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Influence of plant growth regulators on growth and yield of garlic (*Allium sativum* L.)

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ABSTRACT

An investigation was carried out to study the influence of different concentration of growth regulators and chemicals on the growth and yield of garlic (local cultivar Katki). during rabi season of 2010-2011 and 2011-12. Four plant growth regulators viz. GA_3, NAA and thiourea (50 ppm, 100 ppm and 200ppm) along with kinetin (10 ppm, 20 ppm and 40 ppm) and two chemicals viz..KNO_3 and NaH_2PO_4 @ 50 ppm, 100 ppm and 200 ppm were tested in the present investigation. Maximum breadth of large clove (1.20cm), length of medium clove (1.90cm), weight of bulb(24g), yield per plot (1.68kg 2.1m^{-2}) and projected yield (5.89t ha^{-1}) were noticed under thiourea 100 ppm. Highest diameter of bulb (4.21cm) was associated under $GA_3$200 ppm. Maximum length of large (2.53cm) and small clove (1.33 cm) were recorded under kinetin 40 ppm. Maximum cost benefit ratio (1:3.19) was noted under thiourea 100 ppm followed by $NaH_2PO_4$100ppm (1: 3.00). The most promising treatment under the alluvial tracts of West Bengal for garlic production is thiourea 100 ppm followed by $NaH_2PO_4$100 ppm ,GA_3 200 ppm and kinetin 40 ppm.

Keywords **:** Chemicals, garlic, plant growth regulators, yield.

Garlic (*Allium sativum* L., Family- Alliaceae) is one of the important bulbous crops grown worldwide. The clove of garlic is used as spice or condiment that contains 0.1 per cent volatile oil. The major constituents of the oil are diallyl disulphide (60%), diallyl trisulphide (20%) and allyl propyl disulphide (6%). According to the Unani and Ayurvedic systems of medicine as practiced in India, garlic is carminative and gastric stimulant. It has antimicrobial agent and improves blood sugar metabolisim, prevents atherosclerosis and coronary heart disease by reducing platelet aggregation, promoting fibrinolysis, lowering blood triglycirine and cholesterol.

Allicin present in aqueous extract of garlic reduces cholesterol concentration in human blood. In India, garlic is cultivated over 1.65 lakhs hectares, with total production of 8.34 lakhs metric ton and productivity of 5.0 t ha^{-1} (NHRDF, 2011; www.nhb.gov.in). The export potential of garlic in India was 567.39 MT during 2001- 2002 which has increased to 17852 MT during 2009-2010 (NHB, 2010). Madhya Pradesh is the leading producer of garlic in India with an area of 23.63 thousand hectares and productivity of 5.33 t ha^{-1}. In West Bengal, it is cultivated in very small scale mainly in the Terai and Gangatic alluvial plains of Cooch Bihar, Jalpaiguri, Dinajpur (N), Malda, Murshidabad, Nadia and North 24 Parganas. Application of plant growth regulators would increase the production and productivity. Plant growth regulators (Moon and Lee, 1980), Gibberelic acid in particular (Rahim, 1988) play a vital role in bulb development in garlic. Apart from growth regulators, chemicals like potassium nitrate (KNO_3) and sodium dihydrogen phosphate (NaH_2PO_4) have been used to trigger the seed germination (Lanrinpuii, 2012).

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Many studies have indicated that the application of plant growth regulators can affect the growth and development of bulb crops, but information on application of PGRs in yield optimization of garlic is scanty. Hence, the present investigation was carried out to study the effect of different growth regulators and chemicals on growth and bulb yield of garlic and also to optimize different doses of growth regulators.

MATERIAL AND METHODS

The present investigation was undertaken at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India in Gangetic alluvial soil with pH of 6.9 during the *rabi* season of two consecutive years, 2010-2011 and 2011-2012. The experiment was laid out in Randomized Block Design with 19 treatments replicated twice. The selected cloves of 8-10 mm diameter were treated with the plant growth regulators *viz.,* T_1-GA_3 50 ppm, T_2-GA_3 100 ppm, T_3-GA_3 200 ppm, T_4 -Thiourea 50 ppm, T_5-Thiourea 100 ppm, T_6-Thiourea 200 ppm, T_7- NaH_2PO_4 50 ppm, T_8 - NaH_2PO_4 100 ppm, T_9- NaH_2PO_4 200 ppm, T_{10}- KNO_3 50 ppm, T_{11} - KNO_3 100 ppm, T_{12}- KNO_3 200 ppm, T_{13}- NAA 50 ppm, T_{14} -_ NAA 100 ppm, T_{15}- NAA 200

