

IMPROVING THE PRODUCTIVITY AND FRUIT QUALITY OF STRAWBERRY FORTUNA CULTIVAR BY USING SOME NUTRIENTS AS FOLIAR APPLICATION

Mary N. Gawly¹, A. Bardisi¹, Dalia A. S. Nawar¹, Hany G. Zyada¹ and E.E. Abou El- Khair ²

¹Hort. Dept.Fac. Agric., Zagazig University , Egypt

²Hort.Res. .Instit., Agric. Res.Center , Dokki, Egypt.

Corresponding author: Mary N. Gawly

Dr.mary.elgawly@gmail.com

abdallabardisi@yahoo.com; dnawar73@yahoo.com; hgzyada@yahoo.com; Sayed_aboelkhqir@yahoo.com

ABSTRACT: This work was carried out during 2023/2024 and 2024/2025 seasons in a strawberry Private Farm, Kafr El Sahaby , Shebin El Kanater District, Qalubia Governorate, Egypt, to study the effect foliar spray with some nutrients on the productivity and fruit quality of strawberry, Fortuna cultivar under sandy soil conditions. This experiment included nine treatments as follows : Control (spraying with water), Zn in the form of ZnSO₄ at 100 and 200 mg/l, B in the form of boric acid (H₃BO₃) at 100 and 200 mg/l, Fe in the form of FeSO₄ at 100 mg/l and 200 mg/l , Ca in the form of calcium chloride (CaCl₂) at 1% and Si in the form of potassium silicate (K₂SiO₃) at 2.5 ml/l. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Results indicated that treating strawberry Fortuna cultivar grown in sandy soil during winter plantations with some nutrients as foliar application enhanced early and total yield, improved fruit quality and decreased deformed fruits compared to control (water). Spraying with ZnSO₄ at 200 mg /l increased number of fruits/ plant, average fruit weight, yield / plant, early yield , total yield and marketable yield, whereas reduced shape deformed, color deformed and total deformed fruits followed by H₃BO₃ at 100 mg /l . Foliar spray with H₃BO₃ at 200 mg /l increased Vit. C, TSS, glucose and fructose, whereas spraying with ZnSO₄ at 200 mg/l increased anthocyanin and pH in fruits.

Conclusion: Spraying strawberry Fortuna cultivar grown in sandy soil during winter plantations with ZnSO₄ at 200 mg /l increased early yield, total yield and marketable yield, whereas reduced shape and color deformed, as well as total deformed fruits followed by boric acid at 100 mg/l. Foliar spray with boric acid at 200 mg /l increased Vit. C, TSS, glucose and fructose, whereas spraying with ZnSO₄ at 200 mg/l, increased anthocyanin and pH in fruits.

Key words: Strawberry (*Fragaria x ananassa* Duch.) , nutrients , productivity , fruit quality , early yield, deformed fruits

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INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is one of the most popular vegetable crops. In Egypt, the total strawberry cultivated area during 2023 /2024 was 66775 fed., which produced 950043 tons with average 14.228 ton / feddan. The cultivated area in old land was 25158 fed. (about 37.67% from the total area), which produced 431945 tons with average 17.169 ton/fed., whereas the cultivated area in new land was 41617 fed. (about 62.23 % from the total area) which produced 518098 tons with average 12.449 ton/fed. (Agricultural Statistics, Ministry of Agriculture and Land Reclamation, Egypt , 2024).

Fortuna strawberries are known for their sweet and juicy flavor. They have a well-balanced combination of sweetness and acidity, providing a delightful taste that is enjoyed by strawberry lovers. Colour: Fortuna strawberries have a glossy and vibrant red colour when fully ripe. The colour is deep and rich, adding to their visual appeal and making them visually enticing in various culinary creations. Shelf Life: Fortuna strawberries have a relatively good shelf life compared to other strawberry varieties. With proper handling and storage, it is recommended to refrigerate them promptly to extend their shelf life and preserve their quality. Fortuna strawberries are flavored for their delicious taste, attractive colour, and overall quality. They are versatile and can be used in numerous culinary applications, including salads, desserts,

smoothies, and as a topping for various dishes. Their sweetness and juiciness make them a popular choice for both fresh consumption and culinary creations.

Iron plays a main role in the biosynthesis of chlorophylls and cytochromes and its deficiency can result in the bleaching of leaves. Zinc plays a vital role in pollination, fruit setting and improving fruit quality parameters such as increased sugar and decreasing acidity levels (Singh *et al.*, 2025). Boron is reported to play an important role in plant cell growth and is also involved in many physiological processes such as phenol metabolism and tissue differentiation (Barker and Pilbeam, 2006). Its deficiency results in leaf tip necrosis in younger leaves and a decrease in the flower size.

