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EFFICACY OF ZINC APPLICATION ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF STRAWBERRY (*FRAGARIA × ANANASSA* DUCH.) CULTIVARS

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ABSTRACT

This current study shows that the effect of different concentrations of zinc on different strawberry cultivars, an experiment was carried out at Lovely Professional University during 2019-20 and 2020-21. This study was used with two-factor randomized complete block design (RCBD). Four quantities of zinc sulphate (0, 2.5mg/2L, 5mg/2L and 7.5mg/2L) were sprayed to four strawberry cultivars (V1 = Winterdawn, V2 = Ventana, V3 = Nabila and V4 = Camarosa). Vegetative parameters (plant height, the number of leaves, petiole length), reproductive parameters (the number of flowers and fruits), yield and quality parameters (total soluble solid, acidity and vitamin-C) were increased significantly by zinc application. Highest plant height (15.43 cm), number of leaves (19.75)),petiole length(13.41cm), number of flowers (26.75), number of fruits (23.50),total yield (316.81 gm/plant), TSS(6.7 ^{0}brix), vitamin-C (52.75mg/100g) and lowest acidity (0.62%) were recorded for plants sprayed with $ZnSO_4$(5mg/2L), while minimum plant height (11.85 cm), number of leaves (15.24)), petiole length (9.84cm), number of flowers (18.17), number of fruits (14.42),total yield (201.62 gm/plant), TSS(6.05 ^{0}brix), vitamin-C (41.50mg/100g) and highest acidity (0.71%) were observed in control. Plant height, number of leaves, petiole length, total yield, total soluble solid, acidity, vitamin-C were significantly different among varieties. More number of plant height (17.48 cm), petiole length (15.47cm), number of flowers (34), number of fruits (30.3), total yield (434.7 gm/plant) were noted for Nabila cultivar but maximum TSS (6.92^{0}brix, vitamin-C (56.67mg/100g) and lowest acidity (0.57%) were noted in Winter dawn cultivar. Application with 5mg/2l $ZnSO_4$ showed the best results on growth, reproductive and quality parameters.

Key words : Strawberry, Vegetative parameter, Fruit quality, Zinc sulphate, Yield.

Introduction

Strawberry is an essential cash crop grown globally and favored by using many in diverse forms which include fresh culmination, extracts, etc. Botanically strawberry is referred to as *Fragaria ananassa* Duch. Belongs to Rosaceae own family with octaploid chromosome quantity 56 (2n=8x). It is delicious and nutritive gentle fruit with wider adaptability. Besides having the dessert fine, it is a potent supply of antioxidants that render a beneficial contribution to human health. Strawberry has been in cultivation on account that long time and all through the route of information the plant body structure and cultivation, there were many improvements about the cultivation structures, nutritional necessities and other components of strawberry crop manufacturing (Bal, 2014).

Strawberry fruit is a wealthy supply of vitamins and minerals. Vitamin C is present in a higher amount instead of other nutrients. The flavor of fruit includes 3 compounds i.e. Sugar, acids, and fragrant compounds. The essential unstable compound which is liable for the taste of the fruit is Ethyl esters *e.g.*; Ethyl butanoate and ethyl hexanoate. The leaf tissues and crimson achenes include ellagic acid (antimutagenic and anticarcinogenic plant phenol) in strawberry fruit. Due to the presence of greater eleic acid and much less linoleic acid ripe fruit includes

extra lipids than unripe culmination (Chattopadhyay, 2014). It is beneficial to anemic patients. Whiles (University of Illinois Extension (UIE, 2013) mentioned Strawberry consumption can lessen the risk of growing cancer by using 50% because of high ranges of vitamin-C (30-100mg/100gms of fruit) as well as a foliate and phytochemical compound which includes the ellagic acid gift in the fruit. The fruit of strawberry is whole fruit with ninety-eight% safe to eat element and the result are normally are low-calorie carbohydrate however abundant in vitamin C (Ayub *et al*., 2010). It incorporates water-ninety%, energy-37%, protein-1.4%, carbohydrates-eight%, crude fiber-1.5% in 100 grams of fruit.