ppm, T_{16} -- kinetin 10 ppm, T_{17}- kinetin 20 ppm, T_{18}- kinetin 40 ppm and T_{19}- Control (distilled water) for 12hrs before sowing. The cloves were planted at 20 × 15 cm spacing in 2 × 1.05m plots incorporated with 20 t ha^{-1} of FYM and NPK @ 152:124:150 kg ha^{-1} during second week of November in both the years. The matured bulbs of garlic under different treatments and replications were harvested during the third week of March in both the years and were kept for a week in shade for curing. The observations on vegetative characters *viz.,* plant height, number of leaves per plant were taken at 60, 90 and 120 days after planting (DAP). The number of roots per plant, weight of roots and different yield attributing characters like diameter of bulb, number of cloves per bulb, breadth of cloves, length of cloves**,** weight of bulb, yield per plot, projected yield and economics of crop cultivation were recorded after harvest. Pooled analysis of two years experimental data were made following standard statistical methods, (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The data presented in table-1 revealed that the sprouting per cent was significantly influenced by different treatments. The sprouting was recorded to be higher (90.66%) under kinetin 40ppm followed by $NaH_2PO_4$100 ppm (89.77%) and the same was found to be lower in control (76.42%). Plant height at different stages of growth was also significantly varied under different treatments at 60, 90 and 120 DAP. At 60 DAP, the average plant height was higher (44.69 cm) in thiourea at 50 ppm and lower (33.23 cm) in kinetin at 10 ppm. At 90 DAP, the higher plant height of 65.07 cm was recorded with thiourea 100 ppm while it was recorded to be lowest in control plants (53.10 cm). At 120 DAP, the higher plant height (72.00 cm) was obtained with thiourea 200 ppm, while minimum was found under untreated control (62.05 cm). Significant variation was also observed in leaf numbers among different treatments . At 60 DAP, maximum number of leaves was recorded under GA_3 200 ppm (7.51), but the minimum number of leaves was noticed with control plants (5.87). The maximum number of leaves (10.16) was observed with GA_3 200 ppm treatment, while it was minimum (7.82) under control plants at 90 DAP. At 120 days after planting there was a significant increase in number of leaves while compared with the number of leaves observed at 60 and 90 DAP. The maximum number of leaves was

Table 1: Effect of treatments on sprouting and growth attributes of garlic-(Pooled)

Treatment	Sprouting (%)	Plant height (cm)			Number of leaves			No. of roots	Wt. of roots
	30 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP		(g)
T_1: GA_3@50ppm	78.94	35.07	57.70	65.02	6.29	9.13	11.23	71.91	0.81
T_2: GA_3@100ppm	83.63	37.34	60.09	67.99	6.57	9.74	11.77	66.87	0.95
T_3: GA_3@200ppm	88.52	38.09	62.86	71.00	7.51	10.16	12.69	63.52	1.11
T_4: *Thiourea*@50ppm	87.33	44.69	63.41	68.27	6.85	9.81	12.50	66.28	1.09
T_5: *Thiourea*@100ppm	85.37	41.71	65.07	71.42	6.71	9.35	12.17	68.93	0.88
T_6: *Thiourea*@200ppm	78.59	40.59	63.09	72.00	6.14	9.30	11.65	58.22	0.73
T_7: NaH_2PO_4@50ppm	83.82	44.00	58.46	67.72	7.31	9.85	11.84	66.38	0.87
T_8: NaH_2PO_4@100ppm	89.77	37.33	64.95	70.51	5.88	10.10	12.60	67.70	0.96
T_9: NaH_2PO_4@200ppm	84.53	35.28	56.32	66.02	5.89	9.55	11.98	60.72	0.66
T_{10}: KNO_3@50ppm	87.20	37.43	59.47	66.81	6.69	9.23	11.08	69.70	0.80
T_{11}: KNO_3@100ppm	89.05	40.39	60.68	69.65	7.15	9.92	12.50	61.90	1.07
T_{12}: KNO_3@200ppm	80.44	37.40	60.12	67.48	6.95	9.70	12.00	58.24	0.80
T_{13}: NAA@50 ppm	77.39	38.86	57.47	65.64	6.54	9.21	10.67	58.07	0.73
T_{14}: NAA@100 ppm	80.55	39.31	61.60	67.53	6.77	9.58	11.81	63.20	0.83
T_{15}: NAA@200 ppm	87.75	40.34	59.72	69.49	7.00	9.82	12.05	68.06	1.01
T_{16}: Kinetin@10 ppm	79.86	33.23	55.52	63.88	7.01	9.00	11.91	66.44	0.68
T_{17}: Kinetin @20 ppm	85.19	36.66	56.10	65.48	6.44	9.25	11.86	63.92	0.82
T_{18}: Kinetin @40 ppm	90.66	38.11	58.30	67.94	7.00	10.15	12.26	70.96	1.09
T_{19}: Control	76.42	33.44	53.10	62.05	5.87	7.82	9.96	60.65	0.85
SEm(±)	**0.60**	**1.63**	**1.38**	**0.44**	**0.53**	**0.44**	**0.37**	**0.71**	**0.01**
LSD(0.05)	**1.79**	**4.83**	**4.11**	**1.31**	**1.57**	**1.32**	**1.09**	**2.10**	**0.04**

