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Influence of Plant Bio-regulators on Growth, Yield and Quality of Garlic (*Allium sativum* L.)

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ABSTRACT
An experiment was carried out at Horticulture Research Farm, Department of Applied Plant Science(Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow during November 2012 to April 2013 to study the influence of plant bio-regulators on growth and yield of garlic cv. Yamuna Safed- 4 (G232). The experiment consisted foliar application of different doses of PBRs i.e. BA (25, 50, 75 and 100 ppm), NAA (100, 200, 300 and 400 ppm) and GA$_3$ (50, 100,150 and 200ppm).The experiment was arranged in randomized block design and the treatments were replicated thrice. The result showed that maximum plant height (80.53 cm), number of leaves per plant (8.43), length of leaves (45.96 cm) and basal diameter of plant (14.60 mm)were recorded under the treatment T$_9$ i.e. application of GA$_3$@ 50 ppm. The yield attributing parameters were also observed better in terms of diameter of bulb(5.42 cm), number of cloves (45.33 cm), fresh weight of bulb(47.85 g) and yield/ha (22.75 ton/ha) under GA$_3$@ 50 ppm followed by NAA @ 100 ppm.The quality parameters were recorded maximum viz. Total soluble solid (TSS)and maximum bio molecules groups (through FTIR analysis) were also found under treatment T$_9$ and the minimum TSS and bio molecules' group were found in the treatment T$_0$ (control).
Key words: Garlic, Bio-regulators, BA, NAA, GA$_3$, growth and yield, BA- Benzyl adenine, NAA- Naphthalene acetic acid,GA$_3$- Gibberellic acid, FTIR-Fourier Transform Infrared Spectroscopy

INTRODUCTION

Garlic (*Allium sativum* L.) is the foremost alliouaus vegetable belongs to family Alliaceae (Leliaceae). It is a frost hardy bulbous perennial, erect herb having white narrow flat leaves and bears small white flower and bulbils. Central Asia and Southern Europe especially Mediterranean region is believed to be the origin of garlic [15]. Garlic is the second most widely used cultivated Alliums after onion. It has long been recognized all over the world as a valuable spice for foods and a popular remedy for various ailments and physiological disorders. Garlic is also believed to be one of the most important medicinal plants which have broad nutroprotective properties. The important medicinal properties of garlic are mentioned in Egyptian text CodexEmber's (1500BC), Chinese literature and charaksanhita, Manu Sanhita and also in Indian clinical tradition viz. Tibbi, Unani and Aurveda. The study [5, 16, 12, 2, 3, 14, 8, 1, 2,7], revealed that garlic exhibits antibiotics, antioxidants, anticoagulant, hypocholesterolemic and hypoglycaemic activities. It has potentiality to reduce blood pressure level. Garlic could have a protective nature against gastrointestinal neoplasis and also be useful as co-adjuvant therapy in the treatment of diabetes and some of its physiological complications. It has a significant effect in both ventricular and super ventricular arrhythmias, protective effect on the elastic properties of the aorta related to aging in human.

To enhance the garlic production and productivity as well as quality various package of practices are being adopted among them Plant bio regulators (PBRs) have been known to play vital role in bulbing of garlic. It has also been reported that foliar application of PBRs stimulates to form lateral buds and increase the no. of cloves per bulbs. The bio- regulators comprise of both retardants and promoters which

when use in appropriate concentration, much influence on the plant architecture in a typical form. It is evident from the literature that the time and the site of application along with concentrations and formulation of different exogenously applied growth regulators are considered as beneficial factor for improving the productivity and quality of horticultural crops, but a little information is available for their effect of garlic. Therefore, an attempt was made to evaluate the effectiveness of different concentration of PBRs on the growth and yield of garlic which might be help for substantial contribution to the nation.

