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EFFECT OF GA_3 AND NAA ON PHYSIO-MORPHOLOGICAL CHARACTERS, YIELD AND YIELD COMPONENTS OF BRINJAL (*Solanum melongena* L.)

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Abstract

The experiment on brinjal *(Solanum melongena* L.) having seven growth regulators viz., control, 30 ppm GA_3, 40 ppm GA_3, 50 ppm GA_3, 20 ppm NAA, 40 ppm NAA, and 60 ppm NAA and two varieties viz., BARI Begun-5 and BARI Begun -10 was conducted at the field of Plant Physiology Section of HRC during the *rabi* season (November 2011 to May 2013) to find out the suitable variety responsive to growth regulators and to determine the suitable dose of growth regulator for brinjal production. The GA_3 (Gibberellic acid) and NAA (Naphthalene acetic acid) had no significant effect on plant height and stem diameter at the end of the crop period and days to 100% flowering. NAA 40 ppm produced highest percentage of long and medium styled-flower, leaf photosynthesis and Fv/Fm (efficiency of photosystem II), number of fruits /plant and fruit yield (45.50 t/ha). The variety BARI Begun-5 was earlier to 100% flowering which took 44 days after transplanting which outyielded BARI Begun-10. NAA 40 ppm coupled with BARI Begun-5 gave the maximum Fv/Fm, long-styled flower percent, number of fruits/plant, and the highest fruit yield (49.73 t/ha).

Keywords: Gibberellic acid (GA_3), napthalene acitic acid (NAA), leaf photosynthesis, fruit yield, brinjal.

Introduction

Brinjal *(Solanum melongena* L.) is one of the most common tropical vegetables grown throughout the country. It is an economically important crop in Asia, Africa, and the sub-tropics (India, Central America) and it is also cultivated in some warm temperate regions of the Mediterranean and South America (Sihachakr *et al*., 1993). Eggplant fruits are known for being low in calories and having a mineral composition beneficial for human health. They are also a rich source of potassium, magnesium, calcium, and iron (Zenia and Halina, 2008). Role of plant growth regulators in altering plant physiological processes is well known. Plant growth regulators have been reported to improve growth, fruit set, fresh vegetable yield, and yield quality (Saimbhi, 1993). In eggplant, fruit set is

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sometimes insufficient and growth regulators (GRs) are used to enhance fruit setting process which are mostly auxin-like substances (Pessarakli and Dris, 2003). Several different types of GRs used (auxins, gibberellins, amorphactine, and acytocinin) to enhance fruit set in brinjal but among the combinations, auxins and gibberellins offered the best results (Ravestijn, 1983). Sharma (2006) reported higher yield of brinjal with foliar spray of NAA @ 40 ppm whereas Bisaria and Bhatnagar (1978) obtained higher yield of brinjal from the foliar spray of GA_3 @ 50 ppm. There are four types of flowers in brinjal based on the length of the style viz., long-styled with big size ovary, medium-styled with medium size ovary pseudo short-styled with rudimentary ovary and true short – styled with very rudimentary ovary (Krishnamurthy and Subramanian, 1954). Maximum fruit set occurs from long styled and medium styled flowers. No fruit set occurs from pseudo short-styled and true short styled flowers. Pseudo short styled and true short styled flowers are converted into long-styled, and medium-styled flowers when they were treated with different growth regulators and it is possible to get fruits from those flowers (Ravestijn, 1983). Moreover, plant growth regulators help prevent flower fruit drop and increasing fruit set. Varietal response to plant growth regulators is also different. Therefore, the experiment was conducted to find out the suitable variety responsive to growth regulator and to determine the suitable dose of growth regulator for brinjal cultivation.

