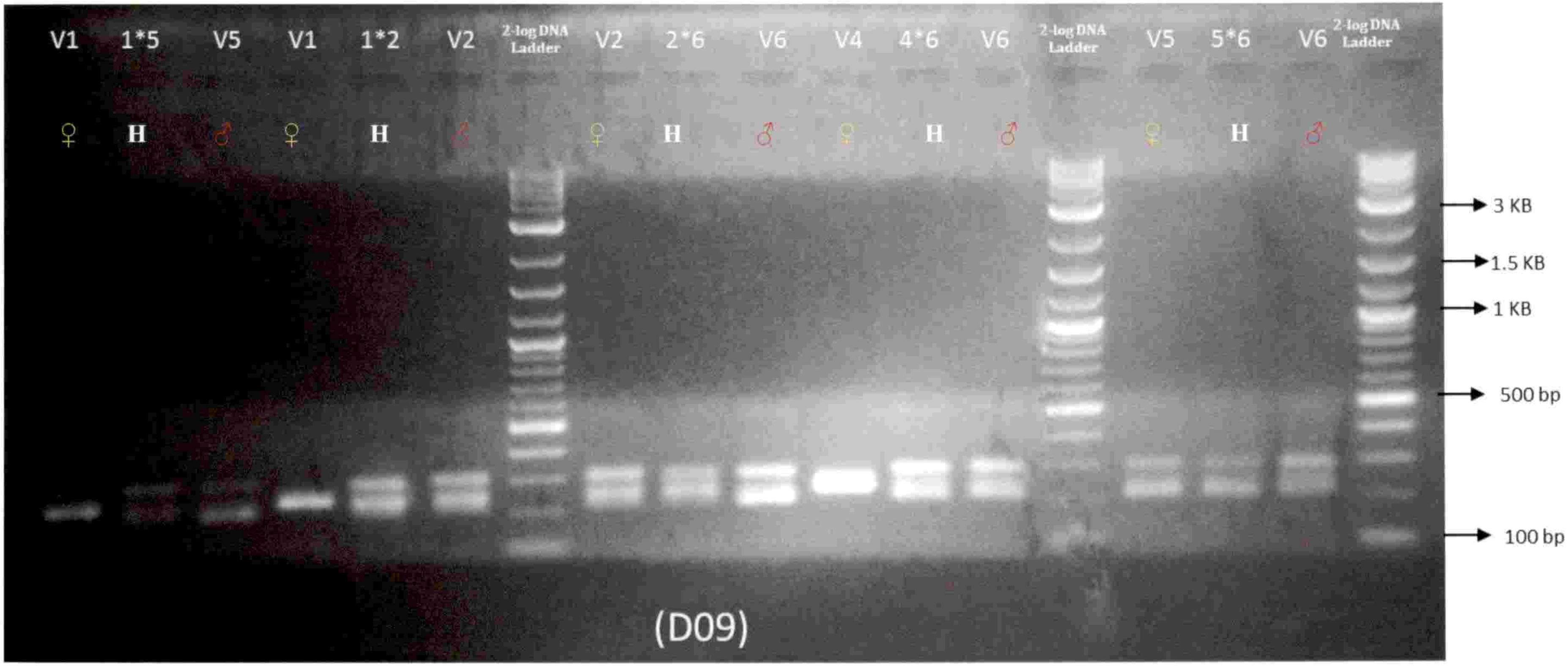


Plate 14. Simple sequence repeat (SSR) profiles of five brinjal hybrids (F_1) and respective parental lines (♀ and ♂) obtained from marker eme08D09.

V1= Wardha local	V2= Palakurthi local	♂= Male	1*2= Wardha local × Palakurthi local
V4= NB4-38	V5= Swetha	H= Hybrid	2*6= Palakurthi local × Vellayani local
V6= Vellayani local	♀= Female	1*5= Wardha local × Swetha	5*6= Swetha × Vellayani local

SMV1×SMV2, SMV2×SMV6 and SMV4×SMV6) and the marker emd05F05 was monomorphic.

The PCR profile of hybrids *viz.* SMV3×SMV4 SMV3×SMV6, SMV4×SMV7, SMV5×SMV6, SMV1×SMV5, SMV1×SMV2, SMV2×SMV6 and SMV4×SMV6 and their parental lines were analysed using three (emb01M15, eme08D09 and CSM31)SSR primers.

The primer emb01M15 amplified two alleles in the range of 260 to 230 bp among four hybrids (SMV3×SMV4 SMV3×SMV6, SMV4×SMV7 and SMV5×SMV6,). The hybrid SMV3×SMV4 resulted in heterozygous profile with two amplicons ranging from 260 to 230 bp where the female parent SMV3 amplified at 260 bp and male parent SMV4 amplified at 230 bp. Hybrid SMV3×SMV6 shared bands from both the parents where the female parent SMV3 produced one amplicon at 260 bp and male parent SMV6 produced two amplicons at 260 and 230 bp. The hybrids SMV4×SMV7 and SMV5×SMV6 resulted in heterozygous profile with two amplicons ranging from 260 to 230 bp where the female parent produced one band at 230 bp and male parent produced two bands at 260 and 230 bp in the their respective parents (Plate 13).

Marker eme08D09 amplified two alleles in the range of 290 to 220 bp across the hybrids *viz.* SMV1×SMV5, SMV1×SMV2, SMV2×SMV6, SMV4×SMV6 and SMV5×SMV6. The hybrids SMV1×SMV5, SMV1×SMV2 and SMV4×SMV6 shared bands from both the parents where the female parent produced one amplicon at 220 bp and male parent produced two amplicons at 290 and 220 bp to their respective parents (Plate 14). Hybrids SMV2×SMV6 and SMV5×SMV6 and their respective parents amplified two alleles in the range of 290 to 220 bp.

Marker CSM31 amplified two alleles in the range of 300 to 220 bp across the hybrids. SMV2×SMV6 shared bands from both the parents where the female parent SMV2 produced one amplicon at 220 bp and male parent SMV6 produced two amplicons at 300 and 220 bp. Further, the primer CSM31 also amplified one specific allele at 220 bp in F_1 hybrid (SMV3×SMV6) and its female parent (SMV3)

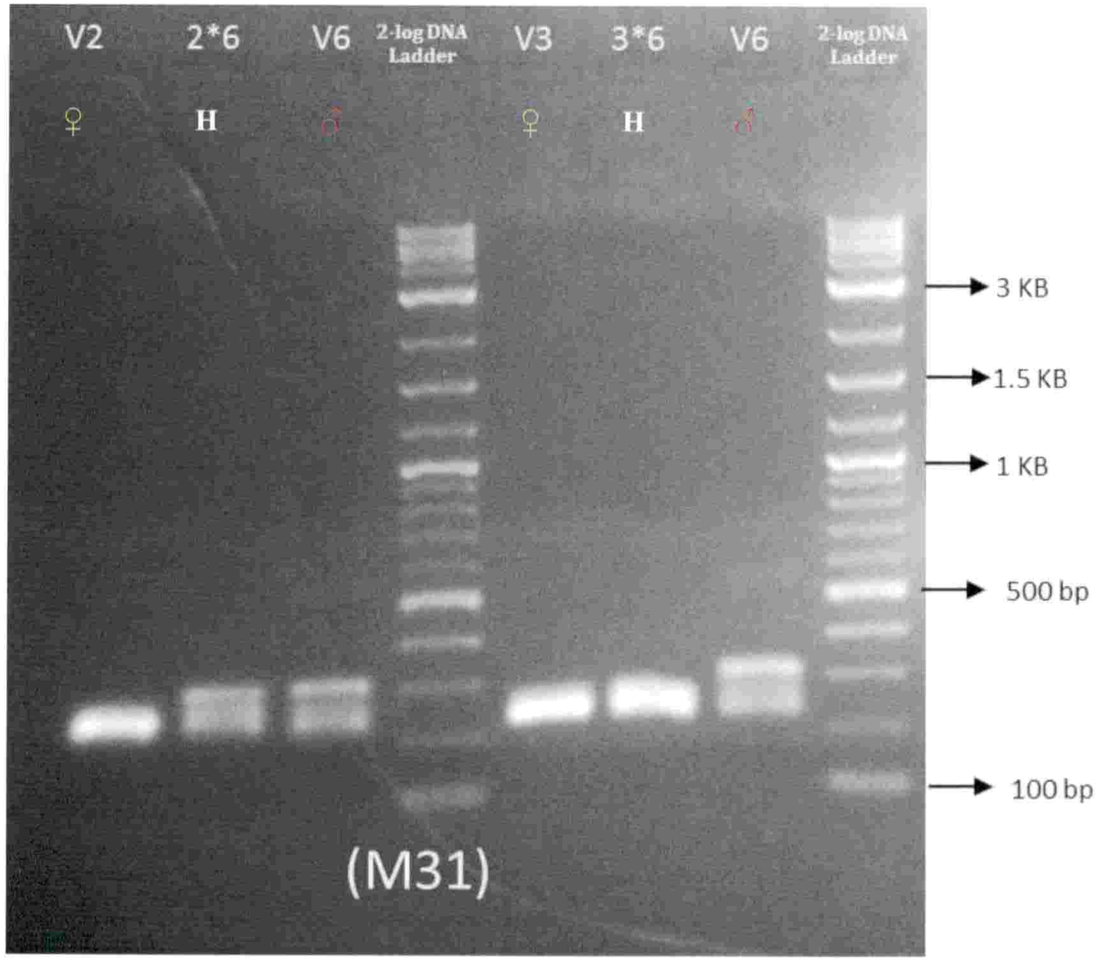


Plate 15. Simple sequence repeat (SSR) profiles of two brinjal hybrids (F_1) and respective parental lines (♀ and ♂) obtained from marker CSM31.

V2= Palakurthi local
V6= Vellayani local
V3= Surya
♀= Female
♂= Male
H= Hybrid
2*6= Palakurthi local × Vellayani local
3*6= Surya × Vellayani local

but the male parent (SMV6) produced two bands at 300 to 220 bp of which one band was absent in the hybrid. (Plate 15)

Table 36. Comparison of stable brinjal hybrids for different yield characters during *kharif* season.

Yield characters	Stable but suitable for unfavourable (poor) environment	Stable genotype (across all environments)	Stable but suitable for favourable (rich) environment
Days to first flowering	Surya × Vellayani local	Wardha local × Palakurthi local NBR-38 × Selection Pooja	-
Days to first harvest	-	-	NBR-38 × Vellayani local
Number of fruits plant^{-1}	-	Wardha local × Palakurthi local Palakurthi local × Vellayani local	-
Fruit weight	NBR-38 × Selection Pooja	Wardha local × Palakurthi local Wardha local × Swetha	-
Fruit length	Wardha local × Surya Palakurthi local × Vellayani local	Wardha local × Palakurthi local	Wardha local × Vellayani local Surya × NBR-38 NBR-38 × Vellayani local Swetha × Vellayani local
Fruit grith	Wardha local × Swetha	Wardha local × Palakurthi local	NBR-38 × Vellayani local
Calyx length	Wardha local × Swetha Surya × NBR-38 NBR-38 × Selection Pooja	Wardha local × Palakurthi local Swetha × Vellayani local	Palakurthi local × Vellayani local Surya × Vellayani local
Yield plant^{-1}	-	Wardha local × Palakurthi local Wardha local × Swetha	Wardha local × Vellayani local
Yield plot^{-1}	-	Wardha local × Palakurthi local Wardha local × Swetha	Wardha local × Vellayani local
Plant height	-	Wardha local × Palakurthi local	Surya × NBR-38

Table 37. Comparison of stable brinjal hybrids for different yield characters during summer season.

