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Research Article

Response of varying levels of phyto-hormones and micro-nutrients on growth and yield of brinjal (*Solanum melongena* L.) in sub-tropical Terai region of India

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ABSTRACT

A field study was conducted at Horticultural Research Farm, Institute of Agricultural Sciences of Banaras Hindu University, Varanasi, India during summer season of 2017-2018 to test the sole effect of phyto-hormones and micro-nutrients on growth and yield of brinjal (*Solanum melongena*, L.). The thirteen treatments having six different concentration of phytohorompnes viz., T_1 (20 ppm NAA), T_2 (40 NAA), T_3 (60 ppm NAA), T_4 (25 ppm GA_3), T_5 (50 ppm GA_3), T_6 (75 ppm GA_3), and six different concentrations of micronutrients viz., T_7 (Boron 0.1%),T_8 (Boron 0.2%), T_9 (Boron 0.3%), T_{10} (Zinc 0.1%), T_{11} (Zinc 0.2%), T_{12} (Zinc 0.3%) and T_{13} (control-water spray) for a "Kashi Uttam" cultivar of brinjal were grown under randomized complete block design (RCBD) having three replications. The results findings indicated that treatment T_4 (25 ppm GA_3) had significant effect on growth parameters, mainly plant height, number of leaves, leaf length, leaf width, crop canopy, number of side roots and main root length. Similarly, yield parameters like number of fruits per plant, fruit weight, fruit yield per plant were found to be significantly superior under treatment T_4 (25 ppm GA_3). Number of branches per plant, stem diameter, main root length and fruit weight were found superior under treatment T_1 (20 ppm NAA). Among the different concentrations of micronutrients treatment T_9 (Boron 0.3%) and T_{12} (Zinc 0.3%) were found to be significant over control. It can be concluded that the phyto-hormones and micro-nutrients can be judiciously used for increasing the growth and yield of brinjal.

Keywords: Brinjal, Gibberellic acid, Micro-nutrients, Naphthalene acetic acid, Phyto-hormones, Growth and yield.

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INTRODUCTION

Brinjal (*Solanum melongena*, L.) is considered to be the king of vegetables, also known as egg plants are the second most important solanaceous fruit crop after tomato (*Lycopersicon esculentum* L.) in the genus solanum. Eggplant is known as one of the ten sources of the

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world's healthiest food which is also described as the best species cultivated worldwide (Bliss and Elstein, 2004, Caguiat and Hautea 2014).The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and the Philipines. Brinjal is an important solanaceous crop of tropics and sub-tropics. It is native to southern India and widely grown in America, Europe, and Asia (Gotame *et al*., 2020). It is a perennial plant native to the Indian sub-continent and grown in many tropical and semi-tropical regions as a popular vegetable all around the year. Brinjal has a staple vegetable in many tropical countries since ancient times. It contains 124 IU of vitamins A, 12 mg of vitamin C, 18 mg of calcium and 47 mg of phosphorous, 0.9 mg of iron, 1.4 g of protein, 4 g of carbohydrates and 92.7 g of moisture per 100 g of edible portion. Apart from trios, it also has some medicinal properties (Chaudhary, 1996). The people of Nepal use it as a sedative while the Moroccan used it to stimulate memory (Stoker, 1995).

Phyto-hormones available in plants are often inadequate in the prolific and high productive plants. The specific quantity in the plants is directly responsible for the promotion, inhibition or otherwise modification in the physiological processes (Gou *et al.,* 2010). Auxin (Naphthalene Acetic Acid) and gibberellins (GA_3) are regulating developmental process within plant bodies. Auxin promotes cell elongation, especially of shoots, and induces apical dominance and rooting, while gibberellin helps in cell growth of stem, leaves and other aerial parts (Gou *et al.,* 2010). A lower concentration of auxin and gibberellins increases plant growth and yield. Thus, only low doses are effective in growth promotion. It is obvious that the growth is directly related to the yield and, hence the role of phyto-hormones is most vital in brinjal too (Singh *et al.,* 2013).