Materials and Method

The experiment was conducted at the field of Plant Physiology Section of Horticulture Research Centre, Bangladesh Agricultural Research Institute during the *rabi* season of 2011-12 to 2012-13. The experiment was laid out in split-plot design having seven growth regulator concentrations viz., T_1 = control (water spray), T_2 = 30 ppm GA_3, T_3 = 40 ppm GA_3, T_4 = 50 ppm GA_3, T_5 = 20 ppm NAA, T_6 = 40 ppm NAA, T_7 = 60 ppm NAA in main plot and two brinjal varieties viz., V_1 = BARI Begun-5 and V_2= BARI Begun -10 in subplot with three replications. The unit plot size was 4.8 m^2 (2.4 × 2.0 m) consisting of 8 plants with the spacing 100cm × 60cm. Forty six days old seedlings were transplanted on 23 November 2011 and 25 November 2012 in consecutive two years, respectively. The hormone was sprayed to the plants at first flowering and other two sprays at 14 days intervals whereas tap water was sprayed in control plot. Cowdung, N, P, and K were applied @ 10 ton, 172 kg, 30 kg, and 124 kg/ha. The source of N, P, and K was urea, TSP, and MoP, respectively. The entire quantity of cowdung, TSP, and half of MoP were applied during final land preparation. The remaining one half of MoP and entire urea were applied in three equal installments at 20, 40, and 60 days after transplanting. The insecticide Comulax (2 g/litre H_2O) and Tracer (I ml/2.5 litre H_2O) were sprayed at 15 days-intervals after transplanting starting from 26 December 2011 and 19 December 2012. Irrigation was given to the plant at 15 days intervals after transplanting.

Weeding was done as when necessary. In the first year, duration of fruit harvest in BARI Begun-5 was from 2 March 2012 to 10 April 2012 while in BARI Begun-10, it was from 14 March 2012 to 26 April 2012. In next year, crop of BARI Begun-5, fruit harvest duration was from 28 February 2013 to 7 March 2013 and in BARI Begun-10, the duration was from 11 March 2013 to 22 April 2013. The data were recorded on days to 100% flowering, plant height (cm), stem diameter at harvest (cm), percent of long-styled flower, percent of medium-styled flower, leaf photosynthesis, number of fruits/plant, single fruit weight, yield/plant, and yield/plot. Leaf photosynthesis was measured at 10.30 am to 13.30 pm (Bangladesh standard time) with an LCpro + portable infrared CO_2 gas analyzer made by ADC Bio-scientific Ltd, Great Amwell, UK. Light intensity was fixed at 1800 PPFD (Photosynthetic Photon flux density). The source of light was an LCpro + conifer chamber red and blue LED lamp attachment. Other conditions were set on ambient mode with diurnal temperature. The changes in fluorescence yield reflect chances in photochemical efficiency and heat dissipation. F_0 is the amount of light absorbed initially to raise the fluorescence from a low level to maximum value Fm after dark adaptation of 20 minutes. $F_v = F_m$-$F_{0,}$ which is the variable. Ratio of F_v/F_m is a dark adapted test used to determine maximum quantum yield (maximum efficiency of Photosystem II). This ratio is also an estimate of the maximum portion of absorbed quanta used in PSII reaction centers (Kitajima and Butler, 1975). The MSTAT-C computer package was used to analyze the data. Mean separation was done by Duncan Multiple Range Test (DMRT).

Results and Discussion

Two years' results did not differ significantly as pooled analyses were done and the results are presented as follows:

A. Effect of plant growth regulator

Gibberellic acid (GA_3) and naphthalene acetic acid (NAA) had no significant effect on days to flowering, plant height, and stem diameter (Table1). This is an agreement with the results of Sharma, 2006. There was no significant difference between treatment T_6 and T_2 in respect of leaf photosynthesis and these two treatments showed better result than other treatments. Initial chlorophyll florescence (F0) had no significant difference. The highest maximum chlorophyll florescence (F_m) was obtained from T_6 treatment which was different from other treatments. Similar trend was followed in case of variable chlorophyll florescence (F_v). The maximum F_v/F_m ratio (florescence yield or efficiency of photosystem II) was obtained from T_6 treatment (0.7925) which was similar to T_2, T_3, T_5, and T_7. Generally, fluorescence yield is the highest when photochemistry and heat dissipation are the lowest. In healthy leaves, this value