The role of boron in improving the fruit quality by reducing titratable acidity and maximizing TSS are consistent with Wojcika (1999 and 2005) and Nagy *et al.* (2008). The role of boron in sugar translocation could help improve fruit quality parameters (Gauch and Dugger 1953 and Sathya *et al.*, 2010). Moreover, the deficiency of boron aggravate the quality of fruit by increasing titratable acidity and its application improves the quality of fruit (Haider *et al.*, 2019).

Zinc is effective in plant nutrition for the synthesis of plant hormones and balancing intake of P and K inside the plant cells. Boron is essential for plant growth, new cell division in meristematic tissue, translocation of sugar, starch, nitrogen, phosphorus,

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certain hormones, synthesis of amino acids and protein, regulations of carbohydrate metabolism, development of phloem etc. Iron act as catalyst in synthesis of chlorophyll molecule and helps on the absorption of other elements. It is a key element in various redox reactions of respiration, photosynthesis and reduction of nitrates and sulphates (Wallihan *et al.*, 1958 and Zende 1996).

Boron has an effect on cell wall structure, cell elongation (pollen tube) and root growth (Barker and Pilbeam, 2006). Zinc induces pollen tube growth through functioning tryptophan as an auxin precursor biosynthesis (Chaplin and Westwood, 1980). Boron deficiency and poor pollination caused a deformed berries. Micronutrients deficiencies, such as boron may cause pollination problems.

Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth, and development, as well as general fruit quality (Kadir, 2004). Potassium silicate is a source of highly soluble silicon; it is used in agricultural production system primarily as a silicon fertilizer (Abou-Baker *et al.*, 2011).

Spraying with B in the form of H_2BO_3 at 25ppm increased fruit firmness, TSS and Vit. C, whereas spraying with Zn in the form of $ZnSO_4$ at 100 ppm gave the lowest values of deformed fruits (Mandour and Bardisi, 2020).

Therefore, the aim of this work was to obtained high yield and good quality of strawberry plants by using some nutrients (Fe, Zn, B, Ca, Si) as foliar application.

MATERIALS AND METHODS

This work was carried out during 2023/2024 and 2024/2025 seasons in a strawberry Private Farm, Kafr El Sahaby, Shebin El Kanater District, Qalubia Governorate, Egypt, to study the effect foliar spray with some nutrients on the productivity and fruit quality of strawberry Fortuna cultivar under sandy soil conditions. This experiment included 9 treatments as follows: Control, Zn in the form of $ZnSO_4$ at 100 and 200 mg/l, B in the form of boric acid (H_3BO_3) at 100 and 200 mg/l, Fe in the form of $FeSO_4$ at 100 mg/l and 200 mg/l, Ca in the form of calcium chloride ($CaCl_2$) at 1% and Si in the form of potassium silicate (K_2SiO_3) at 2.5 ml/l. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The source of $ZnSO_4$, $FeSO_4$ and $CaCl_2$ was Alpha Chemika, India.

Fresh transplants of strawberry Fortuna cultivar was obtained from local nurseries. The experimental unit area was 8.8 m^2 and each unit contained one ridge with 11 m length and 80 cm width. The transplants were planted on 5th and 14th September in the 1st and 2nd seasons, respectively. The transplants were dipped for 10 minutes at doses of 1g/ L Benlet+1g/L Rizolex and planted on the ridge (80 cm) in four rows. The distance between strawberry transplants within the row was 25 cm and between the rows was 20 cm (25 x 20cm). Soil plastic mulch and drip irrigation system were used. Plants were sprayed 5 times, once before flower initiation (vegetative stage) and four times started at the beginning of flowering stage (flowering

and fruiting stages) with 10 days intervals between each one. The agricultural practices concerning cultivation, irrigation, fertilization and insect and disease control were conducted according to the recommendation of the Ministry of Agriculture for strawberry commercial production.

Data recorded:

Early and its components: The early yield was determined by the weights of all harvested fruits from each plot during February and March months, and then early yield per plant and / fed. were calculated, also early average fruit weight was determined.

Total yield and its components: Total yield was recorded from each plot as weights of all harvested fruits during the season up to mid of May, then, yield per plant (g) and total yield per fed. (ton) were calculated, also average fruit weight was determined. (fed.= $4200\text{ m}^2=0.42\text{ ha.}$).

Deformed fruits: Deformed fruits percent (total, shape and color deformed fruits) in early and total yield were determined.

