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Effect of Plant Growth Regulator and Micronutrient on Growth, Flowering, and Physical Quality Parameters of Litchi (*Litchi chinensis* Sonn.) cv. Dehradun

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) during two subsequent years *i.e.,* 2020 and 2021. Sixteen treatments *viz.,* four levels of GA (0, 20, 40 and 60 ppm) and Zn (0, 0.3, 0.5 and 0.7%) were studied in a Factorial Completely Randomized Design with three replications. Spraying was done twice *i.e.,* before flowering (07 Feb.) and at pea stage (05 April) during both the years. Application of GA 60 ppm and Zinc 0.7% increases length of new shoot (24.41 and 24.44 cm), number of leaves per shoot (23.55 and 24.06), length of panicle (34.89 and

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35.96 cm), number of fruit per panicle (21.11 and 22.19), length of fruit (4.21 and 4.30 cm), diameter of fruit (4.22 and 4.29 cm), fruit weight (20.22 and 21.16 g), weight of pulp (13.69 and 13.70 g), and pulp stone ratio (4.65 and 4.62) in both respective years and reduced days required to flowering after first spray (22.13 and 21.30) days, length of seed (2.16 and 2.14 cm), diameter of seed (1.32 and 1.30 cm), weight of seed (3.20 and 3.17 g) and rind weight (2.54 and 2.52 g). We suggest that the foliar application of GA (60ppm) and Zn (0.7%) may be included in strawberry farming for profitable yields and high GA and Zn concentration in strawberry fruit in the plains of Northern India.

Keywords: Litchi; zinc; GA; growth; flowering; physical fruit quality.

1. INTRODUCTION

Strawberry (*Fragaria x ananassa*) is a delicious and nutritious fruit of the world [1]. It is widely consumed as fresh and/or used as flavor in food products i.e., ice-creams, jams, jellies, cakes, and milk shakes [2]. Strawberries serve as an important source of vitamins (A, B_1, B_2 and C), fiber, calories and minerals [3-5]. Moreover, it also possesses some medicinal properties like, anticarcinogenic, antidiabetic and antioxidant [6]. This fruit is achieving popularity among the consumers of all age groups. The nutritional studies suggest that one hundred grams edible portion of strawberry may contain about 90 g water, 0.5 g fats, 59 g ascorbic acid, 8.4g carbohydrates and 0.07g proteins [5,7]. The mature fruit of litchi is a “single seeded nut” in which edible part is “fleshy aril”. The fruits are produced in loose cluster of 2 to 24 or even more. Soft thorn like tubercles is present on all over the fruit skin, which become flat, as the fruit ripens. Though the litchi tree flowers profusely, only a small percentage of the flowers develops into fruits. Poor set of fruits is due to poor pollination and premature flower and fruit drop, which limit the yield.

Over the years plant growth regulators (PGRs) and micronutrient have been consistently used to augment maximum and sustained economic benefits in litchi production through altering the behaviour of fruit or fruit plants. Yield and quality of litchi fruit have been positively influenced by both micronutrients and plant growth regulators. Application of PGRs results in increased flowering, fruiting and retention of fruit. The supply route of cell sap to fruit is severed by formation of abscission layer and gradually thin cork cells separate resulting in fruit dropping.

Micronutrients perform an essential role in the production of fruit crops, and their deficiencies largely affect the quality of fruits. Among micronutrients, horticultural crops suffer from Zn deficiency worldwide [8]. Micronutrients applied in optimum concentrations results in better plant growth which leads to higher yield, better flowering and higher fruit set. Plants require a substantial amount of the total requirement of certain micronutrients to be fed through foliar application which results in improved fruit quality. Metabolic activities of plants greatly depend on zinc. Zinc primarily functions as a metal activator of enzymes like dehydrogenase (Pyridine nucleotide, glucose-6 phosphodiesterase, carbonic anhydrase *etc.*).