is always close to 0.800. The highest percentage of long styled flower was recorded from T_6 treatment (77.82%) and the lowest from control (72.28%). Similar trend was followed in medium styled flower. The T_6 treatment gave the maximum number of fruits (25.45/plant), which was at par with T_2 treatment (23.48/plant). However, there was no significant difference among T_2, T_3, T_4, T_5, and T_7 treatments in respect of number of fruits/plant. The maximum yield/plant was recorded from T_6 treatment (3.45 kg), which was similar to T_2 treatment (3.17 kg) and the lowest yield from control (2.61 kg). The highest yield was obtained from T_6 treatment (45.50 t/ha) and the lowest yield from control (34.99 t/ha). There was no significant difference among T_2, T_3, T_4, T_5, and T_7 treatments in respect to per hectare yield (Table 1). Yield increase of 16% and 23.10% was due to the application of 30 ppm GA_3 and 40 ppm NAA compared to control. This corroborates the results of Sharma (2006). But Morales-Payan (2000) obtainedthe highest yield at 20 ppm GA_3 and 25 ppm NAA. Bisaria and Bhatnagar (1978) obtained maximum fruit number and yield of brinjal at 50 ppm GA_3.

B. Effect of varieties

Two varieties (BARI Begun-5 and BARI Begun-10) differed significantly in respect of all parameters (Table 2). The variety BARI Begun-5 produced flowers significantly earlier than BARI Begun-10. The period from transplanting to 100 percent flowering was 44 days in BARI Begun-5, whereas it was 56 days in BARI Begun-10. BARI Begun-10 had taller plants (81.11 cm) with thinner stem diameter than BARI Begun-5. BARI Begun-10 gave maximum leaf photosynthesis and F_v/F_m ratio whereas BARI Begun -5 produced maximum F_0, F_m and F_v. This variation was due to genetic constitution of the variety. The percentage of long styled flower was higher in BARI Begun -10 but the medium styled flower was higher in BARI Begun-5. BARI Begun-10 gave higher number of fruits but lower individual fruit weight compared to BARI Begun-5 (Table 2). The variety BARI Begun-5 showed higher fruit weight, as a result higher yield was achieved over BARI Begun-10.

C. Combined effect of plant growth regulator and variety

The maximum photosynthesis (17.45 µ mol CO_2 $m^{-2}s^{-1}$) was recorded from $T_2 \times V_2$ which was closely followed by $T_6 \times V_2$ (17.35 µ mol CO_2 $m^{-2}s^{-1}$) and the lowest from $T_1 \times V_1$ (Table 3). Initial chlorophyll florescence was found insignificant among the treatments. The highest Fm was recorded from $T_2 \times V_1$ (3903.1) which was significantly different from the rest of the treatments. The highest F_v was obtained from $T_6 \times V_1$ (3058.2) and the lowest from $T_5 \times V_2$. The F_v/F_m was little affected by the treatment combination where $T_6 \times V_2$ treatment gave the maximum F_v/F_m ratio (0.8010) and $T_1 \times V_1$ gave the minimum.

Table 1. Effect of plant growth regulator on plant characters, leaf photosynthesis, chlorophyll florescence, yield attributes, and yield of brinjal varieties.