Yield characters	Stable but suitable for unfavourable (poor) environment	Stable genotype (across all environments)	Stable but suitable for favourable (rich) environment
Days to first flowering	-	Wardha local × Palakurthi local	Wardha local × Surya
Days to first harvest	Wardha local × Vellayani local Surya × NBR-38	Wardha local × Palakurthi local Wardha local × Swetha	Surya × Vellayani local NBR-38 × Vellayani local Swetha × Vellayani local
Number of fruits plant^{-1}	-	Wardha local × Palakurthi local	-
Fruit weight	-	Wardha local × Palakurthi local Swetha × Vellayani local	-
Fruit length	-	Wardha local × Palakurthi local Swetha × Vellayani local	Wardha local × Surya
Fruit girth	Wardha local × Palakurthi local Wardha local × Swetha Palakurthi local × Vellayani local NBR-38 × Vellayani local	Wardha local × Vellayani local	Surya × Vellayani local
Calyx length	Wardha local × Palakurthi local NBR-38 × Vellayani local	Swetha × Vellayani local	Wardha local × Surya
Yield plant^{-1}	-	Wardha local × Palakurthi local Swetha × Vellayani local	Surya × NBR-38
Yield plot^{-1}	Wardha local × Palakurthi local Wardha local × Swetha	Swetha × Vellayani local	Surya × NBR-38 NBR-38 × Vellayani local
Plant height	NBR-38 × Selection Pooja	Wardha local × Swetha NBR-38 × Vellayani local Swetha × Vellayani local	Surya × NBR-38

Discussion

5. Discussion

Factors that are of economic relevance may be related to complex or polygenic characteristics, and show a high influence of the environment. The changing environmental conditions affect the performance of brinjal genotypes. The phenotypic nature of any character is resultant of the genotype, environment and genotype × environment interaction under which an individual is grown. The major task of a plant breeder is to study G×E interaction of genotypes by conducting multi-locational and multi-seasonal trials to understand the adaptability and the performance of the genotypes under different situations before releasing it as a 'commercial varierty' for cultivation in farmer's field. By growing genotypes in different environments, the highest yielding and most stable genotypes can be identified (Luquez *et al.*, 2002). Genotypes tested in different locations or years often have significant fluctuation in yield due to the response of genotypes to environmental factors such as soil fertility or the presence of disease pathogens (Kang, 2004). These fluctuations are often referred to as genotype × environment interactions. As a result, a genotype is regarded stable if it has low contribution to the G×E interaction. Several methods were proposed to analyze G×E interaction to determine the stability of performance (Becker and Leon, 1988). The most widely used method for estimating the stability is Eberhart and Russel (1966) model. A genotype or a variety would be considered as stable when its performance remains constant over the different situations/environments.

In brinjal, hybrid seeds are produced using "hand emasculation and pollination" technique and so the chances for presence of selfed admixtures is high. Considering this fact, genetic purity testing for seed certification was made mandatory in India by GOT which is time consuming and costly. An easy, rapid and reliable alternative is the molecular marker based assays. Different molecular markers are being used for DNA fingerprinting of cultivars. Among molecular markers, SSR markers were reported to be the best for testing genetic identity and purity of seeds because SSR markers are co-dominant in nature and they determine the heterozygosity of the hybrid by the presence of polymorphic parental alleles.

Hence, this present investigation entitled "Stability analysis and molecular characterization of F_1 hybrids in brinjal (*Solanum melongena* L.)" was carried out during 2015-16 and 2016-17 under four locations *viz*., Vellayani, Thiruvalla, Sadanandapuram and Kayamkulam in Kerala for assessing stability performance of ten brinjal hybrids and one hybrid check for assesing yield attributes and stability during *kharif* and summer seasons. Furthermore, evaluation of segregating generations for yield attributes was conducted and molecular characterization of hybrids and parents were done for confirmation of hybridity.

The results of the study are discussed below in light of available literature under the following headings:

1. Pooled Analysis of variance
2. Stability analysis for yield and its attributing traits
3. Evaluation of segregating generations (F_2 population)
4. Molecular characterization of hybrids and their parents

5.1 EVALUATION OF F_1 HYBRIDS DURING *KHARIF* SEASON

5.1.1 Pooled Analysis of variance

Pooled analysis of variance revealed the presence of wide genetic variability among the genotypes and among the testing environments. The Genotype × Environment interactions (G × E) were also significant for all the characters indicating the substantial interaction between genotype and environment which implies differential response of genotypes across the environments for all the traits. This allowed further analysis to test the stability of the genotypes. Significant genotype × environment interaction in brinjal has been reported by Sarma *et al.* (2000), Mohanty. (2002), Prasad *et al* (2002), Suneetha *et al.* (2006a), Vadodaria *et al.* (2009a) and Mehta *et al.* (2011).

The mean squares due to Environments + (Genotype x Environment) were significant for the characters *viz*., days to first harvest, number of fruits plant^{-1}, fruit weight, fruit girth, yield plant^{-1} and yield plot^{-1}. Sum of squares due to E + (G x E) was further partitioned into that of Environment (linear), Genotype x Environment (linear) and pooled deviation. Mean squares showed that environment (linear) differed significantly and were quite diverse in their effects on the performance of the genotypes. Variance of Genotype x Environment (linear) when tested against pooled deviation was significant for days to first harvest however was found to be non-significant for the rest of the traits. Pooled deviation (non-linear component) variances were significant for all characters suggesting importance of both linear and non-linear components. Similar results were reported by Desai (1990), Srivastava *et al.* (1997), Rai *et al.* (2000), Bora *et al.* (2011b) and Bhushan and Samnotra (2017a,b) in brinjal with different sets of genotypes.

5.1.2 Stability analysis

Identification of stable genotypes suited to different environmental conditions is the ultimate aim of the estimation of stability parameters of individual genotypes. Many stability models have been developed to identify the stable genotypes. Eberhart and Russell (1966) model is the one which has been used in brinjal and other crops by several workers. In this model, phenotypic stability of the genotypes is measured by three parameters *viz.*, mean performance over environment (μ), linear regression (bi) and deviation from regression (S^2di).The regression coefficient (bi) measures the responsiveness whereas, deviations from regression (S^2di) measure the stability of genotypes.

In interpreting the results of the present investigation, S^2di was considered as the measure of stability. Once the genotype was found to be stable based on the non-significant deviation from regression ($S^2di = 0$), then the type of stability was based on regression coefficient and mean values. If bi is equal to unity, a genotype is considered to have average stability (same performance in all the environments). If bi is more than unity, it is suggested to have less than average stability (good performance in favourable environments). If bi is less than unity, it is said to have above average stability and uniform performance in poor environments.

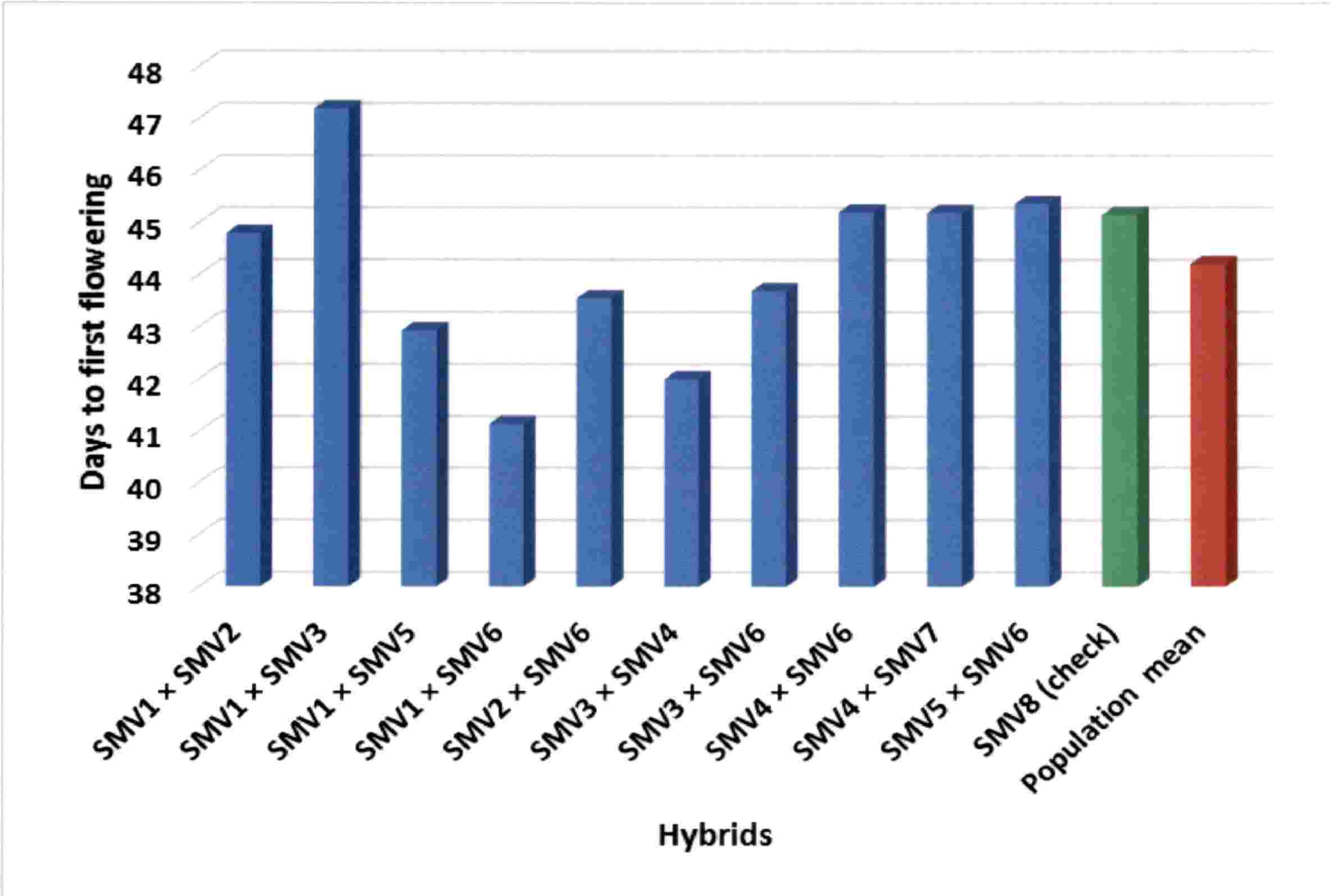


Figure 1. Comparison of days to first flowering with check and population mean of 10 hybrids during *kharif* season

5.1.2.1 Days to first flowering:

Among the hybrids SMV1×SMV2 (μ=44.79, b_i=0.73, S^2_{di}=0.76), SMV4×SMV7 (μ=45.19, b_i=0.65, S^2_{di}=0.50) and SMV3×SMV6 (μ=43.69, b_i=0.23, S^2_{di}=-17) were identified as the stable types, having regression coefficient near to unity and non- significant deviation from regression. The hybrids SMV1×SMV2 and SMV4×SMV7 were considered to be stable which means the performance does not change with change in environment. SMV3×SMV6 exhibited b_i value much lower than unity and hence it is adaptable to poor environment. Rest of the genotypes were found unstable for this trait. The above results are in conformity with the earlier work reported by Mehta *et al.* (2011) who tested seven open pollinated genotypes of long brinjal in three environments for Chhattisgarh plains. Three genotypes were above average for days to first flowering. Similar results were observed by Dhaka *et al*. (2017) in brinjal.

5.1.2.2 Days to first harvest:

Two hybrids, SMV4×SMV6 (μ=67.88, b_i=1.77, S^2_{di}=0.387) and SMV8 (μ=69.96, b_i=0.17, S^2_{di}=0.662) were found to be stable to days to first harvest. The hybrid SMV4×SMV6 resulted with regression coefficient greater than unity and non-significant deviation from regression and hence is ideal for better environments. SMV8 is suitable for unfavourable environments as it has a regression coefficient less than 'unity' and non-significant deviation from regression. Most of the hybrids were found unstable with significant S^2_{di} value for this trait due to variation in the existing environment of the growing system. Suneetha *et al.* (2006a) tested 10 homozygous lines and their 45 hybrids from its 10 x10 diallel mating and reported that only three crosses were stable in respect to days to first harvest in Gujarat environmental conditions. Similar results were reported in brinjal genotypes by Vadodaria *et al.* (2009a) and Dhaka *et al*. (2017).