Micro-nutrients like Boron and Zinc also play a positive role for increasing fruit as well as yield of brinjal (Kalroo *et al.,* 2014). If these elements are not available sufficiently, plants will suffer from physiological stresses caused by inefficiency of several enzymatic systems and other related metabolic functions. Application of phyto-hormones and micro-nutrients will not only enhance productivity, but will also increase the production and the efficiency of fertilizer use in brinjal crop (Kumar *et al.,* 2016). While doing so, there is an urgent need to augment supplies of customized fertilizers supplying secondary and micronutrients to support sufficiently, the integrated use of nutrient management in brinjal production. Keeping in view the consideration of the pertinent problem, an experiment was formulated and conducted with different concentrations of NAA and GA_3 and micro-nutrients B and Zn to find out their appropriate dose under their sole application and effect in brinjal production under sub-tropical Terai region of India.

MATERIALS AND METHODS

The field experiment was conducted during summer season of 2017/18 at Horticultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University (25^0 32' N, 82^0 98' E, 228 masl.) to evaluate the sole effect of phytohormones and micronutrients on brinjal (*Solanum melongena,* L.) cultivar "Kashi Uttam". The soil of plot before experimentation was of normal fertility with good facility of irrigation and drainage. The thirteen treatments having six different concentration of phytohorommnes viz., T_1 (20 ppm NAA), T_2 (40 NAA), T_3 (60 ppm NAA), T_4 (25 ppm GA_3), T_5 (50 ppm GA_3), T_6 (75 ppm GA_3), and six different concentrations of micronutrients viz., T_7 (Boron 0.1%),T_8 (Boron 0.2%), T_9 (Boron 0.3%), T_{10}

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(Zinc 0.1%), T_{11} (Zinc 0.2%), T_{12} (Zinc 0.3%) and T_{13} (control-water spray) were imposed in the study. The experiment was laid out in randomized block design with three replications.

Seed sowing was done in second week of September and one months old seedlings were transplanted at 60 cm row to row and 45 cm plant to plant distance on 11 October. Plot size was kept 2.4 x 1.8 m to accommodate 30 plants in each plot. Recommended dose of Urea, DAP and MOP were applied @ 100:50:50 kg NPK ha^{-1} were applied as urea, diammonium phosphate and muriate of potash, respectively. Compost 20.0 tha^{-1} was broadcasted and incorporated into the soil just before transplanting. Half dose of required nitrogen was applied at the time of transplanting as basal dose. Remaining half dose of nitrogen was applied in 2-3 splits after 30, 45 and 60 days after transplanting in the form of top dressing. Irrigation was done regularly as and when required. Hoeing and weeding were given to all plots evenly whenever required. The data on plant height, number of leaves per plant, number of branches per plant, leaf length, leaf width, stem diameter crop canopy were recorded at last harvest. The crop was harvested at 180 days after transplanting. Data was analyzed statistical software MSTAT-C software to compare the means between the treatments using DMRT at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

All the growth attributes of brinjal taken at the maturity stage in the study *viz.* plant height, number of leaves, number of branches, stem diameter, leaf length and width have shown the significant result due to the application of sole use of various treatments (Table 1). The plant height was significantly higher (80.33 cm) under treatment T_4 (GA_3 25 ppm) over other treatments. Minimum plant height was recorded by Boron 0.1 % (67.96 cm).This might be due to the foliar application of different growth regulators, increased photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improved the plant height. Meena *et al*. (2015) found similar findings in their investigation and confirmed the present findings. GA extended the internodal length of plant (Das and Prusty, 1972). Gibberellins increase the plant elongation (Van Ravestign, 1983). The maximum number of leaves per plant (151.33) was recorded by treatment T_4 (GA_3 25 ppm), whereas the minimum number of leaves per plant (100.00) was recorded by treatment T_{13}-control. The increased number of leaves per plant might be due to promotive effects of growth regulators on vegetative growth, which ultimately lead to more photosynthetic activities. Similar results have also been reported by Samira *et al.* (2015).

