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Influence of PGRs and nitrogen on yield and B:C of garlic (*Allium sativum* L.)

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Abstract
A field experiment was conducted to study the bulb attributes and B:C of garlic (*Allium sativum* L.) as influenced by NAA and thiourea with varying levels of nitrogen during the *rabi* season. The results indicated that among NAA and thiourea treatments, foliar application of thiourea 200 ppm to the garlic crop significantly increased fresh weight of bulb (50.69 g), bulb yield (134.58 q/ha) and net returns (₹ 1,08,062 /ha) and B: C ratio (1.34) as compared to control. Application of nitrogen 125 % of recommended dose of nitrogen significantly increased the weight of bulb (50.11 g) and bulb yield (138.89 q/ha) and net returns (₹1,13,662 /ha) and B: C ratio (1.40), which was statistically at par with application of 100 % of recommended dose of nitrogen. The interaction effect of NAA, thiourea and nitrogen was found significant on the fresh weight and yield of garlic bulb. The maximum fresh weight of bulb and yield (61.59 g and 159.64 q/ha) was recorded under treatment combination thiourea 200 ppm + 125 % recommended dose of nitrogen, respectively. However, it was found statistically at par to treatment thiourea @ 100 ppm + 125 % RDN and thiourea 200 ppm + 100 % recommended dose of nitrogen. B: C ratio was significantly influenced by interaction effect of growth regulators and nitrogen application. However, the application of thiourea 200 ppm + 125 % recommended dose of nitrogen recorded maximum B: C ratio 1.76 for garlic crop, which was at par with treatments thiourea 200 ppm + 100 % recommended dose of nitrogen, thiourea 100 ppm + 125 % recommended dose of nitrogen and thiourea 100 ppm + 100 % recommended dose of nitrogen.

Keywords: garlic, NAA, thiourea, yield, B: C ratio

Introduction
Garlic (*Allium sativum* L.) is a compound bulb consists of smaller bulblets called ‘cloves’ surrounded by a thin white papery sheath. It belongs to the family amaryllidaceae. It is the second important bulb crop after onion. Garlic is used in flavoring of foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. It also contains phosphorus, potash, calcium, magnesium, carbohydrates and a colourless as well as odourless water soluble amino acid called ‘allin’. The principal flavouring ingredient is odoriferous diallyl-disulphide. Medicinally, it is used in stomach troubles, head-ache, tooth ache, nervous disorders, rheumatism etc. It is included in Indian system of medicines (Ayurvedic, Unani and Siddha) as carminative and gastric stimulant to help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces blood cholestrol concentration (Shankaracharya, 1974) [14]. Garlic extract together with chilli and ginger is effective against nematodes. Besides, it is also found effective against several fungi and bacteria (Pandey, 1997) [9] and has recently become an integral component of integrated pest management. India ranks second in area and third in production of garlic in the world. The productivity of this crop is quite low (5.09 t/ha) as compared to China and Egypt. In India, garlic is cultivated throughout the country occupying an area of 261 thousand hectare with production of 1400 thousand MT. In India, the major garlic producing states are Madhya Pradesh, Odissa, Rajasthan, Karnataka and Gujarat (Anonymous, 2015) [2]. In Rajasthan, it is grown extensively in Chittorgarh, Baran, Jodhpur, Jhalawar, Kota, Bundi, Jaipur and Sikar districts. Availability of garlic in India is only 6.34 kg/year/capita in comparison to 11.14 kg / year/capita of Korean republic. This situation of the crop in India may be due to its unscientific cultivation and lesser care of growers to its nutritional management (Anonymous, 2011) [1].