MATERIALS AND METHODS

The experiment was conducted to assess the influence of foliar application of Plant bio- regulators on growth and yield of garlic at the Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow- 226025 during the year November 2012 to April 2013. There were 13 different treatments comprising three different Plant Bio-regulators (BA, NAA and GA_3) each in four different doses i.e.25,50,75 and 100 ppm of BA; 100,200,300 and 400 ppm of NAA and 50,100,150 and 200 ppm of GA_3 and one control (water spray). Each of them applied at 30, 60 and 90 days after planting (DAP).The experiment was laid out in the Randomized Block Design (RBD). The treatment was replicated three times and the whole plot was divided in to three blocks each representing a replication. Each block was then divided in to thirteen unit's plot of 0.75 x 0.75 m^2 in sizes. The blocks were separated from each other by one meter and each plot within the same block was also separated from each other by 50 cm. Seed cloves of a cultivar G-323 (Yamuna Safed-4) of garlic, collected from National Horticulture Research and Development Foundation (NHRDF) Kanpur were used as the propagating materials in this experiment. The cloves of uniform size were selected for planting. The cloves were planted in rows with 15 x15 cm spacing. The experimental plot were fertilized with FYM, Urea and DAP (Di- ammonium phosphate) and MOP (Muriate of potash) @ 25t/ha, 120kg/ha, 100kg/ha, and 80 kg/ha respectively. Total amount of FYM and DAP were added to the soil at the time of final land preparation. Urea and MOP were top dressed in two equal splits at 30 and 60 days after planting the cloves. After harvesting the bulbs and cloves were kept for drying in the dryer about 65±5^{0}C temperature for 48 hours after taking the fresh weight. The observed data were statistically analyzed using Analysis of variance.

RESULT AND DISCUSSION
Effect of PBRs on growth parameters of garlic
The maximum and minimum plant height (Table -1) at 45,75,105 and 135 days after planting (DAP) was 36.63cm, 50.72cm,78.79cm and 80.53cm, respectively were observed in the treatment T_9 (GA_3 @ 50 ppm) . Followed by T_5 (NAA @ 100 ppm) and T_{10} (GA_3 @ 100 ppm). Whereas the least mean plant height values noted at 45, 75, 105 and 135 DAP were (28.43cm, 41.53cm, 68.35cm and 73.77cm, respectively) in the untreated control.

These results are in conformation with the findings of Maurya and Lal [10], Bhople *et al*. [6], Shakhda and Gajipara [13]. The maximum and minimum number of leaves per plant counted at 45, 75, 105 and 135 DAP The data presented in Table-1 showed that the maximum number of leaves (4.70, 6.77, 7.77 and 8.43 respectively) were observed with the application of GA3@ 50 ppm while the minimum number of leaves (3.70, 4.32, 6.17 and 7.23 respectively) were obtained in the untreated control plants. Similar trend was also observed by Maurya and Lal [10] and Shakhda and Gajipara [13].

Data recorded on leaf length showed that GA_3 @ 50 ppm has positive effect on improvement of leaf length at 45, 75,105, and 135 DAP (30.61 cm, 41.35 cm, 50.80 cm and 45.96 cm, respectively).Whereas, the least mean length of leaves was noted (24.38 cm, 34.67 cm, 40.52 cm and 38.75 cm, respective[11] in the untreated control. These results corroborated with the finding of Mandal *et al*. [9] and Patel *et al*. (2010). However there was decrease in length of leaves at 135 DAP was recorded. Though no literature had been found to explain this factor. The decrease in length of leaves at 135 DAP might be due to increase in temperature (data not shown) during this period. The basal diameter was recorded at 45, 75, 105 and 135 DAP (Table-1) and the maximum mean diameter at basal portion (7.03 mm, 10.40 mm, 13.83 mm and 14.60 mm, respectively) was noted with T_9 (GA_3@ 50 ppm) .The minimum mean diameter was recorded (4.80 mm, 7.53 mm, 9.30 mm and 10.43 mm, respectively recorded at 45, 75, 105 and 135 DAP) in untreated control. Such growth behaviour might be due to enhancement of growth and apical dominance. The growth regulators are involved in enhancing photosynthetic activity, efficient assimilation of photosynthetic products and it resulted in rapid cell division and cell elongation in the growing portions of the plant or stimulation of growth besides increasing uptake of nutrients.