The maximum number of branches per plant was recorded by NAA 20 ppm (16.73) and NAA 40 ppm (17.22), whereas minimum number of branches was found by Zinc 0.1% (10.61) and control (11.65). Probable reason for increased number of branches was due to the increased rates of photosynthesis and photosynthetic supply for maximum branches due to change in endogenous auxin in turn in apical dominance. These findings are in agreement with the findings of Dubey *et al.,* (2013), Gogoi *et al.,* (2014) and Meena *et al.,* (2015). The maximum stem diameter was recorded by the treatment NAA 20 ppm (34.06 mm), while control showed the minimum (8.56 mm) stem diameter. The findings are in agreement with findings of Singh *et al.* (2011). The treatment GA_3 25 ppm produced significantly higher leaf length (26.33 cm), while the minimum leaf length was recorded under the control (18.40 cm). At last harvesting stage, the widest leaf was recorded by treatment GA_3 25 ppm (18.72 cm),

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whereas narrow leaf was recorded under control (15.73 cm).The findings are in agreement with findings of Meena and Dhaka (2003).

Table 1: Effect of phyto-hormones and micro-nutrients on plant height, number of leaves, number of branches, stem diameter, leaf length and width of brinjal.

Treatments	Plant height (cm)	No. of leaves	No. of branches	Stem diameter (mm)	Leaf length (cm)	Leaf width (cm)
T_1 (NAA 20 ppm)	76.800^{bc}	142.66^{bc}	16.73^{a}	34.06^{a}	22.53^{bcd}	16.94^{ab}
T_2 (NAA 40 ppm)	78.266^{b}	145.50^{b}	17.22^{a}	13.27^{b}	24.10^{ab}	17.96^{ab}
T_3 (NAA 60 ppm)	75.333^{c}	140.33^{cd}	14.50^{cd}	11.49^{b}	21.66^{bcd}	17.16^{ab}
T_4 (GA_3 25 ppm)	80.333^{a}	151.33^{a}	16.73^{ab}	14.00^{b}	26.33^{a}	18.72^{a}
T_5 (GA_3 50 ppm)	78.540^{b}	146.66^{b}	15.43^{bc}	12.20^{b}	23.30^{bc}	18.06^{ab}
T_6 (GA_3 75 ppm)	76.933^{bc}	137.00^{d}	14.53^{cd}	12.13^{b}	22.73^{bc}	17.07^{ab}
T_7 (Boron 0.1 %)	67.966^{g}	117.66^{g}	11.80^{ef}	9.92^{b}	19.90^{de}	17.39^{ab}
T_8 (Boron 0.2 %)	69.133^{fg}	118.66^{f}	13.16^{de}	10.37^{b}	21.94^{bcd}	17.30^{ab}
T_9 (Boron 0.3 %)	71.033^{de}	130.66^{e}	13.93^{cd}	11.27^{b}	21.80^{bcd}	15.36^{b}
T_{10} (Zinc 0.1 %)	69.166^{fg}	117.66^{f}	10.61^{f}	10.37^{b}	21.10^{cd}	17.82^{ab}
T_{11} (Zinc 0.2 %)	70.233^{ef}	119.33^{f}	11.78^{ef}	10.80^{b}	21.60^{bcd}	16.26^{ab}
T_{12} (Zinc 0.3 %)	72.366^{d}	143.00^{bc}	15.33^{bc}	8.56^{b}	22.63^{bc}	16.16^{ab}
T_{13} (Control)	58.366^{h}	100.66^{g}	11.65^{f}	0.85	18.40^{e}	15.73^{b}
F test	***	***	***	*	***	*
LSD(0.05)	0.086	0.23	0.06	0.91	0.11	0.11
CV (%)	1.400	2.088	5.84	81.91	6.31	8.02

Table 2: Effect of phyto-hormones and micro-nutrients on crop canopy, number of side roots, main root length and main root diameter of brinjal.