2. MATERIALS AND METHODS

The present experiment was conducted at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during two subsequent years *i.e.,* 2020 and 2021. There were 16 treatments tried in a Factorial Completely Randomized Design with three replications. Uniform and healthy 30 years old, sixteen plants of litchi cv. Dehradun were selected on each plant similar three branches were identified and tagged as unit. GA at 0, 20, 40 and 60 ppm and Zinc at 0, 0.3, 0.5 and 0.7% were sprayed twice *i.e.,* first spraying on 5 Feb. before initiation of inflorescence and second at pea stage on 06^{th} April during both the years of experiments. All the manurial requirement, cultural practices and plant protection measured were adopted as per norms. Five panicles in each direction were selected randomly in each treatment for data recorded *i.e.* length of new shoot, number of leaves per shoot, days to flowering, length of panicle, fruits/panicle, fruit weight, length of fruit, diameter of fruit, weight of pulp, rind weight, pulp/stone ratio, weight of seed, length of seed and diameter of seed. Blemished, cracked and very small fruits were discarded and remaining ones were taken as marketable. Observations on growth, flowering and physical quality parameters in all treatments using recommended techniques.

3. RESULTS AND DISCUSSION

3.1 Length of New Shoot (cm)

In respect to different GA and Zinc concentrations on initial length of shoot are an expression the plants which was influenced by GA and Zinc growth regulators over control. The effect GA and Zinc was found to be non-significant combined treatment of G_3Z_3 induced significantly maximum (25.32 and 25.35 cm) length of shoot closely followed by treatment G_2Z_3 (24.53 and 24.56 cm). The minimum (17.26 and 17.29 cm) length of shoot was presented with control (G_0Z_0) during both the years of experiments. All these factors contributed to cell multiplication, which has resulted in to better photosynthetic activity and its translocation to promote better vegetative growth. Thus increased the number of leaves per shoot also pointed out by Dubey et al. [9] in Litchi, Tripathi and Shukla [10] in strawberry and Suman et al. [11], in guava.

3.2 Number of Leaves per Shoot

Referring to different GA and Zinc concentrations on number of leaves per shoot are an expression the plants which was influenced by GA and Zinc growth regulators over control. The United effect GA and Zinc was found to be non-significant combined treatment of G_3Z_3 induced significantly maximum (25.24 and 25.98) number of leaves per shoot closely followed by treatment G_3Z_2 (23.92 and 24.07). The minimum (16.46 and 16.94) number of leaves per shoot was presented with control (G_0Z_0) during both the years of experiments. Improvement in vegetative growth in this present finding are also in conformity with the works of Tagad et al. [12] in acid lime, Lenka et al. [13] in Guava.

3.3 Days Required to Flowering

In relation to different GA and Zinc concentrations on initial days required to flowering after spray are an expression the plants which was influenced by GA and Zinc growth regulators over control. Collective effect GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly minimum (21.18 and 20.16) days required to flowering closely followed by treatment G_2Z_3 (22.75 and 20.78). The maximum (28.14 and 27.13) days required to flowering was presented with control (G_0Z_0) during both the years of experiments. These results are also in conformity with the findings of Mukhtar et al. [14] in olive and Tripathi and Shukla [15] in strawberry. GA application also enhanced the number of flowers per shoot, might be due to enforcement of photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and cell elongation, photosynthetic activity, respiration as well as growth of plant.

3.4 Length of Panicle (mm)

As respects different GA and Zinc concentrations on initial length of panicle are an expression the plants which was influenced by GA and Zinc growth regulators over control. The Combined treatment of G_3Z_3 induced non-significantly maximum (35.18 and 36.66mm) length of panicle closely followed by treatment G_3Z_2 (34.98 and 36.14mm). The minimum (28.16 and 29.18mm) length of panicle was presented with control (G_0Z_0) during both the years of experiments. The foliar sprays of chemical *viz.,* Zn and GA_3, might have induced the synthesis of chlorophyll and thus lead to increase in chlorophyll content which in turn resulted in higher vegetative growth. These results are in accordance to the finding of Tripathi et al. [16] in ber and Tripathi and Shukla [17].