Fruit quality: At harvest (120 days after planting), samples of ten ripe fruits were chosen randomly from each experimental unit at full ripe stage to measure: **Ascorbic acid (Vit. C)** content was determined in mg/100 g fresh weight using 2, 6 Di chloro phenol Indophenol for titration as the method mentioned in A.O.A.C. (2005). **Total soluble solids (TSS)** as brix° using the hand refractometer. **Glucose and Fructose (%)**: It was determined according to both methods described by Forsee (1938). **Anthocyanins mg/100g FW**: The anthocyanin content in fruits was determined according to the method described by Geza *et al.* (1984). **pH**: The acidity: It was estimated by titrating known volume of juice against 0.1 N NaOH using phenolphthalein as an indicator (A.O.A.C., 2005) **Statistical Analysis**:

Recorded data were subjected to the statistical analysis of variance according to Snedecor and Cochran (1980) and means separation were done according to Duncan (1955).

RESULTS AND DISCUSSION

Early yield and its components

Data in Tables 1 and 2 indicated that spraying strawberry cv. Fortuna with Zn as $ZnSO_4$ at 100 and 200mg/l, $FeSO_4$ at 100 and 200 mg/l, boric acid at 100 and 200 mg /l, $CaCl_2$ at 1% and K_2SiO_3 at 2.5 ml/l increased early yield and its components (number of fruits/plant, average fruit weight, yield/plant, total yield /fed. and marketable yield/ fed.) compared to control treatment (spraying with water) in both seasons. Foliar spray with $ZnSO_4$ at 200 mg/l was the best treatment for enhancing early number of fruits/ plant (7.89 and 8.75), early average fruit weight (19.34 and 19.27 g), early yield / plant (152.59 and 168.57 g), early marketable yield / plant (146.76 and 168.57g), early total yield /fed. (5.997 and 6.625 ton), early marketable yield /fed. (5.724 and 6.413ton) in the 1st and 2nd seasons, respectively, followed by H_3BO_3 at 100 mg/l. (fed.= $4200\text{ m}^2=0.42\text{ ha.}$).

The increase in early yield /fed., were about 1.948 and 3.277 ton for $ZnSO_4$ at 200 mg/l and 1.724 and

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2.722 ton for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively . The increase in early marketable yield /fed. were about 2.212 and 3.566 ton for ZnSO₄ at 200 mg/l and 1.873 and 2.977 ton for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively. The decrease in early total deformed fruit yield /fed. were about 0.190 and 0.288 ton for ZnSO₄ at 200 mg/l and 0.207 and 0.332 ton for H₃BO₃ at 100 mg /l less the control treatment in the 1st and 2nd seasons, respectively.

Deformed fruits of early yield

Spraying with ZnSO₄, FeSO₄ and boric acid at 100 and 200 mg/l of each , CaCl₂ at 1% and K₂SiO₃ at 2.5 ml/l decreased early malformed fruit compared to the control in both seasons. Spraying with boric acid at 100 mg/l recorded minimum values of early deformed fruits (3.69 and 1.93% in total early yield) , followed by ZnSO₄ at 200 mg/l (3.80 and 2.43 % in total early yield and boric acid at 200 mg/l (4.89 and 2.88 % in total early yield).

Table 1. Effect of some nutrients on early number of fruits/ plant , early average fruit weight, early yield / plant, early marketable yield/ plant and early deformed yield / plant of strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Num ber of fruits / plant	Aver age fruit weig ht (g)	Yiel d / plan t (g)	Market able yield (g/ plant	Unmarke table yield (g/ plant (deforme d)
2023/2024 season					
Cont rol	6.16 f	16.36 g	100. 78 f	90.06 f	10.72 a
Zn SO₄ at 100 mg/l	7.24 bc	17.99 d	136. 72 c	128.76 c	7.97 c
Zn SO₄ at 200 mg/l	7.89 a	19.34 a	152. 59 a	146.76 a	5.84 f
Fe SO₄ at 100 mg/l	6.50 e	17.43 f	113. 30 e	104.26 e	9.10 b
Fe SO₄ at 200 mg/l	6.84 d	17.58 ef	120. 25 d	112.60 d	7.65 cd
H₃B O₃ at10 0 mg/l	7.81 a	18.37 c	143. 47 b	138.07 b	5.41 f