5.1.2.3 Number of fruits plant^{-1}:

Number of fruits plant^{-1} is an important trait which is directly related to fruit yield. Maximum number of fruits plant^{-1} was recorded by SMV1×SMV2 (37.28),

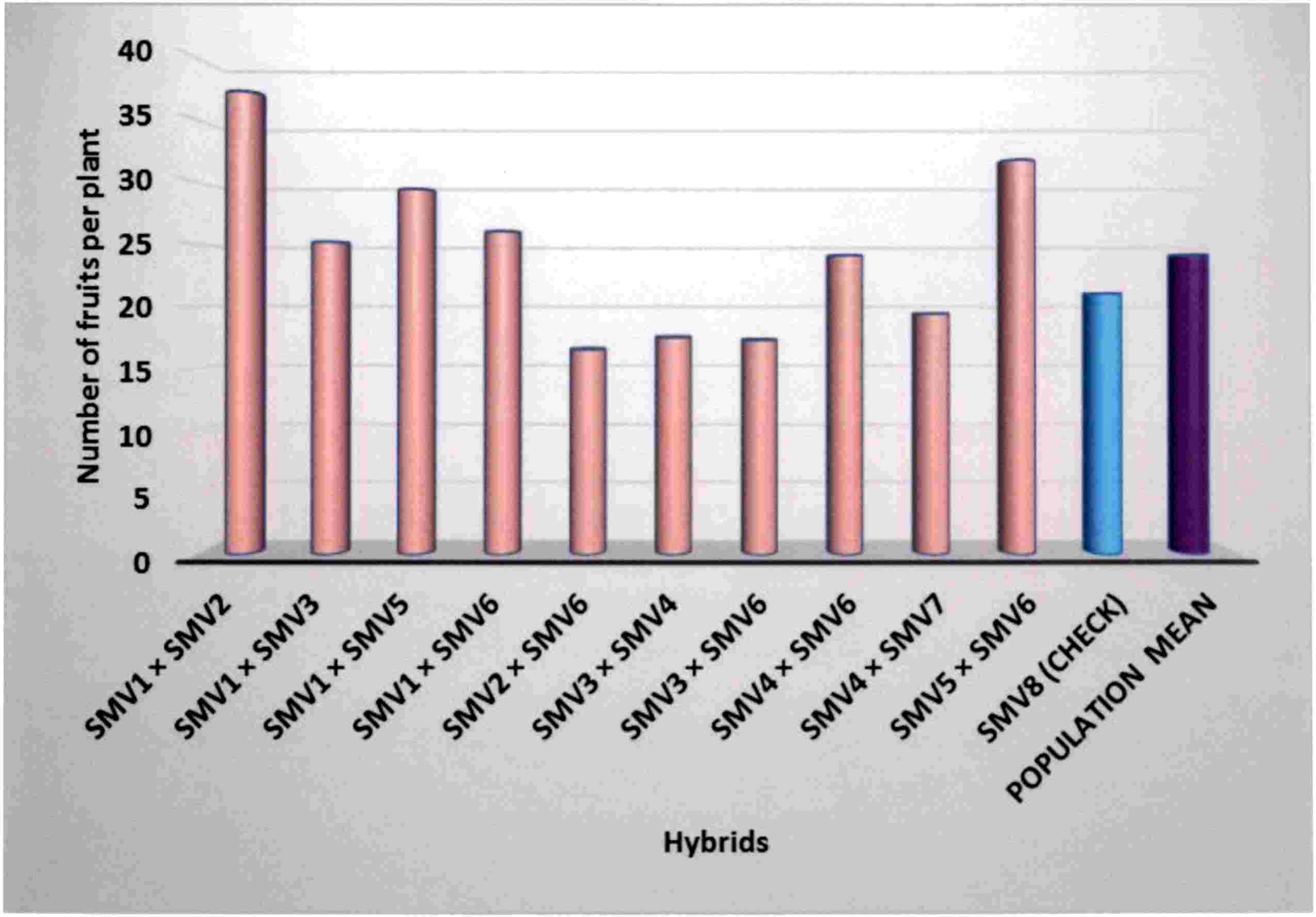


Figure 2. Comparison of number of fruits per plant with check and population mean of 10 hybrids during *kharif* season

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while minimum numbers of fruits plant^{-1} was recorded by SMV2×SMV6 (16.56). The hybrid SMV1×SMV2 had regression coefficient near to unity (0.77) and non-significant (0.575) deviation from regression with high mean value and hence was found to be stable across various environments. Hybrid SMV2×SMV6 had regression coefficient near to unity (0.94) and non-significant (0.348) deviations from regression with lower mean value and was found to be adaptable to unfavourable environments. Mohanty (2002) Chaurasia *et al.* (2005), Mandal and Chaurasia (2007), Vadodaria *et al.* (2009a), Bhushan and Samnotra (2017a) had also reported seasonal effects responsible for wide variation in number of fruits plant^{-1}. Bora *et al*. (2011b) evaluated 17 genotypes, of which six genotypes namely BARI, PB-4, PB-67, PB-71, PB-66 and White Long Green displayed regression coefficient near to unity, non- significant deviation from regression near to zero with above average mean performance and hence was advocated for both winter and summer seasons for general cultivation.

5.1.2.4 Fruit weight:

Fruit weight is one of the component characters directly influencing the fruit yield. The hybrid, SMV1×SMV2 (83.43) and SMV1×SMV5 (79.43) with regression coefficient near to unity and minimum deviation from regression was widely adaptable and stable possessing fruit weight lower than the check SMV8 (109.49). SMV8 could be recommended for favourable environments as it resulted in regression coefficient greater than 'unity' with minimum deviation from regression. The hybrid SMV4×SMV7 with regression coefficient less than one (0.47) and non-significant deviation from regression (10.317) is suitable for poor environments. In case of other genotypes the performance has been found to be highly unpredictable because of their significant deviation from regression values. Varied response of genotypes due to change in environments is in accordance with the findings of Rai *et al*. (2000), Chaurasia *et al.* (2005), Mehta *et al*. (2011). Chaudhari *et al.* (2015) and Bhushan and Samnotra (2017a,b).

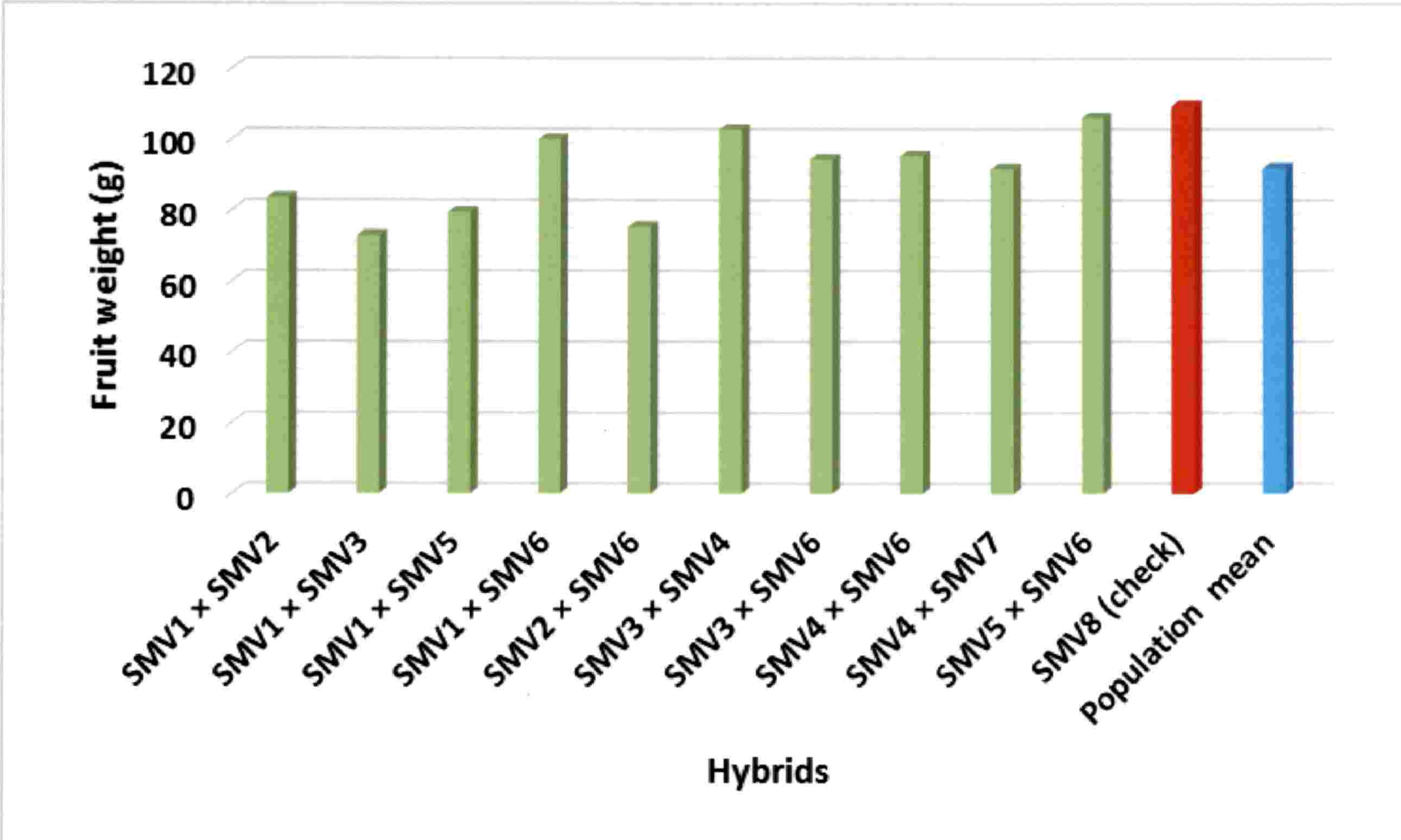

Figure 3. **Comparison of fruit weight with check and population mean of 10 hybrids during *kharif* season**

5.1.2.5 Fruit length:

Fruit length is an important parameter deciding consumer preference. Among eleven genotypes, eight hybrids showed non-significant S^2_{di} value with respect to fruit length which indicated that fruit length did not vary with the growing system. The hybrids SMV1×SMV2 (13.48), SMV1×SMV6 (14.76), SMV2×SMV6 (14.06), SMV4×SMV6 (13.34) and SMV5×SMV6 (14.11) recorded higher mean values for fruit length than the population mean and SMV8 (check). These hybrids also have least deviation from regression. Hybrid SMV1×SMV2 performed well under all types of environments due to b_i=1, SMV1×SMV6, SMV3×SMV4, SMV4×SMV6 and SMV5×SMV6 performed well under favourable environments due to b_i>1. Two hybrids SMV1×SMV3 and SMV2×SMV6 were suitable for unfavourable environments due to b_i<1. Chaurasia *et al.* (2005) also tested fifteen divergent genotypes (round, long and small round) for stability analysis and reported three genotypes *viz.*, KS-224, JC-2 and H-7 as stable under Varanasi conditions for fruit length. These findings are in agreement with those of Mandal and Chaurasia (2007); Bora *et al.* (2011b) and Bhushan and Samnotra (2017a,b).

5.1.2.6 Fruit girth:

Among the hybrids, SMV1×SMV2 (μ=11.76, b_i=1.01, S^2_{di}=0.050) and SMV4×SMV6 (μ=14.29, b_i=1.19, S^2_{di}=0.193) were considered as stable hybrids because regression coefficient was around unity with non-significant deviation from regression and hence can be recommended for wider environments. Further, the hybrid SMV1×SMV5 resulted with regression coefficient less than one (0.33) and non-significant deviation from linearity and so can be recommended for poor environments. Most of the hybrids exhibited significant S^2_{di} values for this trait which indicated their instability. The instability might be due to variation in the existing environments of the growing system. Similar results were reported by Chaurasia *et al.* (2005) who tested fifteen divergent genotypes (round, long and small round) for stability analysis and reported four genotypes *viz.*, KS-331, JC-1, DBSR-91 and H-7 as stable under Varanasi conditions for fruit girth. Prasad *et al.* (2002) reported almost similar results for fruit girth in brinjal genotypes.

5.1.2.7 Calyx length:

Seven out of eleven genotypes were found to have least deviation from regression and hence displayed stability across the environments. The stability parameters b_i=1, S^2_{di}=0 and high mean value with respect to this trait indicated that three genotypes *viz.* SMV1×SMV2, SMV3×SMV6 and SMV5×SMV6 were found to be highly stable across wide environments. Hybrid SMV2×SMV6 was suitable for favourable environments due to b_i>1. The remaining three hybrids (SMV1×SMV5, SMV2×SMV6 and SMV3×SMV6) were suitable for unfavourable environments due to b_i<1. Varied response of genotypes with respect to calyx length has been reported by Dutta *et al*. (2009), Prabakaran (2010) and Nagappan *et al.* (2017).

5.1.2.8 Yield plant^{-1}:

Fruit yield plant^{-1} is a complex quantitative trait and stability achieved in this trait can be utilized for all the growing seasons of brinjal to achieve higher and stable yield increments (Vadodaria *et al,* 2009a). The hybrid, SMV1×SMV2 (μ=3.21, b_i=0.78, S^2_{di}=-0.001) and SMV1×SMV5 (μ=2.45, b_i=0.95, S^2_{di}=0.005) with high mean, regression coefficient near to unity and minimum deviation from regression can be considered as stable and recommended for cultivation over wide range of environments. The hybrid SMV1×SMV6 (μ=2.52, b_i=1.36, S^2_{di}=0.002) which recorded high mean with more than unity regression coefficient and non–significant deviation from linearity were considered as suitable for cultivation in poor environments. Varied response of genotypes with respect to stability parameters for total yield plant^{-1} has been reported by Rai *et al* (2000), Prasad *et al* (2002), Kanwar *et al.* (2005), Mandal and Chaurasia (2007), Suneetha *et al.* (2009a), Vadodaria *et al.* (2009a), Mehta *et al*. (2011) and Chaudhari *et al*. 2015. Twenty five brinjal genotypes were evaluated for yield under six environments at Chatha and it was reported that two genotypes *viz*., Shamli and Punjab Sadabahar were stable for fruit yield plant^{-1} (Bhushan and Samnotra (2017a,b).