3.5 Number of Fruits per Panicle

Joint consequence of GA and Zinc was found to be non-significant in first year and significant in second year treatment of G_3Z_3 induced significantly maximum (22.16 and 23.78) number of fruits per panicle closely followed by treatment G_3Z_2 (21.66 and 22.84). The maximum (15.26 and 16.16) number of fruits per panicle was presented with control (G_0Z_0) during both the years of experiments. The higher number of fruits per node might be due to fact that nitrogen is component of chlorophyll and gibberellic acid and auxin help in chlorophyll formation that regulate the build-up of proper C:N ratio, which controls the flowering and fruiting of plants. It is also assumed that gibberellin and auxin play significant role in photosynthetic activity and better translocation of metabolites for developing fruit lets. These results are in close conformed to the finding of Suman et al. [11] in guava and Kumar et al. [18] in mango.

3.6 Fruit Weight (g)

Correlative effect of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly maximum (20.78 and 21.82g) fruit weight closely followed by treatment G_3Z_2 (20.53 and 21.58g). The minimum (17.13 and 18.14g) fruit weight was presented with control (G_0Z_0) during both the years of experiments. The reason for increase in fruit weight and volume due to spray of $ZnSO_4$ and GA_3 may have due to improve synthesis of more photosynthetic and their translocation to the fruit which ultimately improved the weight and volume of fruit. These findings are in accordance with the reports of Bhadauria et. al. [19] in aonla, Singh et al. [20], and Kumar et al. [18] in mango.

3.7 Length of Fruit (cm)

Interactive effect of GA and Zinc was found to be significant treatment of G_3Z_3 induced significantly maximum (4.33 and 4.34cm) length of fruit closely followed by treatment G_3Z_2 (4.23 and 4.34cm). The maximum (2.10 and 2.40cm) length of fruit was presented with control (G_0Z_0) during both the years of experiments. Spraying of zinc alone or with GA_3 at any concentration markedly increased fruit diameter comparing with the control. The results are shown that use of $ZnSO_4$ at 0.5% with GA_3 resulted in improvement of fruit length compared to the control. Moreover, spraying zinc alone or in combination with GA_3 at any concentration significantly increased yield comparing with the control. Although highest yield was obtained from trees sprayed with GA_3 + $ZnSO_4$. These results are in accordance with the reports of Kumar et al. [18] in mango, Priyadarshi et al. [21], Gupta et al. [22] in Litchi.

3.8 Diameter of Fruit (cm)

Interactive impact of GA and Zinc was found to be significant treatment of G_3Z_3 induced significantly maximum (4.35 and 4.43cm) diameter of fruit closely followed by treatment G_3Z_2 (4.24 and 4.35cm). The minimum (2.10 and 2.52cm) diameter of fruit was presented with control (G_0Z_0) during both the years of experiments. The possible reason for enhancement in fruit size with NAA, GA3 and ZnSO4 might be due to higher synthesis of metabolites and enhanced mobilization of food and minerals from other part of the plant toward the developing fruits as it is a well-established fact that the fruit acts as extremely active metabolic sink. The enhancement of fruit size with NAA, GA_3 and $ZnSO_4$ might be due to their involvement in hormonal metabolism, increased cell division, elongation and expansion of cell. These results are in accordance with Kaur [23], Priyadarshi et al. [21] and Animesh and Bikash [24] in litchi.

3.9 Weight of Pulp (g)

United implication of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly maximum (13.97 and 13.99g) weight of pulp closely followed by treatment G_2Z_3 (13.88 and 13.85g). The maximum (10.33 and 10.36g) weight of pulp was presented with control (G_0Z_0) during both the years of experiments. This increase may be ascribed to enhance synthesis of metabolites, increased absorption of water and mobilization of sugars and minerals in the expanded cells and intercellular space of mesocarp. These enhancements of above physiological activities are accelerated possibly due to growth promoter as well as nutrients also. These findings got the support with the reports of Tripathi and Sharma (2008) in phalsa, Priyadarshi and Hota [F21] in litchi and Pandey et al. [25] in ber.

3.10 Rind Weight (g)

Interactive impact of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly minimum (2.51 and 2.49g) Rind weight at harvesting closely followed by treatment G_3Z_2 (2.53 and 2.51 g). The maximum (2.82 and 2.80g) rind weight at harvesting was presented with control (G_0Z_0) during both the years of experiments. These findings got the support with the reports of Sumi and Sarkar [26] and Kaur [23] in litchi.

