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EFFECT OF GROWTH REGULATOR AND NUTRIENT SPRAY TO IMPROVE THE GROWTH, FLOWERING, AND SEED PRODUCTION OF ZINNIA (*ZINNIA ELEGANS JACQ*.)

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ABSTRACT

The present investigation, entitled "Effect of growth regulator and nutrient spray to improve the growth, flowering, and seed production of zinnia (*Zinnia elegans Jacq*.)" was carried out at the Floriculture experimental field SKUAST-K, Shalimar, during the year 2018-19. The experiment comprised two levels of gibberellic acid (G_1 @100ppm, G_2 @150ppm), two levels of salicylic acid (S_1 @ 100ppm, S_2 @ 150 ppm), and one level of commercial nutrient spray (N_1 = 4mL per liter), constituting a total of 18 treatment combinations replicated thrice in factorial Randomized Complete Block Design (RCBD). Gibberellic acid @150ppm had a significantly increased number of flowers plant^{-1} (26.68), thousand seed weight (8.51g), and seed yield plant^{-1} (15.56g). However, the parameters flower diameter (10.72 cm), length of flowering stalk (12.62 cm), total number of flowers plant^{-1}(25.59), flower fresh weight (12.75), and thousand seed weight (8.22 g) were recorded with salicylic acid @150ppm. Two sprays of nutrient formulation significantly improved the growth, floral attributes, and seed parameters. Nutrient spray @4ml/l significantly increased the number of flowers plant^{-1} (25.02), flower fresh weight (12.52 g), thousand seed weight (8.19g), and seed yield plant^{-1} (15.03g).
***Keywords* :** Growth regulators, Nutrient spray, Zinnia, and Seed yield.

Introduction

Zinnia (*Zinnia elegans* L.) is a highly popular multi-colored flower, exhibiting pink, purple, red, orange, and salmon hues. Native to Mexico, Zinnia belongs to the family Asteraceae and comprises 20 species, with a basic chromosome number of x = 12. Zinnias have been favored by gardeners for generations, resulting in the development of numerous cultivars in various sizes and plant forms, ranging from spreading and dwarfing plants to giant types (Baskin and Baskin, 2023). The elegant, narrow-leaved creeping zinnia is particularly useful for naturalizing in rock gardens, containers, and hanging baskets. Zinnia gained popularity as an annual garden plant only in the late 19th century. In India, annual and perennial species are available, with the annual varieties commonly cultivated as summer season annuals. Additionally, they are grown as cut flowers in certain countries (Janakiram *et al*., 2018; Malakar *et al*., 2025).

Zinnia necessitates appropriate nutrition for optimal growth and development, ensuring it remains sufficiently green and vigorous and produces an abundance of flowers with adequate size, color intensity, and longevity (Qayyum *et al*., 2024; Malakar *et al*., 2025). In recent decades, the cultivation of high-yielding varieties has resulted in significant nutrient depletion from the soil. The imbalanced application of nutrients is a primary constraint to enhancing productivity. The utilization of soluble nutrient formulations in floriculture can effectively supply macro and micronutrients in readily absorbable forms, meeting the plants' requirements at judicious dosages (Kumar and Chaudhary, 2018).

Plant growth regulators can be applied at any stage of a plant's life cycle. Gibberellins, specifically gibberellic acid, are phytohormones that chemically belong to the group of tetracyclic diterpenoids, produced by angiosperms and certain fungi (Carlos *et al*., 2021; Shah *et al*., 2023). Gibberellins play a crucial role in growth and development, regulating processes such as seed germination, leaf expansion, stem elongation, and flowering. The exogenous application of gibberellins to plants results in increased activity of several key enzymes and promotes the elongation of primary roots and shoots. Salicylic acid, a phenolic derivative, is widely distributed across various plant species and is a natural product of phenylpropanoid metabolism (Abbasi *et al*., 2020). It is directly involved in plant growth, thermogenesis, flower induction, and ion uptake. Salicylic acid influences ethylene biosynthesis, stomatal movement and counteracts the effects of abscisic acid on leaf abscission (Bharath *et al*., 2021). Additionally, it enhances chlorophyll and carotenoid pigment levels, increases the rate of photosynthesis, and modifies the activity of certain important enzymes (Hayat *et al*., 2007). The objective of this research was to study the effect of growth regulators and nutrient spray on improving growth, flowering, and seed production of zinnia.

Materials and Methods

Study Area

The experimental site is geographically located at 34°9′ N latitude and 74°50′ E longitude, with an elevation of 1,606 meters above sea level, in the foothills of the Zabarwan mountain range, approximately 15 kilometers northeast of Srinagar, Jammu and Kashmir, India. The region exhibits a temperate-Mediterranean and continental climate characterized by hot summers and severe winters. The average annual precipitation is 944.6 mm, with over 80% of the total rainfall resulting from western disturbances. Meteorological data for the duration of the experiment was obtained from the Meteorological Observatory, Division of Agronomy, SKUAST-Kashmir.

Experimental Area

In 2018-2019, a three-factor field experiment was carried out to study the effect of growth regulators and nutrient sprays to improve the growth, flowering, and seed production of zinnia. The field experiment was executed at the Floriculture Experimental Field, Division of Floriculture and Landscape Architecture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-Kashmir).