Treatments	Days to 100% flowering	Plant height at last harvest (cm)	Stem diameter at last harvest (cm)	Photosynthesis (A) (µ mol CO_2 $m^{-2}s^{-1}$)	F_0	F_m	F_v	F_v/F_m
Control (T_1)	50	76.33	1.45	15.73d	849.8	3819.8g	2803.4g	0.7340b
GA_3 30 ppm (T_2)	50	77.15	1.46	16.09a	885.4	3828.6c	29.47.9c	0.7702ab
GA_3 40 ppm (T_3)	50	77.09	1.47	15.95b	907.8	3824.4d	2916.6e	0.7628ab
GA_3 50 ppm (T_4)	50	76.72	1.45	15.80cd	965.3	3822.6f	2857.3f	0.7480b
NAA 20 ppm (T_5)	51	76.40	1.48	15.94b	898.6	3828.8b	2930.3d	0.7655ab
NAA 40 ppm (T_6)	50	77.04	1.46	16.14a	795.1	3829.0a	3033.9a	0.7925a
NAA 60 ppm (T_7)	50	76.49	1.46	15.86bc	851.4	3823.4e	2972.0b	0.775ab
Level of Sig.	ns	ns	ns	*	ns	*	**	*
CV (%)	5.49	4.95	5.82	3.50	18.51	11.46	6.29	7.43

Table 1. Cont'd.

Treatment	Long- styled flower (%)	Medium- styled flower (%)	Fruits/plant (no.)	Individual fruit wt (g)	Fruit yield/plant (kg)	Fruit yield (t/ha)
Control (T_1)	72.28f	17.61f	19.58 c	130.3	2.61 c	34.99 c
GA_3 30 ppm (T_2)	76.38b	20.03b	23.48 ab	131.3	3.17ab	41.70b
GA_3 40 ppm (T_3)	74.05d	19.36d	22.71 b	131.3	3.06b	40.24b
GA_3 50 ppm (T_4)	73.14e	18.47e	21.68 bc	130.4	2.92 bc	38.29bc
NAA 20 ppm (T_5)	73.88d	19.72c	22.61 b	131.8	3.04b	40.04b
NAA 40 ppm (T_6)	77.82a	21.24a	25.45 a	132.4	3.45a	45.50a
NAA 60 ppm (T_7)	74.82e	20.01b	22.60 b	130.5	3.02b	40.07b
Level of Sig.	*		*	ns	*	**
CV (%)	4.71	7.63	6.58	4.12	6.40	7.48

Means having same letters and without letters are not significant by DMRT. **indicates significant at 1% level, *indicates significant at 5% level, F_0= Initial chlorophyll florescence, F_m = Maximum chlorophyll florescence, $F_v = F_m - F_0$ = Variable chlorophyll florescence, F_v/F_m = Ratio of F_v and F_m means efficiency of photosystem II.

Table 2. Effect of variety on plant characters, leaf photosynthesis, chlorophyll florescence, yield attributes, and fruit yield of brinjal

Treatments	Days to 100% flowering	Plant height at last harvest (cm)	Stem diameter at last harvest (cm)	Photosynthesis (A) (µ mol CO_2 $m^{-2}s^{-1}$)	F_0	F_m	F_v	F_v/F_m
BARI Begun -5 (V_1)	44b	72.39b	1.50a	14.63b	951.58 a	3896.72a	2945.15a	0.756b
BARI Begun -10 (V_2)	56a	81.11a	1.42b	17.23a	806.50b	3753.77b	2900.93b	0.773a
Level of Sig.	**	**	**	**	*	**	**	**
CV (%)	5.49	4.95	5.82	3.50	18.51	11.46	6.29	7.43

Table 2. (Cont'd).

Treatment	Long- styled flower (%)	Medium- styled flower (%)	Fruits/plant (no.)	Individual fruit wt (g)	Fruit yield/plant (kg)	Fruit yield (t/ha)
BARI Begun -5 (V_1)	72.62b	20.45a	20.94b	173.79 a	3.93a	44.52a
BARI Begun -10 (V_2)	76.69a	18.54b	24.24a	88.48 b	2.14b	35.72b
Level of Sig.	**	*	*	**	**	**
CV (%)	4.71	7.63	6.58	4.12	6.40	7.48

Means having same letters and without letters are not significant by DMRT. **indicates significant at 1% level, *indicates significant at 5% level, F_0= Initial chlorophyll florescence, F_m = Maximum chlorophyll florescence, F_v = $F_m - F_0$ = Variable chlorophyll florescence, F_v/F_m = Ratio of F_v and F_m means efficiency of photosystem II.