Strawberry is perennial, stoloniferous herbs that unfold by using stolons and runners. Leaves of strawberry fruit have 3 leaflets which can be stand up from the crown of the plant. Leaves of the strawberry plant are blunt, thick, and toothed, the shade of plant life is white and borne in small clusters. Strawberry fruit is small-sized and mild to deep crimson in color, the flesh of the fruit is smooth with a pleasant aroma. Both hermaphrodite and unisexual plant life are produced in the case of strawberry. Strawberry is an aggregate fruit. The seeds of strawberry are known as achenes. The achenes are the several, tiny, ellipsoid specks that cowl the fruit floor. Thalamus is the fit to be eaten part of the fruit.

Micronutrients are essential to the increase of plant life, appearing as a catalyst in selling numerous organic reactions taking vicinity in the plant and their deficiencies frequently restrict crop productivity in fruit plants. Application of zinc sulphate and ferrous sulphate are elevated the fruit yield, acidity, TSS content, higher concentration of zinc sulphate resulted in the stronger shelf life of result at ambient temperature and higher awareness of ferrous sulphate had a poisonous effect on the plant and retarded the boom, yield and first-class attributes. In the past, there was no want of micronutrients due to the fact those hint elements have been evidently supplied via soil. But due to intensive cultivation, growth Zinc and Boron have a vital role in pollination, fruit set, and yield (Motesharezade *et al.*, 2001) many of the micronutrients. Zinc plays a vital function with the aid of increasing sugar and decreasing acidity (Abedy, 2001). Foliar utility of zinc sulphate accelerated length, TSS and juice of an orange (Dixi and Gamdagin, 1998). Various tests were conducted in advance on a foliar spray of zinc in exceptional fruit crops and shown significant reaction to enhance yield and quality. Some researcher found pre-harvest foliar application of zinc extend shelf-life of strawberry (sudha *et al*., 2018).

Materials and Methods

The current investigation was directed at pomology area, School of Agriculture, Lovely Professional University, Phagwara during the year 2019-20 and 2020-21, in a randomized block design replicated with thrice the examination site is arranged at a latitude of 31.2560° North and longitude of 5.7051° East and a height of 300 meters above mean ocean level (MSL). The least temperature went from 4°-5° C (during Oct - Feb) and the greatest temperature went from 35° - 40° C (during March - April). four cultivars (V1=Winterdawn, V2=Ventana, V3=Nabila, and V4=Camarosa) with uniform estimated strawberry runners were planted during December 2020, keeping a separating of 30 X 30 cm. A set of 16 plants were analyzed per one replication and there were 4 treatments. Every treatment had 3 arrangements of replications. Hence 192 strawberry plants were required for 3 replications. The plant were treated with following Chemicals: T_0 = Control (water), T_1 = $ZnS0_4$ (2.5mg/2L), T_2 = $ZnS0_4$ (5mg/2L), T_3 = $ZnSO_4$ (7.5mg/2L). The data of vegetative parameters, reproductive parameters were recorded after fully grown and quality parameters were recorded after harvesting. The Zinc sulphate solutions were prepared as per the requirement (2.5mg, 5 mg, 7.5 mg of $ZnSO_4$ in 2litres of water) and foliar sprayed with the help of a hand sprayer. Vegetative parameters like plant height and petiole length were observed using a vernier caliper. The yield was recorded using weight balance . Hand refractometer was used for TSS (A.O.A.C., 2010). Ascorbic acid, TSS and titratable acidity content were determined by using the procedure given by A.O.A.C. (2010). OPSTAT software was used for statistical analysis.

