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Growth Regulator Spray to Intensify Fruitset and Seed Yield in Eggplant (*Solanum melongena* L.) Cultivars

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Eggplant or brinjal (*Solanum melongena* L.) produces four type of flowers *viz*., long, medium, short and pseudo short styled flowers, in which short and pseudo short styled flowers do not set fruits. Therefore, a study was conducted to increase the number of long and medium styled flowers and to intensify the fruitset and seed yield. Experimental results showed that the plants sprayed with GA_3 @ 10 ppm at 60, 90 and 120 days after planting (DAP) has recorded the highest number of long styled flowers and fruitset (96.4%) in both the cultivars PLR1 and PLR(Br.)2. Also, the highest seed yield (274.8 and 262.8 kg ha^{-1}) and seed recovery (5.2 and 5.5%) were recorded by this treatment in both the cultivars.

Key words: Brinjal, Eggplant, Heterostyly, Growth regulator, Fruit yield, Seed yield.

Brinjal or eggplant (*Solanum melongena* L.) is an important vegetable crop cultivated throughout the tropical and subtropical regions of India, Bangladesh, Pakistan, China, Philippines, Egypt, France, Italy and United States. In India, it is one of the most common and popular vegetable crop grown throughout the country except in temperate regions. Young fruits are consumed in cooked form which contains protein, fibre and carbohydrate. Also, it is rich in minerals and vitamins particularly calcium, magnesium, phosphorous, sulphur and vitamin A.

Brinjal is a self-pollinating plant, although it can be cross-pollinated (6 -10%) that results from transferring pollen by insects such as ants, thrips, and bees (George, 1985; Lawande and Chavan, 1998). Being hermaphrodite, brinjal flowers show heterostyly phenomenon (Kowalska, 2006) in which four types of flowers have been reported depending on the length of styles *viz*., long styled, medium styled, short styled and pseudoshort styled flowers (Krishnamurthi and Subramaniam, 1954). They also reported that long and medium-styled flowers produce fruits, whereas short and pseudoshort-styled flowers do not set any fruit. It is mainly due to the reason that there is no pollen germination on the stigma or penetration of pollen tube into short styles (Rylski *et. al.,* 1984). The presence of different styled flowers in brinjal depends mainly on variety and season (Kowalska, 2006). Other factors such as fruiting dynamics and plant's age (Lenz, 1970) as well as environmental conditions (Sun *et al*., 1990; Abney and Russo, 1997) also influence the type of flowers. Again, it is evidenced that the flower development along with low auxin contents and low potassium level due to insufficient flow of nutrients favour production of short style flowers (Handique and Sarma, 1995).

Therefore, the auxin level in brinjal flowers can be stimulated for further fruit development by applying growth regulators. Kowalska (2008) opined that by introducing growth substances such as auxins onto the flowers before its pollination, fruit setting can be induced. That fact drew attention that pollination leading to fruit and seed formation is associated with production of endogenous growth regulators such as auxins. Handique and Sarma (1995) applied NAA at 10 ppm concentration and observed increase in number of long style flowers only in some varieties, whereas, higher rates (25 ppm) significantly decreased the number of short style flowers in all tested varieties. Similarly, the fruit yield in brinjal can be increased significantly by two successive sprays of GA_3 and NAA at 35 and 45 days after transplanting (Meena *et al*., 2005). Similar findings of single or combined application of growth hormones for increasing fruit yield in brinjal cultivars were reported (Sharma, 2006; Netam and Sharma, 2014). However, there is no evidence on the application of growth hormones or chemicals towards increasing the matured fruit yield, seed recovery and seed yield. Hence, a study was conducted to find out the suitable hormone to harmonize the long and medium styled flowers for the higher seed recovery and yield.

Materials and Methods

The experiment was conducted in two brinjal cultivars namely, PLR 1 and PLR (Br.) 2 at Vegetable Research Station, Palur during *Rabi* 2014 and *Kharif* 2015 seasons. The seeds of both the cultivars were sown in the raised beds separately and transplanted at 30 days after sowing. The necessary cultural operations were carried out as per the recommendations. The crops were sprayed with the growth hormones as per the treatment schedule *viz*., T_1 - Control, T_2 - GA_3 @ 10 ppm spray at 60, 90 & 120 days after planting (DAP), T_3 - GA_3 @ 25 ppm spray at 60, 90 & 120 DAP, T_4 - GA_3 @ 50 ppm spray

