

Effect of pollination time and crossing ratio on fruit set and seed yield of brinjal (*Solanum melongena* L.) hybrid in middle Gujarat

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Abstract

Flowering and fruit set are two most important factors determining the seed yield of cultivated brinjal. An investigation was carried out to find the effect of different pollination time and female to male flower crossing ratios on fruit set and seed yield parameters of brinjal hybrid seed production. The experiment result revealed that different pollination time and crossing ratios had significant effect on seed quality parameters. Among the different pollination time, pollination at 9.00 to 11.00 am recorded significantly higher fruit set per cent (64.53%) with higher number of fruit set per plant (9.64) fruit weight (342.9 g), fruit length (39.95 cm), fruit girth (15.92 cm), mature fruit yield per plant (3274.9 g), seed yield per plant (23.99 g), number of seeds per fruit (425.5), seed weight per fruit (2.47 g) and 1000 seed weight (5.61 g) in compared to other pollination times irrespective of time of pollination, crossing of four female flowers with one male flower (4:1) recorded significantly higher fruit set per cent (66.17%), number of fruit set per plant (10.22), fruit weight (345.7 g), fruit length (40.89 cm), fruit girth (16.14 cm), mature fruit yield per plant (3486.3 g), seed yield per plant (26.44 g), number of seeds per fruit (475.8), seed weight per fruit (2.71 g) and 1000 seed weight (5.72 g) compared to other crossing ratios in seed parent of brinjal hybrid seed production.

Key words: Brinjal, pollination time, crossing ratio, hybrid seed yield, fruit set

Introduction

Brinjal (*Solanum melongena* L., $2n=2x=24$), also known as eggplant, is belonging to family Solanaceae and is considered as one of the main vegetables in India. It is

mainly grown during *Kharif* season in India occupying an area of 711 thousand hectares with an annual production of about 13,558 thousand MT with average productivity of 19.07 MT/ha. Gujarat standing third for brinjal cultivation having an area of 76.75 thousand hectares and total production of brinjal is about 1477 thousand MT with a productivity of 19.24 MT/ha (NHB 2014). It is a self-pollinated crop, however cross pollination to the extent of 30 to 40 % has also been reported in Bulgaria. Hence, it is categorized as often cross-pollinated due to heteromorphic flower structure known as heterostyly. Four types of flowers have been reported depending on the length of styles, viz. (a) long-styled with large ovary, (b) medium-styled with medium size ovary, (c) pseudoshort-styled with rudimentary ovary and (d) true short-styled with very rudimentary ovary (Krishnamurthi and Subramaniam 1954). Only long- and medium-styled flowers set fruit. The percentage of long and medium styled flowers is a varietal character. Out-crossing primarily takes place with the help of pollinating insects such as bumblebees, wild bees and domestic bees.

The most productive and desirable hybrid seed can be obtained from the female parent when there is a perfect coincidence of stigma receptivity with pollen viability of male parent. In brinjal, both anthesis and anther dehiscence are influenced by day light, temperature, humidity and cultivar difference. Since brinjal is mainly a self-pollinated crop, pollination is done usually on the day of flower opening itself and can be continued till noon hours, though peak anthesis is seen at 8:30 to 10:30 am. The anther dehiscence started from 9:30 to 10:00 am. Stigma was most receptive at the time of flower opening (Anonymous 2001). Early pollination with viable pollen may lead to poor seed setting due to non-receptivity of stigma and similar is the case if flowers are pollinated very late, because of drying of stigma or loss of pollen viability. In addition to this, the amount of F_1 hybrid seed is also decided by the quantity of the pollens

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pollinating on the receptive stigma of the female parent. In case, if more pollen has pollinated the stigma, there may be greater chances of poor seed setting due to competition between germinating pollens. Similar is the case with pollination with inadequate viable pollens (Patil et al. 2008). The quantity of pollens depositing on stigma can be manipulated by adjusting the crossing ratio of female to male flower. Therefore, time of pollination and crossing ratio is to be optimized to get higher seed yield and quality attributes of hybrid brinjal. However, research work pertaining to time of pollination and crossing ratio between female to male flowers is very meagre and inconclusive. There is a need to standardize the techniques for optimum crossing ratio of female to male and pollination time to increase the hybrid seed yield with better quality so that the cost of seed can be reduced. Hence, this investigation was initiated to find out suitable time of pollination and crossing ratio of female to male flower on seed yield of brinjal hybrid, GABH-3.