Results and Discussion

Vegetative parameters

Plant height

The observational data in Table 1 shows that different varieties, zinc content and their interaction have significant effects on plant height. The maximum plant height was recorded in $ZnSO_4$ @ 5 mg/2l with mean value (15.43 cm) followed by (14.04 cm) in $ZnSO_4$ @ 2 mg/2l whereas minimum mean value (11.85 cm) was noted in control. Maximum plant height was noted for cultivar Nabila with a mean value of 14.82 cm followed by 14.12 cm in Camarosa where minimum plant height was recorded in Ventana with a mean value of 11.95 cm. The interaction between cultivars and treatments was found significant. Maximum plant height was noted in Nabila (17.48 cm) sprayed with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest plant height was observed in Ventana (9.87 cm) treated

with water (control). The reason behind plant height was highest in zinc treated plants might be zinc is involved in chlorophyll formation, which might have maximized cell division, apical dominance, cell enlargement, and new cell wall synthesis, (Saleha *et al*., 2015) and similarly found was observed by Saha *et al*. (2019).

Leaves per plant

The data in Table 1 shows that different varieties, zinc content and zinc interaction have significant effects on leaves. The maximum number of leaves were recorded in $ZnSO_4$ @ 5 mg/2l with a mean value (19.75) followed by (17.98) in $ZnSO_4$ @ 2 mg/2l whereas minimum mean value (15.26) was noted in control. The highest numbers of leaves were observed in the Camarosa cultivar with a mean value (18.71) followed by (18.27) in Nabila whereas minimum leaves were recorded in Winterdawn with a mean value of 15.05. The interaction between cultivars and treatments were found significant. Maximum leaves were noted in Comarosa (21.37) sprayed with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest number of leaves were observed in Winterdawn (14) treated with water (control). The reason behind plant height was highest in zinc treated plants might be zinc is involved in chlorophyll formation, which might have maximized cell division, apical dominance, cell enlargement and new cell wall synthesis (Saleha *et al*., 2015) and similarly found was observed by Saha *et al*. (2019).

Petiole length

The data concerning petiole length per plant of strawberry varieties are presented in Table 1. The data shows that different varieties, zinc content and their interaction have significant effects on leaves. Height petiole length was observed in $ZnSO_4$ @ 5 mg/2l with mean value (13.41 cm) followed by $ZnSO_4$ @ 2 mg/2l (12.11cm) whereas minimum mean value (9.84 cm) was recorded in control. Maximum petiole length was noted for cultivar Nabila with a mean value (12.82 cm) followed by (12.12 cm) in Camarosa where minimum petiole length was recorded in Ventana with a mean value of 10.02 cm. The interaction between cultivars and treatments were found significant. Maximum petiole length was noted in Nabila(15.47 cm) sprayed with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest petiole length was observed in Ventena (7.87 cm) treated with water (control). The reason behind petiole length was highest in zinc treated plants might be zinc is involved in chlorophyll formation, which might have maximized cell division, apical dominance, cell enlargement and new cell wall synthesis (Saleha *et al*., 2015), Zinc is essential for the synthesis of tryptophan, which is the precursor of auxin and can promote top growth (Saha *et al*., 2019).

Reproductive parameter

Numbers of flowers per plant

According to the data in Table 2, different varieties and zinc content have significant effects on flowers**.** Maximum numbers of flowers were recorded in $ZnSO_4$ @ 5 mg/2l with a mean value (26.75) followed by (23.25) in $ZnSO_4$ @ 2 mg/2l where a minimum mean value (18.17) was noted in control. The highest numbers of flowers were observed in Nabila cultivar with a mean value (28.92) followed by Winterdawn (22.42) whereas minimum numbers of flowers were recorded in Camarosa with a mean value of 18.67. The interaction between cultivars and treatments were found non-significant. Maximum leaves were noted in Nabila (34) treated with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest number of flowers were observed in Camarosa (15) treated with water (control). Maximum numbers of flowers were found in zinc-treated plants than control, this may because of the impact of Zn, as zinc builds the cell lengthening and division. Zinc is useful in the synthesis of chlorophyll which increments photosynthetic exercises of leaves, which prompting improvement of essential blossoms, creation of feasible blossoms. Comparative outcomes were additionally acquired by Chaturvedi *et al*. (2005), Bakshi *et al*. (2013a), Bakshi *et al*. (2013b), Mehraj *et al*. (2015) and Singh *et al*. (2015) in strawberry, Abdollahi *et al*. (2012) and Saha *et al*. (2019) in strawberry.