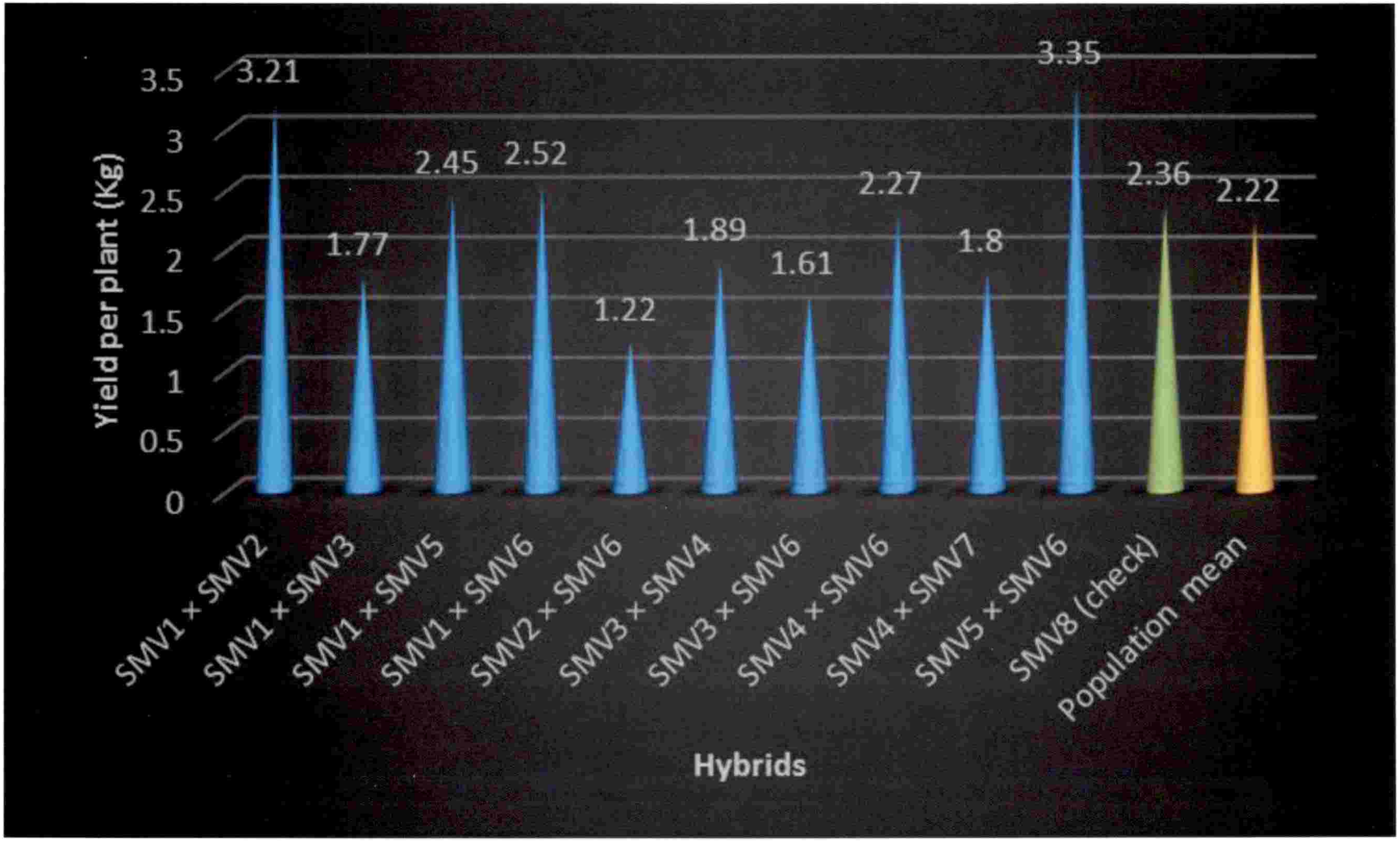

Figure 4. Comparison of yield per plant with check and population mean of 10 hybrids during *kharif* season

5.1.2.9 Yield plot^{-1}:

The hybrids SMV1×SMV2, SMV1×SMV5 and SMV1×SMV6 had highest mean yield plot^{-1} than the population mean and check (SMV8). The hybrids SMV1×SMV2 (μ=57.66, b_i=0.88, S^2_{di}=-0.236) and SMV1×SMV5 (μ=44.68, b_i=0.89, S^2_{di}=4.957) recorded high mean, regression coefficient near unity and non–significant deviation from regression and so were considered as stable genotypes under wide range of environments. The hybrid SMV1×SMV6 (μ=45.86, b_i=1.38, S^2_{di}=-0.099) exhibited regression coefficient more than unity and non–significant deviation from linearity and hence is considered to be stable in rich environments. The stability of the mentioned genotypes is directly linked with stability of their component traits *viz*., fruit weight, number of fruits plant^{-1}, fruit length, plant height and yield plant^{-1} for wide and specific adaptability. Similar reports have been given by various workers in respect of stability of fruit yield/hectare or plot in brinjal such as Rai *et al.* (2000), Prasad *et al.* (2002), Chaurasia *et al.* (2005), Kanwar *et al.* (2005), Mandal and Chaurasia, (2007), Bora *et al.* (2011b), Mehta *et al.* (2011) and Chaudhari *et al*. 2015. Bhushan and Samnotra (2017a,b) reported that only one genotype PPL-74 out of 25 brinjal genotypes evaluated across six different environments was found stable for fruit yield hectare^{-1}.

5.1.2.10 Plant height:

The stable hybrids observed for this trait were SMV1×SMV2 (μ=97.36, b_i=1.23, S^2_{di}=2.082) and SMV3×SMV4 (μ=94.68, b_i=1.98, S^2_{di}=-0.505) which were considered as stable and adaptable to favourable environment because of regression coefficient being more than unity and non–significant deviation from regression. Most of the hybrids were found unstable with respect to this trait due to variation in the existing environments of the growing system. Rai *et al.* (2000), Prasad *et al.* (2002), Chaurasia *et al.* (2005), Mehta *et al.* (2011), Chaudhari *et al*. 2015 and Bhushan and Samnotra (2017a) have reported seasonal effects responsible for wide variation in plant height.

5.1.2.11 Total phenols:

The fruit contains phenolic compounds such as anthocyanins and phenolic acids which have antioxidant properties (Cao et al. 1996; Stommel and Whitaker 2003). The phenols are oxidized by polyphenol oxidases to produce the toxic quinines, protective melanin pigments and other oxidation products (Hung and Rhode, 1973) which might have imparted tolerance through discouraging feeding of the insects.

During *kharif* season significant differences were found among the eleven hybrids across the different environments with respect to total phenols. Highest total phenol content was recorded in SMV5×SMV6 and lowest was found in SMV4×SMV6 across the different environments. But SMV1×SMV3 recorded the lowest at Thiruvalla. Similar results with respect to phenol content in brinjal genotypes have been reported by Prohens *et al.* (2007), Shaheen *et al.* (2013), Tripathi *et al*. (2014), Kandoliya *et al*. (2015) and Nayanathara *et al*. (2016).

5.1.2.12 Total sugars:

Sugar is considered as one of the vital nutrients in plants and this compound might act as phago-stimulant to shoot and fruit borers feeding on eggplant.

During *kharif* season significant differences were found among the eleven hybrids with respect to total sugars across the different environments. The hybrid SMV1×SMV5 recorded the highest total sugar content at Vellayani and Sadanandapuram whereas, SMV4×SMV7 recorded the highest total sugar content at Thiruvalla and Kayamkulam and SMV3×SMV4 recorded the lowest across all the locations. Earlier works by Prabhu *et al.* (2009), Kumari *et al.* (2014), Ayaz *et al.* (2015) and (Nayak and Pandey,2016) have revealed that concentration of feeding stimulants like sugar and protein in the fruits will lead to susceptibility to fruit infestation. These results are in agreement with our study.

5.1.2.13 Vitamin C:

Higher ascorbic acid content in brinjal fruit is associated with increased nutritive value of the fruits which would help in the better retention of colour and flavour (Sasikumar, 1999).

Among the eleven hybrids, significant difference was found among the genotypes with respect to Vitamin C content across the different environments. Vitamin C was higher in SMV8 followed by SMV5×SMV6 while SMV4×SMV7 recorded the least Vitamin C content across all the locations. Kumar and Arumugam, (2013) also recorded ascorbic acid content ranging from 7.38 to 13.47 mg/100g while evaluating 33 indigenous brinjal genotypes. Similar results have been reported by Prohens *et al.* (2007), Jose *et al.* (2014) and Bhushan and Samnotra (2017b).

5.1.2.14 Shoot and fruit borer infestation:

Brinjal shoot and fruit borer is the most serious insect pest of brinjal crop. It attacks shoots in early plant growth stages and causes death of the shoots in vegetative stage (Sivakumar *et al*, 2015). Single most important factor for low productivity of brinjal crop throughout the country can be attributed to incidence of fruit borer, rendering the fruits unmarketable (Sivakumar *et al*, 2015). Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits. The shoot infestation and fruit infestation by shoot and fruit borer has been given the under following headings:

5.1.2.14.1 Shoot infestation percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and the results are discussed in the previous chapter. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids between the locations.

The hybrids SMV5×SMV6 and SMV8 were moderately resistant at Vellayani, Thiruvalla and Kayamkulam but, tolerant at Sadanandapuram. SMV1×SMV2 was found moderately resistant at Vellayani and Sadanandapuram but tolerant at Thiruvalla and Kayamkulam. SMV1×SMV3, SMV1×SMV6 and SMV1×SMV5 were tolerant across all the locations. The hybrids SMV4×SMV6, SMV4×SMV7, SMV3×SMV4, SMV3×SMV6 and SMV2×SMV6 were susceptible across all locations. Similar results were reported by Chaudary and Sharma, (2000), Ahmad *et al*. (2008), Elanchezhyan *et al*. (2008), Vadodaria *et al*. (2009b), Khan and Singh (2014) and Vethamoni and Praneetha (2016).

5.1.2.14.2 Fruit infestation percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and the results are discussed in the previous chapter.

The minimum percentage of fruit infestation was recorded in the hybrid SMV5×SMV6 followed by SMV8 across all the locations and were found tolerant. SMV1×SMV2 was found tolerant at Vellayani and susceptible at other three environments. SMV1×SMV5 was found tolerant at Sadanandapuram and Kayamkulam but was susceptible at Vellayani and Thiruvalla. Highest fruit infestation was noticed in SMV4×SMV6 and SMV4×SMV7 both being highly susceptible across all environments. The rest of the hybrids were found susceptible with medium infestation to fruits by shoot and fruit borer. Screening experiments by various workers have indicated highly differential response of brinjal germplasm to the attack of this pest. (Naqvi *et al.* (2009), Ahmad *et al*. (2008), Elanchezhyan *et al*. (2008),Vadodaria *et al.* (2009b), Nayak *et al.* (2014), Mannan *et al.* (2015) and Singh *et al.* (2016)) have conducted similar screening studies.

5.1.2.15 Bacterial wilt incidence:

Screening of eleven F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiments across different locations.

Among the hybrids, SMV5×SMV6, SMV8, SMV1×SMV2, SMV1×SMV6 and SMV2×SMV6 were resistant with lower percentage of plants wilted. SMV1×SMV3, SMV1×SMV5, SMV1×SMV3, SMV3×SMV6 and SMV4×SMV6 were moderately resistant across all environments. Hybrid SMV4×SMV7 recorded higher percentage of plants wilted and was the most susceptible and SMV3×SMV4 was found moderately resistant at three locations except Vellayani. Hussain *et al.* (2005), Rahman *et al.* (2011), Bora *et al.* (2011a), Kumar *et al.* (2014), Gopalakrishnan *et al.* (2014), Bhavana and Singh (2016) and Yadav *et al.* (2017) also reported similar results with respect to resistance of brinjal genotypes against bacterial wilt.

5.2 EVALUATION OF F_1 HYBRIDS DURING SUMMER SEASON

5.2.1 Pooled Analysis of variance

Pooled analysis of variance revealed the presence of wide genetic variability among the genotypes for all the characters. Significant mean square estimates due to environments indicated substantial difference between the testing environments affecting the performance of the genotypes. The significant mean square due to genotype x environment (G x E) interaction indicated that the genotypes interacted considerably with the environments for expressing all the characters. This result is in consonance with Srivastava *et al.* (1997), Rai et al. (2000), Kumar *et al.* (2008), Mehta *et al.* (2011), Chaudhari *et al.* (2015).