Effect of PBRs on yield and quality of garlic
The result of this study indicated significant variation due to effect of growth regulators in yield and it's attributes (Table-2) viz. equatorial and polar diameter of bulb, fresh and dry weight of bulb, number of

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cloves, yield per hectare and TSS etc. all these component were consistently found superior in all the growth regulators treatments compared to control. They were significantly the highest (5.42cm and 4.38cm, 47.85g and16.15 g, 45.33, TSS43.930B and, 22.75 ton/ha, respectively) in GA$_3$@ 50 ppm as against control (3.40cm and 2.93cm, 32.27g and10.14g, 32.67, TSS 35.73^{0}B and11.35 ton /ha, respectively). It might be due to fact that GA$_3$ initiate the physiological process such as cell division, cell elongation and permeability of cell membrane The result of functional group analysis using FTIR revealed the existence of various characteristics functional groups *viz*. N-N, O-H, N-H, C=C, >C=C<, -NO$_2$, -C-N-, C-O-, -C-C, C-Br in garlic. The application of PBRs on garlic as foliar spray influenced the metabolic activities of garlic which were reflected by FTIR analysis showing variation in presence of functional groups. The present study showed that the various functional groups were found maximum under treatment T$_9$ (GA$_3$ @ 50 ppm) followed by T$_5$ (NAA @ 100 ppm) and minimum under control (T$_0$).

Table 1. Effect of Plant Bio- Regulators on growth parameters of garlic

Treatment	Plant height (cm)				No. of leaves/plant				Length of leaves (cm)				Basal diameter of plant (mm)			
	45 DAP	75 DAP	105 DAP	135 DAP	45 DAP	75 DAP	105 DAP	135 DAP	45 DAP	75 DAP	105 DAP	135 DAP	45 DAP	75 DAP	105 DAP	135 DAP
T$_0$ -Control	28.43	41.53	68.35	73.77	3.70	4.32	6.17	7.23	24.38	34.67	40.52	38.75	4.80	7.53	9.30	10.43
T$_1$ - BA @25 ppm	32.75	43.57	71.33	75.95	4.63	6.20	7.30	7.90	28.12	37.48	45.94	41.99	6.23	9.43	12.95	13.57
T$_2$ - BA @ 50 ppm	33.97	46.67	74.47	77.12	4.57	6.03	7.47	7.93	29.22	39.68	46.75	42.19	6.43	10.47	13.23	13.93
T$_3$ - BA @ 75 ppm	33.67	44.93	73.50	75.58	4.62	6.23	7.33	7.80	27.09	38.87	45.50	41.55	6.37	9.63	12.80	13.67
T$_4$ - BA @ 100 ppm	32.50	41.83	72.78	76.52	4.43	6.20	7.05	7.87	26.69	37.05	43.82	41.18	6.07	9.37	12.46	13.27
T$_5$ - NAA@ 100 ppm	37.48	49.35	77.90	79.97	4.67	6.77	7.50	8.13	29.32	40.34	49.51	45.26	6.70	10.40	13.67	14.16
T$_6$ -NAA @ 200 ppm	35.87	48.10	75.28	78.08	4.67	6.37	7.39	7.97	27.72	39.80	48.12	43.57	6.63	9.73	12.78	13.90
T$_7$ -NAA @ 300 ppm	35.20	47.68	76.71	77.07	4.60	6.27	7.37	7.87	26.51	39.63	46.60	43.40	6.47	9.43	12.39	13.73
T$_8$ -NAA @ 400 ppm	34.47	46.47	75.73	76.90	4.60	6.67	7.37	7.57	26.46	38.52	45.58	42.60	6.13	9.13	12.23	13.31
T$_9$ - GA$_3$ @ 50 ppm	38.63	50.72	78.98	80.53	4.70	6.57	7.77	8.43	30.61	41.35	50.80	45.96	7.03	10.83	13.83	14.60
T$_{10}$ - GA$_3$ @ 100 ppm	36.30	49.03	76.95	78.63	4.63	6.33	7.63	8.33	28.84	40.46	48.71	44.31	6.87	10.57	13.43	14.03
T$_{11}$ –GA $_3$@ 150 ppm	35.43	46.49	75.97	77.30	4.70	6.50	7.60	8.27	28.15	39.73	47.51	43.97	6.43	9.93	13.01	13.97
T$_{12}$ - GA$_3$ @ 200 ppm	34.53	45.53	75.47	77.17	4.77	6.47	7.40	8.23	27.40	38.55	46.65	42.56	6.17	9.30	12.57	13.53
SEm (±)	0.53	0.48	0.57	0.58	0.11	0.23	0.24	0.22	0.93	0.78	0.79	0.76	0.28	0.27	0.37	0.29
CD (P = 0.05)	1.56	1.41	1.67	1.70	0.32	0.67	0.69	0.64	2.72	2.29	2.30	2.21	0.81	0.80	1.07	0.84