The experimental plot, encompassing an area of 54 m², underwent thorough ploughing, and well-decomposed Farmyard Manure (FYM) was incorporated during the field preparation phase. Additionally, Urea, Single Super Phosphate, and Murate of Potash were administered one week before the transplanting process. Flat beds, each measuring 1 m × 1 m, were established, and one-month-old healthy seedlings were transplanted with a spacing of 30 cm × 25 cm, allowing for 12 plants per bed.

At the final stage of maturity, various parameters were measured, including plant height, plant spread, number of branches per plant, number of leaves per plant, leaf area, fresh weight of shoot (g), number of flowers per plant, flower stalk length (cm), flower diameter (cm), flower fresh weight (g), field life (days), seed yield per plant (kg), seed yield (qha^{-1}), and 1000 seed weight (g). These measurements were analyzed using a Randomized Complete Block Design with 18 treatment combinations, as outlined by Steel & Torrie (1980).

Statistical Analysis

The experimental data underwent statistical evaluation using OP STAT software, employing analysis of variance. The means were compared with a significance level of $P \leq 0.05$.

Result and Discussion

Effect on vegetative parameters

Data presented in Table 1 demonstrate that plant height, plant spread, number of branches, number of leaves per plant, leaf area, shoot fresh weight, and root shoot ratio were significantly influenced by various treatments. The application of GA_3 at 150 ppm resulted in the maximum plant height (154.8 cm). The observed increase in plant height with GA_3 application can be attributed to enhanced cell division and elongation in the apical meristem, leading to increased internode length and promotion of protein synthesis, along with higher dry matter accumulation in the plant. Plant growth may be further augmented due to the osmotic uptake of water and nutrients under the influence of GA_3, which maintains turgor pressure against cell wall softening, thereby increasing plant height. The increase in plant height due to GA_3 observed in this study is consistent with the findings of Kumar *et al*. (2003) in China aster, Swaroop *et al*. (2007) in African marigold, and Tyagi and Kumar (2006), as well as Tripathi *et al*. (2003) in French marigold; Kumar *et al*. (2003), Nandre *et al*. (2009), Padmani *et al*. (2013) in China aster, and Surabhi *et al*. (2018) in Zinnia.

Salicylic acid at 150 ppm also recorded a maximum plant height (147.8 cm). Salicylic acid enhances plant height by increasing RUBISCO activity and photosynthetic rate, and it is suggested to play a crucial role in chloroplast synthesis. These observations align with the findings reported by Al-Abbasi *et al*. (2015) and Zeb *et al*. (2017) in Zinnia.

Plant height (cm) was significantly improved by the foliar application of a commercial nutrient formulation. The nutrient spray at 4 ml/l recorded a maximum plant height (147.9 cm). Dadkhan *et al*. (2012) reported that the use of foliar fertilizers stimulates plant growth and enhances the development of plants, leading to improvements in morphological characteristics such as plant height and number of leaves.

Plant Spread

Plant spread, measuring 61.4 cm, was observed following the foliar application of 150 ppm GA_3. The observed increase in the number of branches may be attributed to an augmented number of internodes and enhanced photosynthetic efficiency, likely due to an increase in chlorophyll content. This phenomenon has been similarly reported by Swaroop *et al*. (2007) in African marigold, Tyagi *et al*. (2008) in Calendula officinalis, Sharma *et al*. (2008) in zinnia, and Kumari *et al*. (2017) in China aster. Additionally, a plant spread of 56.4 cm was recorded with the foliar application of a commercial nutrient spray at a concentration of 4 ml/l. The foliar application of nutrient sprays containing micronutrients and amino acids, when applied at optimal concentrations, may have facilitated additional lateral growth. The commercial sprays utilized in this study contained various essential micronutrients, such as Fe, Zn, and Ca, which are crucial for the metabolism and biosynthesis of photo-assimilates in plants. Improved vegetative growth in *chrysanthemum*s through foliar micronutrient applications has also been documented by Karuppaiah (2014) and Saini *et al*. (2015).

Number of branches per plant

GA_3 at 150 ppm resulted in the highest number of branches (23.07). This increase in branching may be attributed to the promotion of horizontal growth in addition to vertical growth. Similar findings were reported by Swaroop *et al*. (2007) in African marigolds, Tyagi *et al*. (2008) in Calendula officinalis, and Ehsanullah *et al*. (2022) in *chrysanthemum*s. Salicylic acid at 150 ppm also recorded a high number of branches (21.16). Salicylic acid enhances plant immunity by ensuring a continuous supply of nutrients and facilitating an effective response to environmental stresses. It acts as a crucial signaling molecule that modifies physiological regulation to improve adaptability under stress conditions. Nutrient Spray (N1) at 4 ml/l recorded a significant number of branches (20.61). Mathew *et al*. (2004) reported that a foliar spray of 1500 ppm Boron combined with 0.5% Zn increased both plant height and the number of branches in African marigold cv. 'Pusa Basanti'.