Partitioning of environment + genotype x environment (E + G x E) mean square showed that environments (linear) differed significantly and were quite diverse in their effects on the performance of the genotypes. Higher magnitude of mean square due to environment (linear) compared with the G x E (linear) indicated that the linear response of the environment accounted for the major part of the total variation for all the characters which further substantiated that the environmental effects and their major influence on yield in brinjal were quite real in nature. Significant mean squares due to pooled deviation for all the characters suggested that the deviation from linear regression contributed substantially towards the differences in stability of genotypes. This suggested that predictable as well as unpredictable components were involved in the differential response of stability. The genotype x environment interaction (linear) was found to be non-significant

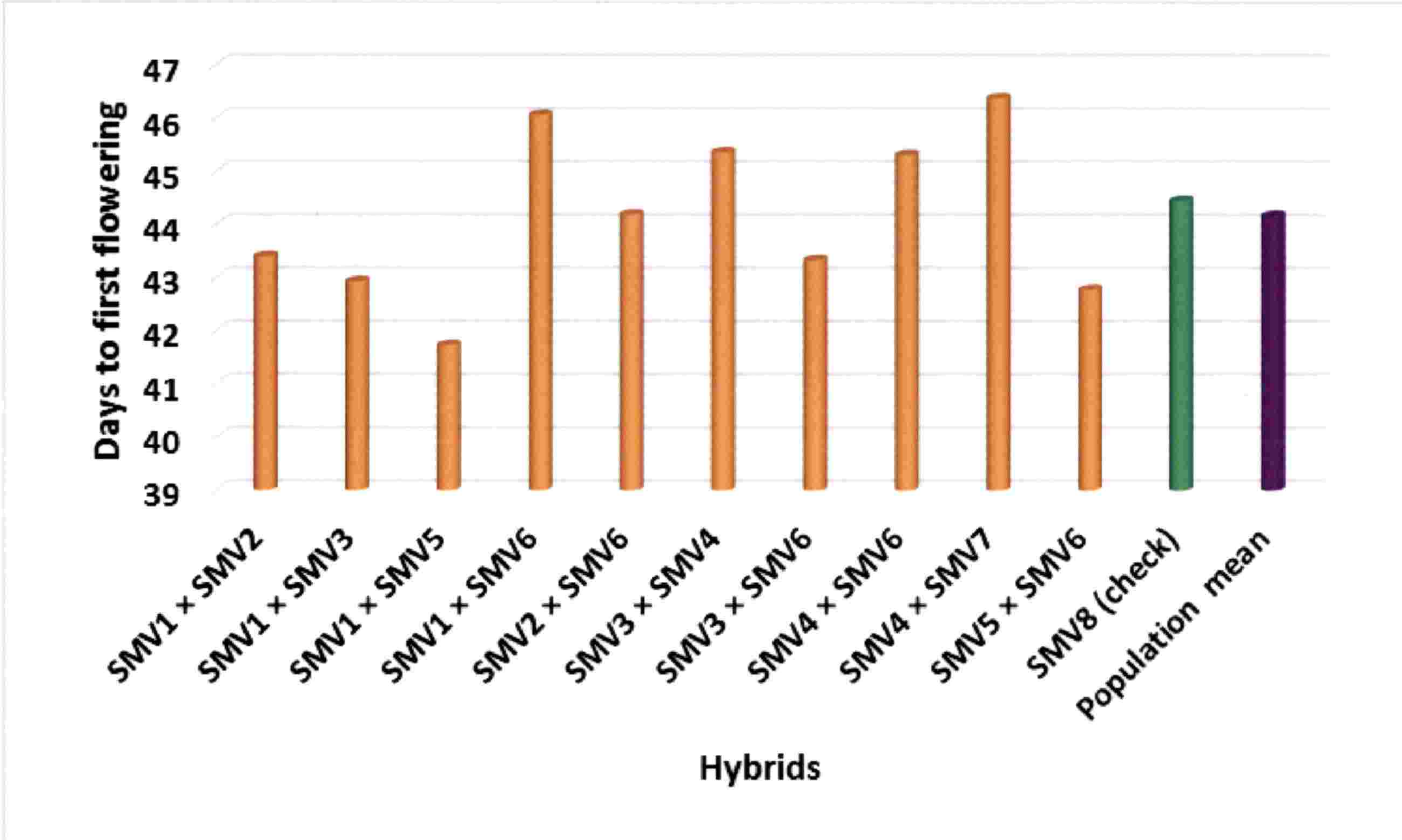

Figure 5. Comparison of days to first flowering with check and population mean of 10 hybrids during summer season

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when tested against pooled deviation, suggesting the preponderance of non-linear component as compared to the linear one for all the characters except days to first harvest. Similar results were reported by Rai *et al.* (2000), Kumar *et al.* (2008), Mehta *et al.* (2011), Chaudhari *et al.* (2015) and Bhushan and Samnotra (2017a).

5.2.2 Stability analysis

5.2.2.1 Days to first flowering:

Among the hybrids evaluated SMV1×SMV2 and SMV1×SMV3 were earlier to flower than the standard check and population mean with non-significant deviation from regression were observed showing that their performances can be predicted. The hybrid SMV1×SMV2 was well adapted over all the environments as its regression coefficient was around unity and hybrid SMV1×SMV3 was found to be suitable for better environment. Sarma *et al*. (2000), Vadodaria *et al.* (2009a) and Mehta *et al.* (2011) reported similar results for earliness in brinjal. Sivakumar *et al.* (2017) evaluated thirty four genotypes for yield and its components in three locations which resulted in identifying four promising hybrids *viz*., Heera × Bhagyamathi, Heera × Shyamala, Heera × Gulabi and Pusa Shyamala × Gulabi which were stable across all three locations for days to 50 % flowering.

5.2.2.2 Days to first harvest:

Among the eleven genotypes, seven hybrids expressed non-significant deviation for this trait. The hybrids SMV1×SMV2 (b_i=1, S^2_{di}=0.256), SMV1×SMV5 (b_i=0.93, S^2_{di}=-0.126) and SMV1×SMV6 (b_i=0.91, S^2_{di}=0.523) recorded regression coefficient around unity and non-significant deviation from linearity, hence they are stable and can be recommended for general cultivation.

Since SMV3×SMV6, SMV4×SMV6 and SMV5×SMV6 recorded regression coefficient greater than unity (1.26, 1.80, 1.46) and non-significant deviations from regression they were found suitable for rich environments. But for hybrid SMV3×SMV4 (μ=71.73, b_i=-0.40, S^2_{di}=0.506) response was negative for regression coefficient with non-significant deviation from linearity and hence it is considered as suitable for poor environment. The early or late maturity is attributed

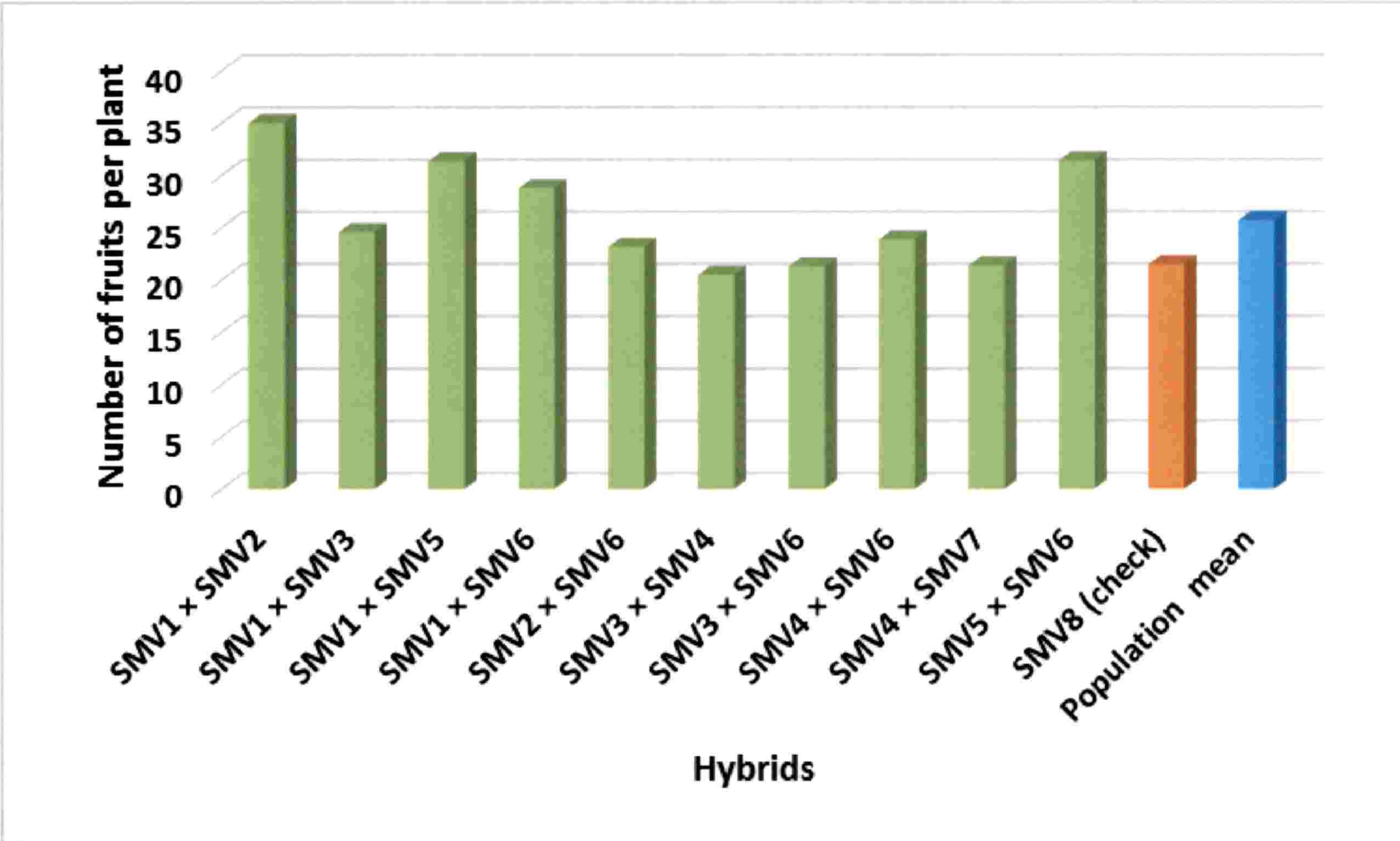

Figure 6. Comparison of number of fruits per plant with check and population mean of 10 hybrids during summer season

to genotypic reasons and is influenced by the environmental conditions of particular growing conditions. Such findings were also reported by Suneetha *et al.* (2006a), Bhushan and Samnotra (2017a) and Dhaka *et al*. (2017) for days to first harvest. Vadodaria *et al.* (2009a) identified seven brinjal hybrids *viz*., JBSR-98 x Pant Rituraj, ABL98-1 x Pant Rituraj, ABL98-1 x GBL1, Morvi4-2 x PLR1 and Green Round x GBL1 in which days to first picking was found to be stable yield attribute.

5.2.2.3 Number of fruits plant^{-1}:

Hybrid SMV1×SMV2 (μ=35.04, b_i=1.18, S^2_{di}=0.002) is considered as a stable genotype because it recorded high mean, regression coefficient around unity and non-significant deviation from regression. It can be considered as highly stable and suitable for cultivation over wide range of environments. The check SMV8 expressed lower mean (21.51), regression coefficient more than one (1.25) and non-significant deviation from linearity (0.243) and hence is suitable for good environment. Kanwar *et al.* (2005), Suneetha *et al.* (2006a), Chaudhari *et al.* (2015) and Sivakumar *et al.* (2017) found varied response of genotypes with respect to stability parameters for number of fruits plant^{-1}. Similar results have been reported by Bora et al. (2011) in seventeen brinjal genotypes of which six genotypes namely BARI, PB-4, PB-67, PB-71, PB-66 and White Long Green were found stable across two different seasons and growing conditions at Pantnagar.

