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A Study on Floral Morphology of Brinjal Genotypes in Gangetic-Alluvial Zone of West Bengal, India

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A B S T R A C T

The present experiment was conducted during autumn-winter seasons 2014-2015 and 2015-2016 at Bidhan Chandra Krishi Viswavidyalaya, West Bengal to study the floral morphology, anthesis-full bloom-anther dehiscense-stigma receptivity, parthenocarpy and other floral characters of eggplant. Twenty one brinjal genotypes were used for this experiment with a randomized block design with three replications. The least time required for flower bud initiation was in the genotype BCB-16 (40.83 DAT) and highest in BCB-1 (58.17 DAT). The maximum days required for 50% plants to be flowered has been reported in BCB-13 (68.33 DAT) and minimum in BCB-22 (50.50 DAT). The highest ratio of (LS+MS): (PS+SS) flowers has been recorded in the genotype BCB-10 (11.52) followed by BCB-8(10.33) and lowest in BCB-11(0.56). Ovary diameter and weight were much higher in the long styled flowers than the rest. Anthesis starts earliest in BCB-18 (6:14 a.m.) and latest by 7:51 a.m. in BCB-11. Full bloom stage generally occurred from 6:50 a.m. (BCB-17) to 8:52 a.m. (BCB-15) and anther dehiscence ranged from 7:00 a.m. (BCB-17) to 9:20 a.m. (BCB-15). Parthenocarpic fruit set was noted only in BCB-6, BCB-11, BCB-14, BCB-15 and BCB-16. The propensity to parthenocarpic fruit set is low in brinjal.

Introduction

Brinjal, eggplant or aubergine (*Solanum melongena* L.) is the most popular and widely cultivated warm season vegetable crop in the central, southern and south-east Asia. Study of floral biology has great importance in plant breeding and hybrid seed production. Flowering in brinjal is extra-axilliary and the pattern of flowering is commonly of three types namely, solitary, cluster (cyme) and mixed and it is the most crucial factor determining the yield of cultivated eggplants. Genotype, as well as environmental factors also influences eggplant flowering and the flower morphology, especially the style length which determines fruit set. According to Passam and Bolmatis (1997), the style length in eggplant is a varietal characteristic. Eggplant has 4 types of flowers viz. 1) long styled with large ovary, 2) medium styled with medium sized ovary, 3) pseudo short-

styled with rudimentary ovary, and 4) true-short-styled with very rudimentary ovary. Heterostyly in brinjal determines and facilitates self or cross-pollination and subsequent fruit set. It played an important role in augmenting genetic diversity in *melongena* cultivars through partial cross-pollination occurring in nature, though it is basically an autogamous crop. Long styled flowers (the stigma is above the stamen) or medium styled flowers (stigma is on the same level as the stamen) are always more appreciable in the number than pseudo and short-styled flowers (the stigma is below the stamen). Pseudo and short-styled flowers fail to set fruits, whereas long and medium-styled flowers produce fruits, but short-styled flowers are not totally sterile (Chen, 2001). Nothmannet *et al.,* (1983) stated that stylar heteromorphism affected fruit set more than did the position of the flower in the cluster. Passam and Bolmatis (1997) stressed that the proximity of the stigma to the anther pores at anthesis influences fruit set, fruit size and seed content, but not seed quality. Fruit weight and seed formation were maximal in flowers with the stigmata at maturity situated close to the anther pores.

Materials and Methods

The present experiment was conducted during autumn-winter seasons 2014-2015 and 2015-2016 at the AB Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal. Average temperature and relative humidity of first year were 25.3°C and 72.94% and in second year it was 25.7°C and 76.44%. Twenty one brinjal genotypes were used for this experiment (Table-1). Present investigation was carried out in a randomized block design with three replications. Randomly five plants from each genotype were taken for recording observations in each replication. Mean data pooled over the years has been furnished and statistically analyzed for all the characters. Mean sum of square is calculated for both the years and the higher value has been divided by the lower one. If this value (F cal) remains lower than the F tab value, it indicates sufficient homogeinity between two seasons and the pool data have been furnished. Five buds per genotype in each replication were tagged to record observations. Anther dehiscence was recorded by visual observation of presence of pollens on the apical pore of the anther by means of a magnifying glass. Two seasons' average data have been furnished. After hand pollination stigma receptivity was studied by fruit set method with viable fresh pollen in two ways viz.1. Three hour interval on the day of anthesis. 2. Daily interval from 6 days before anthesis to 2 days after anthesis and this phenomenon was conducted for 3 genotypes namely BCB-3 (oval type), BCB-9 (round type) and BCB- 11 (long type). Twenty flowers per genotype for each stage has been hand pollinated (emusculation-pollination-bagging) and resulted fruit setting was counted for calculation of stigma receptivity. Parthenocarpy was tested by two ways viz. a) clipping off the stigmatic head in the early morning of the day of anthesis and b) emasculation of anthers day before anthesis. Five flowers per replication of every genotype for each of the two ways were studied for parthenocarpic fruit set.