H₃B O₃ at20 0 mg/l	7.41 b	18.77 b	139. 09 bc	132.14 c	6.95 e
CaCl 2 at 1%	6.84 d	17.64 e	120. 66 d	112.73 d	7.93 c
K₂Si O₃ at 2.5m l/l	7.16 c	18.90 b	135. 32 bc	128.29 c	7.03 de
LSD at 0.05 level	0.18	0.20	5.86	4.61	0.63
2024/2025 season					
Cont rol	5.09 i	16.59 e	84.4 9 f	72.99 f	11.51 a
Zn SO₄ at 100 mg/l	7.84 b	18.02 d	141. 24 c	135.60 c	5.64 de
Zn SO₄ at 200 mg/l	8.75 a	19.27 abc	168. 57 a	164.44 a	4.13 f
Fe SO₄ at 100 mg/l	6.63 h	19.56 ab	129. 72 e	121.84 e	7.88 b
Fe SO₄ at 200 mg/l	7.70 d	19.80 a	152. 54 b	145.48 b	7.07 c
H₃B O₃ at10 0 mg/l	7.80 c	19.52 ab	152. 32 b	149.33 b	3.00 g
H₃B O₃ at20 0 mg/l	7.29 f	19.23 abc	140. 21 cd	136.07 c	4.14 f
CaCl 2 at 1%	7.53 e	19.14 bc	144. 20 c	138.08 c	6.13 d
K₂Si O₃ at 2.5m l/l	7.16 g	18.75 c	134. 25 de	129.09 d	5.17 e
LSD at 0.05 level	0.03	0.58	6.48	6.34	0.65

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Means within a row followed by different letter (s) are
statistically different using the Duncan Multiple Range
Test at 0.05 level of probability.

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Table 2. Effect of some nutrients on early yield / fed., early marketable yield/ fed. and early deformed yield / fed of strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Early Yield /		Marketable yield		Unmarketable yield (deformed)	
	fed. (ton)	± contr ol %	(ton/ fed.)	% in total yield	(ton/ fed.)	% in total yield
2023/2024 season						
Contr ol	3.99 3 g	00.00	3.51 2f	87.9 5	0.418 a	10.4 7
Zn SO₄ at 100 mg/l	5.44 6 cd	36.39	5.02 2 c	92.2 1	0.311 c	5.71
Zn SO₄ at 200 mg/l	5.99 7 a	50.19	5.72 4 a	95.4 5	0.228 f	3.80
Fe SO₄ at 100 mg/l	4.51 4 f	13.05	4.06 6 e	90.0 8	0.355 b	7.86
Fe SO₄ at 200 mg/l	4.79 2 e	20.01	4.39 1 d	91.6 3	0.298 d	6.22
H₃BO₃ at 100 mg/l	5.71 7 b	43.18	5.38 5 b	94.1 9	0.211g	3.69
H₃BO₃ at 200 mg/l	5.54 0 c	38.74	5.15 3 c	93.0 1	0.271e	4.89
CaCl₂ at 1%	4.79 4 e	20.06	4.39 6 d	91.7 0	0.309c	6.45
K₂SiO₃ at 2.5ml/ l	5.36 1 d	34.26	5.00 3 c	93.3 2	0.274e	5.11
LSD at 0.05 level	0.12 5	--	0.22 5	--	0.010	--
2024/2025 season						
Contr ol	3.34 8 e	00.00	2.84 7f	85.0 4	0.449a	13.4 1
Zn SO₄ at 100 mg/l	5.62 6 c	68.04	5.28 8c	93.9 9	0.220d e	3.91

Zn SO₄ at 200 mg/l	6.62 5 a	97.88	6.41 3a	96.8 0	0.161f	2.43
Fe SO₄ at 100 mg/l	5.16 8 d	54.36	4.75 2e	91.9 5	0.307b	5.94
Fe SO₄ at 200 mg/l	6.07 9 b	81.57	5.67 4b	93.3 4	0.276c	4.54
H₃BO₃ at 100 mg/l	6.07 0 b	81.30	5.82 4b	95.9 5	0.117g	1.93
H₃BO₃ at 200 mg/l	5.58 5 c	66.82	5.30 7c	95.0 2	0.161f	2.88
CaCl₂ at 1%	5.72 9 c	71.12	5.38 5d	94.0 0	0.239d	4.17
K₂SiO₃ at 2.5ml/ l	5.34 9 d	59.77	5.03 5d	94.1 3	0.202e	3.78
LSD at 0.05 level	0.20 0	--	0.23 8	---	0.022	---

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

Total yield and its components

Data in Tables 3 and 4 indicate that spraying with FeSO₄, H₃BO₃, CaCl₂ and K₂SiO₃ at different concentrations increased yield and its components of Fortuna cultivar (number of fruits/ plant, average fruit weight, yield / plant, marketable yield / plant, total yield /fed. and marketable yield / fed.) compared to control in both seasons. Spraying with ZnSO₄ at 200 mg /l significantly increased number of fruits/ plant (25.5 and 22.43), average fruit weight (20.70 and 22.21 g), yield / plant (528.06 and 498.17 g) , yield /fed. (20.922 and 19.747 ton) and marketable yield /fed. (19.181 and 17.906 ton), followed by boric acid at 100 mg /l in both seasons . (fed.= 4200 m²=0.42 ha.).