Materials and Methods

The seed material of female and male parent of brinjal hybrid cultivar GABH-3 was obtained from the Main Vegetable Research Station, Anand Agricultural University, Anand. Seeds of female and male parents were sown separately on raised nursery bed of 15 to 20 cm height from ground, in rows 3 to 5 cm apart with 1.2 m width at research farm whose climatic conditions are summarised in Table 1. It was watered alternately and plant protection measures were taken regularly as required. The bed was kept weed free with manual weeding during the nursery period. Uniform sized healthy 30 days old male and female seedlings were transplanted in two adjacent parental blocks of the crossing field preferably in the evening time. One seedling per hill was planted at inter and intra-spacing of 90 and 60 cm for female and 60 and 45 cm for male parents, respectively. A distance of five meter was maintained between the female and male parental blocks. A plot size of 1.8 x 0.9 m (Three plants per treatment) was maintained for female parent.

This experiment was conducted in brinjal hybrid cv. GABH-3 during *kharif* & *rabi* 2015-16 years in randomized block design in factorial concept with three replications. It consisted of two factors and 20 treatment combinations. The time of pollination as one factor *viz.*, P₁: pollination at 7 am to 9 am, P₂: pollination at 9 am to 11 am, P₃: pollination at 11 am to 1 pm, P₄: pollination at 1 pm to 3 pm and female to male flower crossing ratio as another factor *viz.*, C₁: Two female flowers pollinated per male flower, C₂: Four female flowers pollinated per

male flower, C₃: Six female flowers pollinated per male flower, C₄: Eight female flowers pollinated per male flower and C₅: Ten female flowers pollinated per male flower. Crossing program was started after initiation of flowering in 50% plants in female block. The crossing was carried out for a period of 30 days from the initiation of flowering in 50% plants in female block. Emasculation and pollination were done simultaneously. The removal of androecium (stamens) from bisexual flowers is called as emasculation. Usually anthesis starts from 6 to 7:30 am and continues up to 11 am. Well-developed flower buds likely to open next day were selected in female parent and removed the androecium along with the corolla during emasculation. With the help of forceps, the flower buds are opened and the stamens, the number of which varies from five to seven, are removed one by one. These emasculated buds were used for hand pollination.

The just opened flowers were picked from the male parent in a separate petri plate and used for crossing of emasculated flower. The anthers from the male flower are removed. As the pollen grains in the anthers of brinjal are released through apical pores, the anther is held perpendicular to the stigma surface, keeping the apical pores of the anther opposite to the stigma surface. The forceps are tapped and the yellow coloured powder of pollen mass is dusted on the stigma. One male flower was used to pollinate two, four, six, eight and ten female emasculated buds as per the treatments and after crossing the pollinated bud were bagged with white paper bag and label accordingly easy identification of the crossed bud. The mature crossed fruits were harvested and seeds of those fruits further used for recording seed quality parameters. The yield parameters were recorded 30 days after crossing work, the fruit set was computed based on the number of fruits retained out of number of flowers crossed per plant and expressed in percentage. Three full matured fruits were harvested randomly from each treatment of all replications and further used for measuring fruit weight, fruit length and fruit girth. 1000 seed weight were estimated by using the procedure suggested by ISTA (Anon. 1999). The analysis of variance and interpretation of data were done as per procedure given by Panse and Sukhatme (1967) and Gomez and Gomez (1984) using software developed by Department of Agriculture statistics, AAU, Anand.

