Effect of Different Plant Growth Regulators on Economics of Garlic (*Allium sativum* L.)under*Terai*Zone of West Bengal

Abstract

The current study investigated the "Effect of Different concentrations Plant Growth Regulators on Economics of Garlic (Allium sativum L.) under Terai Zone of West Bengal" using various kinds of growth regulators (GA_3@ 50 ppm, GA_3@ 100ppm, GA_3@ 150 ppm, NAA@ 50 ppm, NAA@ 100 ppm, NAA@ 200ppm, Kinetin@ 10 ppm, Kinetin@ 20 ppm, Kinetin@ 40 ppm and Control (Distilled water) at the instructional and research farm of the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, India, during the Rabi season for two consecutive years (October 2019 to March 2020 and October 2020 to March 2021). In view of,effect of different plant growth regulators on economics of garlic under *terai* region of west Bengal has observed significant variation. The result obtained that the foliar application of GA_3@50 ppm generated maximum net returns (812753.5 Rs) and benefit cost ratio(4.44) over other treatments. The control plots treated with distilled water was produced qualitatively inferior bulbs and generated lowest net returns (461946Rs) and benefit cost ratio (2.62). The aim of the study provided valuable results to determine the potential growth regulator for yield, quality and enhancing returns of garlic by employing methodology of Randomized Block Design comprising of three replications with ten treatments. Based on the current experimental results, it may be concluded that foliar application of GA_3 @ 50 ppm proved the best over other plant growth regulators.

Key words: Economics, Garlic, GA_3, NAA, Kinetin, Returns

1. INTRODUCTION

Garlic is the second most commonly grown Allium After onions(FDRECSA, 2013), with chromosome number 2n = 2X = 16 and a member of the Amaryllidaceae family. Garlic is native to Southern Europe and Central Asia, particularly the Mediterranean region. The closest related and garlic's progenitor is thought to have been the wild species of *Allium longicuspis.* It is an annual herbaceous crop with a thin, papery sheath around it. The edible underground stem is a composite bulb made up of several smaller bulbs called cloves. These cloves provide the economic yield. Garlic's distinctive smell and pungent principle are caused by diallyl disulphide (DDS), which is present in allylradicle and alliinin forms. It has long been acknowledged as a beneficial culinary condiment. Most Indians eat this crop, which is

UNDER PEER REVIEW

produced all throughout the country's plains. Garlic has significant therapeutic properties against digestive diseases, eye sores, and earaches, according to the Unani and Ayurvedic systems that are practiced in India. Cloves can be used as a condiment or as a spice for flavouring. It has a high concentration of essential oils (0.1-0.4%), minerals (0.3%), carbohydrates (29%), protein (6.3%), and fat (Memane et al., 2008). Garlic oil (0.5%) has growth stimulating properties (Shafeek et al., 2015). It has a lot of vitamins, such vitamin C, and flavonoid antioxidants, like α-carotene (Chiavarini et al. 2016). A vital component of green garlic is ascorbic acid. According to Meng et al. (1993), garlic has antibacterial, antifungal, antiviral, and antiprotozoal qualities (Reuter et al., 1996). Because of its antioxidant and anti-cancer qualities, it is advantageous to the immune system and cardiovascular system (Meng et al. 1993; Harris et al. 2001). In the current organic agricultural environment, garlic extracts and oils have potential use as efficient fungicides and insecticides. (Kumara et al. 2014). Madhya Pradesh, Gujarat, Maharashtra, Orissa, Rajasthan, Uttar Pradesh, and Karnataka are the principal garlic-growing states in India. In India, 429 thousand hectares are used for the cultivation of garlic, which yields 8366 kg ha-1 and 3498 MT of output year (Anonymous, 2022). Garlic is farmed on a limited scale in west Bengal, mostly on 3.70 thousand hectares of land in the Gagnatic plains of Malda, Nadia, 24 Parganas North district, and Cooch Behar and Jalpaiguri districts in the Terai region. The region produces 36.10 MT of garlic annually, with a productivity of 9.76 MT/ha. (Anonymous, 2018).

