Effect of foliar-applied Plant Growth Regulators on Coriander (*Coriandrum sativum* L.) to regulate growth and yield attributes

ABSTRACT

An investigation titled "Impression of Foliar-Applied Plant Growth Regulators on Coriander (*Coriandrum sativum* L.) to Regulate Growth and Yield Attributes" was conducted to obtain the effect of plant growth regulator on growth, yield and quality. The experiment utilized a Randomized Block Design with three replications and nine treatments, including a control. The four different plant growth regulators (PGRs) used were Benzyl Adenine (10 and 20 ppm), Brassinosteroid (0.5 and 1.0 ppm), Jasmonic Acid (50 and 100 ppm) and Salicylic Acid (50 and 100 ppm), applied as foliar sprays at 30 and 60 days after sowing (DAS). The experiment was conducted during the Rabi season of 2023-24 at the Vegetable Research Centre, Maharajpur, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. The investigation revealed that Brassinosteroid at 0.5 ppm resulted in the maximum plant height (103.67 cm). The highest number of primary (15.53) and secondary (26.50) branches at harvest was achieved with Jasmonic Acid at 50 ppm. Phenological observations indicated that Jasmonic Acid at 50 ppm led to the earliest 50% flowering at 36.67 days. For yield attributes, the highest number of umbels per plant (42.13) and umbellets per umbel (6.31) were found with Jasmonic Acid at 50 ppm. Benzyl Adenine at 20 ppm showed the maximum number of seeds per umbel (36.40), test weight (10.84 g), harvest index (9.92), and seed yield (13.65 q ha^{-1}). Economically, Benzyl Adenine at 20 ppm provided the highest net return (Rs. 170735.81), gross return (Rs. 232117.39), and benefit-cost ratio (2.78). Therefore, it can be concluded that foliar sprays of Brassinosteroid, Jasmonic Acid, and Benzyl Adenine are effective in improving phenological traits, yield attributes, and economic returns in coriander cultivation.

Keywords: coriander, PGR's, growth parameters, seed yield, Harvest Index and economics

1. INTRODUCTION

Coriander (*Coriandrum sativum* L.), a member of the apiaceae family, is extensively utilized for its medicinal and culinary attributes [1]. The genus includes just two recognized species: *C. sativum* L. and *C. tordylium* (Fenzl) Bornm, commonly known as wild coriander. The term *"coriandrum"* originates from Greek, combining "*koriannon*," which refers to a stink bug, and "*annon*," meaning fragrant anise, describing the plant's unique odor as it reaches maturity [2]. Having its origins in the Mediterranean and Middle Eastern regions, this rapidly growing annual herbaceous plant is widely cultivated and thrives in

South America, North Africa, and India [3]. It is a slender-stemmed, small bushy herb that branches extensively, reaching heights of 90 cm with compound umbel as inflorescence, furthermore, its leaves are alternate and compound, becoming highly segmented and linear towards the upper parts [4]. Coriander features a lower ovary with mature fruits showing five calyx teeth around the stylopodium. These teeth vary in length, similar to the petals in outer flowers. Each flower in the umbellet has five petals; those on the periphery are longer and asymmetric, while central flowers have round shapes with small inward-curving petals. Petals typically range in color from pale pink to white [5].