The increase in total yield /fed. were about 7.087 and 3.423 ton for ZnSO₄ at 200 mg/l and 6.37 and 3.376 ton for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively. The increase in marketable yield /fed. were about 7.267 and 3.806 ton for ZnSO₄ at 200 mg/l and 6.614 and 3.326 ton for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively. The decrease in total deformed fruit yield /fed. were about 0.291 and 0.393 ton for ZnSO₄ at 200 mg/l and 0.343 and 0.306 ton for H₃BO₃ at 100 mg /l less the control treatment in the 1st and 2nd seasons, respectively.

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For all treatments , average fruit weight of Fortuna cultivar were around from 15.41 to 19.89 g in the 1st season and around from 18.15 to 22.21 g in the 2nd season, also, number of fruits/ plant were around 22.66 to 25.64 in the 1stseason and around 21.89 to 23.92 g in the 2nd season. The increase in average fruit weight were about 5.29 and 4.06 g for ZnSO₄ at 200 mg/l and 3.48 and 3.50 g for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively .

Table 3. Effect of some nutrients on number of fruits/ plant, average fruit weight, yield / plant, marketable yield/ plant and deformed yield / plant of strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Numb er of fruits/ plant	Avera ge fruit weigh t (g)	Yiel d / plan t (g)	Marketa ble yield (g/ plant	Deform ed yield (g/ plant)
2023/2024 season					
Cont rol	22.66 g	15.41 f	349. 19 e	305.48 f	43.71b
Zn SO₄ at 100 mg/l	24.00 d	18.10 d	434. 40 c	399.59 d	34.82f
Zn SO₄ at 200 mg/l	25.51 a	20.70 a	528. 06 a	491.82 a	36.25e
Fe SO₄ at 100 mg/l	23.32 f	17.11 e	401. 40 d	360.35 e	41.06c
Fe SO₄ at 200 mg/l	24.57 b	19.58 bc	481. 08 b	435.32 c	45.77a
H₃B O₃ at100 mg/l	25.64 a	19.89 b	509. 98 a	475.07 b	34.92f
H₃B O₃ at200 mg/l	24.36 c	19.21 c	467. 96 b	424.42 c	43.55b
CaCl ₂ at 1%	24.67 b	17.40 e	429. 26 cd	390.00 d	39.27d
K₂Si O₃ at 2.5ml /l	23.59 e	19.81 bc	467. 32 b	428.71 c	38.62d
LSD at 0.05	0.16	0.64	28.2 7	13.84	1.31

level					
2024/2025 season					
Cont rol	22.69 c	18.15 g	411. 82 e	361.55 e	50.28a
Zn SO₄ at 100 mg/l	23.92 a	19.29 f	461. 42 d	421.08 c	40.35fg
Zn SO₄ at 200 mg/l	22.43 d	22.21 a	498. 17 ab	459.12 a	39.05g
Fe SO₄ at 100 mg/l	21.89 e	20.78 d	454. 87 d	407.46 d	47.41b
Fe SO₄ at 200 mg/l	22.76 c	21.18 c	482. 06 bc	433.66 b	48.41b
H₃B O₃ at100 mg/l	23.19 b	21.65 b	502. 06 a	459.63 a	42.43d
H₃B O₃ at200 mg/l	21.80 e	21.57 b	470. 23 cd	425.18 bc	45.06c
CaCl ₂ at 1%	23.20 b	20.10 e	466. 32 cd	424.10 bc	42.22de
K₂Si O₃ at 2.5ml /l	22.75 c	20.67 d	470. 24 cd	429.37 bc	40.87ef
LSD at 0.05 level	0.10	0.16	19.6 1	9.80	139

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

Table 4. Effect of some nutrients on total yield/ fed., marketable yield/ fed. and deformed yield /fed. of strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Total yield / fed.		Marketable yield		Total deformed yield	
	(ton)	± contr ol %	(ton/ fed.)	(%) in the tota l yiel	(ton/ fed.)	(%) in the tota l yiel