3.11 Pulp / Stone Ratio

The combine influence of GA and Zinc was found to be significant treatment of G_3Z_3 induced significantly maximum (4.88 and 4.85) pulp /stone ratio closely followed by treatment G_2Z_3 (4.76 and 4.71). The maximum (2.13 and 2.11) pulp /stone ratio were presented with control (G_0Z_0) during both the years of experiments. The scenario of the above findings on pulp: seed ratio showed the prominent influence of borax rather than GA_3 and zinc sulphate in promoting pulp: seed ratio. It might be due to the faster-leading mobilization of sugars into the fruit and increasing intercellular space in the pulp. These findings are in accordance with the reports of Yadav et al. [27] in aonla, Kaur [23], Priyadarshi and Hota [21] in litchi.

Table 1. Effect of foliar application of GA, zinc and their interaction on length of new shoot, no. of leaves per shoot and flowering days in litchi

Parameter	Doses	Zinc % (A)									
	GA_3 ppm (B)	2020					2021				
		A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A	A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A
Length of new Shoot(cm)	B_0 Control	17.26	17.62	18.10	19.12	18.02	17.29	17.65	18.13	19.15	18.05
	B_1 10	19.56	20.13	20.66	21.18	20.38	19.59	20.16	20.69	21.21	20.41
	B_2 20	21.69	22.18	22.56	23.14	22.39	21.72	22.21	22.59	23.20	22.43
	B_3 30	23.63	24.16	24.53	25.32	24.41	23.66	24.19	24.56	25.35	24.44
	Mean A	20.53	21.02	21.46	22.19		20.56	21.05	21.49	22.23	
	Factors	A	B	AXB			A	B	AXB		
	SE (m)±	0.187	0.187	0.374			0.178	0.178	0.356		
	C.D. at 5%	0.541	0.541	NS			0.514	0.514	NS		
	SE (d)±	0.265	0.265	0.529			0.251	0.251	0.503		
No. of leaves per Shoot	B_0 Control	16.46	16.54	17.25	17.79	17.01	16.94	17.01	17.76	18.23	17.48
	B_1 10	18.25	18.83	19.24	19.64	18.99	18.87	19.35	19.78	20.10	19.52
	B_2 20	20.26	20.84	21.23	21.73	21.01	20.96	21.36	21.98	22.15	21.61
	B_3 30	22.18	22.88	23.92	25.24	23.55	22.96	23.26	24.07	25.98	24.06
	Mean A	19.28	19.77	20.41	21.10		19.93	20.24	20.89	21.61	
	Factors	A	B	AXB			A	B	AXB		
	SE (m)±	0.162	0.162	0.324			0.168	0.168	0.337		
	C.D. at 5%	0.469	0.469	NS			0.488	0.488	NS		
	SE (d)±	0.229	0.229	0.458			0.238	0.238	0.477		
Flowering Days	B_0 Control	28.14	28.52	27.16	27.62	27.86	27.13	27.10	26.76	26.18	26.79
	B_1 10	26.22	26.63	25.13	25.66	25.91	25.85	25.26	24.88	24.35	25.08
	B_2 20	24.16	24.53	23.12	23.64	23.86	23.66	23.34	23.16	22.75	23.22
	B_3 30	22.10	22.51	22.75	21.18	22.13	22.50	21.76	20.78	20.16	21.30
	Mean A	25.15	25.54	24.54	24.52		24.78	24.36	23.89	23.36	
	Factors	A	B	AXB			A	B	AXB		
	SE (m)±	0.213	0.213	0.427			0.158	0.158	0.317		
	C.D. at 5%	0.617	0.617	NS			0.458	0.458	NS		
	SE (d) ±	0.302	0.302	0.603			0.224	0.244	0.448		

Table 2. Effect of foliar application of GA, zinc and their interaction on length of panicle, no. of fruit per panicle and length of fruit in litchi