Results and Discussion

Flower bud initiation (Days after Transplanting)

Though flower initiation of brinjal is a varietal character, it also influenced predominantly by temperature and high humidity. Quagliotti (1979) opined that it generally takes about 55-110 DAS to first flowering in eggplant. But in this experiment, the least time required for flower bud initiation was reported in BCB-16 (40.83

DAT) followed by BCB-27 (41.17 DAT) and BCB-22 (41.83 DAT) and they were, however, statistically *at par* (Table-2). The maximum days required for flower bud initiation has been noticed in case of BCB-1 (58.17 DAT) followed by BCB-14 (56.00 DAT), BCB-15 (55.17 DAT) and BCB-9 (54.00 DAT). Similar work has been done by Gavade and Ghadge (2015), but Dhaka and Soni (2012) reported 69.60 days for first flowering.

50% Flowering (Days after transplanting)

The minimum time required for 50% plants to flower (Table-2), was in BCB-22 (50.50 DAT) followed by BCB-12 (51.17 DAT), BCB-10 (51.33 DAT), BCB-21 (51.50 DAT) and BCB-3 (51.83 DAT) and they were, however, statistically *at par*. The maximum days required for this has been reported in BCB-13 (68.33 DAT) followed by BCB-9 (66.50 DAT), BCB-11 (65.33 DAT), BCB-1 (65.13 DAT) and BCB-18 (64.00 DAT) and there was no significance difference among them. The present findings are in consonance with the results obtained by Vandana *et al.*, (2014), Vidhya and Kumar (2015).

Total flowering period (days)

Table-2 clearly showed that BCB-8 has the highest total flowering periods (133.10 days) followed by BCB-12 (113.69 days) and BCB-27 (109.72 days). The genotype BCB-16 was reported as lowest total flowering period (86.67 days) followed by BCB-2 (92.42 days), BCB-4 (94.20 days), BCB-15 (96.17) and BCB-14 (99.00 days).

Ratio of productive and non-productive flowers

The highest ratio of (LS+MS): (PS+SS) flowers (Table-2) has been recorded in the genotype BCB-10 (11.52) followed by BCB-8(10.33) and lowest in BCB-11(0.56) followed by BCB-18(0.85). In 2010, Pandit *et al.*, reported that the higher the ratio of long-style and medium-style flowers to non-productive flowers (i.e. pseudo-short and true short style flowers), better will be the fruit set in brinjal.

Anther, Style and ovary character

A comparison of anther and style length along with ovary characters have been furnished in Tables-3 and 4. Anther lengths correspond with that of style lengths in all the four types of brinjal flowers. Quite obviously ovary diameter and weight were much higher in the long styled flowers than the rest. Heterostyly in brinjal determines and facilitates self or cross-pollination and subsequent fruit set.

Long and peristyly conditions set fruits. In other words, style lengths longer than the anther tips or at around the peripherals of the anther sacs can set fruits. The unfruitfulness of the short styled flowers under natural conditions may be due to their very low ovary diameter and ovary weight. In the present investigation, ovary diameter of the long styled flowers were noted to be almost three times highly than the short styled flowers, on an average. The actual reasons for heterostyly and development of ovary up to rudimentary scale are yet to be explained. Passam and Bolmatis (1997) achieved the highest percentage of fruit set from flowers with long style and medium style pistils.

Domestication, mutation, natural out-crossing, natural selection and human selection, particularly hybridization all have created immense genetic diversity in the cultivated brinjal. Heterostyly played an important role in augmenting genetic diversity in *melongena* cultivars through partial cross-pollination occurring in nature, though it is basically an autogamous crop.