Plant growth substances can be divided into two main groups: plant hormones and plant growth regulators. Plant hormones are organic compound synthesized by plants that have significant effects on growth and development of plants [6]. Plant growth regulators, synthetic substances that are as effective or sometimes more effective than natural plant hormones, are making rapid strides in the pesticide industry. These regulators can modify plant shape, enhance plant resilience to stress, and control different phases of plant growth and development [7]. Jasmonic acid (JA) is a type of lipid hormone found in plants, belonging to a group of fatty acid derivatives with a cyclopentanone core structure. It is widely distributed in nature and plays a crucial role in various plant processes such as seed germination, root growth, leaf aging, flowering timing, anthocyanin accumulation, trichome development, stamen formation, and responses to both biotic and abiotic stresses [8-10]. JA is synthesized by certain young and mature plant tissues and governs how plants react to external environmental stresses like drought, extreme temperatures, ozone, and ultraviolet radiation [11]. Brassinosteroid (BR), an another crucial plant growth-promoting hormone, holds promise for driving the future of agriculture. BR is a steroidal hormone unique to plants, characterized by multiple hydroxyl groups, and it plays diverse roles in controlling significant agricultural characteristics of crops. These include influencing plant structure, grain size, leaf orientation, plant height, tiller production, seed germination, and how plants react to environmental factors [12-13]. Benzyl adenine (BA) is a type of cytokinin known for its synthetic form, which serves as a growth regulator and is more potent than natural cytokinins due to its notable stability [14]. Additionally, BA extends the flowering period, enhances fruit yield, and improves fruit quality. As a plant growth regulator, BA promotes larger and more uniform fruit size, stimulates lateral bud break and shoot growth, thereby enhancing branching in fruit trees and flowering [15]. BA also delays chlorophyll degradation and fruit aging, reduces fruit softening, inhibits ethylene production, lowers respiratory rates, and enhances mechanical strength, thereby slowing down senescence post-harvest [16]. Salicylic acid, which is also considered a plant hormone, constitutes a group of phenolic substances and is a plant growth regulator that creates many metabolic and physiological reactions in plants and therefore affects plant growth and development [17]. The proposed title evaluated to achieve the significance of PGR on growth, yield and quality as well as to estimate the economics of different treatments. This research exploits the increase in yield and quality attributes with use of different doses of PGR at different intervals to know its better impression.

2. MATERIALS AND METHODS

This research examines the effects of foliar-applied of plant growth regulator (PGR) at different concentrations on the growth and yield of coriander. An experiment was conducted during *Rabi* 2023-24 at the Vegetable Research Centre, Maharajpur, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The experimental field had medium black-colored soil texture with a uniform consistency, moderate levels of nitrogen, phosphorus, and potassium (NPK), and effective drainage capacity. The treatments were laid out in Randomized Block Design (RBD) with 3 replications. The experiment comprised of nine treatments *viz.,* Benzyl Adenine (10 and 20 ppm), Brassinosteroid (0.5 and 10. ppm), Jasmonic Acid (50 and 100 ppm), Salicylic Acid (50 and 100 ppm) and Control (Water spray). The number of foliar spraying was conducted two times: once at 30 DAS and again at 60 DAS. To prepare the land for coriander germination, ploughing and harrowing were conducted to achieve a finely tilled soil. Ploughing was performed twice in orthogonal directions using tractor-drawn implements, followed by harrowing to break up clods and level the soil surface. Prior to sowing, seeds of the coriander variety Jawahar Dhaniya-10 obtained from JNKW, Jabalpur, were split into halves through rubbing and treated with *Trichoderma viridae* at a rate of 4 g/kg of seed. These seeds were manually sown in rows spaced 30 cm apart using the line sowing method in the main field. Thinning was carried out at 25 days after sowing (DAS) to maintain a plant-to-plant distance of approximately 10 cm. A general recommended dose of 20 kg N, 40 kg P and 30 kg K as basal along with 1 tonne of FYM. Throughout the cultivation period, standard coriander farming practices were followed diligently. The specified amount of PGR was dissolved in 10 mL of ethanol and mixed thoroughly until fully dissolved, except Benzyl adenine. The dissolved PGR solution was then transferred into a 100 mL volumetric flask and topped up to the final volume of 100 mL with distilled water. To prepare the working solution at the desired concentration from the stock solution, appropriate dilution was performed. The plants were sprayed twice with PGRs using a Knapsack battery sprayer to ensure thorough coverage of both sides of the leaves. The Plant Growth Regulators were purchased from Sisco Research Laboratory (SRL), India. Stock solution of each PGR was prepared at 10^{-3} M. For a 10^{-3} M. solution:

1 L = 0.001×Molecular Weight of PGR (g).

The recorded data were tabulated and subjected to statistical analysis to determine the superiority of treatment means using the critical difference (CD) calculated by MS-Excel software.