Results and Discussion

Fruit set per cent and other seed yield parameters were significantly influenced by the pollination time and crossing ratios. The data on seed yield parameters as

influenced by pollination time, number of female flowers pollinated per male flower and their interaction effect are presented in Table 2.

Effect of flower pollination time on fruit set and seed yield parameters: Pollination time had significant effect on fruit set and seed yield parameters. The data presented in Table 2 showed that Among the different pollination time, pollination at 9.00 am to 11.00 am (P_2) recorded significantly higher fruit set per cent (64.53%) with higher number of fruit set per plant (9.64), fruit weight (342.9 g), fruit length (39.95 cm), fruit girth (15.92 cm), mature fruit yield per plant (3274.9 g), seed yield per plant (23.99 g), number of seeds per fruit (425.5), seed weight per fruit (2.47 g) and 1000 seed weight (5.61 g) in compared to other pollination times. Significantly higher fruit set per cent and seed yield

attributes recorded in the pollination treatments of 9.00 am to 11.00 am, is due to high coincidence of stigma receptivity and peak pollen viability during 9 am to 11 am pollination (P_2) and plants will be more active physiologically at this stage and translocate sufficient amount of photosynthates for individual seed development and thus resulting in increased seed index thereby seed weight per fruit and fruit weight and also increase in fertilization of ovules and retention of crossed fruits per plant at 9 am to 11 am pollination time. However, pollination at 1.00 pm to 3.00 pm (P_4) recorded lower fruit set per cent (46.10%) with lower number of fruit set per plant (6.79), fruit weight (274.7 g), fruit length (38.02 cm), fruit girth (15.32 cm), mature fruit yield per plant (1887.8 g), seed yield per plant (15.40 g), number of seeds per fruit (342.7), seed weight per

Table 1: Meterological data of the brinjal seed production experiment site

Date	Temperature °C		Humidity (%)	Date	Temperature (°C)		Humidity (%)
	Max.	Min.			Max.	Min.	
16 th Nov-2015	34.0	15.7	59	26 th Dec-2015	25.8	8.5	50
17 th Nov-2015	35.0	15.6	70	27 th Dec-2015	27.8	8.2	49
18 th Nov-2015	32.8	15.5	50	28 th Dec-2015	30.0	10.5	53
19 th Nov-2015	34.0	16.0	44	29 th Dec-2015	32.0	11.3	58
20 th Nov-2015	33.5	15.1	49	30 th Dec-2015	35.0	12.0	65
21 th Nov-2015	34.0	15.6	46	31 th Dec-2015	35.1	12.2	69
22 th Nov-2015	34.2	20.0	46	1 st Jan-2016	33.1	10.2	65
23 th Nov-2015	32.6	20.0	64	2 nd Jan-2016	32.2	9.4	67
24 th Nov-2015	34.2	20.2	65	3 rd Jan-2016	31.0	10.0	68
25 th Nov-2015	33.7	21.0	51	4 th Jan-2016	30.2	11.0	61
26 th Nov-2015	34.2	19.5	54	5 th Jan-2016	32.4	10.5	64
27 th Nov-2015	34.2	17.0	34	6 th Jan-2016	32.6	10.6	67
28 th Nov-2015	30.0	13.7	41	7 th Jan-2016	31.6	12.9	64
29 th Nov-2015	29.7	12.2	52	8 th Jan-2016	31.1	13.3	67
30 th Nov-2015	30.0	17.0	59	9 th Jan-2016	30.8	10.0	63
1 st Dec-2015	34.0	17.5	62	10 th Jan-2016	30.2	8.4	63
2 nd Dec-2015	32.5	14.8	57	11 th Jan-2016	30.0	9.5	67
3 rd Dec-2015	32.0	14.0	47	12 th Jan-2016	31.0	10.7	63
4 th Dec-2015	30.6	9.9	57	13 th Jan-2016	29.0	10.0	72
5 th Dec-2015	32.0	11.2	63	14 th Jan-2016	28.2	10.8	64
6 th Dec-2015	34.8	11.8	61	15 th Jan-2016	28.0	9.0	65
7 th Dec-2015	33.6	11.8	59	16 th Jan-2016	29.0	12.0	72
8 th Dec-2015	34.5	11.4	64	17 th Jan-2016	27.8	12.2	72
9 th Dec-2015	33.2	12.0	64	18 th Jan-2016	27.7	14.4	66
10 th Dec-2015	33.5	16.0	71	19 th Jan-2016	26.6	8.0	68
11 th Dec-2015	30.2	15.0	63	20 th Jan-2016	26.9	9.7	69
12 th Dec-2015	28.0	8.2	64	21 th Jan-2016	26.8	6.0	56
13 th Dec-2015	27.8	9.3	52	22 th Jan-2016	25.6	4.5	61
14 th Dec-2015	27.0	10.0	49	23 th Jan-2016	27.7	5.0	58
15 th Dec-2015	26.6	8.1	61	24 th Jan-2016	28.5	5.2	62
16 th Dec-2015	27.0	7.1	54	25 th Jan-2016	29.0	4.0	61
17 th Dec-2015	28.6	6.7	59	26 th Jan-2016	29.2	5.8	63
18 th Dec-2015	28.0	8.0	47	27 th Jan-2016	29.0	9.0	70
19 th Dec-2015	27.7	8.5	54	28 th Jan-2016	28.4	12.8	73
20 th Dec-2015	28.0	10.5	52	29 th Jan-2016	30.0	13.2	61
21 th Dec-2015	28.0	6.5	54				
22 th Dec-2015	27.0	9.0	54				
23 th Dec-2015	26.7	7.2	62				
24 th Dec-2015	25.8	6.8	57				
25 th Dec-2015	26.0	8.7	56				