5.2.2.4 Fruit weight:

The hybrid, SMV1×SMV2 and SMV5×SMV6 with regression coefficient near to unity and minimum deviation from regression are widely adaptable and stable, possessing lower fruit weight than the standard check SMV8. These hybrids can be recommended for general cultivation across different environments. Most of the genotypes showed significant values whose performance cannot be predicted. Kanwar *et al.* (2005) studied stability of six cultivars of aubergine grown under four environments in Ludhiana. Among them only one cultivar, Punjab Jamuni Gola was identified as good for fruit weight which is in agreement with our results. Varied response of genotypes due to changes in environments is in accordance with the

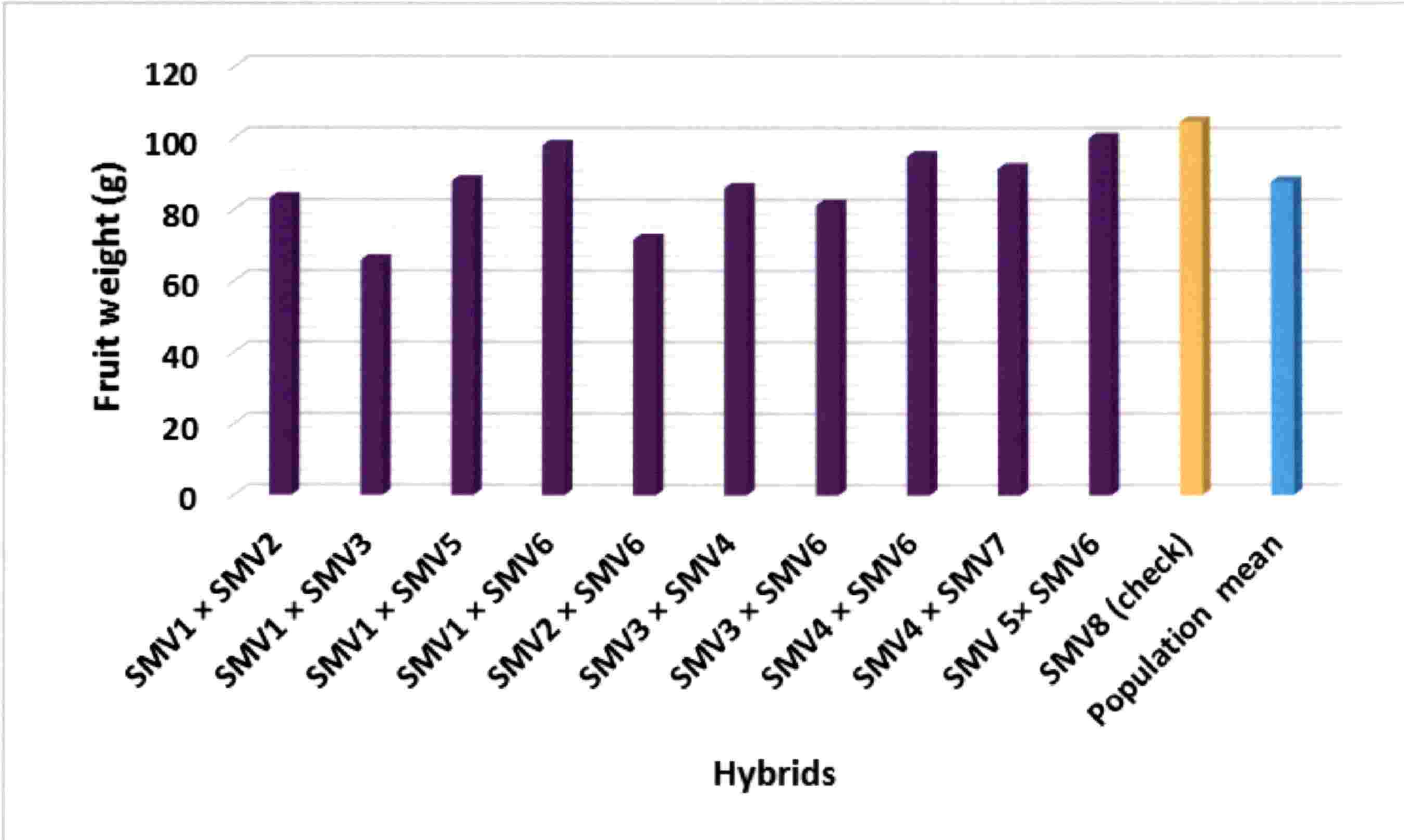

Figure 7. Comparison of fruit weight with check and population mean of 10 hybrids during summer season

findings of Mohanty and Prusuti (2000), Sarma *et al.* (2000), Suneetha *et al.* (2006a), Vadodaria *et al.* (2009a), Chaudhari *et al.* (2015) and Sivakumar *et al.* (2017).

5.2.2.5 Fruit length:

The hybrids with high mean, regression coefficient near unity and non-significant deviation from regression *viz.*, SMV1×SMV2 (μ=13.51, b_i=0.95, S^2_{di}=0.134) and SMV5×SMV6 (μ=14.17, b_i=1.03, S^2_{di}=-0.028) were considered as stable one for this trait. The hybrid SMV1×SMV3 exhibited more than unit value of regression (1.30) and non-significant deviation from regression (-0.016) and hence is suitable for favourable environments, while other genotypes gave unpredictable performance with significant deviations from regression. These findings are in agreement with those of Rai *et al.* (2000), Chaurasia *et al.* (2005), and Sivakumar *et al.* (2017). Bora *et al.* (2011b) also reported similar results that only four genotypes namely *viz.*, White Long Green, PB-67, PB-4 and Pant Samrat were found average responsive across all the environments among the seventeen genotypes evaluated for stability.

5.2.2.6 Fruit girth:

Among the hybrids, SMV1×SMV6 (μ=13.60, b_i=0.87, S^2_{di}=0.166) was considered as stable for fruit girth because of desirable mean, regression coefficient around 'unity' and non–significant deviation from regression making it suitable for cultivation across wide range of environments. Further, the hybrids SMV1×SMV2, SMV1×SMV5, SMV2×SMV6 and SMV4×SMV6 were observed with less than 'unity' regression (0.75, 0.50, 0.85 and 0.80) and non–significant deviation from linearity and hence is suitable for poor environments. SMV3×SMV6 was the only hybrid which expressed regression coefficient greater than one (1.46) and non-significant deviation from linearity (0.103) being suitable for favourable environments. These results are in consonance with Sarma *et al.* (2000), Suneetha *et al.* (2006a), Bora *et al.* (2011b) and Sivakumar *et al.* (2017).

5.2.2.7 Calyx length:

Among the hybrids, SMV5×SMV6 and SMV8 were stable with regression coefficients around unity (0.83, 0.97) and non-significant deviations from linearity (0.0036, 0.0007) and hence suitable for cultivation across different environments. Hybrids SMV1×SMV2 and SMV4×SMV6 were recommended for unfavourable environments due to regression coefficients being less than 'unity'(0.72, 0.50) whereas, SMV1×SMV3 was suitable for favourable environments due to regression coefficient being greater than unity (2.02). Similar results were reported by Dutta *et al.* (2009), Praneetha *et al.* (2011) and Nagappam *et al.* (2017).

5.2.2.8 Yield plant^{-1}:

Among the hybrids studied, four genotypes revealed non-significant deviations from the regression (S^2_{di}) values, which implies that the hybrids were within the range of minimum deviation from regression and so their performance could be predicted. The hybrids *viz*. SMV1×SMV2, SMV5×SMV6 and SMV8 were considered as stable as they recorded high mean than population mean with regression coefficient near unity and non–significant deviation from regression. These hybrids deserve merit as high yielding hybrids for summer season. The hybrid SMV3×SMV4 (μ=1.81, b_i=1.67, S^2_{di}=-0.001) exhibited lower mean with regression coefficient more than unity and non–significant deviation from regression and so was found suitable for rich environment. The hybrids showing unpredictable performance with highly significant deviation from regression were unstable due to wide variation in environment at growing system. A similar result for yield plant^{-1} with respect to stability parameters has been reported by Sarma *et al.* (2000), Vadodaria *et al.* (2009a) and Bora *et al.* (2011b). Prasad *et al.* (2002) evaluated forty-five aubergine inbred lines in three environments for yield attributes of which four inbred lines (CH 303, CH 309, CH 267 and CH 205) showed supremacy in yield and stability. Sivakumar *et al.* (2017) reported that 5 hybrids (Heera x Bhagyamathi, Heera x Gulabi, Heera x Shyamala, Pusa Shyamala x Gulabi and IC 285140 x Bhagyamathi) were found stable and widely adapted with high mean performance, average responsiveness (bi ≈ 1) for fruit yield plant^{-1} and could be utilized for variable environments.

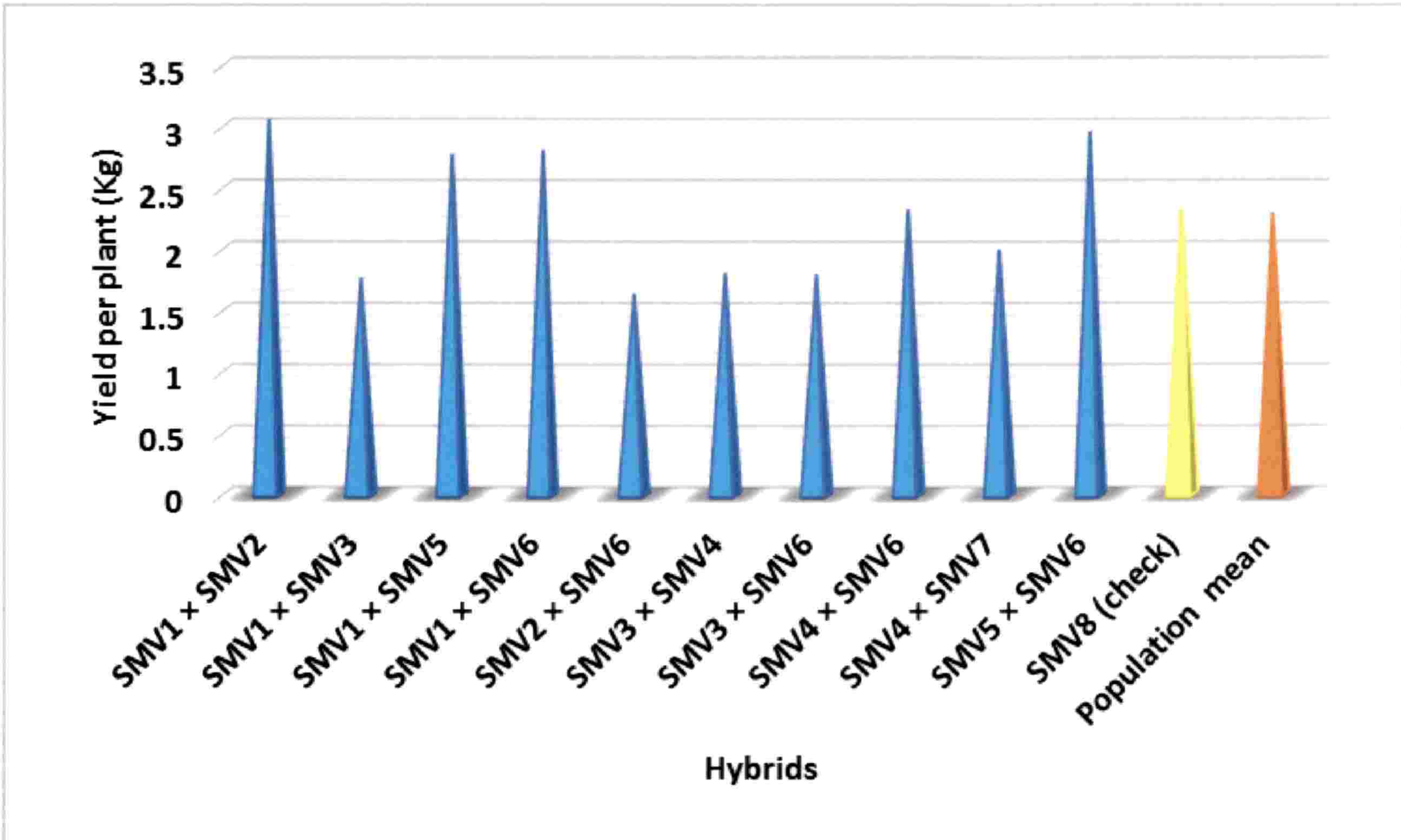

Figure 8. Comparison of yield per plant with check and population mean of 10 hybrids during summer season

5.2.2.9 Yield plot^{1}:

The hybrids with high mean, regression coefficient near 'unity' and non-significant deviation from regression *viz.,* SMV5×SMV6 (μ=57.33, b_i=0.96, S^2_{di}=1.147) and SMV8 (μ=43.58, b_i=1.05, S^2_{di}=1.924) were considered as the stable ones for this trait. Hybrids SMV1×SMV2 (μ=55.76, b_i=0.65, S^2_{di}=3.150) and SMV1×SMV5 (μ=51.35, b_i=0.07, S^2_{di}=-0.674) which recorded high means with less than unity regression coefficients and non–significant deviations from linearity were suitable for poor environments. SMV3×SMV4 and SMV4×SMV6 performed well and were suitable for rich environments due to regression coefficient being greater than unity. This indicates that the genotypes mentioned above were stable in their performance across the environments and less sensitive to environment. The stability of genotypes is directly linked with stability of their component traits *viz.*, fruit weight, number of fruits plant^{-1}, plant height, yield plant^{-1} and yield plot^{-1} for wide and specific adaptability. Similar results were reported by Sarma *et al.* (2000), Prasad *et al.* (2002), Vadodaria *et al.* (2009a), Bora *et al.* (2011b) and Sivakumar *et al.* (2017).

5.2.2.10 Plant height:

Hybrid SMV1×SMV5 (μ=97.11, b_i =1.05, S^2_{di}=-1.057), with regression coefficient near to unity and non–significant deviation from regression was the stable genotype though its height was less when compared to check and population mean. For better environment, the genotypes SMV5×SMV6 (μ=100.49, b_i =1.14, S^2_{di}=1.546) and SMV4×SMV6 (μ=101.16, b_i =1.18, S^2_{di}=1.873) with regression coefficient greater than unity was suitable and for poor environment, only one hybrid *viz.,* SMV4×SMV7 (μ=96.10, b_i=0.34, S^2_{di}=5.752) was better, as it recorded regression coefficient less than unity. In case of other hybrids the performance has been found to be highly unpredictable because of their significant deviations from regression values. These results are in accordance with the findings of Rai *et al.* (2000), Sarma *et al.* (2000), Suneetha *et al.* (2006a) and Bora *et al.* (2011b).