Table.1 Name and source of the genotypes

Symbol	Name	Source
BCB- 1	Sada local	Banamalipara, Nadia, West Bengal
BCB- 2	Makra	Kanthaltala, Nadia, West Bengal
BCB- 3	Makra mid-long	Madanpur, Nadia, West Bengal
BCB- 4	Daab begun	Kalyani, Nadia, West Bengal
BCB- 5	Thubi	Kalyani, Nadia, West Bengal
BCB- 6	Bhangar	Ghoragacha, Nadia, West Bengal
BCB- 7	Gola	Chakdaha, Nadia, West Bengal
BCB- 8	Hajari	Tekkali, Andhra Pradesh
BCB- 9	Debgiri	Barasat, North 24 Parganas, West Bengal
BCB- 10	Simanta	Bhootta bazaar, Kalyani, Nadia, West Bengal
BCB- 11	Sada lamba	Bangaon, N-24 Pgs, West Bengal
BCB- 12	Kranti	New Delhi
BCB- 13	Anubhav	New Delhi
BCB- 14	Tara	New Delhi
BCB- 15	Purushottom	Raipur, Chattishgarh
BCB- 16	Purple round	New Delhi
BCB- 17	Kooli	Balagarh, Hooghly, West Bengal
BCB- 18	Utkal	Bhubeneswar, Odissa
BCB- 21	Jhuri	Basantapur, Nadia, West Bengal
BCB- 22	Makra mid	Haringhata, Nadia, West Bengal
BCB- 27	Kalyani	Kalyani market, West Bengal

Table.2 Flower bud emergence, flowering span and ratio of productive and Non-productive flowers

Genotype	Floral bud emergence (DAT)	Days to 50% flowering (DAT)	Total flowering period (Days)	(LS+MS) : (PS+SS)
BCB-1	58.17	65.13	105.12	1.92
BCB-2	49.50	61.08	92.42	7.40
BCB-3	42.00	51.83	117.97	5.89
BCB-4	42.33	54.00	94.20	6.87
BCB-5	43.33	62.00	119.63	1.92
BCB-6	50.33	58.17	112.93	7.28
BCB-7	46.67	57.17	105.13	7.83
BCB-8	49.00	54.00	133.10	10.33
BCB-9	54.00	66.50	102.38	8.72
BCB-10	42.83	51.33	100.10	11.52
BCB-11	45.67	65.33	110.77	0.56
BCB-12	42.67	51.17	126.63	3.48
BCB-13	51.83	68.33	100.42	7.05
BCB-14	56.00	60.50	99.00	1.32
BCB-15	55.17	59.67	96.17	3.21
BCB-16	40.83	55.50	86.67	1.35
BCB-17	43.00	58.50	106.27	4.48
BCB-18	50.00	64.00	100.83	0.85
BCB-21	45.33	51.50	123.62	2.47
BCB-22	41.83	50.50	118.00	3.18
BCB-27	41.17	57.33	120.83	2.96
SEm(±)	1.41	1.24	2.44	0.92
CD(0.05)	3.95	3.48	6.83	2.62

Table.3 Anther and style length

Genotype	Anther length (mm)				Style length (mm)			
	LS	MS	PS	SS	LS	MS	PS	SS
BCB-1	12.48	-	-	8.99	11.39	-	-	0.74
BCB-2	12.96	-	-	11.59	9.84	-	-	1.51
BCB-3	11.59	12.77	10.48	9.17	9.34	8.7	2.73	1.7
BCB-4	-	12.54	-	4	-	10.09	-	2.28
BCB-5	10.93	-	-	10.35	10.12	-	-	1.42
BCB-6	11.82	-	-	-	11.42	-	-	-
BCB-7	13.73	13.34	-	12.96	10.87	10	-	2.14
BCB-8	11.48	11.88	-	-	11.01	10.87	-	-
BCB-9	12.35	-	-	-	11.27	-	-	-
BCB-10	13.57	-	13.24	-	9.77	-	7.53	-
BCB-11	13.62	-	-	11.08	10.41	-	-	2.39
BCB-12	10.98	12.82	-	9.96	10.79	9.55	-	1.65
BCB-13	12.32	10.65	-	-	9.08	8.92	-	-
BCB-14	10.61	-	-	10.57	13.23	-	-	2.2
BCB-15	-	12.02	-	-	-	11	-	-
BCB-16	9.82	-	9.25	8.38	7.94	-	3.44	1.52
BCB-17	12.73	-	-	10.16	12.33	-	-	3.6
BCB-18	12.31	-	-	-	13.53	-	-	-
BCB-21	8.82	-	9.3	-	9.65	-	2.86	-
BCB-22	9.79	-	-	-	9.96	-	-	-
BCB-27	9.74	-	9.84	-	8.76	-	3.69	-