A plant's ability to change its growth behaviour is largely dependent on plant growth regulators, which in turn improve plant growth, quality, and production. These are organic substances other than nutrients that, when applied in tiny amounts, encourage, hinder, or otherwise change some physiological and biochemical process reactions in plants. Synthetic auxins like naphthalene acetic acid (NAA) can alter a plant's phenotypic and growth, speeding up the pace at which shoots and roots grow and ultimately increasing production (Patel and Patel. 2010). The positive effect of plant growth regulators on horticultural crops have been shown by many workers (Lal et al.2013, Tameshwar et al.2017).Tetracyclic di-terpenoid chemical gibberellic acid (GA) is a plant hormone that promotes plant growth and development. Growth-stimulating agents like GA3 encourage cell division and elongation, which aids in the growth and development of several plants. Garlic can break dormancy and sprout more quickly when GA_3 is added. Gibberellic acid is essential for many different growth processes, including as the formation of seeds, the lengthening of organs, senescence, and the regulation of blooming time(Ouzounidou et al. 2008); Yamaguchi, (2008). NAA root

UNDER PEER REVIEW

dipping treatment was shown to prevent physiological weight loss as well as deterioration (Patel et al. 2010). In media culture, kinetin is vital for processes like callus renewal. Though little is known about how exogenously applied growth regulators affect garlic, various doses and formulations are thought to be advantageous for increasing crop production and net returns via regulating physiological processes within the plant. Consequently, an effort was undertaken to assess the impact of various PGR concentrations on the qualitative, quantitative, and economic characteristics of garlic, which might potentially aid in making a significant contribution to the country.

2. MATERIALS AND METHODS

2.1 Environmental conditions

The instruction/research farm of the Department of Plantation Crops and Processing, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, located at 26.52430 North latitude and 89.10750 East longitude, was the site of the current experiment, which was carried out during the Rabi season for two consecutive years (October-2019to March 2020 and October-2020 to march-2021). At the experimental location (0–15 cm depth), the sandy loam soil had an acidic response with a pH of 5.59, 0.06 EC, and 0.28 % organic carbon (OC). The contents of available N, P2O5, K2O, and S were 100.62, 19.15, 103.45, and 23.83 kg ha-1, respectively.According to meteorological data maximum and lowest temperatures in 2020 and 2021, respectively, varied between 33.07 and 5.77 degrees. In both years, the range of maximum and minimum relative humidity was between 97.67 and 40.43%.

2.2 Experiment and treatments

The experiment compromising three different growth regulators namely-gibberellic acid (GA_3), Naphthalene Acetic Acid (NAA) and Kinetin each sprayed with different concentrations i.e., 50,100 and 150 ppm of GA_3; 50,100 and 200 ppm of NAA and 10,20 and 40 ppm of Kinetin and one control plot sprayed with distilled water each of them sprayed at different intervals of 30, 60 and 90 days after planting. The experiment laid out in Randomized Block Design comprising of ten treatments (T_1:50ppm GA_3, T_2:100ppm GA_3, T_3:150ppm GA_3, T_4:50ppm NAA, T_5:100ppm NAA, T_6:200ppm NAA, T_7:10ppm Kinetin, T_8:20ppm Kinetin, T_9:40ppm Kinetin and T_{10}: Control andreplicated thrice.

2.3 Cultural practices

UNDER PEER REVIEW

Garlic cloves treated with carbendazim were seeded in 2.0 x 1.0 m^2 area plots with a spacing of 20 x 10 cm. Cloves were manually dropped with the use of a hand tool, 3-5 cm below the earth's surface, and then carefully covered with dirt. The fertilizer was sprayed in accordance with the required dosage, which is N, P, K, and S @ 100:60:80:40 kg/ha (Abdul et al. 2002). For improved germination, irrigation was given after seeding, and further irrigation was given based on the moisture content. Along with weeding, earthing up is done at intervals between 35 and 60 days. During the crop cycle, propiconazole (1 milligram per litre) was applied every 25 days to avoid fungal infections. When 70% of the leaves on the plants had dried and the tops of the plants had turn yellow at the neck fall stage, the plants were ready to be harvested. At that point, the bulb was removed, packed in bunches with greenery, and sun-dried for five days to let it to cure. The dried leaves were placed in perforated nylon bags and chopped with a sickle at the neck region after drying.

2.4 Preparation of stock solution

In order to create a stock solution, a sufficient amount of gibberellic acid (GA3), (NAA), and kinetin were all in the solid state, that is, in the form of powder. The weighed powder was then transferred into a volumetric flask, and very little alcohol (ethanol) and 1.0 percent Na $(OH)_2$was needed to dissolve the powder in the form Following that, distilled water was added to dilute it to the necessary concentration of solution.

2.5 Economics

1. Gross Income (Rs) = Total crop production (TCP) x Value of the product (VOP)
2. Total cost (TC) = Common cost (CC) + Treatment cost (TC)
3. Net return (Rs per ha): Net return (Rs per ha) of individual treatment was calculated by deduction of cost of cultivation from the gross return (GR) of particular treatment

Net return (NR) = Gross Return (GR) – Total Cost of Cultivation (TCC).

Benefit: Cost ratio to find out the B:C Ratio = Net return/ Total Cost of Cultivation.

UNDER PEER REVIEW

Table 1: Common cost of cultivation for one hectare of the experiment.