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				d		d
2023/2024 season						
Contr ol	13.8 35 f	00.00	11.9 14 e	86.1 1	1.705 b	12.3 2
Zn SO ₄ at 100 mg/l	17.2 11 d	24.40	15.5 84 c	90.5 5	1.358 e	7.89
Zn SO ₄ at 200 mg/l	20.9 22 a	51.23	19.1 81 a	91.6 8	1.414 e	6.76
Fe SO ₄ at 100 mg/l	15.9 03 e	14.95	14.0 54 d	88.3 7	1.601 c	10.0 7
Fe SO ₄ at 200 mg/l	19.0 60 c	37.77	16.9 77 b	89.0 7	1.785 a	9.37
H ₃ BO ₃ at100 mg/l	20.2 05 b	46.04	18.5 28 a	91.7 0	1.362 e	6.74
H ₃ BO ₃ at200 mg/l	18.5 41 c	34.02	16.5 52 b	89.2 7	1.698 b	9.16
CaCl ₂ at 1%	17.0 07 d	22.93	15.2 10 c	89.4 3	1.532 d	9.01
K ₂ Si O ₃ at 2.5ml/ l	18.5 15 c	33.83	16.7 20 b	90.3 1	1.506 d	8.13
LSD at 0.05 level	0.69 8	--	0.69 8	--	0.123	--
2024/2025 season						
Contr ol	16.3 24 e	00.00	14.1 00 d	86.3 8	1.961 a	12.0 1
Zn SO ₄ at 100 mg/l	18.2 90 d	12.04	16.4 22 bc	89.7 9	1.574 ef	8.61
Zn SO ₄ at 200 mg/l	19.7 47 ab	20.97	17.9 06 a	90.6 8	1.523f	7.71
Fe SO ₄ at 100 mg/l	18.0 31 d	10.46	15.8 91 c	88.1 3	1.849 b	10.2 5
Fe SO ₄ at 200	19.1 09 bc	17.06	16.9 13 b	88.5 1	1.888 b	9.88

mg/l						
H ₃ BO ₃ at100 mg/l	19.9 02 a	21.92	17.9 26 a	90.0 7	1.655 d	8.32
H ₃ BO ₃ at200 mg/l	18.6 40 cd	14.19	16.5 82 b	88.9 6	1.757 c	9.43
CaCl ₂ at 1%	18.4 85 cd	13.24	16.5 40 b	89.4 8	1.647 d	8.91
K ₂ Si O ₃ at 2.5ml/ l	18.6 40 cd	14.19	16.7 45 b	89.8 3	1.594 de	8.55
LSD at 0.05 level	0.76 3	--	0.63 4	--	0.071	--

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

Deformed fruits of total yield

Spraying with ZnSO₄, FeSO₄ and boric acid, CaCl₂ and K₂SiO₃ at different concentrations were the best treatments for decreasing deformed fruit (shape and color) compared to control in both seasons (Tables 4 and 5 , Figs 1 and 2). Spraying strawberry plants Fortuna cultivar with ZnSO₄ at 200 mg/l gave the lowest values of color deformed (3.31 and 3.79 % in total yield) (and total fruits deformed (6.76 and 7.71% in total yield) followed by spraying with boric acid at 100 mg /l which produced the lowest shape deformed (3.14 and 4.01% in total yield)in both seasons. Zinc induces pollen tube growth through its role in tryptophan as an auxin precursor biosynthesis (Chaplin and Westwood, 1980). Spraying with Zn in the form of ZnSO₄ at100 ppm gave the lowest values of fruits deformed about 3.62 % of total yield (Mandour and Bardisi, 2020).

For all treatments, shape deformed fruits were around from 3.14 to 5.98 % in the total yield in the 1st season and around from 4.01 to 5.55% in total yield in the 2nd season. Also, color deformed fruits were around from 3.31 to 6.54 in the total yield in the 1stseason and around from 3.79 to 6.66 % in the total yield in the 2nd season.

Strawberry fruit malformation is caused by issues with pollination, environmental factors like temperature and ;frost nutrient imbalances such as boron deficiency or excessive nitrogen, and insect pests like the tarnished plant bug. Boron is the most commonly deficient micronutrient in strawberry plantings as it is very prone to leaching. Boron deficiency causes many symptoms, but among the most obvious are deformed berries. Poorly pollinated berries tend to be small with a rough, dimpled, seedy appearance similar to that of boron deficiency. Fe deficiency symptoms which resulted in lower yields and increased fruit deformation (Lieten, 2003) .