Table.4 Ovary characters

Genotype	Ovary Diameter(mm)				Ovary Weight(g)			
	LS	**MS**	**PS**	**SS**	**LS**	**MS**	**PS**	**SS**
BCB-1	5.41	-	-	1.95	0.0912	-	-	0.00695
BCB-2	6.93	-	-	2.16	0.195	-	-	0.006
BCB-3	5.12	4.77	4.42	1.42	0.1	0.09	0.06	0.01
BCB-4	-	6.15	-	4.05	-	0.157	-	0.0099
BCB-5	4.48	-	-	1.36	0.0507	-	-	0.0016
BCB-6	6.5	-	-	-	0.1173	-	-	-
BCB-7	5.72	5.03	-	3.74	0.1774	0.1053	-	0.0239
BCB-8	3.14	4.14	-	-	0.09	0.04	-	-
BCB-9	6.07	-	-	-	0.1281	-	-	-
BCB-10	6.8	-	5.23	-	0.1989	-	0.077	-
BCB-11	4.7	-	-	1.95	0.11	-	-	0.01
BCB-12	3.6	3.25	-	1.3	0.0313	0.039	-	0.0007
BCB-13	4.73	4.74	-	-	0.10385	0.06	-	-
BCB-14	2.46	-	-	1.98	0.02	-	-	0.0026
BCB-15	-	4.03	-	-	-	0.0698	-	-
BCB-16	6.73	-	5.37	3.81	0.23	-	0.18	0.03
BCB-17	2.31	-	-	1.56	0.0168	-	-	0.0048
BCB-18	3.24	-	-	-	0.0332	-	-	-
BCB-21	2.78	-	2.97	-	0.03	-	0.03	-
BCB-22	2.98	-	-	-	0.03	-	-	-
BCB-27	4.86	-	4.27	-	0.12	-	0.1	-

Table.5 Other floral characters

Genotype	Flowering pattern	No. of flowers/ cyme	Ratio of (ls:ms:ps:ss)	Corolla colour	Calyx colour	Calyx spinyness	Flower structure
BCB-1	Solitary + Cluster	2 to 3	1:1:0:4	White	Green	Smooth	Fully opened
BCB-2	Solitary	1	4:1:1:1	Pale violet	Green	Highly thorny	Fully opened
BCB-3	Solitary + Cluster	3 to 5	1:3:1:2	Light violet	Green	Medium thorny	Fully opened
BCB-4	Solitary	1	0:5:0:1	Light violet	Green	Smooth	Fully opened
BCB-5	Solitary + Cluster	2 to 6	2:0:0:4	Bluish violet	Dark purple	Smooth	Fully opened
BCB-6	Solitary	1	4:0:0:0	Light violet	Green	Smooth	Semi opened
BCB-7	Solitary + Cluster	2 to 3	1:1:0:6	Light violet	Green	Smooth	Fully opened
BCB-8	Solitary + Cluster	4 to 6	4.5:1:0:0	Light violet	Light purple	Smooth	Fully opened
BCB-9	Solitary	1	4:0:0:0	Light violet	Green	Medium thorny	Fully opened
BCB-10	Solitary + Cluster	1 to 3	1:0:2:0	Light violet	Green	Smooth	Fully opened
BCB-11	Solitary + Cluster	2 to 4	2:0:0:3	Light violet	Green	Smooth	Fully opened
BCB-12	Solitary + Cluster	3 to 4	1:1:0:3.2	Light violet	Green	Highly thorny	Fully opened
BCB-13	Solitary	1	2:2:0:0	Light violet	Green	Smooth	Fully opened
BCB-14	Solitary + Cluster	3 to 4	1:0:0:4.5	Light violet	Light purple	Smooth	Fully opened
BCB-15	Solitary	1	0:5:0:0	Greenish white	Green	Smooth	Fully opened
BCB-16	Solitary + Cluster	2 to 5	1:0:1:2.1	Light violet	Green	Smooth	Fully opened
BCB-17	Solitary + Cluster	2 to 3	5:0:0:10	Bluish violet	Dark purple	Smooth	Half opened
BCB-18	Solitary + Cluster	3 to 5	6:0:0:15	Light violet	Green	Smooth	Fully opened
BCB-21	Solitary + Cluster	3 to 6	1:0:0:2	Light violet	Light purple	Highly thorny	Half opened
BCB-22	Solitary + Cluster	3 to 4	5:0:0:4	Light violet	Green	Highly thorny	Fully opened
BCB-27	Solitary + Cluster	2 to 3	2:0:5:0	Light violet	Green	Medium thorny	Half opened