2.1 Plant Height

2.2 Number of primary and secondary branches

2.3 Days to 50% flowering

2.4 Umbels per plant

2.5 Umbellets per umbel

2.6 Seeds per umbel

2.7 Seed yield (q ha^{-1})

2.8 Test weight

2.9 Harvest Index

2.10 B:C ratio

3. RESULT AND DISCUSSION

3.1 Growth Attributes

The foliar-applied PGRs examined significant difference between the treatments in the plant height at maturity and is rendered in Table 1. Interpretation of result revealed that PGRs influence the vegetative development of Coriander. Among different treatments, T3 (BR@ 0.5ppm) resulted in maximum plant height (103.67 cm) which was at par with T6 (JA@ 50ppm) with height (99.53 cm). The minimum plant height (81.87cm) was reported in T9 (Control). The growth enhancement in plants may be attributed to increased cell division and elongation, which result from the heightened metabolic activity facilitated by BRs [19]. Correspondence to current results were reported by Xu et al. [20] in coriander, where BR at 0.5 5mg L^{-1} increased plant height by 17.45%, which was comparable to BR at 1.0 5mg L^{-1}, resulting in a 14.56% increase. The findings in alignment to current study was also observed by Balba et al. [21] in Fenugreek, Kuri et al. [22] in Coriander, Rai et al. [23] in Coriander and Sridhara et. al. [24] in Tomato increment in plant height due to BR application.

The analyzed data of number of primary and secondary branches revealed that JA@ 50ppm resulted in maximum (15.53 and 26.50) at harvest, respectively followed by 100 ppm JA (14.73) and (25.90), however lowest values were reported in SA@ 100ppm in primary and secondary branches with 13.80 and 23.33 respectively. Jasmonic acid (JA) contributes to higher concentrations of potassium (K) and nitrogen (N), essential for strengthening cells and regulating carbon metabolism. This enhances the plant's water retention capacity, leading to an increase in cell numbers and subsequently, a higher rate of branch formation per plant [25]. Correspondingly, Arpitha et al. [26] in Black Cumin demonstrated the maximum (5.43) primary branches with foliar application of JA@ 100ppm on Pant Krishna variety. The findings adherence to result was found in Rahimi et al. [27] in Cumin and Awang et al. [28] in Chilli.

The days to 50% flowering for JA@50 ppm and 100 ppm treatments indicate earliness of flowering at 32.33 and 36.67 days, respectively. In comparison to other treatments, except for the control, the 100 ppm SA treatment shows a delay in reaching 50% flowering, taking 43.00 days. Jasmonic acid (JA) and its derivatives play significant roles as regulators of plant growth and responses to stress, influencing various developmental processes such as callus growth, seed germination, flowering, primary root growth, and senescence [29]. The studies in accordance to result was recorded in Hatakeyama et. al. [30] in *Brassica rapa* and Niwa et al. [31] in tomato. Conversely, Arpitha et al. [26] in Black Cumin and Lalnunzawama et al. [32] in Strawberry.

3.2 Yield and Yield Attributes

The data analysis of foliar-applied PGRs indicates the significant increment in yield and yield-promoting attributes of Coriander in Table 2. It reveals that the increase in umbels per plant was attained by Spray of 50 ppm JA (42.13) followed by 100 ppm JA (38.47) over control. Plants exhibit physiological responses to jasmonates, with varying effects on fruits observed at different concentrations of exogenously applied jasmonates. Comparable findings have been reported regarding the external application of jasmonic acid. El-Gamal et al. [33] in Coriander, Arpitha et al. [26] in Black cumin and Awang et al. [28] in Chilli. Conversely, Rahimi et al. [27] in Cumin reported non-significant.

The manifested findings found maximum number of umbellets per umbel in treatment T6 (50 ppm JA) which is at par with T7 (100 ppm JA), with 6.31 and 6.01 respectively. The minimum number of umbellets per umbel (5.31) was recorded in treatment T9 (Control). Several biological stimulants like JA, SA, PBZ, and others have been demonstrated to enhance plant growth and yield when applied externally. Additionally, they aid plants in tolerating unfavorable abiotic conditions by improving their resilience to environmental stresses [34-36]. Adherent to current findings, Noori et al. [37] reported in Cumin the highest number of umbellets in 60µmol/L of JA application (3.53 per umbel).

The utmost number of seeds per umbel is reported in T2 (BA@ 20ppm) which was at par with T6 (JA@ 50ppm) and T1 (BA@ 10ppm), with 36.40, 35.89 and 35.16 respectively. The fewest seeds per umbel (30.63) is reported in T9 (Control). The study reported by Kumar et al. [38] in Black pepper, Kusuma et al. [39] in Fennel and Nayak et al. [40] in Ginger is in harmonization with the present research.