Numbers of fruits per plant

The observed data in Table 2 for the number of fruits per plant of strawberry varieties. The data in Table 2 showed that different varieties, zinc content and their interactions have significant effects on fruit setting. Maximum numbers of fruit per plant was observed in treatment $ZnSO_4$ @ 5 mg / 2 L(23.50), then (19.75), in $ZnSO_4$ @ 2 mg / 2 L, the smallest average value (14.42) was found in the control. The highest numbers of flowers were observed in Nabila cultivar with a mean value (24,83) followed by Winterdawn (18.68), whereas minimum numbers of flowers were recorded in Camarosa with a mean value (15.50). The interaction between cultivars and treatments were found significant. Maximum numbers of fruits were noted in Nabila (30.3) treated with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest number of leaves were observed in Camarosa (12) treated with water (control). Due to the important role of $ZnSO_4$ in pollination and strawberry fruit formation, $ZnSO_4$ can increase fruit yield in strawberry cv. Selva, Abdollahi *et al*. (2012) and Saha *et al*. (2019) in strawberry cv. Winter

Table 1 : Effect of zinc on plant height, number of leaves, and petiole length per plant of strawberry cultivars.

Treatments		Plant height (cm)					Leaves per plant					Petiole length (cm)				
		V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
Control		12.33	9.87	12.83	12.36	11.85	14	15.45	15.45	16.06	15.24	10.31	7.87	10.87	10.32	9.84
	2.5ml/2l	14.19	11.98	15.11	14.88	14.04	15.06	18.68	18.68	19.48	17.98	12.18	10.3	13.09	12.85	12.11
	5ml/2l	15.32	13.21	17.48	15.71	15.43	16.48	20.08	21.08	21.37	19.75	13.26	11.19	15.47	13.71	13.41
$ZnSO_4$	**7.5ml/2l**	13.61	12.75	13.87	13.54	13.44	14.64	17.78	17.78	17.82	17.01	11.56	10.72	11.83	11.54	11.41
	Mean	13.86	11.95	14.82	14.12	13.69	15.05	18.00	18.25	18.68	17.49	11.83	10.02	12.82	12.12	11.69
Factors		**C.D.**		**SE(d)**		**SE(m)**	**C.D.**		**SE(d)**		**SE(m)**	**C.D.**		**SE(d)**		**SE(m)**
Treatments		0.284		0.138		0.098	0.2		0.097		0.069	0.303		0.148		0.104
Cultivars		0.284		0.138		0.098	0.2		0.097		0.069	0.303		0.148		0.104
Interaction		0.567		0.277		0.196	0.399		0.195		0.138	0.606		0.295		0.209

V_1 = Winterdawn, V_2 = Ventana, V_3 = Nabila and V_4 = Camarosa.

Table 2 : Effect of zinc on number of Flowers, number of Fruits and yield per plant of strawberry cultivars.

Treatments		Flowers per plant					Fruits per plant					Yield(g/plant)				
		V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
Control		18	15.66	24	15	18.17	14	12.67	19	12	14.42	194.51	151.69	277.75	182.55	201.62
	2.5ml/2l	23.67	20	30	19.33	23.25	20	17	26	16	19.75	279.05	197.34	377.94	240.35	273.67
	5ml/2l	26	23.67	34	23.33	26.75	22.7	21	30.3	20	23.50	321.50	209.97	434.70	301.07	316.81
$ZnSO_4$	**7.5ml/2l**	22	18	27.67	17	21.17	18	14	24	14	17.50	249.94	166.73	328.39	210.28	238.83
	Mean	22.42	19.33	28.92	18.67	22.33	18.68	16.17	24.83	15.50	18.79	261.25	181.43	354.69	233.56	257.73
Factors		**C.D.**		**SE(d)**		**SE(m)**	**C.D.**		**SE(d)**		**SE(m)**	**C.D.**		**SE(d)**		**SE(m)**
Treatments		0.779		0.38		0.269	0.76		0.37		0.262	13.278		6.47		4.575
Cultivars		0.779		0.38		0.269	0.76		0.37		0.262	13.278		6.47		4.575
Interaction		N/A		0.76		0.537	1.521		0.741		0.524	26.556		12.941		9.15

V_1 = Winterdawn, V_2 = Ventana, V_3 = Nabila and V_4 = Camarosa.

dawn. Maximum numbers of fruits were found in zinc-treated plants than control, similar observation was found in Abdollahi *et al*. (2012) and Saha *et al*. (2019) in strawberry.