5.2.2.11 Total phenols:

Phenolics are secondary metabolites synthesized by the plant during growth and reproduction and are also produced as a response to environment stress conditions, defense against infection by pathogens and UV radiation (Karakaya, 2004; Naczk and Shahidi, 2004).

During summer season significant difference was found among the eleven hybrids with respect to total phenols across the different environments. Highest total phenol content was recorded in SMV5×SMV6 and lowest was found in SMV4×SMV6 across the different environments. Okmen *et al.* (2009), Boubekri *et al.* (2013), Jose *et al.* (2014), Somavathi *et al.* (2014) and Bhushan and Samnotra (2017b) reported similar results which explained association of higher phenolic content in a particular genotype to shoot and fruit borer resistance.

5.2.2.12 Total sugars:

Total sugar has a strong association with pest and diseases. Higher concentration of sugars in eggplant fruits may act as feeding stimulant in the susceptible varieties.

During summer season significant differences were found among the eleven hybrids with respect to total sugars across the different environments. The hybrid SMV1×SMV5 recorded the highest total sugar content at Vellayani and Sadanandapuram whereas, SMV4×SMV7 recorded the highest total sugar content at Thiruvalla and Kayamkulam and SMV3×SMV4 recorded the lowest across all the locations. Earlier works by Prabhu *et al.* (2009), Kumari *et al.* (2014), Ayaz *et al.* (2015) and Nayak and Pandey (2016) revealed that concentration of feeding stimulants like sugar and protein in the fruits will lead to susceptibility to fruit borer infestation. These results were in agreement with our study.

5.2.2.13 Vitamin C:

Among the eleven hybrids, significant difference was found among the genotypes with respect to Vitamin C content across the different environments. Vitamin C was the highest in SMV8 followed by SMV5×SMV6 while SMV4×SMV6 and SMV4×SMV7 (Sadanadapuram location) recorded the lowest

Kumar and Arumugam, (2013), Chaudhari *et al.* (2015) and Bhushan and Samnotra (2017b). Kandoliya *et al.* (2015) recorded significant variation among genotypes regarding ascorbic acid content ranging between 9.43 and 16.75 mg/100g while evaluating eight brinjal genotypes.

5.2.2.14 Shoot and fruit borer infestation:

Screening of eleven F_1 hybrids for shoot and fruit borer resistance/ tolerance was done based on the extent of damage to shoots and fruits during summer season. The data on damage parameters collected from field experiment across different environments were subjected to statistical analysis. The shoot infestation and fruit infestation by shoot and fruit borer was given under the following headings:

5.2.2.14.1 Shoot infestation percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the shoot infestation percentage from 60 to 100 days after transplanting at 20 days interval and the results are discussed in previous chapter. Wide variation for shoot infestation by shoot and fruit borer was observed among the hybrids between the locations.

The hybrids SMV5×SMV6 and SMV8 were moderately resistant across all environments. SMV1×SMV2 was found moderately resistant at Vellayani and Kayamkulam but tolerant at Thiruvalla and Sadanandapuram. SMV1×SMV3, SMV1×SMV6, SMV3×SMV6 and SMV1×SMV5 were tolerant across all the locations. The hybrids SMV4×SMV6, SMV4×SMV7, SMV3×SMV4, and SMV2×SMV6 were susceptible across all locations. Elanchezhyan *et al.* (2008), Chaudhary and Sharma, (2000), and Behera *et al.* (1999) have reported similar results.

5.2.2.14.2 Fruit infestation percentage:

Shoot and fruit borer was screened for all eleven F_1 hybrids based on the fruit infestation percentage from 80 to 120 days after transplanting at 20 days interval and the results are discussed in previous chapter.

The minimum percentage of fruit infestation was recorded in the hybrid SMV5×SMV6 followed by SMV8 across all the locations. SMV1×SMV2 and SMV1×SMV5 were found to be tolerant at three locations except Sadanandapuram. Highest fruit infestation was noticed in SMV4×SMV7 was highly susceptible across all environments. The rest of the hybrids were found susceptible with medium infestation to fruits by shoot and fruit borer. Results in conformity with the above have been reported by Khan and Singh (2014), Nayak *et al.* (2014), Malik and Rishipal, (2013), Naqvi *et al.* (2009), Elanchezhyan *et al.* (2008), Chandrashekhar *et al.* (2008) and Chaudhary and Sharma, (2000).

5.2.2.15 Bacterial wilt incidence:

Screening of 11 F_1 hybrids for bacterial wilt resistance/ tolerance was done based on percentage of plants wilted. The data on number of plants wilted at 90 DAT was collected from field experiment across different locations.

Among the hybrids, SMV5×SMV6, SMV8, SMV1×SMV2, SMV1×SMV6, SMV1×SMV3, SMV1×SMV5 and SMV2×SMV6 were resistant with less percentage of plants wilted. SMV3×SMV4, SMV3×SMV6 and SMV4×SMV6 were moderately resistant across all environments. Hybrid SMV4×SMV7 recorded higher percentage of plants wilted and was most susceptible across all locations. Similar observations have been made by Bora *et al.* (2011a), Kumar *et al.* (2014), Bhavana and Singh (2016) and Yadav *et al.* (2017).

5.3 EVALUATION OF SEGREGATING GENERATIONS (F_2 POPULATION)

Genetic variability for yield and yield contributing traits in the base population is essential for successful crop improvement. (Allard, 1960). The larger the variability, the better is the chance of identifying superior genotypes. The analysis of variance conducted for four F_2 families of brinjal showed significant differences among the progenies for the different characters studied. This clearly showed that families were different from each other. Identification of superior F_2 progenies is useful in further improvement programmes.

Early flowering is a desirable attribute. SMV5×SMV6 (F_2) was the earliest to bloom and SMV1×SMV6 (F_2) took maximum days to flower. SMV5×SMV6 (F_2) took the minimum number of days to first harvest and SMV1×SMV6 (F_2) took maximum number of days to first harvest. Number of fruits plant^{-1} varied from a minimum of 17.13 (SMV5×SMV6) to a maximum of 28.00 (SMV1×SMV2) and the difference was significant in F_2 population. Maximum individual fruit weight within F_2 population was recorded in the SMV5×SMV6 (80.80 g) and minimum in SMV1×SMV5 (60.20 g). The F_2 populations differed significantly with respect to fruit length which ranged from 12.06 cm in SMV1×SMV2 to 15.06 cm in SMV5×SMV6. Girth of fruit ranged from 9.36 cm (SMV1×SMV2) to 12.81 cm (SMV1×SMV6) in F_2 population. Calyx length varied from SMV1×SMV5 (2.84 cm) to SMV5×SMV6 (3.22 cm) in segregating generation (F_2). Minimum yield plant^{-1} was recorded in SMV1×SMV5 (1.73 kg) while maximum yield plant^{-1} was attained by SMV1×SMV6 (1.86 kg) followed by SMV1×SMV2 (1.83 kg) segregating individuals. Yield plot^{-1} recorded significant difference among the four F_2 families. Yield plot^{-1} ranged from 22.47 kg (SMV1×SMV6) to 29.23 kg (SMV1×SMV2). SMV5×SMV6 was the tallest (114.13 cm) Segregant among the F_2 families and SMV1×SMV6 (94.00 cm) was the shortest in plant height. These results of various yield attributes is in accordance with the findings of Kamani and Monpara (2007), Prabhu *et al*. (2007), Ram and Singh (2007), Dhameliya and Dobariya (2008), Prasad *et al.* (2010) and Chattopadhyay *et al.* (2011), Thangavel *et al*. (2011) and Dhaka and Soni (2012).

5.4 MOLECULAR CHARACTERIZATION OF HYBRIDS AND THEIR PARENTS

The genuineness of the variety is one of the most important characteristics of good quality seed. Genetic purity test is done to verify any deviation from genuineness of the variety during its multiplications. Genetic purity test is compulsory for seed certification of all foundation and certified hybrid seeds.

Higher genetic purity is an essential prerequisite for the commercialization of any hybrid seeds. Besides, success of any hybrid technology depends on the availability of quality seed supplied in time at reasonable cost. The genetic purity during multiplication stages is prone to contaminate due to the presence of pollen shedders, out crossing with foreign pollen etc. besides physical admixtures. Thus use of seeds with low genetic purity results in segregation of the traits, lower yields and genetic deterioration of varieties.

Traditional GOT based on morphological markers are time consuming and are environmental dependent. To overcome this disadvantage, the molecular markers are being used in many of the crops. However, due to repeatability of the results and accuracy of the obtained results are under question. This made a way for use of molecular markers particularly the co-dominant markers. The SSR markers are of great importance for rapid assessment of hybrid and parental line seed purity (Yashitola *et al.,* 2002, Antonova *et al.,* 2006 and Pallavi *et al*., 2011).

SSR marker was first developed for brinjal by Nunome *et al.* 2003 where they confirmed the usefulness of these markers for genetic analysis that could facilitate marker assisted breeding. A variety of DNA markers are now available in brinjal for phylogenetic interpretations, fingerprinting of cultivars and marker assisted selection. (Doganlar *et al.,* 2002, Nunome *et al.,* 2003, 2009 Tiwari *et al.,* 2009, Chao *et al.,* 2010, Barchi *et al.,* 2011, Fukuoka *et al.,* 2012, Verma *et al.,* 2012). Hence the study was undertaken with the objective of identifying SSR markers that can be used to confirm hybridity of brinjal hybrids.

A good quality genomic DNA is a prerequisite for doing molecular maker analysis. The CTAB method (Doyle and Doyle, 1987) used in this study was satisfactory for DNA extraction from all the parents and F_1 progeny. The quality of DNA was good with A260/A280 values ranging between 1.71 and 2.42. The concentration of DNA ranged between 350and 3540 ng/μl.

SSR has technological simplicity, high efficiency and needs small amount of genomic DNA. The present study utilized the SSR marker techniques for identification of brinjal hybrids from their parental lines. Among the 4 SSR markers used in this study, three (*viz.*emb01M15, eme08D09 and CSM31) clearly distinguished the parental lines of hybrids (SMV3×SMV4 SMV3×SMV6, SMV4×SMV7, SMV5×SMV6, SMV1×SMV5, SMV1×SMV2, SMV2×SMV6 and SMV4×SMV6) studied and were found to be useful in testing the genetic purity of hybrids and their parental lines. Remaining one marker (emd05F05) was found to be monomorphic among the parental lines and hybrids studied.

Marker emb01M15 amplified two alleles in the range of 260 to 230 bp among four hybrids (SMV3×SMV4 SMV3×SMV6, SMV4×SMV7 and SMV5×SMV6). The hybrid SMV3×SMV4 resulted in heterozygous profile and was clearly distinguished from its parental lines. Hybrids (SMV3×SMV6, SMV4×SMV7 and SMV5×SMV6) shared bands from their parental lines. However, the F_1 hybrid exhibited both the alleles of the parents confirming the heterozygosity condition. Marker emb01M15 was identified as the effective primer to distinguish F_1 hybrid from its parental lines.

Marker eme08D09 amplified two alleles in the range of 290 to 220 bp, which was useful in ensuring the genetic purity of three hybrids *viz.* SMV1×SMV5, SMV1×SMV2 and SMV4×SMV6, whereas the marker failed to distinguish the hybrids SMV2×SMV6 and SMV5×SMV6 from its parental lines.

Marker CSM31 was useful in testing the genetic purity of hybrid SMV2×SMV6 by amplifying two alleles in the range of 300 to 220 bp. The hybrid shared bands from both the parents where, the female parent SMV2 produced one amplicon at 220 bp and male parent SMV6 produced two amplicons at 300 and 220 bp.

None of the SSR markers screened was found to be suitable for ensuring the genetic purity of brinjal hybrids SMV1×SMV3 and SMV1×SMV6. This could be because of the fact that the SSR markers used in the present study are less in number and does not provide genome wide coverage, due to which they failed in capturing the observed phenotypic variation at DNA level. This calls for further screening of more number of brinjal SSR markers providing uniform coverage across the genome. In brinjal, the available genomic markers (genomic SSRs and EST-SSRs) are limited in number in comparison to other crops such as rice where 5,700 to 10,000 markers are available which are distributed uniformly throughout the genome (Temnykh *et al.,* 2000). Hence there is a need for development of marker resources providing high density coverage, which can be utilised for testing genetic purity as well as marker assisted selection applications in binjal.

Thus emb01M15, eme08D09 and CSM31 were effective in the present study for identification of parents and hybrids. Similar findings on identification of SSR markers for the molecular characterization of hybrids in brinjal have been reported by Khorsheduzzaman *et al.* (2008), Kumar *et al.* (2014), Jha *et al.* (2016) and Mangal *et al.* (2016). However the relevance of the entire set of three markers cannot be undermined as they can be effectively used to differentiate future eggplant hybrids from these existing hybrids.