Treatments	Crop canopy (cm^2)	Number of side roots	Main root length (cm)	Main root diameter (cm)
T_1 (NAA 20 ppm)	3148.33^{cde}	14.07^{ab}	9.75^{a}	0.92^{a}
T_2 (NAA 40 ppm)	3415.66^{bc}	14.73^{a}	10.12^{a}	0.95^{a}
T_3 (NAA 60 ppm)	3009.00^{e}	12.74^{bc}	9.50^{a}	0.91^{a}
T_4 (GA_3 25 ppm)	4194.66^{a}	15.24^{a}	10.33^{a}	1.03^{a}
T_5 (GA_3 50 ppm)	3636.66^{b}	14.00^{ab}	10.03^{a}	0.94^{a}
T_6 (GA_3 75 ppm)	3332.33^{cd}	12.74^{bc}	9.87^{a}	0.91^{a}
T_7 (Boron 0.1 %)	2360.33^{g}	8.64^{f}	7.51^{c}	0.88^{a}
T_8 (Boron 0.2 %)	2667.00^{f}	9.53^{ef}	8.74^{abc}	0.83^{a}
T_9 (Boron 0.3 %)	$2883.66e^{f}$	10.44^{de}	9.70^{a}	0.87^{a}
T_{10} (Zinc 0.1 %)	2663.66^{f}	9.89^{ef}	9.31^{ab}	0.82^{a}
T_{11} (Zinc 0.2 %)	2842.33^{ef}	10.53^{de}	9.60^{a}	0.84^{a}
T_{12} (Zinc 0.3 %)	3092.66^{de}	11.90^{cd}	10.01^{a}	0.91^{a}
T_{13} (Control)	1856.66^{h}	8.56^{f}	7.81^{bc}	0.74^{a}
F test	***	***	*	NS
LSD(0.05)	14.03	0.07	0.07	0.01
CV (%)	5.50	7.32	9.68	20.60

Crop canopy, number of side roots, main root length and root diameter of brinjal were significantly affected by the sole application of phyto-hormones and micro-nutrients (Table 2). The highest crop canopy (4194.66 cm^2) was recorded under the treatment GA_3 25 ppm at final harvesting stage. Application of GA_3 increases cell growth and elongation and leads to

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bigger plants with longer shoots which promote the maximum canopy in many plants. Application of GA_3 increases cell growth and elongation and leads to bigger plants with longer shoots which promote the maximum canopy in many plants. The findings are in agreement with findings of Meena and Dhaka (2003). The number of side roots was significantly higher (15.24) under the treatment GA_3 25 ppm (15.24) and NAA 40 ppm (14.73), while minimum side roots were observed under the control (8.56). Main root length was increased under the treatment of NAA and GA_3 at different concentrations, whereas minimum root length was found under control (7.81 cm). There was no more significant result due to the sole application of both phyto-hormones and micro-nutrients on main root diameter of the brinjal under the rest of the treatment. GA_3 significantly increased the fresh and dry weight of the shoots and roots. The findings are in agreement with findings of Sorte (2001).

Yield parameters

The yield parameters in brinjal mainly the number of fruits per plant, fruit weight, yield per plant and per hectare were found to be significantly affected by sole application of phyto-hormones and micro-nutrients (Table 3).

Table: 3 Effect of phyto-hormones and micro-nutrients on number of fruit, fruit weight, yield per plant, plot and hectare of brinjal.

Treatments	No. of fruit plant^{-1}	Fruit weight (gfruit^{-1})	Yield (Kg plant^{-1})	Yield (kgplot$^{-1)}$	Yield (tonha^{-1})
T_1 (NAA 20 ppm)	8.97^{abc}	110.71^{a}	0.98^{bc}	29.67^{bc}	36.63^{bc}
T_2 (NAA 40 ppm)	9.00^{abc}	112.38^{ab}	1.01^{abc}	30.32^{ab}	47.43^{abc}
T_3 (NAA 60 ppm)	8.43^{bc}	109.65^{bc}	0.92^{cd}	27.64^{bcde}	34.13^{cd}
T_4 (GA_3 25 ppm)	9.57^{a}	115.77^{a}	1.10^{a}	33.12^{a}	48.89^{a}
T_5 (GA_3 50 ppm)	9.14a^{b}	113.58^{ab}	1.03^{ab}	30.97^{ab}	38.24^{ab}
T_6 (GA_3 75 ppm)	8.84^{abc}	111.65^{b}	0.98^{bc}	29.49^{bcd}	36.41^{bc}
T_7 (Boron 0.1 %)	8.04^{cd}	100.22^{e}	0.80^{ef}	24.14^{fg}	29.80^{ef}
T_8 (Boron 0.2 %)	8.24^{bc}	103.55d^{e}	0.84^{de}	25.42^{ef}	31.38^{de}
T_9 (Boron 0.3 %)	8.33^{bc}	112.74^{d}	0.87^{de}	26.22^{def}	42.38^{de}
T_{10} (Zinc 0.1 %)	8.09^{bcd}	104.18^{d}	0.83^{de}	25.17^{ef}	31.08^{de}
T_{11} (Zinc 0.2 %)	8.23^{bc}	107.04^{cd}	0.87^{de}	26.36^{cdef}	32.55^{de}
T_{12} (Zinc 0.3 %)	8.51^{bc}	110.24^{bc}	0.93^{bcd}	27.96^{bcde}	43.52^{bcd}
T_{13} (Control)	7.20^{d}	100.06^{e}	0.72^{f}	21.62^{g}	26.27^{f}
F test	**	***	***	***	***
DMRT	0.04	0.17	0.004	0.15	0.17
CV (%)	6.37	1.93	6.12	6.50	6.05