recorded under GA_3 200ppm (12.69) and the minimum numbers of leaves was obtained in control plants (9.96). All the treatments have significant influence on the growth parameters as compared to the control. The chemicals and growth regulators also showed significant influence on the fruit retention and yield of mango cv. Amrapalli over control (Vejendla *et al*., 2008). The pooled data for number of roots was higher (71.91) was noticed under GA_3 50 ppm followed by kinetin 40 ppm (70.96) and KNO_3 50ppm (69.70) as compared to least number of roots (58.07) under NAA 50 ppm. The decreasing trend in number of roots was noticed in increasing concentration under GA_3 and KNO_3. In case of both thiourea and NaH_2PO_4 medium concentration exhibit the higher number of roots per plant. Individual root weight was found to be varied significantly under different treatments which has been observed to be higher in GA_3 200 ppm (1.11g) followed by treatments with thiourea 50 ppm (1.09g) and KNO_3 100 ppm (1.07g). The lowest root weight was associated with NaH_2PO_4 200 ppm treatment (0.66g).

Significant difference in the length of clove was observed under different treatments. The clove was grouped into three categories large, medium and small according to the size of cloves. The clove length was higher 2.53 cm under kinetin 40ppm and lowest clove length of 2.21cm was obtained under control. In respect to medium clove the highest clove length of 1.90cm was noticed under *thiourea* 100 ppm whereas, the minimum clove length of 1.60 cm was obtained under untreated plots. Maximum clove length was obtained from kinetin 40 ppm (1.33) closely followed by $GA_3$200ppm (1.32cm) and NAA 200 ppm (1.30 cm) while the least clove length of 1.08 cm was noticed under NaH_2PO_4 50 ppm in case of small clove. The data revealed that different treatments produced significant variation on the breadth of cloves (large, medium and small). In pooled data maximum breadth of large clove (1.20cm) was recorded under thiourea 100 ppm treatment followed by GA_3 200 ppm (1.16 cm) and NaH_2PO_4 100 ppm (1.14 cm). The minimum clove breadth of 0.93cm was noticed under untreated control. In medium sized clove as per pooled data the maximum breadth of 0.86cm was noticed under KNO_3 100 ppm and kinetin 20 ppm, followed by 0.85cm (kinetin 40 ppm) and 0.81cm (thiourea 100 ppm) and the least was recorded under GA_3 50 ppm (0.69cm). In respect of small clove, the maximum breadth of 0.64 cm was obtained under NaH_2PO_4 50 ppm, and the least breadth of 0.52 cm was noticed

Table 2: Effect of treatments on length, breadth, no. of cloves and diameter of bulb in garlic-(Pooled)