From the findings and discussions made so far it may be said that any generalization regarding stability of genotypes for all the characters is too difficult since the genotypes may not simultaneously exhibit uniform responsiveness and stability patterns for all the characters. (Singh and Singh, 1980). The present investigation revealed that the hybrids Wardha local × Palakurthi local (SMV1 × SMV2) and Swetha × Vellayani local (SMV5 × SMV6) were stable and widely adaptaed over different locations and seasons with respect to yield and yield attributing characters. The hybrids Wardha local × Palakurthi local, Swetha × Vellayani local and Neelima recorded minimum infestation of shoot and fruit borer and was found resistant to bacterial wilt also. SSR markers, emb01M15 and eme08D09 were effective in the present study for identification of parents and hybrids.

Summary

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6. SUMMARY

The present investigation entitled "Stability analysis and molecular characterization of F_1 hybrids in brinjal (*Solanum melongena* L.)" was carried out during 2015-16 and 2016-17 under four locations *viz.*, Vellayani, Thiruvalla, Sadanandapuram and Kayamkulam in Kerala for assessing stability performance of eleven brinjal hybrids over different locations and seasons and to confirm the hybridity using SSR markers. The individual experiments were conducted in randomized block design with four replications. Stability parameters were worked out using the model given by Eberhert and Russell (1966). Furthermore, evaluation of segregating generations (F_2) for yield attributes was conducted. The results obtained have been discussed in the preceding chapter in light of the available literature and salient findings of the present investigation are described as under:

- Analysis of variance for individual locations showed significant difference among the genotypes for all the characters in all the environments which revealed the presence of genetic variability among the genotypes.
- Pooled analysis of variance revealed significant differences among the genotypes, environments and genotype × environment interaction for all the characters studied. The presence of significant interactions indicated the differential response of genotypes to various environment conditions. Hence further analysis was done to test the stability of genotypes.
- The mean squares due to Environments + (Genotype x Environment) were significant for the characters *viz.*, days to first harvest, number of fruits plant^{-1}, fruit weight, fruit girth, yield plant^{-1} and yield plot^{-1} which depicts the existence of genotype × environment interaction during *kharif* season and also resulted significance for the characters *viz.*, days to first flowering, days to first harvest, fruit girth, calyx length and yield plant^{-1} during summer season. Sum of squares due to E + (G x E) was further partitioned into that of Environment (linear), Genotype x Environment (linear) and pooled deviation. Mean squares showed that environment (linear) differed significantly and were quite diverse in their effects on the performance of

the genotypes across four locations and both seasons. Variance of Genotype x Environment (linear) when tested against pooled deviation was significant for days to first harvest however was found to be non-significant for the rest of the traits. Pooled deviation (non-linear component) variances were significant for all characters across four locations and both seasons suggesting importance of both linear and non-linear components. The mean performance of a genotype along with two parameters *viz.*, regression coefficient (bi) and deviation from regression (S^2di) considered simultaneously represents a measure of adaptability of the genotype

- In *kharif* season, the hybrid Wardha local × Palakurthi local (SMV1×SMV2) was observed to be stable and widely adapted to all environments for days to first flowering, number of fruits plant^{-1}, fruit weight, fruit length, fruit girth, calyx length, yield plant^{-1}, yield plot^{-1} and plant height as indicated from high mean values, regression coefficient equal to unity and non-significant deviation from regression. The hybrid Surya × Vellayani local (SMV3×SMV6) was found to be suited for poor environments with regression coefficient lower than unity and non-significant deviation from regression for days to first flowering. Hybrid NBR-38 × Vellayani local (SMV4×SMV6) was stable for favourable environments with high mean values, regression coefficient greater than unity and non-significant deviation from regression for days to first harvest. The hybrid Wardha local × Swetha (SMV1×SMV5) was identified as stable with regard to fruit weight, yield plant^{-1} and yield plot^{-1}. The hybrid Wardha local × Vellayani local (SMV1×SMV6) was identified as stable in favourable environments with regard to fruit length, yield plant^{-1} and yield plot^{-1}.
- Stability analysis for the summer season crop also revealed the hybrid Wardha local × Palakurthi local (SMV1×SMV2) as stable across all environments with respect to days to first flowering, days to first harvest, number of fruits plant^{-1}, fruit weight, fruit length and yield plant^{-1}. Swetha × Vellayani local (SMV5×SMV6) hybrid was stable across all

environments with regard to days to first harvest, fruit weight, fruit length, calyx length, yield plant^{-1}, yield plot^{-1} and plant height. Hybrid Wardha local × Surya (SMV1×SMV3) exhibited stability for rich environments with regard to days to first flowering. The hybrids Wardha local × Swetha (SMV1×SMV5) and Wardha local × Vellayani local (SMV1×SMV6) were found stable across all environments with regard to days to first harvest. The hybrid Surya × NBR-38 (SMV3×SMV4) was found stable with respect to yield plant^{-1}, yield plot^{-1} and plant height for favourable environments.

- Biochemical characters *viz.*, total phenols, total sugars and vitamin C content and biotic stress traits *viz.*, shoot and fruit borer infestation and bacterial wilt incidence were recorded for the eleven hybrids in *kharif* and summer seasons across four locations. On the basis of overall mean performance of hybrids, results illustrated that the hybrid Swetha × Vellayani local (SMV5×SMV6) recorded the highest values for total phenols and the hybrid NBR-38 × Vellayani local (SMV4×SMV6) recorded the lowest values. Total sugar content was highest in Wardha local × Swetha (SMV1×SMV5) and NBR-38 × Selection Pooja (SMV4×SMV7) and lowest in Surya × NBR-38 (SMV3×SMV4). The hybrid Neelima (SMV8) and Swetha × Vellayani local (SMV5×SMV6) recorded higher quantity of vitamin C and NBR-38 × Vellayani local (SMV4×SMV6) and NBR-38 × Selection Pooja (SMV4×SMV7) recorded the lowest values. The hybrids Wardha local × Palakurthi local (SMV1×SMV2), Swetha × Vellayani local (SMV5×SMV6) and Neelima (SMV8) recorded minimum infestation of shoot and fruit borer and was found resistant to bacterial wilt also.
- Hybrids and their parental lines were characterized using SSR markers. Among the four markers studied, three markers *viz.*, emb01M15, eme08D09 and CSM31 were found to be polymorphic among the parental lines of respective hybrids *viz.*, Surya × NBR-38 (SMV3×SMV4), Surya × Vellayani local (SMV3×SMV6), NBR-38 × Selection Pooja (SMV4×SMV7), Swetha × Vellayani local (SMV5×SMV6), Wardha local × Swetha (SMV1×SMV5), Wardha local × Palakurthi local

(SMV1×SMV2), Palakurthi local × Vellayani local (SMV2×SMV6) and NBR-38 × Vellayani local (SMV4×SMV6) which could be used for ensuring the genetic purity of respective parental lines and hybrids.

- F_2 families *viz*., Wardha local × Palakurthi local (SMV1×SMV2), Wardha local × Swetha (SMV1×SMV5), Wardha local × Vellayani local (SMV1×SMV6) and Swetha × Vellayani local (SMV5×SMV6) were selected on the basis of yield performance from F_1 for further evaluation. F_2 populations revealed that family Wardha local × Palakurthi local (SMV1×SMV2) and Wardha local × Vellayani local (SMV1×SMV6) were superior in yield performance and yield attributing characters.

The present investigation revealed that the hybrids Wardha local × Palakurthi local (SMV1×SMV2) and Swetha × Vellayani local (SMV5×SMV6) were stable and widely adaptaed over different locations and seasons and the hybridity was confirmed with the SSR markers, emb01M15 and eme08D09. The hybrids which recorded minimum infestation of shoot and fruit borer and was found resistant to bacterial wilt also can be further used in future breeding programmes to develop resistant varieties and identify the gene responsible for expression of resistance. The superior hybrids identified in the present study can be further promoted to farm trials before releasing them as variety and also can be recommended for general cultivation in south zone of Kerala.

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Appendix I

CTAB Extraction Buffer

NaEDTA (PH 8.0)	0.5M
Tris HCL (PH 8.0)	1M
CTAB	10%
NaCl	4M
PVP	0.1% w/v
Sodium metabisulphite	0.1% w/v
β Mercatoethanol	1% v/v

TE Buffer

Tris-HCL (p^H 8.0)	10mM
EDTA (p^H 8.0)	1mM

50X TAE Buffer

Tris base	242g
Glacial acetic acid	5.71 ml
0.5M EDTA (P^H 8.0)	100ml

Gel loading buffer

Bromophenol blue	0.25% w/v
Glycerol	30%v/v
Sterile water	70%v/v

STABILITY ANALYSIS AND MOLECULAR CHARACTERIZATION OF F_1 HYBRIDS IN BRINJAL (*Solanum melongena* L.)

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ABSTRACT

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ABSTRACT

Stability analysis helps in assessing genotype × environment interaction in order to identify stable genotypes in large multi-environment trials. Therefore the present study entitled "Stability analysis and molecular characterization of F_1 hybrids in brinjal (*Solanum melongena* L.)" was carried out to evaluate ten hybrids along with one check across four locations. The locations selected for trials were College of Agriculture, Vellayani and farmer's fields at Thiruvalla, Sadanandapuram and Kayamkulam in Kerala. The trial seasons were *kharif* (2015-16) and summer (2016-17). The objective was to study the performance of superior hybrids over different locations and seasons from heterotic crosses of brinjal and to confirm the hybridity using SSR markers. Randomized block design with four replications was employed. Stability and adaptability of yield and yield attributing characters of hybrids were analysed by Eberhart-Russell model (1966).

Pooled analysis of variance revealed significant differences among the genotypes, environments and genotype × environment interaction for all the characters studied. The indication was that the hybrids responded differently to changes in the environment. Promising hybrids were identified on the basis of stability parameters *viz*., overall mean, regression coefficient (b_i) and deviation from regression (S^2_{di}).

In *kharif* season, the hybrid Wardha local × Palakurthi local was observed to be stable and widely adapted to all environments for days to first flowering, number of fruits plant^{-1}, fruit weight, fruit length, fruit girth, calyx length, yield plant^{-1}, yield plot^{-1} and plant height. The hybrid Wardha local × Swetha was identified as stable with regard to fruit weight, yield plant^{-1} and yield plot^{-1}. The hybrid Wardha local × Vellayani local was identified as stable for favourable environments with regard to fruit length, yield plant^{-1} and yield plot^{-1}. The hybrid Surya × Vellayani local was found stable for poor environments with regard to days to first flowering.

Stability analysis for the summer season crop also revealed the hybrid Wardha local × Palakurthi local as stable across all environments with respect to

days to first flowering, days to first harvest, number of fruits plant^{-1}, fruit weight, fruit length and yield plant^{-1}. Swetha × Vellayani local hybrid was stable across all environments with regard to days to first harvest, fruit weight, fruit length, calyx length, yield plant^{-1}, yield plot^{-1} and plant height. The hybrid Surya × NBR-38 was found stable with respect to yield plant^{-1}, yield plot^{-1} and plant height for favourable environments.

Qualitative characters *viz.*, total phenols, total sugars and vitamin C content and biotic stress traits *viz.*, shoot and fruit borer infestation and bacterial wilt incidence were recorded for the eleven hybrids in *kharif* and summer season in all four locations. On the basis of overall mean performance of hybrids, results illustrated that the hybrid Swetha × Vellayani local recorded the highest values for total phenols and the hybrid NBR-38 × Vellayani local recorded the lowest values. Total sugar content was highest in Wardha local × Swetha and NBR-38 × Selection Pooja and lowest in Surya × NBR-38. The hybrid Neelima and Swetha × Vellayani local recorded higher quantity of vitamin C and NBR-38 × Vellayani local and NBR-38 × Selection Pooja recorded the lowest values. The hybrids Wardha local × Palakurthi local, Swetha × Vellayani local and Neelima recorded minimum infestation of shoot and fruit borer and was found resistant to bacterial wilt also.

Hybrids and their parental lines were characterized using SSR markers. Among the four markers studied, three markers *viz.*, emb01M15, eme08D09 and CSM31 were found to be polymorphic among the parental lines of respective hybrids *viz.*, Surya × NBR-38, Surya × Vellayani local, NBR-38 × Selection Pooja, Swetha × Vellayani local, Wardha local × Swetha, Wardha local × Palakurthi local, Palakurthi local × Vellayani local and NBR-38 × Vellayani local which could be used for ensuring the genetic purity of respective parental lines and hybrids.

F_2 families *viz.*, Wardha local × Palakurthi local, Wardha local × Swetha, Wardha local × Vellayani local and Swetha × Vellayani local were selected on the basis of yield performance from F_1 for further evaluation. F_2 populations revealed that family Wardha local × Palakurthi local and Wardha local × Vellayani local were superior in yield performance and yield attributing characters.

The present investigation revealed that the hybrids Wardha local × Palakurthi local and Swetha × Vellayani local were stable and widely adapted over different locations and seasons and the hybridity was confirmed with the SSR markers, emb01M15 and eme08D09.