Plant growth regulator presents a new possibility to break yield barrier, particularly imposed by the environment (Witter, 1971) [18]. The application of naphthalene acetic acid (NAA) has been reported to improve photosynthetic ability of plants which resulted in better growth and yield

of several crop without substantial increase in cost of production (Sumeriya *et al.*, 2000) [16]. NAA play a vital role for modifying the growth behaviour of plant by stimulating cell elongation and cell division which results in increase in growth of shoot and root and finally increase yield (Patil and Patel, 2010) [10]. It plays a key role in root and shoots development, promoting the germination of seeds and inducing the flower buds. Thiourea plays a vital role in the physiology of plants both as a sulphydryl compound and to some extent as an amino compound like urea. The stimulating action of thiourea in various physiological activities of plant is well known. Nitrogen is vital to plants because it is a major component in chlorophyll. Although nitrogen is an essential nutrient for plants, too much nitrogen can be harmful. Excess nitrogen appplication can cause water to leach from plants, leaving them dehydrated. Excess nitrogen can also cause stunted root growth and excess foliage growth. Keeping these points in view, the present investigation was carried out to study the effect of NAA, thiourea with varying level of nitrogen on growth, yield and quality of garlic.

Materials and Methods

The present study was conducted at the Horticulture farm and quality observations recorded at Laboratory of Department of Horticulture, S. K. N. College of Agriculture, Jobner during the *rabi* season, 2017-18. The experimental farm is situated at 26˚05᾽North latitude, 75˚28᾽East longitude and an altitude of 427 meters above mean sea level. The experiment was comprised of five levels of NAA & thiourea (control, NAA 100 ppm, NAA 200 ppm, thiourea 100 ppm and thiourea 200 ppm) and four levels of nitrogen {control, 75 % of recommended dose of nitrogen (RDN), 100 % recommended dose of nitrogen and 125% recommended dose of nitrogen} in factorial randomized block design. The treatments were randomly allotted to different plots using random number table of Fisher and Yates (1963) [4]. Beds of 1.5 m x 1.2 m size and paths and channels were also prepared according to the layout of the experiment.

The seeds of cultivar G-41 procured from NHRDF, Karnal (Haryana). The seeds of garlic were first treated with carbendazim 2 g per kg seed to control seed borne diseases. The seeds were sown in row at 15 x 10 cm^2 apart on 14th November 2017 by hand dibbling method. Phosphorus, potash and sulphur dose were applied uniformly in all plots as per recommended dose of P, K and S as basal dose only. Two foliar spray of NAA @ 100 and 200 ppm and thiourea @ 100 and 200 ppm through planofix (4.5%) and thiourea (99.9%), respectively were applied at 20 and 40 days after sowing. Nitrogen was applied as per treatments in two splits *i.e.* half as basal dose and rest half dose as top dressing at 30 days of sowing. Observations on growth, yield and quality parameters of crop were recorded.

Results and Discussion

Bulb fresh weight

It is apparent from data illustrated in fig. 1 that fresh weight of bulb significantly influenced by foliar spray of different growth regulators and nitrogen application. The fresh weight of bulb (50.69 g) was recorded significantly higher with the treatment thiourea 200 ppm over control, NAA 100 ppm and NAA 200 ppm. However, It was observed statistically at par with treatment thiourea @ 100 ppm. The increase in fresh weight of bulb under treatment thiourea 200 ppm was found to be 92.88, 30.74 and 27.42 per cent higher as compared to control, NAA 100 ppm and NAA 200 ppm, respectively.

The maximum fresh weight of bulb (50.11 g) was recorded with treatment 125 % RDN and minimum (26.72 g) under control. The per cent increase in fresh weight of bulb under treatment 125 % RDN was recorded 87.54, 28.88 and 3.43 per cent higher over control, 75 % RDN and 100 % RDN, respectively.