On comprehending the experimental data, the maximum test weight of seed was observed in T2 i.e. (BA@ 20ppm) which was at par with T1 (BA@ 10ppm) and T3(BR@ 0.5ppm) with 10.84g, 9.78g and 9.55g respectively. The minimum test weight (7.65g) was observed in (Control). It has been demonstrated that BA enhances plant growth and development, as well as promoting blossom setting [41]. The results of this investigation align with the findings of Kumar et al. [38] in black pepper, Aminifard et al. [42] in Coriander and Ren et al. [43] in maize.

The significant variation in Harvest index reported highest (10.84) in treatment T2 (BA@ 20ppm) followed by T1 (BA@ 10ppm) with 9.92, and the lowest (7.65) was obtained in treatment T9 (Control). BA slows down the aging of leaves, extending their photosynthetic activity, which boosts biomass production and enhances potential grain yield. Adherent results were reported by Kusuma et al. [39] in Fennel. Conversely, Menaria and Maliwal, [44] in fennel found the non-significant effect of BA.

The highest seed yield (13.65 q ha^{-1}) was obtained in treatment T2 (BA@ 20ppm) which is at par with 12.27 q ha^{-1} T1 (BA@ 10ppm) and 12.04 q ha^{-1} T3 (BR@ 0.5ppm) which is increased by 32.45%, 24.85% and 23.42%. The lowest seed yield (9.22 q ha^{-1}) is registered in treatment T9 (Control). These results can be attributed to the stimulating effects of CK on cell division, regulation of biochemical processes, vegetative development, and plant components, all of which can influence fruit production and yield. Correspondingly, Kusuma et al. [39] in Fennel, Hassan [45] in Coriander and Mohamed et al. [46] in Broccoli reported the finding which align with studies.

3.3 Economics

The study emphasized notable economic advantages of using PGRs in coriander cultivation. The highest net return (Rs. 170,735.81) and gross return (Rs. 232,117.39) were achieved with a foliar spray of BA at 20 ppm, which also resulted in an increased B:C ratio of 2.78 for this PGR application. Benzyl Adenine (BA) is a synthetic plant growth regulator categorized as a cytokinin phytohormone, recognized for elevating cytokinin levels in plants [43]. The results of the present investigation dovetail with Singh [47] in Fenugreek and Jayashree [48] in Asiatic lily.

4.CONCLUSION

The findings of the current study reveal that foliar application of plant growth regulators (PGRs) significantly affects a range of treatment outcomes. The foliar spray of 0.5ppm Brassinosteroid showed the highest plant height and 50ppm Jasmonic acid promoted the maximum number of primary, secondary branches and reduces the days to 50% flowering, compare to other treatments. Among different treatments, the varying effects are noted in yield attributes. 50ppm Jasmonic acid treated plot obtained highest number of umbels per plant and umbellets per umbel whereas 20ppm Benzyl adenine boost the seeds per umbel, test weight, harvest index and seed yield. From an economic perspective, the application of 20 ppm BA yielded the highest net return, gross return and B:C ratio. The exceptional performance of 20 ppm BA is due to its notable influence on yield components, leading to greater economic benefits.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

REFERENCES

1. Arora V, Adler C, Tepikin A, Ziv G, Kahane T, Abu-Nassar J, Golan S, Mayzlish-Gati E, Gonda I. Wild coriander: an untapped genetic resource for future coriander breeding. Euphytica. 2021; 217(7):138.
2. Bhat S, Kaushal P, Kaur M, Sharma HK. Coriander (*Coriandrum sativum* L.): Processing, nutritional and functional aspects. African Journal of plant science. 2014; 8(1):25-33.
3. Mahleyuddin NN, Moshawih S, Ming LC, Zulkifly HH, Kifli N, Loy MJ, Sarker MMR, Al-Worafi YM, Goh BH, Thuraisingam S. *Coriandrum sativum* L.: A Review on Ethnopharmacology, Phytochemistry, and Cardiovascular Benefits. *Molecules.* 2022; 27(1):209.
4. Narendhiran V, Shobanadevi C, Indhuja G. Effect of Plant Growth Regulators on growth and yield of Coriander (*Coriandrum sativum* L.). International Journal of Science Academic Research. 2024; 5(1): 6962-6963.
5. Khan IU, Dubey W, Gupta V. Taxonomical aspect of coriander (*Coriandrum sativum* L.). International Journal of Current Research. 2014; 6(11): 9926-9930.
6. Li Z, Ahammed GJ. Hormonal Regulation of Anthocyanin Biosynthesis for Improved Stress Tolerance in Plants. Plant Physiology and Biochemistry. 2023; 201: 107-835.