Number of leaves per plant

The application of GA_3 at a concentration of 150 ppm resulted in the highest number of leaves per plant, with a recorded maximum of 148.7 leaves. This increase in leaf production may be attributed to GA_3's role in enhancing vegetative growth, as well as facilitating the transport and utilization of photosynthetic products. These findings are supported by the research of Nandre *et al*. (2009) on China aster and Tyagi *et al*. (2008) on Calendula officinalis, both of which involved the application of GA_3. Similarly, salicylic acid at 150 ppm also resulted in a high leaf count, with a maximum of 145.3 leaves, while the control group exhibited the lowest leaf count at 136.5. The observed increase in plant height with higher concentrations of salicylic acid may be linked to its role in inducing protective mechanisms under adverse environmental conditions, thereby influencing plant physiology. The activation of specific enzymes may directly enhance gene function related to defensive control, leading to changes in leaf number. The structure of chloroplasts plays a crucial role in the plant's energy status, as plants utilize two photosystems in series to generate ATP. The storage of these assimilates enables plants to increase leaf number. These findings are corroborated by Zeb *et al*. (2017) in zinnia cultivars, Mahroof *et al*. (2017) in Zinnia elegans, and Chaudhary *et al*. (2015) in African marigolds.

Root Shoot Ratio

The foregoing study recorded a significantly increased root shoot ratio at all the growing stages of Zinnia because of commercial nutrient spray. The maximum root shoot ratio (0.28) was found in plants without any treatment (control), and the minimum root shoot ratio (0.15) was recorded in plots treated with GA3 @ 150ppm and salicylic acid @150ppm recorded root shoot ration (0.20). The maximum root shoot ratio (0.22) was recorded with a nutrient spray @ 4ml/l application. This is due to higher enzymatic activity because of the availability of essential nutrients that significantly increase the root shoot ratio in plants. The same results were observed by Sharma *et al*. (2013) in gladiolus and Jat *et al*. (2014) in the African marigold. This conforms to our findings.

Effect of growth regulators and nutrient spray on flowering parameters of zinnia

Total number of flowers per plant

The current study observed a significant increase in the number of flowers per plant. The application of GA_3 at 150 ppm resulted in the highest number of flowers per plant (26.68), which was significantly greater than that observed with GA_3 at 100 ppm. The lowest number of flowers per plant (21.58) was recorded with GA_3 at 0 ppm. The increase in flower number due to GA_3 application is attributed to enhanced plant height and an increased number of branches (Table 2). GA_3, through its effects on amylase activity, auxin stimulation, and cell elongation, positively influenced leaf area, thereby expanding the photosynthetic area and increasing carbohydrate accumulation. Similar findings were reported by Rakesh *et al*. (2003), Moond and Rakesh (2006) in *chrysanthemum*, Ramdev Putra *et al*. (2009) in marigold, and Padmani *et al*. (2013) in China aster.

The significant influence of salicylic acid on the number of flowers per plant was also observed. Salicylic acid at 150 ppm recorded the maximum number of flowers per plant (25.59), while the minimum number (23.07) was recorded with salicylic acid at 0 ppm. The role of salicylic acid is attributed to its enhancement of vegetative growth, leading to increased nutrient absorption and promoted photosynthesis, which in turn facilitates carbohydrate synthesis. This effect is evident in flower differentiation and the hormonal balance that leads to flower primordia formation, as well as its role in auxin production, which enhances flower emergence (Hayat *et al*., 2007). A similar trend was observed by Al-abbasi *et al*. (2015) and Zeb *et al*. (2017) in zinnia, where they demonstrated improved flower diameter and stalk length with salicylic acid application.

Furthermore, the significant impact of nutrient applications on the number of flowers per plant was noted. The maximum number of flowers per plant (25.02) was recorded with nutrient sprays at 4 ml/l, while the minimum (23.93) was observed in the control. An extended nutrient application schedule promotes plant growth throughout the crop cycle, potentially contributing to the development of more flowers per plant. Halder *et al*. (2007) reported a positive correlation between micronutrients and flower production in various crops, such as Gladiolus. This may explain the improvement in individual flower fresh weight (6.63 g) observed in the current study with nutrient spray. These findings are consistent with the results of Deshmukh (1998) and Wavhal (1999) in China aster, and Surabhi *et al*. (2018) in *chrysanthemum*.

Flower diameter and flower stalk length (cm)

The application of GA_3 spray significantly influenced both flower diameter and flower stalk length. Specifically, GA_3 at a concentration of 150 ppm resulted in the largest flower diameter (11.00 cm) and flower stalk length (13.05 cm). The enhancement in flower size due to GA_3 can be attributed to the translocation of metabolites to the site of flower bud development (Table 2). This trend is consistent with findings by Moond and Rakesh (2006) in chrysanthemums, Tyagi and Vijay Kumar (2006) and Bihari and Narayan (2009) in marigolds, and Padmini *et al*. (2013) in China aster. Similarly, the application of salicylic acid spray significantly affected flower diameter and flower stalk length. At a concentration of 150 ppm, salicylic acid achieved maximum flower diameter and stalk length (10.72 cm and 12.62 cm, respectively), while the minimum values (9.32 cm and 11.53 cm, respectively) were recorded with GA_3 at 0 ppm. Salicylic acid plays a crucial role in enhancing flower stem length, primarily through cell elongation and expansion as its concentration increases. The increase in flavonoid content within the inflorescence, associated with higher levels of salicylic acid, further contributed to the enhancement of flower length, as observed by Al-Abbasi *et al*. (2015) in *Zinnia elegance* L.