Fig.1 Anthesis-Full bloom stage-Anther dehiscence

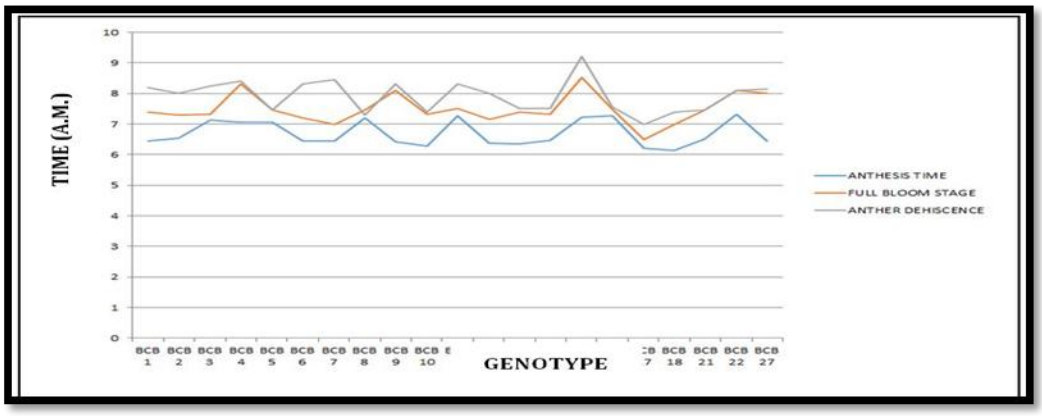


Fig.2 Stigma receptivity

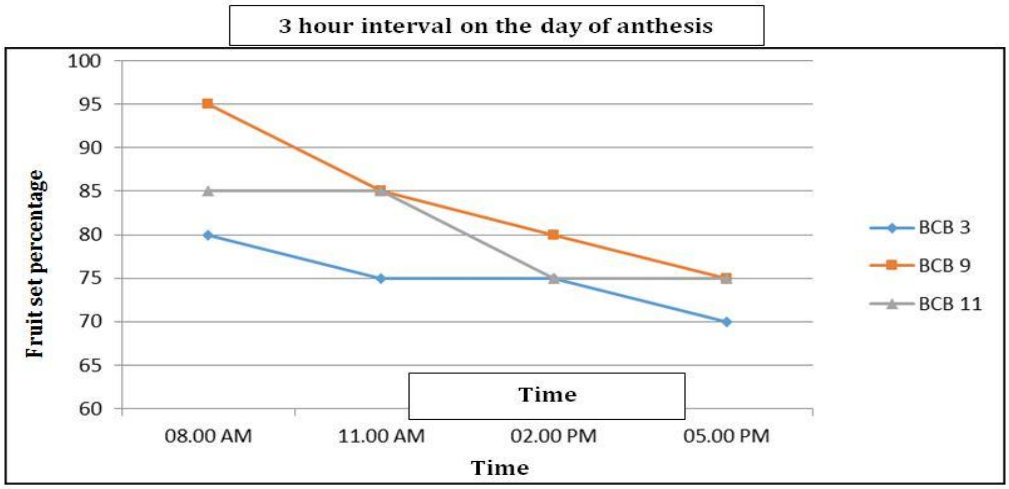
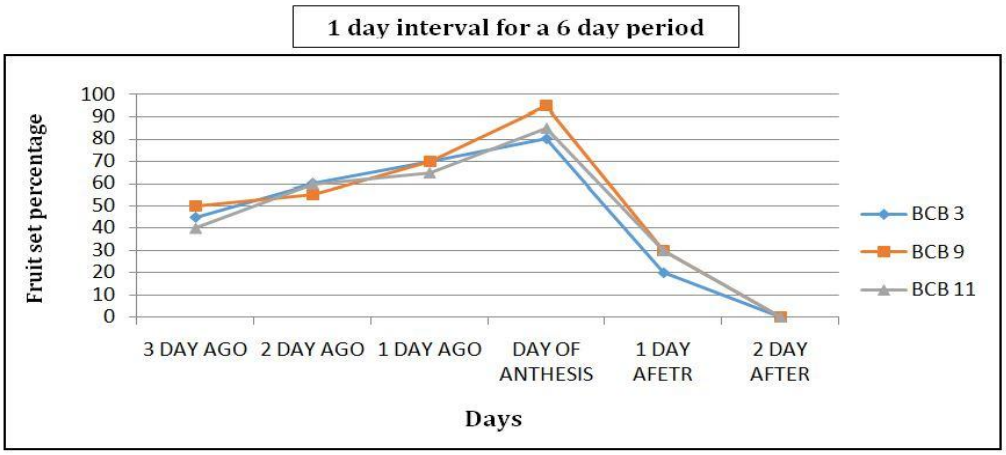