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at 60, 90 and 120 DAP, T_5 - NAA @ 10 ppm spray at 60, 90 and 120 DAP, T_6 - NAA @ 25 ppm spray at 60, 90 and 120 DAP, T_7 - NAA @ 50 ppm spray at 60, 90 and 120 DAP, T_8 - Kinetin @ 10 ppm spray at 60, 90 and 120 DAP, T_9-Kinetin @ 25 ppm spray at 60, 90 and 120 DAP, T_{10}-Kinetin @ 50 ppm spray at 60, 90 and 120 DAP, T_{11} - Coconut water @ 5 % spray at 60, 90 and 120 DAP and T_{12} - Coconut water @ 10 % spray at 60, 90 and 120 DAP. The experiment was conducted by adopting the randomized block design in three replications. The number of different styled flowers and fruitset were observed at 120 days after planting. Similarly, the matured fruit yield, seed recovery and seed yield were recorded at the time of harvests. The data generated in both seasons were pooled and subjected to analysis of variance (ANOVA) at (0.05) significant level and Duncan`s Multiple Range Test was used for means separation (Panse and Sukhatme, 1967).

Results and Discussion

Experimental results showed that the spraying of growth regulators has showed significant differences in different-styled flower production, fruitset and seed yield in both the seasons. Pooled data indicated that the brinjal plants sprayed with GA_3 @ 10 ppm on 60, 90 and 120 DAP (T_2) has recorded higher number of long styled flowers plant^{-1} *viz*., 5.6 in cv. PLR 1 and 10.2 in cv. PLR (Br.) 2 followed by medium styled flowers during the observation on 120 days after planting (Table 1 & 2). Also, the production of short and pseudo short styled flowers were decreased considerably in this treatment. The fruitset percentage was high in both the cultivars. Similarly, the highest fruitset was observed through long styled flowers in PLR 1 (96.5%) and PLR (Br.) 2 (96.2%) followed by medium styled flowers when GA_3 @ 10 ppm was sprayed on 60, 90 and 120 DAP. Moreover, GA_3 @ 10 ppm spray increased an average fruitset of 46.7% and 46.9% in PLR 1 and PLR (Br.) 2 cultivars, respectively (Table 1 and 2). However, the short and pseudo short styled flowers did not set the fruits irrespective of the treatments. This might be due to the fact that the long and medium styled flowers have well developed nodules and well permissible tissues rich in polysaccharides and proteins. However, short styled flowers have small stigma with underdeveloped nodules and due to worse absorption, they are not pollinated and do not set fruits (Kowalska, 2008). Similar to the current findings, Passam and Bolmatis (1997) achieved the highest percentage of fruits set from flowers with long and medium styled pistil but flowers with short styled pistil did not set fruits at all.

Table 1. Effect of growth regulators spray on flower production and fruitset in brinjal cv. PLR1

Treatments / heterostyly flowers	No. of flowers plant^{-1} on 120 DAP					Fruit set (%)				
	Long	Medium	Short	Pseudo short	Mean	Long	Medium	Short	Pseudo short	Mean
T_1-Control	3.5	2.7	2.0	1.7	2.5	90.1	89.4	0.0	0.0	44.9
T_2-GA_3 @ 10 ppm spray	5.6	3.0	1.8	1.0	2.6	96.5	90.3	0.0	0.0	46.7
T_3-GA_3 @ 25 ppm spray	4.5	3.1	1.9	1.1	2.6	95.5	82.9	0.0	0.0	44.6
T_4-GA_3 @ 50 ppm spray	3.9	2.9	2.1	1.1	2.5	93.8	90.6	0.0	0.0	46.1
T_5-NAA @ 10 ppm spray	4.2	2.2	1.9	1.0	2.3	91.2	87.2	0.0	0.0	44.6
T_6-NAA @ 25 ppm spray	4.0	2.7	1.7	1.0	2.3	94.9	84.5	0.0	0.0	44.8
T_7-NAA @ 50 ppm spray	4.4	2.1	1.8	1.1	2.3	90.2	89.9	0.0	0.0	45.0
T_8-Kinetin @ 10 ppm spray	4.4	2.2	1.5	0.8	2.2	92.4	86.7	0.0	0.0	44.8
T_9-Kinetin @ 25 ppm spray	4.6	2.4	1.6	1.1	2.4	89.3	83.4	0.0	0.0	43.2
T_{10}-Kinetin @ 50 ppm spray	4.5	2.5	1.5	0.9	2.3	90.2	86.6	0.0	0.0	44.2
T_{11}-Coconut water @ 5 % spray	5.6	3.0	1.8	0.8	2.8	92.9	88.5	0.0	0.0	45.3
T_{12}-Coconut water @ 10 % spray	5.1	3.3	1.4	0.8	2.6	91.4	84.8	0.0	0.0	44.0
	Treatment		Style length			Treatment		Style length		
SEd	0.2		0.1			1.5		0.8		
CD (P=0.05)	0.5		0.2			3.0		1.7		