Field life

The application of GA_3 and salicylic acid sprays significantly influenced the field life of plants. Specifically, GA_3 at 150 ppm and salicylic acid at 150 ppm resulted in the longest field life, measuring 101.1 days and 99.94 days, respectively, whereas the control group exhibited the shortest field life, with durations of 95.54 and 97.08 days (Table 2). The enhancement of vegetative growth in Zinnia plants by plant growth regulators (PGRs) is attributed to increased nutrient absorption and the promotion of photosynthetic activities, ultimately leading to higher carbohydrate assimilation. This physiological process facilitated both vegetative and floral development by maintaining hormonal balance, thereby extending the field life of the plants. These findings are consistent with the results reported by Abbass *et al*. (2016) in Antirrhinum majus and Zeb *et al*. (2017) in Zinnia.

Effect of growth regulators and nutrient spray on seed parameters of zinnia

Seed yield plant^{-1} (g), 1000 seed weight (g) and Seed yield (q ha^{-1})

The current study demonstrates a significant enhancement in seed yield per plant, 1000-seed weight per plant, and seed yield per hectare. The application of GA_3 at 150 ppm resulted in the highest seed yield per plant (15.56 g), 1000-seed weight (8.51 g), and seed yield per hectare (14.00 q), which were significantly greater than those observed with GA_3 at 100 ppm. Conversely, the lowest seed yield per plant (13.28 g), 1000-seed weight (7.30 g), and seed yield per hectare (11.97 q) were recorded with GA_3 at 0 ppm. Similarly, salicylic acid exhibited a significant impact on seed yield per plant, 1000-seed weight, and seed yield. At 150 ppm, salicylic acid achieved the maximum seed yield per plant (15.15 g), 1000-seed weight (8.22 g), and seed yield (13.64 q ha^{-1}), which were significantly higher than those at 100 ppm. The minimum seed yield per plant (13.98 g), 1000-seed weight (7.68 g), and seed yield per hectare (12.60 q ha^{-1}) were observed with salicylic acid at 0 ppm (Table 3). The observed increase in seed yield per plant and per unit area due to gibberellic acid and salicylic acid can be attributed to enhanced yield attributes, such as the number of flowers, thousand-seed weight, and growth parameters, including the number of branches per plant. These findings are consistent with the results of Swaroop *et al*. (2007) in African marigolds and Sunitha *et al*. (2007) in marigolds treated with GA_3 and salicylic acid spray. The increase in thousand-seed weight may be attributed to the augmentation of individual seed weight due to foliar applications of GA_3 and salicylic acid. Similar observations regarding the increase in thousand-seed weight due to GA_3 and salicylic acid spray were reported by Sunitha *et al*. (2007) in marigolds.

Extending the frequency of nutrient sprays into the crop cycle resulted in improved 1000 seed weight and seed yield (kg ha^{-1}). Most of the seed filling takes place towards the end of the crop cycle. This indicated the importance of a continued supply of nutrients for improving seed plumpness and total seed yield. Numerous studies like Kumar *et al*. (2003) and Surabhi *et al*. (2018) in zinnia in carnation reported improved 1000 seed weight and seed yield with the application of foliar nutrients.

Effect of growth regulators and commercial nutrient formulation on Relative economics of zinnia (*Zinnia elegance Jacq*.)

The efficacy of a treatment is ultimately determined by its economic viability, specifically the benefit-to-cost ratio, as illustrated in Table 4. The current study identified that the highest benefit-to-cost ratio (3.31) was achieved with the treatment combination $G_1S_2N_1$. This was closely followed by the $G_2S_1N_1$ treatment combination, which exhibited a benefit-to-cost ratio of 3.18. The treatment combination $G_1S_2N_1$ yielded the highest total income of Rs 980,850 and net returns of Rs 753,442 per hectare. Consequently, the $G_1S_2N_1$ treatment combination (GA3 at 100 ppm, Salicylic acid at 150 ppm, and commercial nutrient spray at 4 ml/l) was deemed the most effective in terms of return per rupee invested. This finding underscores the synergistic effect of growth regulators and nutrient spray in achieving higher net returns per unit area.

Conclusion

The findings of this study demonstrate that the application of gibberellic acid (GA_3), salicylic acid, and nutrient spray exerts a statistically significant influence on the growth, flowering, and seed production of *Zinnia elegans*. Among the treatments, GA_3 at 150 ppm yielded the greatest plant height, number of branches, and leaf growth, likely due to its effects on cell division, elongation, and photosynthetic efficiency. Salicylic acid also contributed to enhanced plant growth, presumably through its role in regulating stress responses and chlorophyll production, thereby influencing physiological functions. Furthermore, nutrient spray applied at 4 ml/L enhanced overall plant vigor, promoting lateral growth and the assimilation of essential micronutrients. The combined application of growth regulators and nutrient formulations exhibited a synergistic effect, improving plant architecture and physiological efficiency, thereby supporting optimal growth and development of zinnia. The research further indicated that flowering and seed yield parameters were significantly enhanced with the use of GA_3, salicylic acid, and nutrient formulations. Additionally, the number of flowers per plant, flower diameter, seed weight, and total seed yield per hectare were substantially improved due to physiological and biochemical enhancements. The economic analysis within the study confirmed that the highest benefit-cost ratio was achieved with the use of 100 ppm GA_3 combined with 150 ppm salicylic acid and a nutrient spray at 4 ml/L, illustrating the economic viability of this treatment for commercial floriculture. This research underscores the significance of plant growth regulators and nutrient management as strategies for enhancing flower quality and seed productivity, thereby providing a scientifically validated methodology for the improved commercial production of *Zinnia elegans.*

Table 1: Effect of growth regulators and nutrient spray on vegetative parameters of zinnia.