7. Huang Y, Ji Z, Zhang S, Li S. Function of Hormone Signaling in Regulating Nitrogen-Use Efficiency in Plants. Journal of Plant Physiology. 2024; 294: 154-191.

8. Ruan J, Zhou Y, Zhou, M, Yan J, Khurshid M, Weng W, Cheng J, Zhang K. Jasmonic Acid Signaling Pathway in Plants. International Journal of Molecular Science. 2019; 20: 2479.

9. Wang Y, Mostafa S, Zeng W, Jin B. Function and Mechanism of Jasmonic Acid in Plant Responses to Abiotic and Biotic Stresses. International Journal of Molecular Science. 2021; 22: 8568.

10. Shikha D, Jakhar P, Satbhai SB. Role of jasmonate signaling in the regulation of plant responses to nutrient deficiency. Journal of Experimental Botany. 2023; 74: 1221–1243.

11. Wu J, Chen Y, Xu Y, An Y, Hu Z, Xiong A, Wang G. Effects of Jasmonic Acid on Stress Response and Quality Formation in Vegetable Crops and Their Underlying Molecular Mechanisms. Plants. 2024; 13(11): 1557.

12. Tong H, Chu C. Functional specificities of brassinosteroid and potential utilization for crop improvement. Trends in Plant Science. 2018; 23:1016−1028.

13. Xiong M, Feng G, Gao Q, Zhang C, Li Q. Brassinosteroid regulation in rice seed biology. Seed Biology. 2022; 1:2.

14. Hamza OM, AL-Taey DKA. A study on the effect of glutamic acid and benzyl adenine application up on growth and yield parameters and active components of two Broccoli hybrids. International Journal of Agriculture Statistic and Science. 2020;16(1): 1163-1167.

15. Gautam MK, Mishra S. Impact of Plant Growth Regulators on Growth, Fruit Yield and Quality of Strawberry (*Fragaria ananassa* Duch.) cv. Winter Dawn. Journal of Experimental Agriculture International. 2024; 46(7):1205-1212.

16. Yadav I, Singh J, Meena B, Singh P, Meena S, Neware S, Patidar DK. Strawberry yield and yield attributes after application of plant growth regulators and micronutrients on cv. Winter Dawn. Chemical Science Review and Letters. 2017; 6(21):589-594.

17. Özçınar AB. *Salisilik Asit Uygulamasının Ayçiçeği (Helianthus annus* L.*) Bitkisi Gelişimi Üzerine Etkisi*. Turkish Journal of Agriculture-Food Science and Technology. 2024; 12(5):828-833.

18. Singh ID, Stoskopf NC. Harvest index in cereals 1. Agronomy Journal. 1971; 63(2):224-226.

19. Clouse SD, Sasse JM. Brassinosteroids: Essential Regulators of Plant Growth and Development. Annual Revolution Plant Physiology Plant Molecular Biology. 1998; 49: 427-451

20. Xu Z, Huang S, Xie Y, Wang S, Jin N, Tie J, Meng X, Li Z, Lyu J, Yu J. Physiological responses of Coriander (*Coriandrum sativum* L.) to exogenous 2,4- epibrassinolide at different concentrations. BMC Plant Biology. 2023; 23: 649-661.

21. Balbaa LK. Response of Two Fenugreek (*Trigonella foenum-graecum* L.) Cultivars To Foliar Application with Brassinosteroids. Alexandria Science Exchange Journal. 2007; 28(4):209-214.

22. Kuri BR, Jat NL, Shivran AC, Saharawat YS, Bana RS, Dadarwal RS. Effect of sowing time, varieties and plant growth regulators on growth, physiological indices and productivity of Coriander (*Coriandrum sativum* L.). Indian Journal of Agronomy (The Indian Society of Agronomy). 2015; 60(3): 464-470.

23. Rai S, Singh KV, Kashyap A, Gangale P. Influence of PGRs, sowing time and varieties on growth of coriander (*Coriandrum sativum* L.). Journal of Pharmacognosy and Phytochemistry. 2020; 9(5):1400-1403.