Fig.3 Stigma receptivity



Other floral characters

In the present investigation, majority of the genotypes possessed mixed type (solitary and cyme) flowering pattern except BCB-2, 4, 9, 13 and 15, which were of solitary flowering type. In the solitary flowering genotype functionally fertile flowers set fruits where as

in genotypes with mixed type flowering pattern, number of flowers/cyme did vary from 2-6 (Table-5); in almost 87% of the genotypes the flower structure of fully open orientation was recorded with light-pale violet to bluish violet corolla colour.

A close perusal of the data in the Table-5 authenticates that in the mixed cymes the range of non-productive flowers (both PS+SS) spanned from 0-6 and that in the cluster flowering genotypes, only few additional flowers were fertile to set fruits.

Anthesis-full bloom-anther dehiscence

It has been noticed that the anthesis starts earliest in BCB-18 (6:14 a.m.) and latest by 7:51 a.m. in BCB-11. Full bloom stage generally occurred from 6:50 a.m. (BCB-17) to 8:52 a.m. (BCB-15) and anther dehiscence from 7:00 a.m. (BCB-17) to 9:20 a.m. (BCB-15).

From the graphical presentation (Fig.1), it can be easily understood that in case of some genotypes, the anther dehiscence line coincides or crossed over the full bloom line indicator that means for those genotypes anther dehiscence occurs at the full bloom stage or just before the full bloom stage. In case of BCB-4, BCB-5, BCB-8, BCB-9, BCB-13, BCB-18, BCB-21 and BCB-22, the time of anther dehiscence and full bloom stage is almost same. Same trend of result have been obtained by Oyelana and Ogunwenmo (2012), Deshpandey *et al.*, (1978), Basavaraja (1986).

Stigma receptivity

On the day of anthesis, stigma receptivity was highest at around 8:00 a.m., and just after the anthesis it declined slowly afterwards (Fig-2.1). Oyelana and Ogunwenmo (2012), Hazra *et al.*, 2003) also stated the same earlier. From Fig.-2.2, it can be noted that stigma became receptive from 3 days before anthesis and remain so 1 day after anthesis, receptivity being maximum on the day of anthesis. Three days before and 1 day after anthesis, there was no fruit set instead of hand pollinating the flowers with viable pollens and this result is supported by Deshpandey (1978) and Basavaraja (1986) but Pal and singh (1943) and Popova (1962) reported long extended stigma receptivity up to 9 days after anthesis.

Parthenocarpy

Parthenocarpic fruit set in all the genotypes have been studied and it was noted that propensity to parthenocarpic fruit set in brinjal was low. Parthenocarpic fruit set was noted in BCB-6, BCB-11, BCB-14, BCB-15 and BCB-16. There are many results of natural parthenocarpy like, Shibing *et al.*, (2003) and Bailey and Munson (1891).

All these twenty one genotypes of brinjal differed significantly for most of floral characters under study. The floral bud initiation, 50% flowering, total flowering period and productive: non-productive flower ratio varies from 40.83-58.17 DAT, 50.50-68.33 DAT, 133.10-86.67 days and 0.56-11.52 respectively. Anther length, style length, ovary diameter and ovary weight of brinjal varies from 4.00-13.73mm, 0.74-13.53mm, 1.30-6.93mm and 0.0007-0.2 gm. Anthesis, full bloom and anther dehiscense generally occurs during 6:14-7.51 a.m., 6:50-8:52 a.m. and 7:00-9:20 a.m. Stigma receptivity is highest on the day of flower opening and in morning anthesis time. So, any kind of hybridization programme should be operated morning on the day of anthesis. Occurrence of parthenocarpic fruit development is less. Majority of the genotypes possessed mixed type (solitary and cyme) flowering pattern with fully opened violet flower and smooth calyx. Number of flowers/cyme did vary from 2-6. Calyx colour varies from green to violet. The highest ratio

of (LS+MS): (PS+SS) flowers have been recorded in the genotype BCB-10 (11.52) followed by BCB-8(10.33) and these two genotypes may be used in future as maximum fruits/yield can be achieved.

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