Treatment code	Detail of treatments	Plant height	Plant spread	No. of branch	No. of leaves /plant	Leaf area /plant	Fresh weight of shoot	Root shoot ratio
T_1	Control	124.8	40.3	14.1	127.3	42.9	898.7	0.285
T_2	Nutrient spray 04 ml/ltr	128.4	43.3	14.9	129.8	48.3	923.7	0.293
T_3	Salicylic acid 100ppm	129.5	44.2	14.8	130.2	49.7	932.2	0.253
T_4	Salicylic acid 100 ppm+ nutrient spray 04 ml/ltr	132.3	45.1	15.5	133.0	51.8	949.2	0.305
T_5	Salicylic acid 150 ppm	130.4	46.2	15.6	131.8	50.0	940.8	0.269
T_6	Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	133.1	51.4	16.4	135.1	54.7	953.8	0.306
T_7	GA_3 100 ppm	135.4	49.0	17.4	136.3	51.9	955.4	0.247
T_8	GA_3 100 ppm + nutrient spray 04 ml/ltr	139.4	53.3	18.5	138.5	53.6	959.5	0.235
T_9	GA_3 100 ppm + Salicylic acid 100 ppm	143.3	56.7	19.3	140.0	56.3	962.8	0.214
T_{10}	GA_3 100 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	161.3	60.6	22.4	150.8	70.7	1152.3	0.23
T_{11}	GA_3 100 ppm + Salicylic acid 150 ppm	146.5	53.6	19.4	146.2	62.7	986.6	0.198
T_{12}	GA_3 100 ppm + Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	159.3	62.5	24.4	154.2	74.7	1281.0	0.202
T_{13}	GA_3 150 ppm	140.6	54.0	18.7	142.5	60.9	965.7	0.165
T_{14}	GA_3 150 ppm + nutrient spray 04 ml/ltr	149.4	56.9	21.1	145.1	59.1	973.6	0.187
T_{15}	GA_3 150 ppm + Salicylic acid 100 ppm	155.1	59.1	21.6	148.0	65.9	994.3	0.176
T_{16}	GA_3 150 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	162.4	68.1	25.8	152.3	72.9	1122.3	0.156
T_{17}	GA_3 150 ppm + Salicylic acid 150 ppm	152.4	64.0	24.7	148.8	65.0	1008.4	0.128
T_{18}	GA_3 150 ppm + Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	164.4	66.4	26.6	156.1	68.8	1312.0	0.133
C.D($P \leq 0.05$)								
	GA_3 (G)	0.22	0.63	0.30	0.30	1.97	0.79	0.002
	Salicylic acid (S)	0.22	0.63	0.30	0.30	1.97	0.79	0.002
	Nutrient Formulation (N)	0.18	0.51	0.24	0.24	1.61	0.65	0.001
	G x S	0.39	1.09	0.52	0.52	3.41	1.38	0.003
	G x N	0.32	0.89	0.43	0.43	2.78	1.12	0.002
	S x N	0.32	0.89	0.43	0.43	2.78	1.12	0.002
	G x S x N	0.55	1.55	0.74	0.74	4.83	1.95	0.004

Table 2: Effect of growth regulators and nutrient spray on flowering parameters of zinnia.

Treatment code	Detail of treatments	No. flower / plant	Flower stalk length	Flower fresh weight	Flower diameter	Field life
T_1	Control	20.2	9.46	10.32	8.17	93.45
T_2	Nutrient spray 04 ml/ltr	21.5	10.43	10.90	8.59	94.50
T_3	Salicylic acid 100ppm	22.4	11.63	11.32	8.77	96.16
T_4	Salicylic acid 100 ppm+ nutrient spray 04 ml/ltr	20.6	10.39	10.71	8.40	94.00
T_5	Salicylic acid 150 ppm	21.9	11.22	11.16	8.61	96.58
T_6	Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	22.7	11.49	11.58	8.87	97.41
T_7	GA_3 100 ppm	23.3	11.79	11.60	9.23	97.75
T_8	GA_3 100 ppm + nutrient spray 04 ml/ltr	24.3	12.19	12.32	10.30	99.35
T_9	GA_3 100 ppm + Salicylic acid 100 ppm	25.2	12.52	12.49	10.65	98.25
T_{10}	GA_3 100 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	23.7	12.35	11.69	9.70	99.48
T_{11}	GA_3 100 ppm + Salicylic acid 150 ppm	26.8	13.39	13.60	12.10	101.4
T_{12}	GA_3 100 ppm + Salicylic acid 150 ppm + nutrient	27.4	13.52	13.68	12.56	102.5

	spray 04 ml/ltr	.4.				
T_{13}	GA_3 150 ppm	24.7	12.49	12.63	10.20	98.50
T_{14}	GA_3 150 ppm + nutrient spray 04 ml/ltr	26.2	12.78	12.80	10.59	100.5
T_{15}	GA_3 150 ppm + Salicylic acid 100 ppm	27.2	13.04	13.63	11.68	101.0
T_{16}	GA_3 150 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	25.7	12.70	12.74	10.36	99.33
T_{17}	GA_3 150 ppm + Salicylic acid 150 ppm	27.7	13.79	13.72	11.37	102.5
T_{18}	GA_3 150 ppm + Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	28.4	13.54	13.85	11.83	104.5
C.D(P≤0.05)						
GA_3 (G)		0.12	0.09	0.03	0.18	.017
Salicylic acid (S)		0.12	0.09	0.03	0.18	0.17
Nutrient Formulation (N)		0.10	0.07	0.03	0.15	0.14
G x S		0.22	0.16	0.06	0.32	0.30
G x N		0.18	0.13	0.05	0.26	0.25
S x N		0.18	0.13	0.05	0.26	0.25
G x S x N		0.31	0.24	0.09	0.45	0.43

Table 3: Effect of growth regulators and nutrient spray on seed parameters of zinnia.