Yield per plant (g/plant)

The observational data in Table 2 revealed that different varieties, zinc content, and their interaction had a significant effect on yield. Maximum yield was recorded in $ZnSO_4$ @ 5 mg/2l with a mean value (316.81g) followed by (273.67 g) in $ZnSO_4$ @ 2 mg/2l whereas minimum mean value (201.62 g) was noted in control. Maximum yield was noted for cultivar Nabila with mean value (354.69 g) cm followed by Winerdawn (261.25g) where minimum yield was recorded in Ventana with mean value (181.43). The interaction between cultivars and treatments was found significant. Maximum yield was observed in Nabila (434.7 g) sprayed with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest yield was recorded in Ventana (151.69g) treated with water (control). The higher fruit yield is due to the larger size, diameter and weight of the fruit. In addition, there may be a clearer redirection of photosynthesis in the direction of sink (fruit), which ultimately increases fruit yield. Bakshi *et al*. (2013), Bakshi *et al*. (2013b) and Mehraj *et al*. (2015) Strawberry.

Quality parameters

TSS : Observation data presented in Table 3 revealed that various cultivars and zinc levels had a significant effect on TSS. Highest TSS was recorded in $ZnSO_4$ @ 5 mg/2l with a mean value (6.70 ^{0} Brix) followed by (6.48 ^{0}Brix) in $ZnSO_4$ @ 2 mg/2l, where a minimum mean value (6.05 ^{0}Brix) was noted in control. Highest TSS was noted for cultivar Winterdawn with a mean value (6.61^0 Brix) cm followed by 6.48^0 Brix in Camarosa where

Table 3 : Effect of zinc application on TSS, acidity and vitamin-C of fruit quality Strawberry cultivars.

Treatments		TSS (^{0} brix)					Acidity (%)					Vitamin-C(mg/100g)				
		V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
Control		6.19	5.89	6.02	6.10	6.05	0.67	0.75	0.71	0.69	0.71	44.00	39.00	40.00	43.00	41.50
$ZnSO_4$	2.5ml/2l	6.78	6.05	6.49	6.59	6.48	0.63	0.7	0.68	0.64	0.66	50.33	47.00	49.00	49.67	49.00
	5ml/2l	6.92	6.51	6.61	6.76	6.70	0.57	0.67	0.65	0.59	0.62	56.67	50.00	51.00	53.33	52.75
	7.5ml/2l	6.55	6.20	6.25	6.47	6.37	0.63	0.72	0.7	0.65	0.68	48.00	45.00	47.33	46.00	46.58
	Mean	6.61	6.16	6.34	6.48	6.40	0.63	0.7	0.69	0.64	0.67	49.75	45.25	46.83	48.00	47.46
Factors		C.D.		SE(d)		SE(m)	C.D.		SE(d)		SE(m)	C.D.		SE(d)		SE(m)
Treatments		0.121		0.059		0.042	0.01		0.005		0.003	1.016		0.497		0.351
Cultivars		0.121		0.059		0.042	0.01		0.005		0.003	1.016		0.497		0.351
Interaction		N/A		0.118		0.084	N/A		0.01		0.007	2.032		0.993		0.702

V_1 = Winterdawn, V_2 = Ventana, V_3 = Nabila and V_4 = Camarosa.

minimum plant height was recorded in Ventana with the mean value of 6.16^0 Brix. The interaction between cultivars and treatments were found non-significant. Maximum TSS was noted in Winterdawn (6.92 ^{0}Brix) sprayed with $ZnSO_4$ @ 5 mg/2l meanwhile the lowest plant height was observed in Ventana (5.89 ^{0}Brix) treated with water (control). The TSS was highest in the zinc-treated plant than in control because zinc sprays proved highly favorable in the procession of photosynthesis which eventually increased fruit quality. Zinc additionally manages the enzymatic action and chemicals activate the carbon compounds into glucose. Comparative outcomes were likewise acquired by Chaturvedi *et al.* (2005), Bakshi *et al.* (2013) in strawberry.