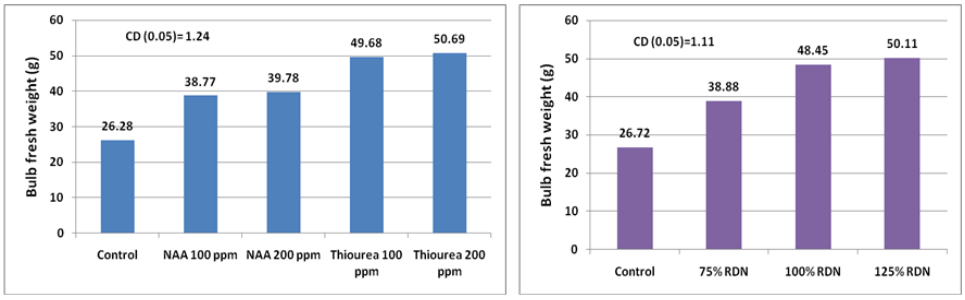

Fig 1: Effect of NAA, thiourea and nitrogen on average fresh weight of bulb (g)

The interaction effect of NAA, thiourea and nitrogen was noticed significant on the average fresh weight of garlic bulb. The data (Table 1) revealed that maximum fresh weight of bulb (61.59 g) was recorded under treatment combination thiourea 200 ppm + 125 % RDN. However, it was found statistically at par to treatment thiourea 100 ppm + 125 % RDN and thiourea 200 ppm + 100 % RDN.

Thiourea supply sufficient nitrogen and sulfur which promotes vegetative growth of the plant. The favourable effect of thiourea on plant growth might be due to improved photosynthetic efficiency and bio-regulatory role in plants (Meena *et al.*, 2015) [7]. Nitrogen increases chlorophyll content in leaves thus, resulting in higher photosynthetic rate and higher vegetative growth of the plant (Rani *et al.*, 2015) [13].

Table 1: Effect of NAA, thiourea and nitrogen on average fresh weight of bulb (g)

Treatments	Control	75 % RDN	100 % RDN	125 % RDN
Control	17.11	24.90	31.03	32.09
NAA 100 ppm	25.24	36.72	45.76	47.33
NAA 200 ppm	25.90	37.69	46.96	48.57
Thiourea 100 ppm	32.51	47.30	57.94	60.96
Thiourea 200 ppm	32.84	47.79	60.55	61.59
SEm±	0.87			
CD (p=0.05)	2.49			

Bulb yield

The perusal of data depicted in fig. 2 reveals that bulb yield per hectare significantly affected with foliar spray of different growth regulators and nitrogen application. The treatment thiourea 200 ppm registered maximum bulb yield (134.58

q/ha) followed by thiourea 100 ppm (131.21 q/ha) which was significantly superior over control, NAA 100 ppm and NAA 200 ppm. The increase in bulb yield under treatment thiourea 200 ppm was found to be 63.27, 18.81 and 8.60 per cent higher as compared to control, NAA 100 ppm and NAA 200 ppm, respectively.

The highest bulb yield (138.89 q/ha) registered under treatment 125% RDN which was statistically at par to 100% RDN (135.56 q/ha) but significantly superior over control and 75% RDN. The increase in bulb yield under treatment 125% RDN and 100% RDN was to the tune of 73.61and 69.45 over control, respectively.

An increase in yield with thiourea application might have induced large number of reproductive sinks leading to greater activity of carboxylating enzymes resulting in higher photosynthetic rates with greater translocation and accumulation of metabolites in sink and ultimately higher yield (Nehra *et al*., 2006) [8]. Similar response with foliar spray of thiourea was also recorded by Balai and Keshwa (2011) [3], Shanu *et al*. (2013) [15] in coriander and Gupta and Yadav **(**2009) [5] in fenugreek. This stimulatory effect may be occurred with foliar application which might have transferred to roots and finally resulting an increase in organic acid and protons efflux. This can increase the uptake of ions such as nitrogen and phosphorus by plants, which ultimately enhance yield and yield attributes (Maleki *et al*., 2013) [6].