The maximum number of fruits per plant (9.57) was recorded under treatment T_4 (GA_3 25 ppm) and the minimum (7.21) under T_{13} (control). The application of GA_3 increases cell growth and elongation and leads to bigger plants with longer shoots, leaves and maximum canopy in many plants. The higher concentration of phyto-hormoens and micro-nutrients leads higher vegetative growth which may cause the lower fruit set per plants. Increased number of fruits due to foliar spray of growth regulators and micro-nutrients might be attributed to enhanced photosynthetic activity, resulting in increased production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of flowers and fruits, which might have increased number and weight of fruits. These findings

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are in agreement with the results reported by Meena and Dhaka (2003). Khan *et al.* (2006) also indicated the significant role of GA_3 in tomato plant to increase fruit set that leads to larger number of fruits per plant and increased fruit size, which is most applicable in brinjal, in the present investigation. The significantly higher over other eleven treatments, but statistically at par values on fruit weight per plant was recorded under GA_3 25 ppm (115.7 g) and treatment NAA 20 ppm (110.71 g) in brinjal, whereas minimum fruit weight (100.06 g) was recorded by treatment T_{13} (control). These findings are in agreement with the results reported by Lodhi *et al.* (2002).

It was also observed that treatment T_4 (GA_3 25 ppm) produced maximum yield per plant (1.10 kg), while the minimum yield per plant (0.80 kg) was recorded under treatment T_{13} (control). These findings are in agreement with those of Gavaskar and Anburani (2004) and Natesh *et al.* (2005). The similar trend was found in case of fruit yield per plot. The maximum fruit yield per plot (33.12 kg) was produced under treatment T_4 ($GA_3$25 ppm), whereas minimum fruit yield per plot (21.62 kg) was recorded under treatment T_{13} (control). As similar, the treatment T_4 ($GA_3$25 ppm) produced maximum yield (48.89 t/ha), while the minimum yield (26.27 t/ha) was recorded in treatment T_{13} (control). Similar result in brinjal was found by Meena and Dhaka (2003) indicating the highest yield at 25 ppm GA_3. It is said that higher concentrations of GA_3 were found uneconomical. Application of GA_3 increases cell growth and elongation and leads to bigger plants with longer shoots, leaves and maximum canopy in many plants with higher crop yields. Pablo (2000) found that application of gibberellic acid in the range of 10 to 30 ppm significantly increased fruit yield as gibberellic acid increased from 0 to 20 ppm, but not when rates increased from 20 to 30 ppm.

CONCLUSION

It is concluded that among the phyto-hormones, effect of gibberellic acid on growth, yield and quality parameters of brinjal showed the best performance with treatment T_4 (GA_3 25 ppm), whereas in micronutrients treatment T_9 (Boron 0.3%) and T_{12} (Zinc 0.3%) was found better suggesting that the judicious use of both phyto-hormones and micronutrients were safe for increasing the production of brinjal in sub-tropical Terai region. The trials, however, tested the sole effect of application of phyto-hormones and micro-nutrients on brinjal suggested to study their combined effect on overall perspectives of brinjal not only for a season and location, at least for 2-3 years in multi-locations.

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Authors' contributions

B. R. Bhattarai- Accomplished research on brinjal.
A. K. Pal- Planned to frame this compiled article as a major supervisor of the concerned students at PG Program of Banaras Hindu University, India.
L. P. Amgain - Given the outline and architect the final version of this manuscript.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper

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