*Foliar spray was given on 60, 90 and 120 days after planting

The application of hormone modifies heterostyly by influencing on anatomical structure and nutrients transport through pistil's ducts (Handique and

Sarma, 1995). Observations of low-pistil anatomy revealed smaller cells as compared to high-pistils and hormones application affected the enlargement of those cells. Gibberellic acid plays a role on cell elongation and growth (Yamaguchi, 2008) and that might have also contributed for the style elongation and better pollination in brinjal. Kowalska (2006) noted that NAA reduced the occurrence of

Table 2. Effect of growth regulators spray on flower production and fruitset in brinjal Cv. PLR(Br.)2

Treatments / heterostyly flowers	No. of flowers plant^{-1} on 120 DAP					Fruit set (%)				
	Long	Medium	Short	Pseudo short	Mean	Long	Medium	Short	Pseudo short	Mean
T_1-Control	4.7	2.7	2.0	2.1	2.9	90.3	84.6	0.0	0.0	43.7
T_2-GA_3 @ 10 ppm spray	10.2	2.0	0.9	0.8	3.5	96.2	91.3	0.0	0.0	46.9
T_3-GA_3 @ 25 ppm spray	10.0	2.6	1.1	0.6	3.5	96.0	91.4	0.0	0.0	46.9
T_4-GA_3 @ 50 ppm spray	7.9	2.3	0.9	0.7	2.9	95.9	83.5	0.0	0.0	44.8
T_5-NAA @ 10 ppm spray	6.9	2.5	1.3	0.8	2.9	91.5	79.6	0.0	0.0	42.8
T_6-NAA @ 25 ppm spray	6.1	2.3	0.9	0.7	2.5	94.5	81.2	0.0	0.0	43.9
T_7-NAA @ 50 ppm spray	6.5	2.5	1.2	0.7	2.7	93.9	90.1	0.0	0.0	46.0
T_8-Kinetin @ 10 ppm spray	8.7	2.7	1.1	0.6	3.2	94.6	91.1	0.0	0.0	46.4
T_9-Kinetin @ 25 ppm spray	9.4	2.8	0.9	0.6	3.4	95.6	86.4	0.0	0.0	45.5
T_{10}-Kinetin @ 50 ppm spray	8.4	2.7	1.2	0.7	3.2	93.1	84.9	0.0	0.0	44.5
T_{11}-Coconut water @ 5 % spray	8.0	3.2	1.1	0.7	3.2	92.2	92.2	0.0	0.0	46.1
T_{12}-Coconut water @ 10 % spray	7.9	3.1	0.9	0.5	3.0	92.6	86.0	0.0	0.0	44.7
	Treatment	Style length				Treatment	Style length			
SEd	0.3	0.2				0.8	0.4			
CD (P=0.05)	0.6	0.3				1.5	0.8			

*Foliar spray was given on 60, 90 and 120 days after planting

short styled flowers remarkably, but increased the number of long styled flowers. Netam and Sharma (2014) opined that the combined application of GA_3, NAA and 2,4-D @ 10 ppm, 20 ppm and one ppm had significantly increased vegetative growth, yield and quality of brinjal. However, the maximum yield and net profit

Table 3. Effect of growth regulators spray on fruit and seed yield and seed recovery in brinjal cultivars