Table 3. Combined effect of plant growth regulator and variety on leaf photosynthesis, chlorophyll florescence, yield attributes, and yield of brinjal.

Interaction (T × V)	Photosynthesis (A) (μ mol CO_2 $m^{-2}s^{-1}$)	F_0	F_m	F_v	F_v/F_m
$T_1 \times V_1$	14.36g	1065.7	3890.1g	2824.3m	0.7260c
$T_1 \times V_2$	17.10c	633.8	3749.6m	2782.5n	0.7420bc
$T_2 \times V_1$	14.73e	931.7	3903.1a	2971.4d	0.7613abc
$T_2 \times V_2$	17.45a	839.0	3754.1j	2924.5h	0.7790ab
$T_3 \times V_1$	14.65e	955.1	3896.7d	2941.6g	0.7550abc
$T_3 \times V_2$	17.25b	860.6	3752.1k	2891.5j	0.7707abc
$T_4 \times V_1$	14.50f	1015.0	3893.0f	2878.40k	0.7400bc
$T_4 \times V_2$	17.10c	915.6	3752.0l	2836.1l	0.7560abc
$T_5 \times V_1$	14.64ef	951.2	3898.2c	2947.0f	0.7560abc
$T_5 \times V_2$	17.27b	845.9	3759.5h	2913.6i	0.7750abc
$T_6 \times V_1$	14.92d	842.5	3900.7b	3058.2a	0.7840ab
$T_6 \times V_2$	17.35ab	747.7	3757.3i	3009.6b	0.8010a
$T_7 \times V_1$	14.62ef	899.8	3895.00f	2995.2c	0.7690abc
$T_7 \times V_2$	17.11c	803.0	3751.7l	2948.7e	0.7860ab
Level of Sig.	*	ns	*	**	*
CV (%)	3.50	18.51	11.46	6.29	7.43

Table 3. (Cont'd).

Interaction (T × V)	Long-styled flower (%)	Medium - styled flower (%)	Fruits/ plant (no.)	Individual fruit wt. (g)	Fruit yield/plant (kg)	Fruit yield (t/ha)
$T_1 \times V_1$	69.97m	17.03k	18.16j	173.1	3.38	39.36f
$T_1 \times V_2$	74.60h	18.19i	21.02h	87.63	1.84	30.61j
$T_2 \times V_1$	74.70h	21.25b	21.76g	174.3	4.12	**46.35b**
$T_2 \times V_2$	78.07b	18.80g	25.20b	88.24	2.22	37.05g
$T_3 \times V_1$	71.97j	20.45d	20.88h	174.4	3.95	44.47c
$T_3 \times V_2$	76.13f	18.27i	24.55c	88.16	2.16	36.05gh
$T_4 \times V_1$	70.70l	19.52f	20.26i	173.2	3.81	42.86d
$T_4 \times V_2$	75.58g	17.42j	23.10f	87.72	2.02	37.72i
$T_5 \times V_1$	71.50k	20.74c	20.85h	174.4	3.93	44.25c
$T_5 \times V_2$	76.27e	18.70h	24.36cd	89.12	2.15	35.83gh
$T_6 \times V_1$	77.00c	22.84a	23.60e	174.1	4.42	**49.73a**
$T_6 \times V_2$	78.63a	19.64c	27.30a	90.67	2.45	41.27e
$T_7 \times V_1$	72.50i	21.31b	21.05h	173.1	3.91	44.59c
$T_7 \times V_2$	76.84d	18.72gh	24.15d	87.78	2.13	35.55h
Level of Sig.	*	**	*	ns	ns	*
CV (%)	4.71	7.63	6.58	4.12	6.40	7.48

Means having same letters and without letters in a column are not significant by DMRT.