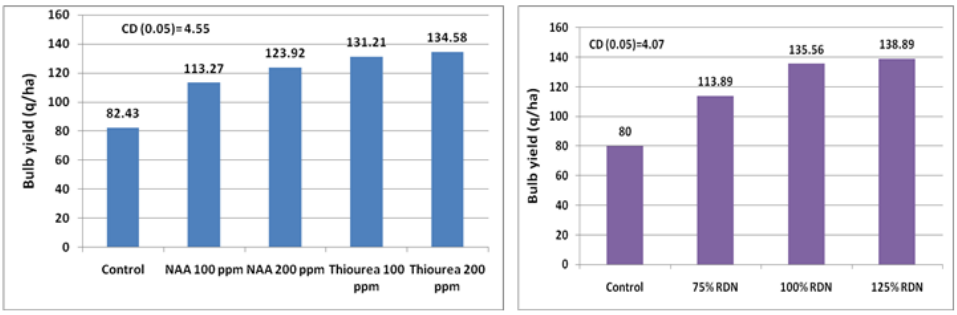

Fig 2: Effect of NAA, thiourea and nitrogen on bulb yield (q /ha) of garlic

A perusal of data presented in table 2 revealed that the combined effect of foliar spray of growth regulators and nitrogen application was found to be significant on bulb yield. The significantly higher bulb yield per hectare (159.64, 155.65, 155.81 and 151.92 q) was recorded with treatment thiourea 200 ppm + 125 % RDN, thiourea 100 ppm + 125 % RDN, thiourea 200 ppm + 100 % RDN and thiourea 100 ppm + 100 % RDN, respectively, which were statistically at par with each other and significantly superior over treatment combination without growth regulators (control) + without nitrogen (control).

Table 2: Effect of NAA, thiourea and nitrogen on bulb yield per hectare (q)

Treatments	Control	75 % RDN	100 % RDN	125 % RDN
Control	56.32	80.18	95.43	97.78
NAA 100 ppm	77.39	110.18	131.14	134.37
NAA 200 ppm	84.67	120.54	143.48	147.00
Thiourea 100 ppm	89.66	127.63	151.92	155.65
Thiourea 200 ppm	91.95	130.91	155.81	159.64
SEm±	3.18			
CD (P = 0.05)	9.09			

Net returns

It is apparent from data (Fig. 3) that net returns of garlic crop influenced significantly with foliar spray of different growth regulators and nitrogen application. The maximum net returns ₹1,08,062 per hectare was recorded under treatment thiourea 200 ppm followed by thiourea 100 ppm (₹1,03,372 /ha), which were statistically at par with each other and found significantly superior over control, NAA 100 ppm and NAA 200 ppm. The increase in net returns under treatment thiourea 200 ppm was found to be 200.23, 38.58 and 16.50 per cent higher as compared to control, NAA 100 ppm and NAA 200 ppm, respectively. Significantly higher net returns registered under 125 % RDN and 100 % RDN, which were statistically at par to each other but found significantly superior over control and 75 % RDN. Treatment 125 % RDN registered 244.87 and 44.19 per cent more net returns over control and 75 % RDN, respectively.

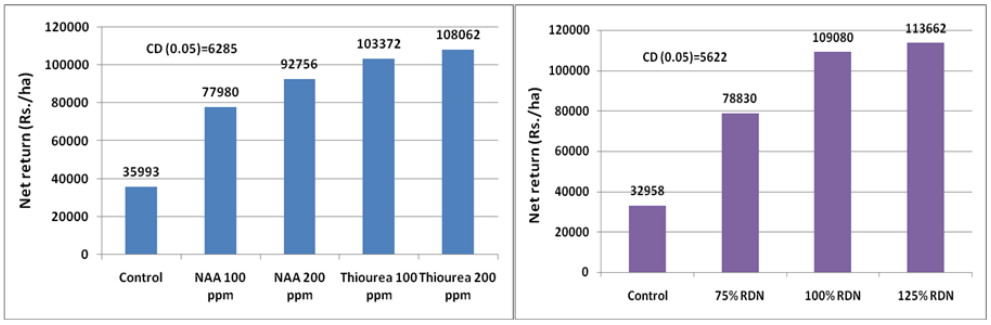

Fig 3: Effect of NAA, thiourea and nitrogen levels on net returns of garlic production

Data presented in table 3 reveals that the combined effect of foliar spray of growth regulators and nitrogen application was found to be significant on net returns for garlic crop. The maximum net returns for garlic crop ₹1,42,533 per hectare was recorded with treatment combination thiourea 200 ppm + 125 % RDN followed by thiourea 200 ppm + 100 % RDN (₹ 1,37,253), thiourea 100 ppm + 125 % RDN (₹1,36,966) and thiourea 100 ppm + 100% RDN (₹1,31,820) per hectare, respectively which were found to be statistically at par with each other. A minimum net return was recorded with treatment combination without growth regulators (control) + without nitrogen (control).