Parameter	Doses	Zinc % (A)									
	GA ppm (B)	2020					2021				
		A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A	A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A
Length of Panicle(mm)	B_0 Control	28.16	28.76	29.23	29.56	28.92	29.18	29.78	30.26	30.56	29.94
	B_1 10	30.31	30.66	31.18	31.65	30.95	31.35	31.46	32.42	32.69	31.98
	B_2 20	32.24	32.86	33.14	33.56	32.95	33.19	33.76	34.38	34.78	34.02
	B_3 30	34.54	34.86	34.98	35.18	34.89	35.16	35.88	36.14	36.66	35.96
	Mean A	31.31	31.78	32.13	32.48		32.22	32.72	33.30	33.67	
	Factors	A	B	A X B			A	B	A X B		
	SE (m)±	0.250	0.250	0.499			0.206	0.206	0.412		
	C.D. at 5%	0.722	0.722	NS			0.597	0.597	NS		
	SE (d) ±	0.353	0.353	0.706			0.292	0.292	0.583		
No. fruit per panicle	B_0 Control	15.26	15.35	15.66	16.34	15.65	16.16	16.38	16.67	17.23	16.61
	B_1 10	16.67	16.88	17.34	17.46	17.08	17.46	17.96	18.13	18.76	18.07
	B_2 20	17.88	18.16	18.63	19.33	18.50	18.83	19.16	19.63	20.64	19.56
	B_3 30	19.69	20.95	21.66	22.16	21.11	20.88	21.26	22.84	23.78	22.19
	Mean A	17.37	17.83	18.32	18.82		18.33	18.69	19.31	20.10	
	Factors	A	B	A X B			A	B	A X B		
	SE (m) ±	0.150	0.150	0.300			0.143	0.143	0.286		
	C.D. at 5%	0.434	0.434	NS			0.414	0.414	0.827		
	SE (d) ±	0.212	0.212	0.424			0.202	0.202	0.404		
Length of fruit(cm)	B_0 Control	2.10	2.33	2.46	2.58	2.36	2.40	2.48	2.53	2.70	2.52
	B_1 10	2.76	2.88	3.11	3.56	3.07	2.85	2.95	3.18	3.65	3.15
	B_2 20	3.79	3.88	3.96	4.01	3.91	3.85	3.95	4.00	4.11	3.97
	B_3 30	4.10	4.18	4.23	4.33	4.21	4.23	4.29	4.34	4.34	4.30
	Mean A	3.18	3.31	3.44	3.62		3.33	3.41	3.51	3.70	
	Factors	A	B	A X B			A	B	A X B		
	SE (m)±	0.030	0.030	0.059			0.031	0.031	0.061		
	C.D. at 5%	0.085	0.085	0.171			0.089	0.089	0.177		
	SE (d) ±	0.042	0.042	0.084			0.043	0.043	0.087		

Table 3. Effect of foliar application of GA, zinc and their interaction on diameter of fruit, length of seed and diameter of seed in litchi

Parameter	Doses	Zinc % (A)									
	GA ppm (B)	2020					2021				
		A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A	A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A
Diameter of fruit(cm)	B_0 Control	2.10	2.36	2.46	2.60	2.38	2.52	2.58	2.66	2.73	2.62
	B_1 10	2.78	2.86	3.12	3.57	3.08	2.89	2.97	3.15	3.65	3.16
	B_2 20	3.80	3.89	3.98	4.02	3.92	3.86	3.95	4.01	4.06	3.97
	B_3 30	4.11	4.19	4.24	4.35	4.22	4.15	4.26	4.35	4.43	4.29
	Mean A	3.19	3.32	3.45	3.63		3.35	3.44	3.54	3.71	
	Factors	A	B	A X B			A	B	A X B		
	SE (m)±	0.034	0.034	0.068			0.023	0.023	0.047		
	C.D. at 5%	0.098	0.098	0.197			0.068	0.068	0.136		
	SE (d) ±	0.048	0.048	0.096			0.033	0.033	0.066		
Length of seed(cm)	B_0 Control	2.98	2.93	2.90	2.85	2.91	2.96	2.92	2.88	2.83	2.89
	B_1 10	2.80	2.74	2.69	2.64	2.71	2.79	2.72	2.68	2.62	2.70
	B_2 20	2.56	2.48	2.37	2.31	2.43	2.55	2.46	2.36	2.29	2.41
	B_3 30	2.24	2.21	2.15	2.06	2.16	2.23	2.19	2.13	2.03	2.14
	Mean A	2.64	2.59	2.52	2.46		2.63	2.57	2.51	2.44	
	Factors	A	B	A X B			A	B	A X B		
	SE(m)±	0.019	0.019	0.039			0.018	0.018	0.036		
	C.D. at 5%	0.056	0.056	NS			0.052	0.052	NS		
	SE (d) ±	0.028	0.028	0.055			0.025	0.025	0.051		
Diameter of seed(cm)	B_0Control	1.97	1.93	1.86	1.84	1.90	1.95	1.91	1.84	1.82	1.88
	B_1 10	1.79	1.73	1.69	1.65	1.71	1.78	1.72	1.68	1.63	1.70
	B_2 20	1.61	1.56	1.48	1.44	1.52	1.59	1.54	1.46	1.43	1.50
	B_3 30	1.40	1.53	1.30	1.26	1.32	1.38	1.33	1.28	1.24	1.30
	Mean A	1.69	1.64	1.58	1.54		1.67	1.62	1.56	1.53	
	Factors	A	B	A X B			A	B	A X B		
	SE(m)±	0.010	0.010	0.020			0.013	0.013	0.026		
	C.D. at 5%	0.029	0.029	NS			0.037	0.037	NS		
	SE (d) ±	0.014	0.014	0.029			0.018	0.018	0.036		