fruit (1.99 g) and 1000 seed weight (5.35 g) in compared to other pollination times and it might be attributed to decline in pollen viability and drying of stigmatic surface because of high temperature and dry air prevailed in the afternoon hours. These results are in agreements with reports of Patil et al. (2008) in brinjal; Sanjeevkumar et al. (2008) in tomato hybrid seed production; and Priya et al. (2009) in chilli.

Effect of crossing ratio on fruit set and seed yield parameters: Fruit set and seed yield attributes differed significantly due to effect of crossing ratios. In case of effect of crossing ratios, four female flowers pollinated per male flower (C_4) recorded significantly higher fruit set per cent (66.17%) with higher number of fruit set per plant (10.22), fruit weight (345.7 g), fruit length (40.89 cm), fruit girth (16.14 cm), mature fruit yield

per plant (3486.3 g), seed yield per plant (26.44 g), number of seeds per fruit (475.8), seed weight per fruit (2.71 g) and 1000 seed weight (5.72 g) in compared to other crossing ratios. The success of higher fruit set per cent and seed yield attributes in 4:1 crossing ratio is influenced due to sufficient availability and optimum utilization of viable pollens for fertilization and fruit formation compared to other crossing ratio and plant with lower fruit load would provide more photosynthates to the individual fruit and less competition among the fruits and thereby individual fruits develop more properly than the fruits present on the plant with more load. However, crossing ratio 10:1 (C_5) recorded lower fruit set per cent (47.95%) with lower number of fruit set per plant (6.71), fruit weight (291.4 g), fruit length (37.82 cm), fruit girth (15.14 cm), mature fruit yield

Table 2: Effect of pollination time and crossing ratio on fruit set and seed yield attributes in brinjal hybrid seed production