S. No.	Particulars of operation	Rate	Quantity, Men Days, Area/Ha.	Cost/Ha.
A.	**Fixed cost of cultivation**			
1	Land lease	Rs 2000 /Bigha	7.5 Bigha.	15000

2	Ploughing	Rs 1000 /Bigha	7.5 Bigha.	7500
3	Fertilizers			
	i. FYM	Rs 1000 /t	25 t/ha.	25000
	ii. Urea	Rs 7 /Kg	217 Kg/ha.	1519
	iii. SSP	Rs 9 /Kg	475 Kg/ha.	4275
	iv. MOP	Rs 20 /Kg	133 Kg/ha.	2660
	v. Sulphur	Rs 98 /Kg	50 Kg/ha.	4900
4	Planting material (Seed) cost	Rs 150 /Kg	500 Kg/ha.	75000
5	Layout and bed preparation	Rs 300 /Day	30 MD	9000
6	Sowing	Rs 300 /Day	15 MD	4500
7	Intercultural operations i. Hoeing ii. Irrigation iii. Weeding v. Drainage vi. Earthing up vii. Spraying	Rs 300 /Day	65 MD	19500
8	Harvesting	Rs 300 /Day	15 MD	4500
9	Plant protection measures	Rs 1800 /L	1.5L	2700
	Total fixed cost			**176054**
B.	**Treatment Cost**			
I	**Growth regulators**			
a.	GA_3 @ 50 ppm GA_3 @ 100 ppm GA_3 @ 150 ppm	Rs 95.9 /g	75g 150g 225g	7192.5 14385 21577.5
b.	NAA @ 50 ppm NAA @ 100 ppm NAA @ 200 ppm	Rs 5.8/g	75g 150g 300g	435 870 1740
c.	Kinetin @ 10 ppm Kinetin @ 20 ppm Kinetin @ 40 ppm Control	Rs 159.32 /g 0	15g 30g 60g 0	2389.8 4779.6 9559.2 0
	Total treatment cost (Rs.)			**62928.6**

UNDER PEER REVIEW

2.7 Statistical analysis

After two years of field and laboratory data collection, the data was organized into tabular form and statistical analysis was performed using the randomized block design recommended by Panse and Sukhatme (1967). Using the F test and the Least Significant Difference (LSD) test at a 5% threshold of significance (P 0.05), the significance of treatment changed under different parameters (Cochran and Cox, 1975). At a significance level of 5%, the crucial difference was ascertained using the Fisher and Yates table. Additionally, a two-year pooled analysis was conducted utilizing the Gomez and Gomez methodology (1983). Analysis of variance was carried out for each parameter using Pro Glm, a tool included in the Statistical Analysis System (SAS) software.

3.RESULTS AND DISCUSSION

3.1 Economics and benefit cost ratio

Among the foliar application of growth regulators T_1 -GA_3 @ 50 ppm gave the highest net returns (812753.5 Rs) and benefit cost ratio (4.44) which was subsequently followed by T_5-NAA @ 100 ppm (3.73) treated plants. The lowest benefit (2.62) was obtained from T_{10} (control) plants without any application of plant growth regulators concentration. foliar spray of GA_3@50 ppm independently gave higher growth, yield and better quality.

Yield has direct effect on economics, Numerous processes, including photosynthetic efficiency, cell elongation, vegetative meristem activity, and secondary wall biosynthesis, are crucial for increased output. These processes can be altered by growth regulators or are controlled by genetics. The maximum plant height and average bulb weight in the current study may have contributed to the maximum bulb output since they increased the total yield while requiring a lower dosage of gibberellic acid than other growth regulators.

It could be because growth regulators are physiologically more active to change source and sink connections for growing bulbs, which raises overall yields, and accumulate enough food reserves. The anticipated yield rises in tandem with the bulb yield, proportionately. Maximum returns under GA3 at 50 ppm result from improving the yield under GA3 foliar spray.The current experimental results ware correlated with Zinzala and Kumar (2016).

UNDER PEER REVIEW

Table 2: Economics and benefit cost ratio of garlic atdifferent concentration of growth regulators under *terai* region of West Bengal