Treatment code	Detail of treatments	seed^{-1} flower head	Seed yield plant $^{-1}$	Seed yield ha $^{-1}$	Test weight
T_1	Control	77.0	12.59	11.46	6.35
T_2	Nutrient spray 04 ml/ltr	85.3	13.17	11.85	7.42
T_3	Salicylic acid 100ppm	89.0	13.66	12.29	7.47
T_4	Salicylic acid 100 ppm+ nutrient spray 04 ml/ltr	84.1	13.12	11.81	7.25
T_5	Salicylic acid 150 ppm	91.0	13.31	11.98	7.60
T_6	Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	93.6	13.81	12.42	7.71
T_7	GA_3 100 ppm	94.6	14.16	12.74	7.96
T_8	GA_3 100 ppm + nutrient spray 04 ml/ltr	99.6	14.87	13.38	8.24
T_9	GA_3 100 ppm + Salicylic acid 100 ppm	99.2	14.77	13.20	8.10
T_{10}	GA_3 100 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	97.4	14.46	13.01	8.13
T_{11}	GA_3 100 ppm + Salicylic acid 150 ppm	103.0	15.87	14.20	8.41
T_{12}	GA_3 100 ppm + Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	106.2	16.77	15.09	8.48
T_{13}	GA_3 150 ppm	86.4	14.03	12.87	8.19
T_{14}	GA_3 150 ppm + nutrient spray 04 ml/ltr	103.3	15.46	13.92	8.30
T_{15}	GA_3 150 ppm + Salicylic acid 100 ppm	106.5	15.67	14.10	8.45
T_{16}	GA_3 150 ppm + Salicylic acid 100 ppm + nutrient spray 04 ml/ltr	102.8	15.23	13.71	8.21
T_{17}	GA_3 150 ppm + Salicylic acid 150 ppm	109.3	16.46	14.82	8.80
T_{18}	GA_3 150 ppm + Salicylic acid 150 ppm + nutrient spray 04 ml/ltr	111.4	16.24	14.62	9.12
C.D(P≤0.05)					
GA_3 (G)		2.99	0.09	0.05	0.05
Salicylic acid (S)		2.99	0.09	0.05	0.05
Nutrient Formulation (N)		2.44	0.07	0.04	0.04
G x S		NS	0.15	0.09	0.09
G x N		NS	0.13	0.07	0.07
S x N		NS	0.13	0.07	0.07
G x S x N		NS	0.22	0.13	0.13

Table 4: Effect of growth regulators and commercial nutrient formulation on Relative economics of zinnia (*Zinnia elegance Jacq*.)

Treatments	Gross Income	Cost of cultivation	Net Return	Benefit cost ratio
$G_0S_0N_0$	744,900	220,400	524,500	2.37
$G_0S_0N_1$	767,650	221300	546,350	2.46
$G_0S_1N_0$	770,900	220,472	550,428	2.49
$G_0S_1N_1$	778,700	221,372	557,328	2.51
$G_0S_2N_0$	798,850	220,508	578,342	2.62
$G_0S_2N_1$	850,950	220,580	630,370	2.85
$G_1S_0N_0$	828,750	226,400	602,350	2.66
$G_1S_0N_1$	845,650	227300	618,350	2.72
$G_1S_1N_0$	870,350	226472	643,878	2.84
$G_1S_1N_1$	928,200	227,372	700,828	3.08
$G_1S_2N_0$	863,850	226508	637,342	2.81
$G_1S_2N_1$	980,850	227408	753,442	3.31
$G_2S_0N_0$	835,250	229400	605,850	2.64
$G_2S_0N_1$	891,150	230300	660,850	2.86
$G_2S_1N_0$	904,800	229,472	675,328	2.94
$G_2S_1N_1$	963,300	230372	732,928	3.18
$G_2S_2N_0$	916,500	229508	686,992	2.99
$G_2S_2N_1$	950,300	230408	719,892	3.12

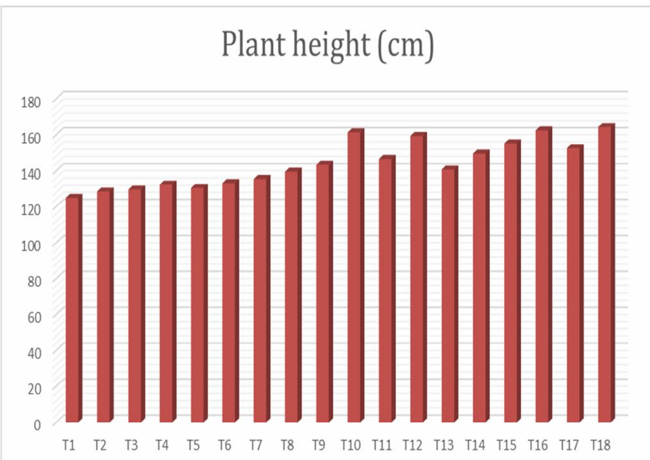

Fig. 1: Effect of growth regulators and nutrient spray on plant height (cm) of zinnia