24. Sridhara S, Ramesh N, Gopakkali P, Paramesh V, Tamam N, Abdelbacki AMM, Elansary HO, El-Sabrout AM, Abdelmohsen SAM. Application of Homobrassinolide enhances growth, yield and quality of tomato. Saudi Journal of Biological Sciences. 2021; 28: 4800-4806.

25. Sheteaw SA. Improving Growth and Yield of Salt-Stresses Soybean by Exogenous Application of Jasmonic Acid and Ascobin. International Journal of Agriculture and Biology. 2007; 9: 473-478.

26. Arpitha HS, Umesha K, Anilkumar GS. Influence of Elicitors on Growth and Yield of Black Cumin (*Nigella sativa* L.) Varieties. Asian Journal of Soil Science and Plant Nutrition. 2024; 10(2): 182-189

27. Rahimi AR, Rokhzadi A, Amini S, Karami E. Effect of salicylic acid and methyl jasmonate on growth and secondary metabolites in *Cuminum cyminum* L. Journal of Biodiversity and Environmental Sciences. 2013; 3(12): 140-149.

28. Awang NA, Ismail MR, Omar D, Islam MR. Comparative Study of the application of Jasmonic acid and pesticide in chilli: Effects of physiological activities, yield and viruses control. Bioscience Journal of Uberlandia. 2015; 31(3): 672-681.

29. Fahad S, Hussain S, Matloob A. Phytohormones and plant responses to salinity stress: a review. Plant Growth Regulator. 2015; **75**: 391–404.

30. Hatakeyama K, Ishiguro S, Okada K. Antisense inhibition of a nuclear gene, BrDAD1, in Brassica causes male sterility that is restorable with Jasmonic acid treatment. Molecular Breeding. 2003; 11: 325-336.

31. Niwa T, Suzuki T, Takebayashi Y, Ishiguro R, Higashiyama T, Sakakibara H, Ishiguro S. Jasmonic acid facilitates flower opening and floral organ development through the upregulated expression of SlMYB21 transcription factor in tomato. Bioscience, Biotechnology, and Biochemistry. 2018; 82(2): 292-303.

32. Lalnunzawma, Karuna K, Rani R, Nahakpam S, Bahera SK, Sahay S. Effect of methyl jasmonate on growth and flowering behavior of strawberry cv. Nabila. International Journal of Current Microbiology and Applied Sciences. 2020; 9(9):2690-2695.

33. El-Gamal S, Ahmed HM. Optimization coriander production for fruit and essential oil B: Yield improvement by chitosan and salicylic acid foliar application. Journal of Plant Production. 2016; 7(12): 1481-1488.

34. Hajihashemi S, Ehsanpour AA. Influence of exogenously applied paclobutrazol on some physiological traits and growth of *Stevia rebaudiana* under in vitro drought stress. Biologia. 2013; 68: 414-420.

35. Afshari F, Nakhaei F, Mosavi S, Seghatoleslami M. Evaluating the role of nutri-priming in improving PEG-induced drought stress tolerance of stevia (*Stevia rebuadiana* Bertoni). Iranian Journal of Plant Physiology. 2020; 11:3509-3522.

36. Gorzi A, Omidi H, Bostani A. Morpho-physiological responses of Stevia (*Stevia rebaudiana* Bertoni) to various priming treatments under drought stress. Applied Ecology and Environmental Research. 2017; 16: 4753-4771.

37. Noori H, Moosavi SG, Seghatoleslami M, Fazeli Rostampour M. Morpho-physiological and yield responses of cumin (*Cuminum cyminum* L.) to the application of growth regulators under drought stress. Iranian Journal of Plant Physiology. 2022; 12(1): 4013-4025.

38. Kumar AR, Sathiamoorthy S, Subbiah A. Effect of plant growth regulators on yield parameters, yield and quality of black pepper (*Piper nigram* L.) variety Panniyur – 1. Journal of Spices and Aromatic Crops. 2002; 11 (2): 125-128.

39. Kusuma MV, Venkatesha J, Ganghadarappa PM, Hiremath JS, Manjunatha G. Effect of Growth Regulators at different stages on growth and yield of Fennel (*Foeniculum Vulgare* MILL.). International Journal of Current Research. 2019; 11(1): 392-397.

40. Nayak RJ, Ravi CS, Ganapathi M, Shivaprasad M, Bhoomika HR. Influence of Foliar Application of Benzyl Adenine and Nutrients on Growth and Yield of Transplanted Ginger (*Zingiber officinale* rosc.) under Hill Zone of Karnataka. International Journal of Current Microbiology and Applied Sciences. 2020; 9(9): 1793-1798.