Table 3: Effect of NAA, thiourea and nitrogen on net returns (₹/ha)

Treatments	Control	75 % RDN	100 % RDN	125 % RDN
Control	145	32695	53966	57167
NAA 100 ppm	28906	73354	102615	107046
NAA 200 ppm	38958	87723	119744	124600
Thiourea 100 ppm	46791	97910	131820	136966
Thiourea 200 ppm	49990	102471	137253	142533
SEm±	4398			
CD (P = 0.05)	12571			

Benefit cost (B: C) ratio

A perusal of data in fig. 4 exhibits that benefit cost ratio for garlic crop influenced significantly with foliar spray of different growth regulators and nitrogen application. The significantly higher B:C ratio 1.34 was recorded under thiourea 200 ppm treatment which is statistically at par with treatment thiourea 100 ppm (1.28). The increase in B:C ratio for garlic under treatment thiourea 200 ppm was observed as 197.78, 39.58 and 16.52 per cent higher as compared to control, NAA 100 ppm and NAA 200 ppm, respectively. Significantly higher B:C ratio recorded with treatment 125 % RDN which was statistically at par with 100 % RDN and found significantly superior over control and 75 % RDN. Treatment 125 % RDN registered 233.33 and 42.86 per cent more B:C ratio over control and 75 % RDN, respectively.

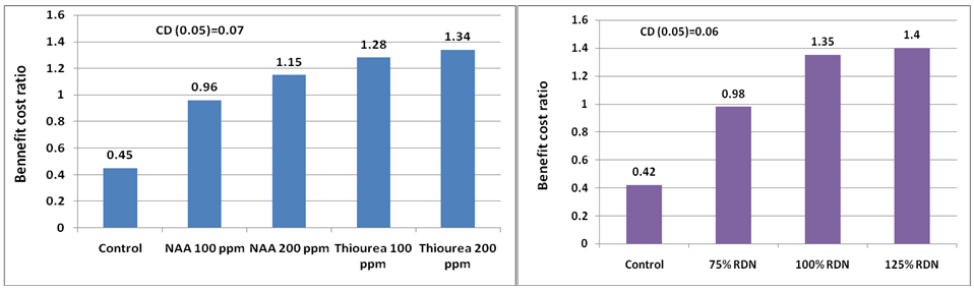

Fig 4: Effect of NAA, thiourea and nitrogen on B:C ratio of garlic production

Benefit cost ratio for garlic crop was influenced significantly by interactive effect of growth regulators and nitrogen application (Table 4). However, the application of thiourea 200 ppm + 125 % RDN recorded maximum B:C ratio 1.76 for garlic crop, which was at par to treatment thiourea 200 ppm + 100 % RDN, thiourea 100 ppm + 125 % RDN and thiourea 100 ppm + 100 % RDN whereas, minimum B:C ratio 0.02 was observed with treatment combination without growth regulators (control) + without nitrogen (control). These results were correlated with the findings of Pratap *et al*. (2011) [11], Puttaraju *et al*. (2011) [12] and Verma and Gupta (2011) [17].

Table 4: Effect of NAA, thiourea and nitrogen on benefit cost ratio (B:C)

Treatments	Control	75 % RDN	100 % RDN	125 % RDN
Control	0.02	0.41	0.68	0.72
NAA 100 ppm	0.36	0.91	1.27	1.32
NAA 200 ppm	0.49	1.08	1.48	1.53
Thiourea 100 ppm	0.59	1.21	1.63	1.69
Thiourea 200 ppm	0.63	1.27	1.70	1.76
SEm±	0.05			
CD (P = 0.05)	0.14			

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