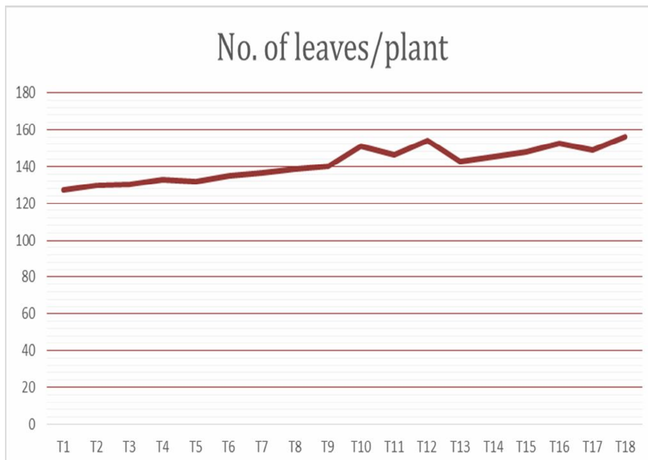

Fig. 3: Effect of growth regulators and nutrient spray on No. of leaves per plant of zinnia

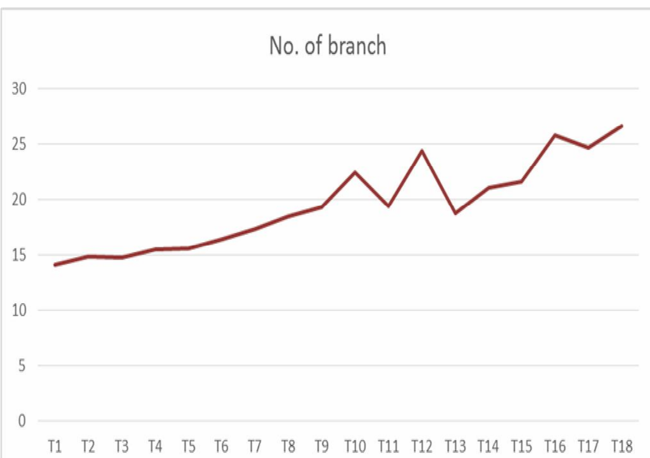

Fig. 2: Effect of growth regulators and nutrient spray no. of branches per plant of zinnia

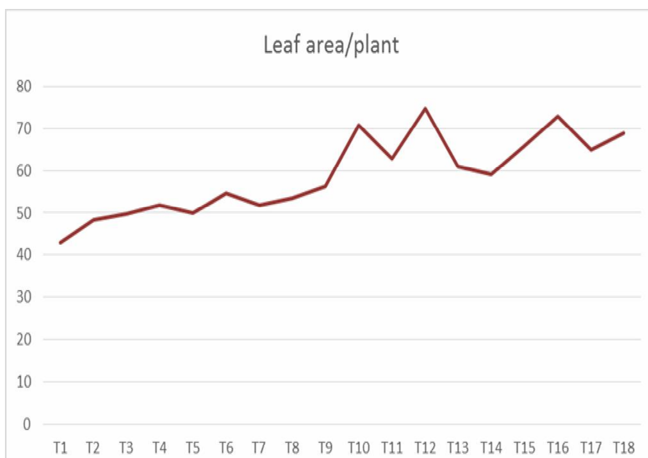

Fig. 4: Effect of growth regulators and nutrient spray on leaf area per plant of zinnia

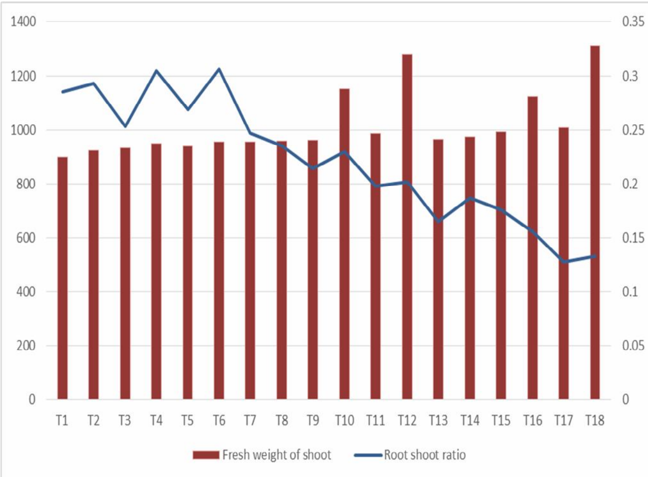

Fig. 5: Effect of growth regulators and nutrient spray fresh weight of shoot and Root shoot ratio of zinnia

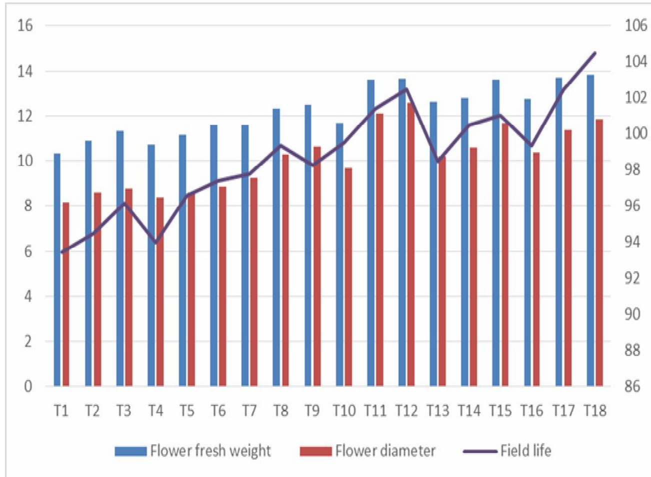

Fig. 8: Effect of growth regulators and nutrient spray on fresh weight, flower diameter and field life of zinnia