Treatments	Doses (g)	Fixed cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	Bulb yield (t/ha)	Price of Bulb (Rs/Kg)	Gross return (Rs)	Net return (Rs)	B:C Ratio
T_1: GA_3 @ 50 ppm	75	176054	7192.5	183246.5	9.96	100	996000	812753.5	**4.44**
T_2: GA_3 @ 100 ppm	150	176054	14385	190439	7.36	100	736000	545561	**2.86**
T_3: GA_3 @ 150 ppm	225	176054	21577.5	197631.5	8.17	100	817000	619368.5	**3.13**
T_4: NAA @ 50 ppm	75	176054	435	176489	7.51	100	751000	574511	**3.26**
T_5: NAA @ 100 ppm	150	176054	870	176924	8.36	100	836000	659076	**3.73**
T_6: NAA @ 200 ppm	300	176054	1740	177794	7.62	100	762000	584206	**3.29**
T_7: Kinetin @ 10 ppm	15	176054	2389.8	178443.8	7.88	100	788000	609556.2	**3.42**
T_8: Kinetin @ 20 ppm	30	176054	4779.6	180833.6	7.97	100	797000	616166.4	**3.41**
T_9: Kinetin @ 40 ppm	60	176054	9559.2	185613.2	8.37	100	837000	651386.8	**3.51**
T_{10}: Control	0	176054	0	176054	6.38	100	638000	461946	**2.62**

UNDER PEER REVIEW

4. CONCLUSION

In the present investigation, foliar application of plant growth regulators boosted the yield and Quality characteristics of garlic which are direct effect on net returns and benefit cost ratio of garlic and based on the current experimental results, GA_3 @ 50 boosted the yield and economics of garlic. Based on the experiment it may be concluded that foliar application of GA_3 proved the best over other treatments of plant growth regulators

REFERNCES

1. Abdhul Hye Md, Md Haque S, Abdul M. Influence of growth regulators and their time of application on yield of onion. Pakistan Journal of Biological Sciences(2002);5(10),1021-1023.
2. Anonymous. Government of India, ministry of agriculture and farmers welfare, department of agriculture, co-operation of farmers welfare, horticulture statistics division. 2018
3. Anonymous. E&S Division Department of Agriculture & Farmers Welfare, Agricultural & commercial crops 2022; as per 4th Advance Estimate 2021-22 and Horticultural Crops as per 2nd Advance Estimate 2021-22 https://desagri.gov.in/wp-content/uploads/2023/05/Agricultural-Statistics-at-a-Glance-2022.pdf
4. Cochran WG, Cox GM. Experimental Designs. Wiley, New York. 1975
5. FDRECSA. Federal Democratic Republic of Ethiopia, Central Statistical Agency, agricultural sample survey of 2012/2013 (2005EC), Volume I, Report on area and production of major crops. Addis Ababa Ethiopia, statistical bulletin532 2013.
6. Harris JC, Cottrell SL, Plummer S, Lloyd D. Antimicrobial Properties of *Allium sativum* L (garlic). Applied Microbiology and Biotechnology 2001;57, 282-286.
7. Kumara BR, Patil, Shankar gouda. Application of organic manures and inorganic sources of nitrogen on yield, quality, soil properties and nitrogen uptake by garlic (*Allium sativum* L.). Trends in Biosciences2014;7 (12), 1331-1336.
8. Lal N, DasRP, Verma LR. Effect of plant growth regulators on flowering and fruit growth of guava (*Psidium guajava* L) cv. Allahabad safeda. Asian Journal of Horticulture 2013;8(1), 54-56.
9. Meng Y, Lu D, Guo N, Zhang L, Zhou G. Anti-HCMV effect of garlic components. VirologicaSinica1993;8 147-150.

UNDER PEER REVIEW

10. Ouzounidou G, Papadopoulou P, Giannakoula A, Ilias I. Plant growth regulators treatments modulate growth, physiology and quality characteristics of Cucumis melo L. plants. Pak. J Bot. 2008; 40:1185-1193.
11. Patel MJ, Patel HC, Chavda JC.Influence of plant growth regulators and their application methods on yield and quality of onion (Allium cepa L.). Asian Journal of Horticulture.; 2010; 5(2):263-265.
12. ReuterHD, Koch HP, Lawson LD. Therapeutic effects and applications of garlic and its preparations. In: Garlic: the science and therapeutic applications of Allium sativum L and related species (HP Koch and LD Lawson eds). Baltimore: Williams and Wilkins, 1996; pp 135- 213.
13. ShafeekMR, HelmyYI, Omar NM. Stimulants for improving the growth, yield and bulb quality of onion plants (*Allium cepa*, L.) under sandy soil conditions. Middle East Journal of Applied Sciences 2015; 5(1), 68-75.
14. Tameshwar, Prasad VM, Lal N. Effect of plant growth regulators on gladiolus cv. Jester. Trends in Biosciences2017; 10 (20), 3982-3985.
15. Yamaguchi S. Gibberellin metabolism and its regulation. Annual Review Plant Biology. 2008;59:225-251.
16. Zinzala MR, Bhalerao PP, Patil S J. Effect of foliar application of plant growth regulators on growth, yield and quality of garlic (*Allium sativum* L.) Var. GG-3. *Green Farming* 2017; 8 (2): 483 – 485.

UNDER PEER REVIEW

UNDER PEER REVIEW