Table 4. Effect of foliar application of GA, zinc and their interaction on Fruit weight, Pulp weight and Seed weight in litchi

Parameter	Doses	Zinc % (A)									
	GA ppm (B)	2020					2021				
		A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A	A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A
Fruit weight(g)	B_0Control	17.13	17.26	17.37	17.43	17.29	18.14	18.27	18.38	18.46	18.31
	B_1 10	17.58	17.69	18.14	18.26	17.91	19.61	19.72	19.16	19.28	19.44
	B_2 20	18.37	18.68	18.72	19.33	18.77	19.41	19.65	19.74	20.36	19.79
	B_3 30	19.74	19.86	20.53	20.78	20.22	20.76	20.88	21.58	21.82	21.26
	Mean A	18.20	18.37	18.69	18.95		19.48	19.63	19.71	19.98	
	Factors	A	B	AXB			A	B	AXB		
	SE (m)±	0.136	0.136	0.273			0.147	0.147	0.294		
	C.D. at 5%	0.395	0.395	NS			0.425	0.425	NS		
	SE (d) ±	0.193	0.193	0.386			0.208	0.208	0.415		
Pulp weight(g)	B_0Control	10.33	10.38	10.47	10.66	10.46	10.36	10.41	10.50	10.69	10.49
	B_1 10	11.15	11.26	11.37	11.58	11.34	11.18	11.29	11.40	11.61	11.37
	B_2 20	12.11	12.33	12.63	12.68	12.43	12.14	12.36	12.66	12.81	12.49
	B_3 30	13.26	13.66	13.88	13.97	13.69	13.29	13.69	13.85	13.99	13.70
	Mean A	11.71	11.90	12.08	12.22		11.74	11.93	12.10	12.27	
	Factors	A	B	A X B			A	B	A X B		
	SE(m) ±	0.073	0.073	0.146			0.076	0.076	0.152		
	C.D. at 5%	0.211	0.211	NS			0.220	0.220	NS		
	SE (d) ±	0.103	0.103	0.206			0.108	0.108	0.215		
Seed weight(g)	B_0Control	3.88	3.83	3.76	3.73	3.80	3.80	3.78	3.72	3.68	3.74
	B_1 10	3.69	3.66	3.59	3.57	3.62	3.66	3.61	3.56	3.53	3.59
	B_2 20	3.48	3.46	3.42	3.32	3.42	3.47	3.42	3.38	3.26	3.38
	B_3 30	3.26	3.22	3.19	3.15	3.20	3.22	3.18	3.16	3.13	3.17
	Mean A	3.57	3.54	3.49	3.44		3.53	3.49	3.45	3.40	
	Factors	A	B	A X B			A	B	A X B		
	SE(m) ±	0.026	0.026	0.052			0.020	0.020	0.040		
	C.D. at 5%	0.076	0.076	NS			0.058	0.058	NS		
	SE (d) ±	0.037	0.037	0.074			0.028	0.028	0.057		

Table 5. Effect of foliar application of GA, zinc and their interaction on rind weight and pulp/stone ratio in litchi