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Table 5. Effect of some nutrients on shape and color deformed in strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Shape deformed		Color deformed	
	(ton /fed.)	% in total yield	(ton/fed.)	% in total yield
2023/2024 season				
Control	0.827 b	5.98	0.905 a	6.54
Zn SO ₄ at 100 mg/l	0.693 d	4.03	0.687 e	3.99
Zn SO ₄ at 200 mg/l	0.744 c	3.56	0.693 e	3.31
Fe SO ₄ at 100 mg/l	0.817 b	5.14	0.810 c	5.10
Fe SO ₄ at 200 mg/l	0.901 a	4.73	0.912 a	4.79
H ₃ BO ₃ at 100 mg/l	0.634 e	3.14	0.750 d	3.71
H ₃ BO ₃ at 200 mg/l	0.842 b	4.54	0.884 ab	4.77
CaCl ₂ at 1%	0.698 d	4.11	0.858 b	5.04
K ₂ SiO ₃ at 2.5ml/l	0.732 c	3.96	0.798 c	4.31
LSD at 0.05 level	0.029	--	0.032	-
2024/2025 season				
Control	0.906 b	5.55	1.086 a	6.66
Zn SO ₄ at 100 mg/l	0.880 bc	4.81	0.719 f	3.93
Zn SO ₄ at 200 mg/l	0.799 d	4.05	0.749 f	3.79
Fe SO ₄ at 100 mg/l	0.951 a	5.28	0.928 b	5.15
Fe SO ₄ at 200 mg/l	0.864 c	4.52	1.055 a	5.52
H ₃ BO ₃ at 100 mg/l	0.797 d	4.01	0.884 c	4.44
H ₃ BO ₃ at 200 mg/l	0.849 c	4.55	0.937 b	5.03
CaCl ₂ at 1%	0.876 bc	4.74	0.798 e	4.32
K ₂ SiO ₃ at 2.5ml/l	0.771 d	4.14	0.849 d	4.56
LSD at 0.05 level	0.034	---	0.033	--

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range

Test at 0.05 level of probability.

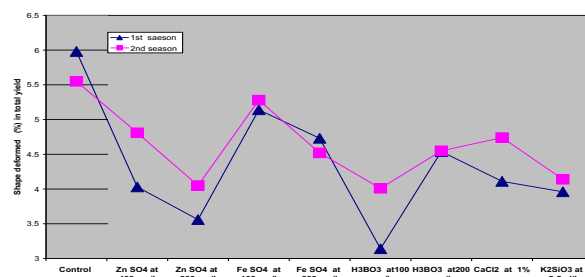


Fig (1). Effect of some nutrients on shape deformed in strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions.

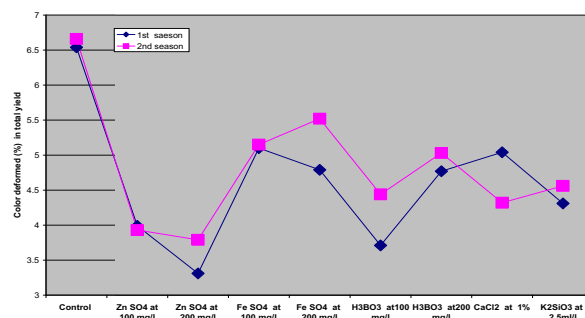


Fig (2). Effect of some nutrients on color deformed in strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions.

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Fruit quality at harvest

Foliar spray with boric acid at 200 mg /l increased vit. C (37.66 and 38.23 mg /100 g FW), TSS (7.11 and 7.65 %), glucose (3.713 and 4.090 %) and fructose (4.270 and 4.609 % in both seasons , whereas spraying with ZnSO₄ at 200 mg/l increased anthocyanin (18.24 and 19.85 mg /100 g FW) and pH (3.58 and 3.51) in both seasons (Table 5). With respect to anthocyanin in Fortuna fruits , ZnSO₄ at 100 and 200 mg /l gave the highest values of anthocyanin followed by boric acid at (100 and 200 mg/l) and FeSO₄ (100 and 200 mg/l) compared to CaCl₂, potassium silicate and control treatments. Spraying with B in the form of boric acid at 25 ppm increased fruit firmness, TSS and Vit. C (**Mandour and Bardisi, 2020**).

For all treatments vit. C in Fortuna cultivar fruits around from 29.83 to 37.66 mg /100 g FW) in the 1stseason and 30.75 to 38.23 mg/100 g FW) in the 2ndseason , also, TSS were around from 6.15 to 7.19 Brix° in the 1st season and 6.15 to 8.05 Brix° in the 2ndseason . Anthocyanins were around from 15.69 to 18.24 mg/100g FW in the 1st season and 16.08 to 19.85 mg/100g FW in the 2nd season.