Table -2.Effect of Plant Bio- Regulators on yield and quality of garlic

Treatments	Diameter of bulb (cm)		No. of cloves / bulb	Weight of bulb (g)		Yield (tonnes/ha)	TSS (in B^0)
	Equatorial	Polar		Fresh	Dry		
sT$_0$ –Control	3.40	2.93	32.67	32.27	10.14	11.35	35.73
T$_1$ - BA @ 25 ppm	4.45	3.87	38.33	38.53	12.43	17.13	38.57
T$_2$ - BA @ 50 ppm	4.83	3.98	40.35	40.18	13.63	17.86	39.70
T$_3$ - BA @ 75 ppm	4.57	3.88	39.57	39.23	13.33	17.43	39.28
T$_4$ - BA @ 100 ppm	4.40	3.65	36.93	38.22	12.27	16.98	40.86
T$_5$ – NAA @ 100 ppm	5.10	4.33	43.95	46.62	15.95	22.30	40.55
T$_6$ - NAA @ 200 ppm	5.08	4.32	41.35	45.58	15.53	20.59	41.60
T$_7$ - NAA @ 300 ppm	4.92	4.29	40.36	44.67	15.04	19.85	41.74
T$_8$ - NAA @ 400 ppm	4.68	4.15	38.96	43.87	14.67	19.50	43.83
T$_9$ - GA$_3$ @ 50 ppm	5.42	4.46	45.33	47.85	16.15	22.75	43.93
T$_{10}$ - GA$_3$ @ 100 ppm	5.03	3.98	42.93	46.18	15.13	21.77	42.55
T$_{11}$ - GA$_3$ @ 150 ppm	4.75	3.67	40.94	44.56	14.48	20.40	43.06
T$_{12}$ - GA$_3$ @ 200 ppm	4.53	3.40	39.47	42.49	13.95	11.35	43.06
SEm (±)	0.22	0.11	0.90	0.96	0.59	1.01	0.46
CD (P = 0.05)	0.66	0.33	2.64	2.79	1.73	2.95	0.95

CONCLUSION

The present study recorded that the use of Plant Bio- regulators enhanced the performance of garlic in general compared to untreated control. The vegetative growth of garlic with respect to height of plant, number of leaves, maximum length of leaves, basal diameter etc. and yield and yield attributes viz. diameter of bulb, fresh and dry weight of bulb, number of cloves, yield per hectare and qualityTSS andvarious functional groupwere obtained maximum with the foliar application of GA_3 @ 50 ppm among the bio- regulators in the present study under Lucknow condition. Therefore, it may be concluded that foliar application of GA_3 @ 50 ppm can be recommended to garlic growers and pharmacists for obtaining better growth, yield and quality improvement of garlic cv. Yamuna Safed- 4 (G-232) under Lucknow condition.

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