Treatments		Character								
Pollination time (P)	Number of fruit set per plant	Fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Mature fruit yield per plant (g)	Seed yield per plant (g)	Number of seeds per fruit	Seed weight per fruit (g)	Test weight (g)
P ₁ -7 am to 9 am	8.12	53.11	322.8	39.19	15.46	2696.9	18.65	368.8	2.12	5.44
P ₂ -9 am to 11 am	9.64	64.53	342.9	39.95	15.92	3274.9	23.99	425.5	2.47	5.61
P ₃ -11 am to 1 pm	9.01	59.77	335.3	39.53	15.75	2872.9	21.58	410.2	2.34	5.54
P ₄ -1 pm to 3 pm	6.79	46.10	274.7	38.02	15.32	1887.8	15.40	342.7	1.99	5.35
S. Em \pm	0.23	1.98	2.8	0.21	0.14	37.8	0.45	6.8	0.02	0.04
CD @ 5%	0.67	5.66	8.1	0.59	0.39	108.3	1.28	19.5	0.06	0.11
Crossing ratio (C)										
C ₁ -2:1	9.50	61.39	332.1	39.63	15.81	3073.7	23.29	439.1	2.43	5.62
C ₂ -4:1	10.22	66.17	345.7	40.89	16.14	3486.3	26.44	475.8	2.71	5.72
C ₃ -6:1	8.15	54.10	328.9	39.31	15.59	2678.7	19.44	408.1	2.28	5.54
C ₄ -8:1	7.38	49.77	300.5	38.20	15.38	2189.3	16.03	324.3	1.97	5.30
C ₅ -10:1	6.71	47.95	291.4	37.82	15.14	1987.6	14.34	286.6	1.77	5.24
S. Em \pm	0.26	2.21	3.2	0.23	0.15	42.3	0.50	7.6	0.02	0.04
CD @ 5%	0.75	6.33	9.1	0.66	0.43	121.1	1.43	21.8	0.07	0.13
Interaction (P x C)										
P ₁ x C ₁	9.11	54.57	336.8	39.30	15.63	2824.9	21.15	420.0	2.32	5.58
P ₁ x C ₂	9.89	62.63	346.8	40.89	16.08	3587.5	24.92	443.6	2.60	5.70
P ₁ x C ₃	7.70	51.30	334.5	39.27	15.45	2679.1	18.40	394.4	2.16	5.52
P ₁ x C ₄	7.33	49.03	308.3	38.45	15.15	2285.7	15.00	303.3	1.85	5.21
P ₁ x C ₅	6.58	48.03	287.8	38.06	15.01	2107.5	13.76	282.6	1.68	5.17
P ₂ x C ₁	10.89	71.30	353.5	40.51	16.12	3928.3	29.10	476.3	2.68	5.76
P ₂ x C ₂	12.00	76.23	378.0	41.44	16.46	4152.6	32.57	522.1	2.98	5.82
P ₂ x C ₃	9.70	64.43	343.5	39.83	15.89	3319.6	23.73	460.5	2.54	5.59
P ₂ x C ₄	8.56	57.10	321.0	39.22	15.76	2706.5	18.60	358.3	2.21	5.48
P ₂ x C ₅	7.07	53.60	318.3	38.73	15.37	2267.4	15.96	310.0	1.94	5.40
P ₃ x C ₁	10.22	68.33	346.3	39.67	16.00	3300.3	26.61	469.5	2.60	5.63
P ₃ x C ₂	11.00	72.23	362.0	41.18	16.15	3851.5	28.57	496.9	2.79	5.76
P ₃ x C ₃	8.37	55.47	341.4	38.41	15.74	2821.8	20.49	445.7	2.45	5.58
P ₃ x C ₄	7.89	52.37	318.2	38.78	15.51	2199.6	17.19	347.5	1.98	5.41
P ₃ x C ₅	7.56	50.43	308.5	38.60	15.33	2191.3	15.03	291.5	1.86	5.33
P ₄ x C ₁	7.78	51.37	291.7	39.04	15.49	2241.4	16.30	390.5	2.11	5.52
P ₄ x C ₂	8.00	53.60	296.5	40.08	15.87	2353.6	19.69	440.5	2.46	5.59
P ₄ x C ₃	6.81	45.20	280.4	38.77	15.30	1894.1	15.12	331.8	1.98	5.48
P ₄ x C ₄	5.72	40.57	254.4	36.33	15.10	1565.6	13.32	288.3	1.84	5.11
P ₄ x C ₅	5.64	39.73	251.0	35.89	14.85	1384.4	12.60	262.1	1.58	5.07
Mean (C x D)	8.39	55.88	318.5	39.12	15.61	2683.1	19.90	386.8	2.23	5.48
S. Em. \pm	0.52	4.42	6.3	0.46	0.30	84.6	1.00	15.2	0.05	0.09
CD @ 5%	NS	NS	NS	NS	NS	242.3	2.86	NS	NS	NS
CV %	10.80	13.70	3.4	2.04	3.36	5.5	8.69	6.8	3.62	2.76