Parameter	Doses	Zinc % (A)									
	GA ppm (B)	2020					2021				
		A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A	A_0 Control	A_1 0.3	A_2 0.5	A_3 0.7	Mean A
Rind weight(g)	B_0 Control	2.82	2.78	2.74	2.72	2.76	2.80	2.77	2.73	2.71	2.75
	B_1 10	2.71	2.69	2.68	2.66	2.68	2.69	2.67	2.66	2.63	2.66
	B_2 20	2.65	2.63	2.61	2.60	2.62	2.62	2.60	2.59	2.57	2.59
	B_3 30	2.58	2.56	2.53	2.51	2.54	2.55	2.54	2.51	2.49	2.52
	Mean A	2.69	2.66	2.64	2.62		2.66	2.64	2.62	2.60	
	Factors	A	B	A X B			A	B	A X B		
	SE(m)±	0.019	0.019	0.039			0.017	0.017	0.034		
	C.D. at 5%	0.056	0.056	NS			0.050	0.050	NS		
	SE (d) ±	0.027	0.027	0.055			0.024	0.024	0.049		
Pulp/stone ratio	B_0 Control	2.13	2.24	2.31	2.36	2.26	2.11	2.21	2.28	2.33	2.23
	B_1 10	2.41	2.46	3.51	3.56	2.98	2.40	2.89	3.48	3.53	3.07
	B_2 20	3.63	3.68	3.76	4.14	3.80	3.62	3.76	3.93	4.11	3.85
	B_3 30	4.38	4.58	4.76	4.88	4.65	4.35	4.57	4.71	4.85	4.62
	Mean A	3.13	3.24	3.58	3.73		3.12	3.35	3.60	3.70	
	Factors	A	B	A X B			A	B	A X B		
	SE(m) ±	0.025	0.025	0.049			0.023	0.023	0.046		
	C.D. at 5%	0.071	0.071	0.142			0.066	0.066	0.132		
	SE (d) ±	0.035	0.035	0.069			0.032	0.032	0.065		

3.12 Weight of Seed (g)

Joint effect of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly minimum (3.15 and 3.13 g) weight of seed at harvesting closely followed by treatment G_2Z_3 (3.19 and 3.16g). The maximum (3.88 and 3.80g) weight of seed at harvesting was presented with control (G_0Z_0) during both the years of experiments. These findings are in accordance with the reports of Singh et al. [20] in phalsa, Singh et al. [20] in mango and Priyadarshi et al. [21] in litchi.

3.13 Length of Seed (cm)

Combine influence of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly minimum (2.06 and 2.03cm) length of seed at harvesting closely followed by treatment G_2Z_3 (2.15 and 2.13cm). The maximum (2.98 and 2.96cm) length of seed was presented with control (G_0Z_0) during both the years of experiments. These findings are in accordance with the reports of Priyadarshi et al. [21], Kaur [23] in litchi.

3.14 Diameter of Seed (cm)

Interactive consequence of GA and Zinc was found to be non-significant treatment of G_3Z_3 induced significantly minimum (1.26 and 1.24cm) diameter of seed at harvesting closely followed by treatment G_3Z_2 (1.30 and 1.28cm). The maximum (1.97 and 1.95cm) diameter of seed at harvesting was presented with control (G_0Z_0) during both the years of experiments. These findings are in accordance with the reports of Priyadarshi et al. [21], Kaur [23] in litchi [28-30].

4. CONCLUSION

On the basis of results obtained in the present investigations, it may be concluded that the application of GA and Zinc resulted in a significant reduction in fruit drop, improvement in flowering, growth and fruit quality parameters of litchi with maximum fruit set and retention as well as physical characters such as size of fruit (length and diameter), weight of fruit with increased the yield per plant and per hectare in both GA 60ppm and Zinc 0.7 % treated plants. It is suggested that the application of GA at the rate of 60ppm with Zn at the rate 0.7% should be included in strawberry cultivation for enhanced growth, yield, and Zn concentration in fruits. Since there was a constant increase in growth, yield, and zinc concentration in strawberry fruits with increasing Zn applications, further studies may be designed with higher rates of GA and Zn (foliar as well as soil applied) to investigate the response of strawberry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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