41. Ramtin A, Kalatejari S, Naderi R, Matinizadeh M. Effect of benzyl adenine and salicylic acid on biochemical traits of two cultivars of carnation. Journal of Experimental Biology and Agricultural Sciences. 2016; 4: 427-434.

42. Aminifard MH, Jorkesh A, Fallahi HR, Moslemi FS. Influences of benzyl adenine and salicylic acid and on growth, yield, and biochemical characteristics of coriander (*Coriandrum sativum* L.). South African Journal of Botany. 2020; 132: 299-303.

43. Ren B, Zhang J, Dong S, Liu P, Zhao B. Root and shoot responses of summer maize to waterlogging at different stages. Agronomy Journal. 2016; 108(3):1060-1069.

44. Menaria BL, Maliwal PL. Maximization of seed yield in transplanted fennel (*Foeniculum vulgare* Mill.). Indian Journal of Spices and Aromatic Crops. 2007; 16(1): 46-49.

45. Hassan SB. Impact of humic acid and benzyl adenine Spraying on Coriandre Plant Development and yield (*Coriandrum sativum* L.). Journal of Medicinal and Industrial plant Sciences. 2023; 0(0): 50-56.

46. Mohamed AM, Mahmoud EA, Younes NA. Impact of foliar application of carbon nanotube and benzyl adenine on broccoli growth and head yield. Archives of Agriculture Sciences Journal. 2021; 4(1): 81-101.

47. Singh L. Effect of foliar application of Kinetin on growth, leaf yield, seed yield and quality attributes in Fenugreek. Dr Yashwant Singh Parmar University of Horticulture and Forestry Solan (Nauni) HP-173 230 INDIA. 2023.

48. Jayashree N. Effect of Benzyl adenine and Gibberelic acid on growth, flowering, yield of flowers and bulbs in Asiatic lily. University of Agricultural and Horticulture Science, Shivamogga. 2020.

Table 1. Effect of foliar-applied Plant Growth Regulators on Growth and phenological parameters

Treatments	Plant height (cm) at maturity	Primary branches per plant at maturity	Secondary branches per plant at maturity	Days to 50% flowering
T1 Benzyl Adenine (10 ppm)	95.87	14.60	24.29	41.67
T2 Benzyl Adenine (20 ppm)	94.13	14.33	25.09	43.33
T3 Brassinosteroid (0.5 ppm)	103.67	14.60	25.56	41.00
T4 Brassinosteroid (1.0 ppm)	95.60	14.53	25.37	42.33
T5 Jasmonic Acid (50 ppm)	99.53	15.53	26.50	32.33
T6 Jasmonic Acid (100 ppm)	98.17	14.73	25.73	36.67
T7 Salicylic Acid (50 ppm)	90.67	13.87	25.90	39.67
T8 Salicylic Acid (100 ppm)	94.80	13.80	23.33	43.00
T9 Control	81.87	13.77	22.49	46.00
S.E.(m) ±	4.13	0.49	0.60	0.82
C.D.(*p=0.05*)	12.40	1.48	1.81	2.46
CV	7.54	5.94	4.19	4.23

Table 2. Effect of foliar-applied Plant Growth Regulators on Seed Yield, its attributing characters, test weight and harvest index

Treatments	Umbels per plant	Umbellets per Umbel	Seeds per umbel	Seed Yield (q/ha)	Test Weight (g)	Harvest Index
T1 Benzyl Adenine (10 ppm)	35.20	5.68	35.16	12.27	9.78	9.92
T2 Benzyl Adenine (20 ppm)	34.33	5.79	36.40	13.65	10.84	10.84
T3 Brassinosteroid (0.5 ppm)	33.73	5.77	31.67	12.04	9.55	8.98
T4 Brassinosteroid (1.0 ppm)	35.67	5.83	34.69	10.32	8.78	8.78
T5 Jasmonic Acid (50 ppm)	42.13	6.31	35.89	11.99	9.50	8.64
T6 Jasmonic Acid (100 ppm)	38.47	6.01	32.31	10.48	9.11	8.97
T7 Salicylic Acid (50 ppm)	37.27	5.69	34.62	10.88	8.43	8.43
T8 Salicylic Acid (100 ppm)	37.67	5.76	34.21	10.89	8.55	8.55
T9 Control	29.80	5.31	30.63	9.22	7.65	7.65
S.E.(m) ±	1.69	0.21	1.27	0.58	0.38	0.43
C.D.(*p=0.05*)	5.07	0.63	3.83	1.74	1.16	1.31
CV	8.13	6.30	6.52	9.20	7.36	8.47