Acidity : Observation data presented in Table 3 revealed that various cultivars and zinc levels had a significant effect on acidity. Lowest acidity was recorded in $ZnSO_4$ @ 5 mg/2l with mean value (0.62%) followed by (0.66%) in $ZnSO_4$ @ 2 mg/2l whereas highest mean value (0.71%) was noted in control. The lowest acidity was noted for cultivar Winterdawn with a mean value of 0.63% followed by 0.64% in Camarosa where the highest acidity was recorded in Ventana with a mean value of 0.7%. The interaction between cultivars and treatments were found non-significant. The lowest acidity was noted in Winterdawn (0.57%) sprayed with $ZnSO_4$ @ 5 mg/2l mean while the highest acidity was observed in Ventana (0.75%) treated with water (control). The acidity content of fruit decreased with the different levels of zinc. zinc application decreased the level of acid which due to an increase in total soluble solids and ultimately better movement of sugars into fruit tissues and conversion of organic acids into sugars (Kumar *et al.*, 2015). Similar results were, Bakshi *et al.* (2013), Saha *et al.* (2019) in strawberry.

Vitamin-C : Observation data presented in Table 3 revealed that various cultivars, zinc level and their interaction had a significant effect on Vitamin-C. Highest Vitamin-C was recorded in $ZnSO_4$ @ 5 mg/2l with mean value (52.75mg/100g) followed by (49mg/100g) in $ZnSO_4$ @ 2 mg/2l, whereas minimum mean value (41.50mg/100g) was noted in control. Maximum Vitamin-C was noted for cultivar Winterdawn with a mean value of 49.75mg/100g followed by 48mg/100g in Camarosa where the lowest Vitamin-C was recorded in Ventana with a mean value (45.25mg/100g). The interaction between cultivars and treatments were found significant. The highest Vitamin-c was noted in Winterdawn (56.67mg/100g) sprayed with $ZnSO_4$ @ 5 mg/2l mean while the lowest Vitamin-C was observed in Ventana (39mg/100g) treated with water (control). The zinc application increased the ascorbic acid synthesis. These results are in confirmation with the findings of Kumar *et al.* (2010).

Conclusion

The current experiment the effect of various concentrations of zinc on strawberry cultivars showed vegetative parameters (plant height, number of leaves, petiole length), reproductive parameters (the number of flowers and fruits), Yield and quality parameters (TSS, acidity and vitamin-C) were increased significantly. Maximum plant height (15.43 cm), leaf number (19.75), Petiole length (13.41 cm), flower number (26.75), fruit number (23.50), total yield (316.81 g/plant), TSS (6.7 ^{0}Brix), vitamin C (52.75 mg/100 g) and low acidity (0.62%) were registered as plants sprayed with $ZnSO_4$ (5 mg / 2 L) and the minimum plant height (11.85 cm), leaf number (15.24), petiole length (9.84 cm), flower

number (18.17), fruit number (14.42)), total yield (201.62 g/plant), TSS (6.05 Brix), vitamin-C (41.50 mg/100 g) and highest acidity (0.71%). Under control. Plant height, number of leaves, petiole length, total yield, TSS, acidity, vitamin-c were significantly different among varieties. More number of plant height (17.48 cm), petiole length (15.47cm), number of flowers (34), number of fruits (30.3), total yield (434.7 gm/plant), were noted for Nabila cultiver but maximum TSS(6.92 ^{0}brix, vitamin-C (56.67mg/100g) and lowest acidity (0.57%) were noted in Winterdawn cultivar.

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