Treatments	cv.PLR 1			cv.PLR(Br.)2		
	Fruit yield (q ha^{-1})	Seed yield (kg ha^{-1})	Seed recovery (%)	Fruit yield (q ha^{-1})	Seed yield (kg ha^{-1})	Seed recovery (%)
T_1-Control	29.2	135.2	4.7	20.3	102.9	4.9
T_2-GA_3 @ 10 ppm spray	56.8	274.8	5.2	49.0	262.8	5.5
T_3-GA_3 @ 25 ppm spray	49.9	248.9	5.0	43.3	214.5	5.0
T_4-GA_3 @ 50 ppm spray	45.1	226.4	5.1	29.0	145.4	5.0
T_5-NAA @ 10 ppm spray	42.4	214.0	5.1	27.5	133.7	4.9
T_6-NAA @ 25 ppm spray	46.2	231.9	5.0	34.0	180.5	5.0
T_7-NAA @ 50 ppm spray	43.5	217.9	5.0	30.7	155.5	5.1
T_8-Kinetin @ 10 ppm spray	41.4	211.7	5.2	31.3	153.7	4.9
T_9-Kinetin @ 25 ppm spray	44.4	214.5	4.9	28.1	154.1	5.2
T_{10}-Kinetin @ 50 ppm spray	47.2	243.2	5.1	40.9	205.2	5.2
T_{11}-Coconut water @ 5 % spray	43.9	213.3	4.9	34.8	172.6	4.9
T_{12}-Coconut water @ 10 % spray	44.9	207.4	4.7	31.8	159.2	4.9
SEd	1.5	4.4	0.2	1.2	6.3	0.1
CD (P=0.05)	3.2	9.6	NS	2.7	13.7	0.2

*Foliar spray was given on 60, 90 and 120 days after planting

can be obtained by two successive sprays of GA_3 @ 100 ppm (Meena *et al*., 2005). Similarly, treating the brinjal with kinetins considerably decreased the number of short style flowers (Kowalska, 2006). He also pointed out that the greatest number of fruits developed from long-styled flowers and plants, whose flowers were pollinated by bumble bees Hormonization resulted in more number of fruits.

The fruit and seed yield and seed recovery were also highest in the brinjal plants sprayed with GA_3 @ 10 ppm on 60, 90 and 120 DAP (T_2) in both the cultivars. The highest fruit yield ha^{-1} (56.8 q), seed yield ha^{-1} (274.8 kg) and seed recovery (5.2%) were recorded in this treatment in Cv. PLR1. Similarly, the Cv. PLR (Br.2) recorded the highest fruit yield ha^{-1} (49.0 q), seed yield ha^{-1} (262.8 kg) and seed recovery (5.5%) for the spraying of GA_3 @ 10 ppm on 60, 90 & 120 DAP (T_2) (Table 3). The cost benefit ratio was also higher (1:2.7 and 1:2.6) in this treatment when compared to control in both the cultivars (Table 4). The increased yield and seed recovery might be due to the hormonal regulation in fruitset, fruit and seed development. Similar trends of growth regulators spray on increased fruit yield has been reported in brinjal by several workers (Nothmann *et al*., 1983; Handique and Sarma, 1995; Meena *et al*., 2005; Sharma, 2006; Kowalska, 2008; Netam and Sharma, 2014). Kowalska (2003a, 2003b, 2006) confirm positive influence of flower hormonization process on the eggplant's yielding. Significantly higher early and commercial yields of fruits were produced by plants stimulated with growth regulators as compared to those with self-pollination. However, in experiments of Passam *et al*. (2001), application of auxins (IAA) significantly reduced the pistil length in eggplant flowers. Hormonization had negative effects of eggplant's flowering intensification.

Table 4. Effect of growth regulators spray on cost benefit ratio in brinjal cultivars

Particulars	Cost (Rs.)			
	cv. PLR1		cv. PLR(Br.)2	
	Control	GA_3@10 ppm	Control	GA_3@10 ppm
Expenditure				
Nursery seedling production	4,250	4,250	4,250	4,250
Main field preparation & planting	13,075	13,075	13,075	13,075
Manures & Fertilizers	25,500	25,500	25,500	25,500
Intercultural operations	18,500	18,500	18,500	18,500
Roguing	2,400	2,400	2,400	2,400
Plant protection	15,350	15,350	15,350	15,350
GA_3 spraying	0	8,450	0	8,450
Harvesting and seed extraction	10,950	10,950	10,950	10,950
Seed drying and processing	1,000	1,000	1,000	1,000
Total	91,025	99,475	91,025	99,475
Income				
Seed yield (kg)	135.2	274.8	102.9	262.8
Income (Rs.)	1,35,200	2,74,800	1,02,900	2,62,800
Net profit (Rs.)	44,175	1,75,825	11,875	1,63,325
C:B ratio	1:1.5	1:2.7	1:1.1	1:2.6

It is concluded that the brinjal plants sprayed with GA_3 @ 10 ppm at 60, 90 and 120 DAP have recorded the highest fruitset, fruit yield, seed yield and seed recovery in PLR1 and PLR (Br.)2 cultivars.

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