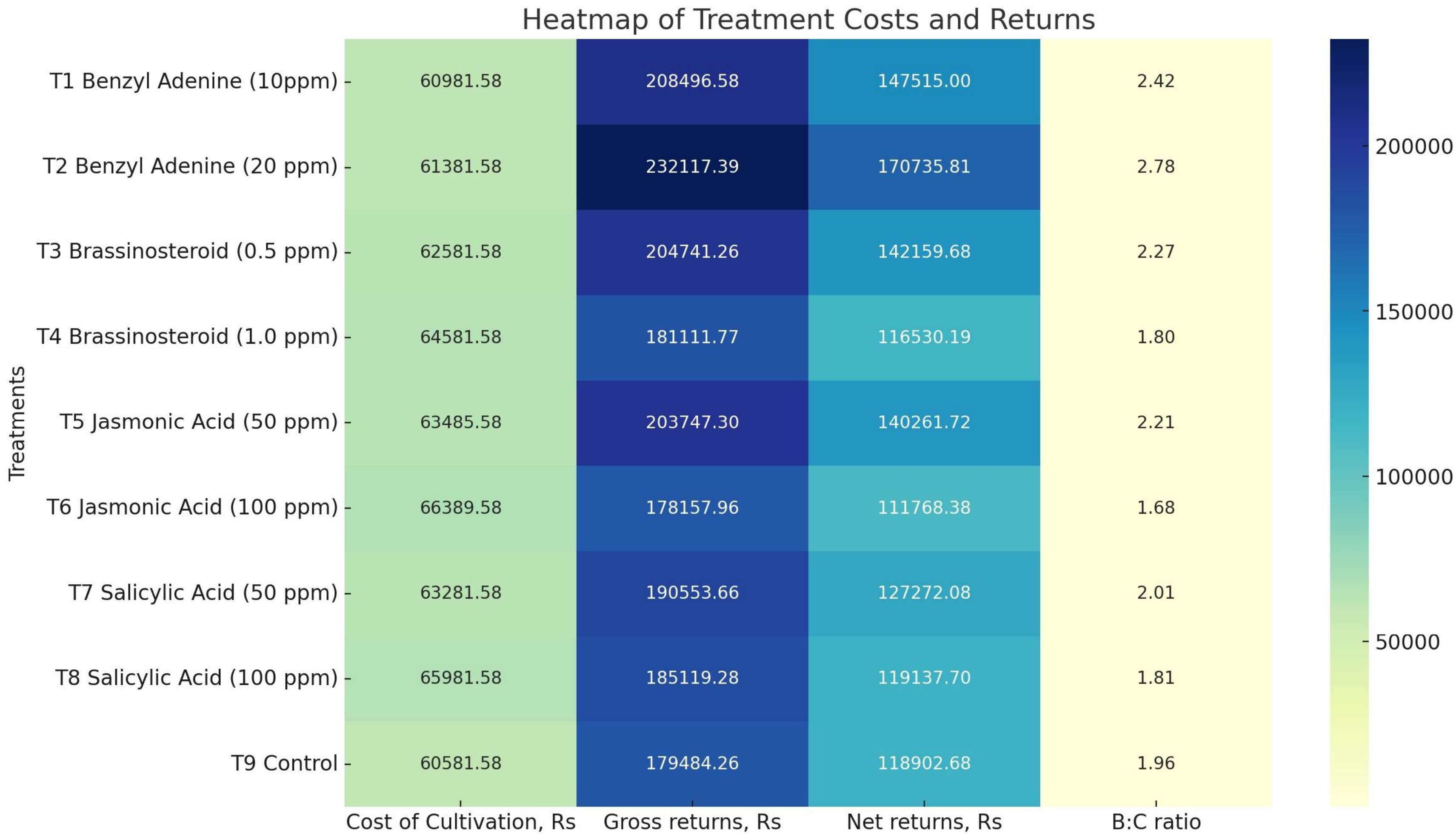

Figure: Heat Map for mean economic parameters