per plant (1987.6 g), seed yield per plant (14.34 g), number of seeds per fruit (286.6), seed weight per fruit (1.77 g) and 1000 seed weight (5.24 g) in compared to other crossing ratios and it might be attributed to pollen mass depositing on stigma of the female flower is scarce and insufficient amount of pollens may not be completely fertilized all the ovules present in brinjal ovary, it might be lead to flower drop and poor fruit and seed setting. Similar results are earlier reported by Patil *et al.* (2008) in brinjal and Sanjeevkumar *et al.* (2008) in tomato.

Among the interaction between pollination time and female to male flower crossing ratio (P x C), there were non-significant differences for all seed yield attributes except mature fruit yield per plant (4152.6 g) and seed yield per plant (32.57 g) which was found significantly higher in P₂C₂. It could be inferred due to optimum environmental condition (Table 1) pollen viability and stigma receptivity have caused good fertilization and seed formation. In light of results obtained from this investigation, optimum time for pollination of emasculated bud in brinjal hybrid GABH-3 seed production in *Kharif* season under middle Gujarat condition can be practiced from 9.00 to 11.00 am which resulted higher percentage of fruit set and hybrid seed yield per fruit with high seed quality attributes. For seed production of brinjal hybrid GABH-3, the crossing ratio of 4:1 compared to 2:1, 6:1, 8:1 and 10:1 found to be most ideal as it registered higher percentage of crossed fruit and hybrid seed yield per fruit.

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बैंगन में पुष्पन एवं फल धारण दो महत्वपूर्ण घटक हैं जो बीज उपज को निर्धारित करते हैं। विभिन्न समय पर परागण एवं मादा एवं नर पितृ के संकरण में फल धारण व बीज उपज घटकों के अनुपात को ज्ञात करने के लिए परीक्षण किया गया। प्रयोग के परिणाम से स्पष्ट हुआ कि विभिन्न परागण समय एवं संकरण अनुपात का सार्थक प्रभाव बीज गुणवत्ता घटकों पर पड़ता है। विभिन्न परागण समयों में 9 बजे से 11 बजे तक (दिन में) में सबसे ज्यादा फल धारण (64.53 प्रतिशत) के साथ सबसे अधिक फलों की संख्या प्रति पौध (9.64), फल भार (342.9 ग्राम), फल की लम्बाई (39.95 सेमी.), फल परिधि (15–92

सेमी.) पके फलों की उपज प्रति पौध (3274.9 ग्राम), बीज उपज प्रति पौध (23.99 ग्राम), बीजों की संख्या प्रति पौध (425.5), बीज भार प्रति फल (2.47 ग्राम) एवं 1000 बीज का भार (5.61 ग्राम) दूसरे परागण के समय निरपेक्ष पर पाया गया। चार मादा पुष्पों का एक नर पुष्प से परागण (4:1) में सार्थक रूप में सबसे ज्यादा फल धारण प्रतिशत (66.17 प्रतिशत), प्रति पौध फलों की संख्या (10.22), फल भार (345.7 ग्राम), फल की लम्बाई (40.89 सेमी.), फल परिधि (16.14 सेमी.), प्रति पौध पके फलों की उपज (3486.3 ग्राम), प्रति पौध बीज उपज (26.44 ग्राम), प्रति फल बीजों की संख्या (5.72 ग्राम), दूसरे संकरण अनुपात की तुलना में पाया गया जो बैंगन के संकर बीज उत्पादन हेतु बीजपितृ के रूप में उपयोग किया जा सकता है।

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