For good strawberry quality, the fruit should be consistently heart-shaped and have a vibrant, uniform red color, while the calyx (stem) should be green. The red color is not only visually appealing but also a key indicator of ripeness and flavor, though shape can vary between varieties. Red pigments in strawberry are anthocyanins. Zinc plays a vital role in pollination, fruit ,setting and improving fruit quality parameters such as increased sugar and decreasing acidity levels (**Singh et al. , 2025**). The role of boron in improving the fruit quality by reducing titratable acidity and maximizing TSS are consistent with **Wojcika (1999 and 2005)** and **Nagy et al. (2008)**. The role of boron in sugar translocation could help improve fruit quality parameters (**Gauch and Dugger 1953 and Sathya et al., 2010**). Moreover, the deficiency of boron aggravate the quality of fruit by increasing titratable acidity and its application improves the quality of fruit (**Haider et al., 2019**)

Table 5. Effect of some nutrients on fruit quality of strawberry cv. Fortuna during 2023/2024 and 2024/2025 seasons under sandy soil conditions

	Vita min C (mg/1 00 g FW)	T SS (%)	Gluc ose (%)	Fruct ose (%)	Anthocy anins mg/100g FW	p H
2023/2024 season						
Cont rol	29.33 g	6. 15 e	2.208 h	3.069 i	15.92 g	3. 62 a
Zn SO₄ at 100 mg/l	34.63 c	7. 04 b	3.319 c	3.540 f	18.10 ab	2. 96 d

Zn SO₄ at 200 mg/l	36.84 b	6. 74 c	3.069 g	3.197 h	18.24 a	3. 58 a
Fe SO₄ at 100 mg/l	33.48 d	6. 18 e	3.157 e	3.726 d	16.91 e	3. 04 d
Fe SO₄ at 200 mg/l	34.61 c	6. 53 d	3.282 d	3.665 e	17.85 c	3. 21 c
H₃B O₃ at10 0 mg/l	36.35 b	7. 04 b	3.665 b	3.898 c	17.15 d	2. 64 e
H₃B O₃ at20 0 mg/l	37.66 a	7. 11 ab	3.713 a	4.270 a	18.03 bc	2. 96 d
CaCl 2 at 1%	32.65 e	7. 14 a	3.133 f	3.405 g	16.35 f	3. 41 b
K₂Si O₃ at 2.5m l/l	31.72 f	7. 19 a	3.719 a	3.922 b	15.69 h	3. 52 ab
LSD at 0.05 level	0.76	0. 08	0.011	0.012	0.20	0. 12
2024/2025 season						
Cont rol	30.75 e	6. 15 h	3.203 f	3.438 g	16.08 h	2. 55 f
Zn SO₄ at 100 mg/l	34.74 c	7. 07 f	3.229 e	4.183 d	19.09 b	3. 16 b
Zn SO₄ at 200 mg/l	37.22 b	7. 11 ef	3.086 h	4.045 e	19.85 a	3. 51 a
Fe SO₄ at 100 mg/l	33.51 d	7. 14 e	3.166 g	3.822 f	16.89 f	3. 02 c
Fe SO₄ at 200 mg/l	34.63 c	6. 72 g	3.635 c	3.200 i	17.78 d	2. 99 cd
H₃B O₃	37.71 ab	7. 39	3.897 b	4.219 c	17.19 e	2. 89

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at10 0 mg/l		d				e
H ₃ B O ₃ at20 0 mg/l	38.23 a	7. 65 c	4.090 a	4.609 a	18.39 c	2. 95 de
CaCl 2 at 1%	33.33 d	8. 05 a	3.254 d	3.394 h	16.47 g	2. 50 f
K ₂ Si O ₃ at 2.5m l/l	33.41 d	7. 94 b	4.095 a	4.247 b	16.89 f	3. 11 b
LSD at 0.05 level	0.70	0. 05	0.016	0.027	0.10	0. 06

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

Conclusion

Spraying strawberry Fortuna cultivar grown in sandy soil during winter plantations with ZnSO₄ at 200 mg /l increased number of fruits/ plant, average fruit weight, yield / plant, early yield, total yield and marketable yield, whereas reduced shape and color deformed, as well as total deformed fruits followed by boric acid at 100 mg /l . Foliar spray with boric acid at 200 mg /l increased Vit. C, TSS, glucose and fructose, whereas spraying with ZnSO₄ at 200 mg/l increased anthocyanin and pH in fruits. The increase in marketable yield /fed., were about 7.267 and 3.806 ton for ZnSO₄ at 200 mg/l and 6.614 and 3.326 ton for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively. The decrease in total deformed fruit yield /fed. were about 0.291 and 0.393 ton for ZnSO₄ at 200 mg/l and 0.343 and 0.306 ton for H₃BO₃ at 100 mg /l less the control treatment in the 1st and 2nd seasons, respectively. The increase in average fruit weight were about 5.25 and 4.08 g for ZnSO₄ at 200 mg/l and 4.48 and 3.50 g for H₃BO₃ at 100 mg /l over the control treatment in the 1st and 2nd seasons, respectively.

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