Treatment	Length of cloves (cm)			Breadth of cloves (cm)			No. of cloves	Diameter of bulb (cm)
	Large	Medium	Small	Large	Medium	Small		
T_1: GA_3@50ppm	2.26	1.68	1.27	1.05	0.69	0.59	28.60	3.97
T_2: GA_3@100ppm	2.35	1.67	1.27	1.02	0.73	0.62	30.82	3.95
T_3: GA_3@200ppm	2.39	1.79	1.32	1.16	0.74	0.62	32.70	4.21
T_4: *Thiourea*@50ppm	2.36	1.76	1.19	1.06	0.77	0.61	30.61	3.97
T_5: *Thiourea*@100ppm	2.44	1.90	1.28	1.20	0.81	0.59	33.21	3.79
T_6: *Thiourea*@200ppm	2.29	1.65	1.23	1.04	0.77	0.63	29.65	3.72
T_7: NaH_2PO_4@50ppm	2.38	1.77	1.08	1.13	0.78	0.64	31.84	3.96
T_8: NaH_2PO_4@100ppm	2.34	1.82	1.28	1.14	0.79	0.63	35.37	3.88
T_9: NaH_2PO_4@200ppm	2.23	1.63	1.26	1.07	0.71	0.61	30.79	3.67
T_{10}: KNO_3@50ppm	2.34	1.72	1.21	1.09	0.77	0.60	27.31	3.93
T_{11}: KNO_3@100ppm	2.41	1.81	1.26	1.06	0.86	0.62	33.73	3.91
T_{12}: KNO_3@200ppm	2.26	1.70	1.09	1.03	0.73	0.59	32.68	3.88
T_{13}: NAA@50 ppm	2.31	1.69	1.16	1.03	0.70	0.56	29.69	3.71
T_{14}: NAA@100 ppm	2.36	1.69	1.24	1.14	0.76	0.63	36.03	3.93
T_{15}: NAA@200 ppm	2.42	1.77	1.30	1.09	0.79	0.62	36.29	4.03
T_{16}: Kinetin@10 ppm	2.38	1.70	1.23	1.02	0.77	0.58	30.67	3.81
T_{17}: Kinetin @20 ppm	2.31	1.77	1.28	1.11	0.86	0.61	29.68	3.82
T_{18}: Kinetin @40 ppm	2.53	1.83	1.33	1.10	0.85	0.57	33.28	3.98
T_{19}: Control	2.21	1.60	1.21	0.93	0.77	0.52	27.04	3.76
SEm(±)	**0.04**	**0.03**	**0.03**	**0.37**	**0.01**	**0.01**	**0.54**	**0.06**
LSD(0.05)	**0.11**	**0.08**	**0.08**	**1.10**	**0.03**	**0.03**	**1.61**	**0.18**

under control plants. The treatment with NAA 200 ppm gave the highest number of cloves per bulb (36.29) closely followed by NAA 100 ppm (36.03) and NaH_2PO_4 100 ppm (35.37) while the minimum number of cloves per bulb was recorded under control (27.04). The bulb diameter was significantly affected by different treatments. The maximum diameter of bulb (4.21 cm) was obtained from GA_3 200 ppm while it was minimum under NaH_2PO_4 200 ppm (3.67cm) in pooled data (Table 2).

Data presented in table-3 clearly indicated that, the weight of bulb was significantly increased under different concentration of growth regulators and chemicals. The maximum bulb weight of 24g was found under thiourea 100ppm followed by GA_3 200 ppm (23.11g) and NaH_2PO_4 100 ppm (22.99g) as compared to minimum weight of 17.24g under NAA 50 ppm. The increasing trend in weight of bulb was noticed with the increasing concentration of both GA_3 and thiourea. From pooled data the maximum yield of 1.68 kg 2.1 m^{-2} was recorded with thiourea 100 ppm treatment followed by GA_3 200 ppm with 1.62kg 2.1m^{-2}. The minimum plot yield of 1.23 kg was noticed under kinetin 10 ppm. The medium and higher concentration of thiourea and GA_3 gave higher yield. From the result of the same table it revealed that, the trend was similar like yield per plot. Highest bulb of 5.89 t ha^{-1} was obtained under thiourea 100 ppm followed by GA_3 200 ppm (5.66 t ha^{-1}) and NaH_2PO_4 100 ppm (5.62 t ha^{-1}) as compared to lowest yield of 4.31 t ha^{-1} under kinetin 10 ppm. The data presented in table- 3 is also revealed that the net profit per hectare is influenced by the application of different concentration of growth regulators and chemicals. Among all the treatments it was observed that medium concentration of thiourea 100 ppm (Rs. 1,34,539.89) had a pronounced effect in promoting the net economic return followed by $NaH_2PO_4$100ppm (1,26,447.09) and GA_3 200 ppm (Rs.1,23,454.59) and the least was recorded with NAA100 ppm with a net profit of Rs.86,664.59 per hectare. The maximum cost benefit ratio (1: 3.19) was noted under thiourea 100 ppm followed by $NaH_2PO_4$100ppm (1:3.00) and least in NAA100 ppm (1:2.03).