**indicates significant at 5% level, *indicates significant at 5% level, T_1 = control, T_2 = GA_3 30 ppm, T_3 = GA_3 40 ppm, T_4 = GA_3 50 ppm, T_5 = NAA 20 ppm, T_6 = NAA 40 ppm, T_7 = NAA 60 ppm; V_1 = BARI Begun-5, V_2 = BARI Begun-10, F_0= Initial chlorophyll florescence, F_m = Maximum chlorophyll florescence, $F_v = F_m - F_0$ = Variable chlorophyll florescence, F_v/F_m = Ratio of F_v and F_m means efficiency of photosytem II.

The interaction of PGRs and varieties had significant influence on percent of long and medium styled flower, number of fruits/plant, and yield per hectare (Table 3). The maximum long styled flower percent was noticed in $T_6 \times V_2$ (78.63) and minimum from $T_1 \times V_1$ (69.97%) but the maximum medium styled flower was recorded in $T_6 \times V_1$ (22.84%). The highest number of fruits/plant was recorded from $T_6 \times V_2$ and the lowest from control. The highest fruit yield was obtained from $T_6 \times V_1$ (49.73 t/ha) and the lowest from $T_6 \times V_1$. The T_6 treatment gave the highest yield due to higher individual fruit weight and fruit yield/plant. In BARI Begun-5, 40 ppm NAA increased fruit yield (20.85%) compared to control while in BARI Begun-10, 40 ppm NAA increased fruit yield (25.83%) compared to control. Sharma (2006) obtained the highest fruit yield in cv. Pusa Purple Long at 40 ppm NAA.

Conclusion

Based on the above discussion, it can be concluded that BARI Begun-5 treated with NAA 40 ppm emerged as the best treatment combination in terms of physio-morphological characters, yield components, and yield of brinjal.

References

Bisaria, A. K. and V. K. Bhatnagar. 1978. Effect of growth regulators on growth, fruits and yield in brinjal (*Solanum melongena* L). *Indian J. Hort.***29:**334-335.

Kitajima, M and W. L. Butler. 1975. Quenching of chlorophyll fluorescence and primary photochemistry in chloroplast by dibromothymoquinone. *Biochem. Biophy. Acta.* **376:** 105-115.

Krishnamurthy, S. and D. Subramanian. 1954. Some investigations on the types of flowers in brinjal (*Solanum melongena* L.) based on style length and their fruit set under natural conditions and in response to 2,4-D. *Indian J. Hort.* **11:** 63-67.

Pessarakli, M. M. and Dris M. 2003. Effects of growth regulators on eggplants: Genetic engineering issues. *Food. Agric. Enviro.* **1**(3&4): 206-212

Ravestijin, V. W. 1983. Improvement of fruit set in eggplants with 4-CPA (tomatotones), XX1st. Int. Hortic Congr. On Growth Regul., Hamburg, Germany F. R., 1982. Acta Hortic. 137.

Saimbhi, M. S. 1993. Growth regulators on vegetable crops. In: K. L. Chadha and G. Kallo (eds.). Advances in Horticulture, Vol. 6(1). Malhotra Pub. House, New Delhi, India. Pp. 619-642.

Sharma, M. D. 2006. Effect of plant growth regulators on growth and yield of brinjal at Khajura, Banke. *J. Ins. Agric. Anim. Sci.* **27:**153-156.

Sihachakr, D., M. H. Chaput, L. Serraf and G. Ducreux. 1993. Regeneration of plants from protoplasts of eggplant (Solanum melongena L.). In: Bajaj, Y. P. S. (Ed.), Biotechnology in Agriculture and Forestry, Vol. 23. Plant Protoplasts and Genetic Engeneuring. Springer, Berlin. Pp. 108-122.

Zenia, M. and B. Halina. 2008. Content of microelements in eggplant fruits depending on nitrogen fertilization and plant training method. *J. Elementol.* **13**(2): 269-274.