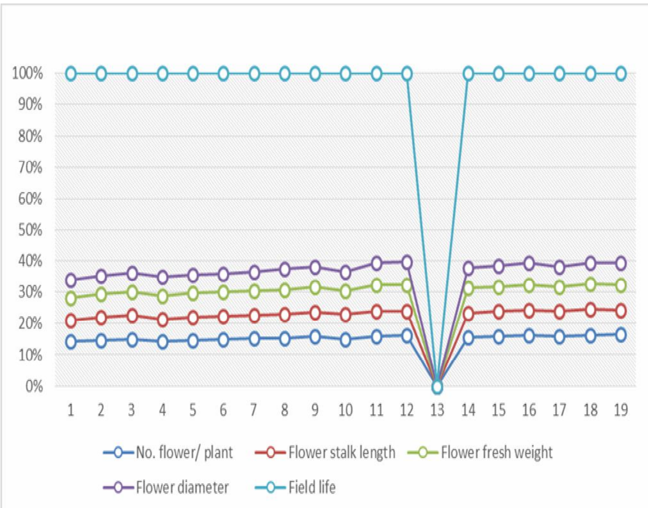

Fig. 6: Effect of growth regulators and nutrient spray on flowering parameters of zinnia

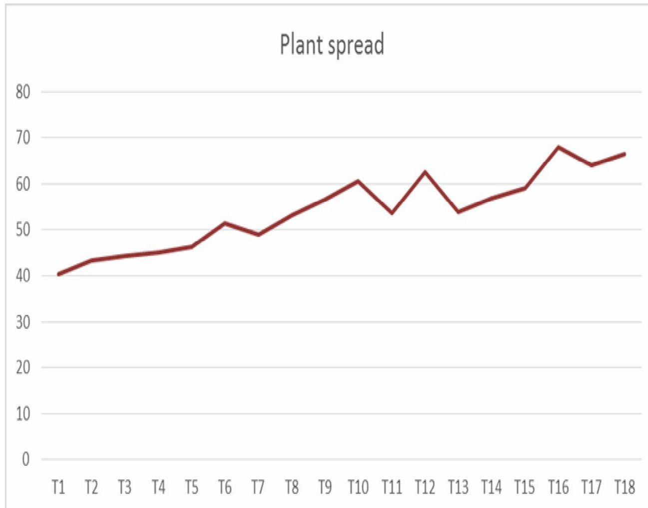

Fig. 9: Effect of growth regulators and nutrient spray on plant spread of zinnia

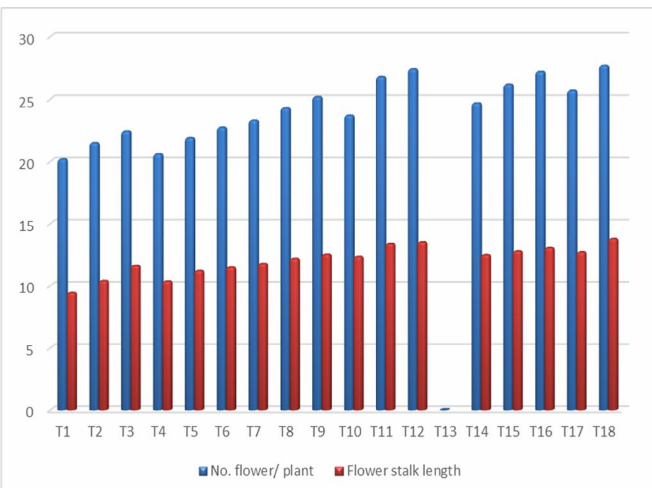

Fig. 7: Effect of growth regulators and nutrient spray on no. of flowers per plant and flower stalk length of zinnia

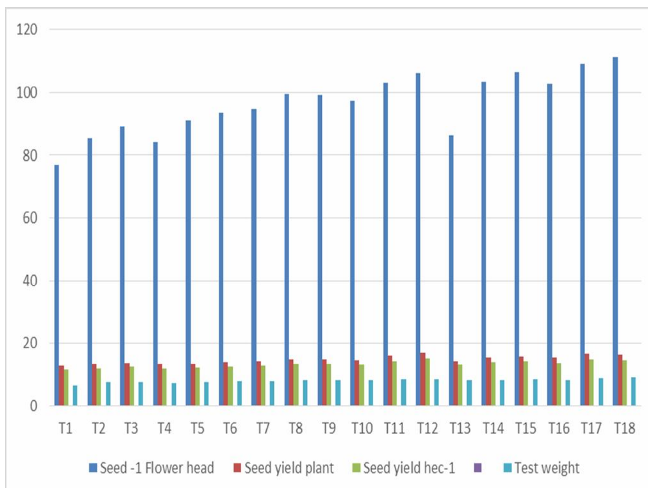

Fig. 10: Effect of growth regulators and nutrient spray on seed parameters of zinnia

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