Among the treatments, thiourea 100 ppm and NaH_2PO_4 100 ppm were found to be promising followed by $GA_3$200 ppm and kinetin 40 ppm for growth and yield of garlic. Cloves treated with GA_3 200 ppm gave the highest result. GA_3 affects the rate of cell division and an increased in cell division leading to production of larger leaves. Md. Hye *et al.*

Table 3: Effect of treatments on yield and economics of garlic cultivation (Pooled)

Treatment	Weight of bulb (g)	Yield (kg $plot^{-1}$)	Projected yield (t ha^{-1})	Gross return (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net profit (Rs ha^{-1})	Cost : benefit
T_1: GA_3@50ppm	18.10	1.27	4.45	133500	43195.31	90304.69	1:2.09
T_2: GA_3@100ppm	19.62	1.37	4.80	144000	44245.41	99754.59	1:2.25
T_3: GA_3@200ppm	23.11	1.62	5.66	169800	46345.41	123454.59	1:2.66
T_4: *Thiourea*@50ppm	18.33	1.29	4.50	135000	42152.76	92847.24	1:2.20
T_5: *Thiourea*@100ppm	24.00	1.68	5.89	176700	42160.11	134539.89	1:3.19
T_6: *Thiourea*@200ppm	19.42	1.36	4.78	143400	42174.81	101225.19	1:2.40
T_7: NaH_2PO_4@50ppm	20.51	1.44	5.04	151200	42149.19	109050.81	1:2.59
T_8: NaH_2PO_4@100ppm	22.99	1.61	5.62	168600	42152.91	126447.09	1:3.00
T_9: NaH_2PO_4@200ppm	18.54	1.30	4.54	137100	42160.53	94939.47	1:2.25
T_{10}: KNO_3@50ppm	17.82	1.39	4.85	145500	42148.91	103351.09	1:2.45
T_{11}: KNO_3@100ppm	21.08	1.48	5.17	155100	42152.91	112947.09	1:2.68
T_{12}: KNO_3@200ppm	18.64	1.31	4.57	148200	42159.91	106040.09	1:2.52
T_{13}: NAA@50 ppm	17.24	1.39	4.85	151800	42390.41	109409.59	1:2.58
T_{14}: NAA@100 ppm	20.14	1.40	4.94	129300	42635.41	86664.59	1:2.03
T_{15}: NAA@200 ppm	21.66	1.45	5.06	157200	43125.41	114074.59	1:2.65
T_{16}: Kinetin@10 ppm	17.59	1.23	4.31	129300	42285.41	87014.59	1:2.06
T_{17}: Kinetin @20 ppm	21.40	1.52	5.24	157200	42565.41	114634.59	1:2.69
T_{18}: Kinetin @40 ppm	22.62	1.58	5.54	166200	42845.41	123354.59	1:2.88
T_{19}: Control	19.53	1.37	4.68	140400	42145.41	98254.59	1:2.33
SEm(±)	**0.38**	**0.05**	**0.07**	—	—	—	—
LSD(0.05)	**1 .12**	**0.14**	**0.21**	—	—	—	—

(2002) reported that GA_3 200 ppm induced maximum number of leaves and there was a gradual increased in leaf number with the concentration of GA_3. Yield attributing characters, such as bulb weight, clove length, clove breadth and number of cloves per bulb was significantly influenced by both growth regulators and chemicals. The highest bulb weight of 24g was obtained in thiourea 100 ppm. The maximum bulb diameter of 4.21 cm was obtained under $GA_3$200 ppm. Md. Hye *et al*. (2002) reported the highest bulb diameter under $GA_3$200 ppm. The highest number of cloves per bulb was associated with NAA 200 ppm. NAA induced cell elongation and rapid cell division in the growing portion causing bulb development. It was noticed that application of thiourea 100 ppm proved to be the best with various yield attributing characters. Thiourea a sulf hydral compound is known for breaking dormancy and stimulating germination and improved the growth and yield of crops. Sahu and Singh (1995) opined that thiourea delay senescence and enhance photosynthetic efficiency leading to increased growth and yield of plants. Thiourea affects both carbohydrates and nitrogen metabolism which in turn enhances plant performance and increased dry matter production and yield.

The most promising treatment of PGRs for garlic production under the alluvial tracts of West Bengal is thiourea 100 ppm followed by $NaH_2PO_4$100 ppm, GA_3 200 ppm and kinetin 40 ppm.

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