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Effect of Foliar Application of Iron (Fe) and Zinc (Zn) on Growth, Yield and Quality of Strawberry (*Fragaria ananassa*) Cv. Winter Dawn

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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

An experiment on strawberry (*Fragaria ananassa*) cv. winter dawn was conducted during December 2021 to April 2022, in Horticulture Research Farm of Horticulture Department, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) India. The experiment was performed on strawberry variety of winter dawn. There are 16 treatments, *viz*., T_0 (water spray),T_1(Zn 0.2%+Fe 0.2%),T_2 (Zn 0.4%+Fe 0.4%),T_3 (Zn 0.6%+Fe 0.6%),T_4(Zn 0.2%+Fe 0.4%),T_5 (Zn 0.2%+Fe 0.6%)T_6(Zn 0.4%+Fe 0.2%)T_7 (Zn 0.4%+Fe 0.6%)T_8(Zn 0.6%+Fe0.4%)T_9(Zn 0.6%+Fe 0.2%) ,T_{10} (Zn 0.2%),T_{11}(Zn 0.4%),T_{12}(Zn 0.6%) ,T_{13}(Fe 0.2%),T_{14} (Fe 0.4%),T_{15} (Fe 0.6%) replicated thrice in Randomized Block Design (RBD). The results of the present investigation, regarding the cultivation of strawberry with different concentrations of Zinc (Zn) and Iron (Fe) found as the best option for higher productivity whereas the treatment T_3 with concentration of Zn (0.6%)+ Fe (0.6%) showed the best result in terms of plant height at 30 days to transplanting (8.1 cm), 60 days to transplanting (15.4 cm) and 90 days to transplanting (22.1 cm), Number of leaves plant^{-1} at 30 days to transplanting (7.3), 60 days to transplanting (21.3) and 90 days to transplanting (27.4), Plant Spread (27.2 cm), runner plant^{-1} (5.9), yield/ha (6.0 t), fruit length (4.3 cm), fruit weight (29.3 g), fruit diameter (3.4 cm), TSS (9.3^{o} Brix), showed

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the best results in terms of vegetative growth, yield, quality. Hence the T_3 Zn (0.6%) + Fe (0.6%) is best suited for the farmers in terms of growth, yield, quality and net returns.

Keywords: Strawberry; growth; yield; quality.

1. INTRODUCTION

Strawberry (*Fragaria x ananassa duch*.) is one of the most important temperate fruit belongs to the family Rosaceae. It is an octoploid (8x) in nature having (x=7) basic chromosome number. It is herbaceous, perennial and short-day plant. Among all the berries, strawberry gives the quickest return in a shortest possible time [1]. It is an herbaceous perennial plant and is adapted to different climates, and can ever be grown from tropical and sub-tropical to temperate regions of high altitudes up to 3000 meter above mean sea level with assured irrigation facility. Water is a major constituents of strawberry fruits. It's phenomenal increases in production during the recent years show the popularity of strawberry fruit cultivation. In India, the total area of strawberry is 1000 Ha with production of 5000 MT.

Maharashtra is the leading State in production of strawberry fruits. It is also commercially grown in Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand and lower hills of Himachal Pradesh. As compared to other berry fruits strawberries contain a higher percentage of vitamin C, phenolics and flavonoids [2]. It is commercially grown in China (38.7%), USA (17.5%), Mexico (4.9%), Turkey (4.8%), Spain (4%), total world production [3]. The area and production of strawberry in India during 2015-16 was reported 77 ha and 5602 mt respectively (NHB, 2016).

Iron (Fe) deficiency induces chlorosis is a major nutritional disorder in calcareous soils [4]. The phenotype introduction by hairpin RNA i-based siliencing can be heritable moreover, the transcripts of multigene families can be silenced by a single construct making this technique a powerful tool to study the loss of function phenotype of a target gene in plants with high levels of polyploidy such as strawberry [5]. Zinc is an important essential micronutrient for the plant. Zinc is an essential metal for normal plant growth and development since it's a structural element of proteins and enxzymes in living organisms. High concentration of Zn in many soils indicated correct management methods including application of sewage sludge or animal manure [6]. Therefore, the present study was conducted to study the effect of foliar application of Iron and Zinc on the growth, yield and quality of strawberry in cv. winter dawn.

2. MATERIALS AND METHODS

A field experiment was conducted during December 2021 to April 2022. At Departmental field of Horticulture Department, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The experiment entitled "Effect of foliar application of iron and zinc on growth, yield and quality of strawberry was conducted in rabi season adapting Randomized Block Design (RBD) consisting of 16 treatments and three replications replications are showed in mentioned in Table 1. The experimental field has an even topography with a gentle slope and good drainage. The sample from each replication of experimental plot at 0-15 cm depth before sowing of the crop and a composite sample was made to determine the physical and chemical properties of soil. Normal cultural practices and plant protection measures were followed during the cultivation process. Plants were selected randomly from each plot as a representative sample for recording the data.

Iron and Zinc applied to the seedlings of strawberry manually at at 30, 60 and 90 days after transplanting days after transplanting as per treatments. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined in Panse and Sukhatme [7]. Critical difference (CD) values were calculated whenever the "F" test was significant at 5 per cent level.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Effect of iron and zinc on growth parameters on plant height (cm) at 30,60 ,90 DAT

The plant height (cm) was minimum at 30 days was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (8.1 cm), followed

Table 1. Treatment details

S.NO	Treatment Notations	Treatment Details
1.	T_0	WATER SPRAY
2.	T_1	Zn(0.2)+Fe(0.2)
3.	T_2	Zn(0.4)+Fe(0.4)
4.	T_3	Zn(0.6)+Fe(0.6)
5.	T_4	Zn(0.2)+Fe(0.4)
6.	T_5	Zn(0.2)+Fe(0.6)
7.	T_6	Zn(0.4)+Fe(0.2)
8.	T_7	Zn(0.4)+Fe(0.6)
9.	T_8	Zn(0.6)+Fe(0.4)
10.	T_9	Zn(0.6)+Fe(0.2)
11.	T_{10}	Zn(0.2)
12.	T_{11}	Zn(0.4)
13.	T_{12}	Zn(0.6)
14.	T_{13}	Fe(0.2)
15.	T_{14}	Fe(0.4)
16.	T_{15}	Fe(0.6)

by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (7.8 cm). Whereas minimum was recorded in treatment T_0 (5.4 cm) which consisted of water spray as shown in Table 2.

The maximum plant height at (60 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (15.4 cm), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (15.1 cm). Whereas minimum was recorded in treatment T_0 (12 cm) which consisted of water spray.

The maximum plant height at (90 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (22.1 cm), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (21.9 cm). Whereas minimum in treatment T_0 (16.9 cm) which consisted of water spray.

Zinc is a component of carbonic anhydrase as well as several dehydrogenases and auxin production which in turn enhance plant growth and iron is necessary for the biosynthesis of chlorophyll and cytochrome, leading to increase in the biosynthesis of materials and growth. Abdollahi et al., [8] reported increased inflorescence and fruit size with $ZnSO_4$ application because of its important role in pollination and fruit set in strawberry, cultivar Selva. Increase in shelf life of berry might be due to the fact that zinc works as stimulant of amino acids and appears to be helpful in the process of photosynthesis.

Effect of iron and zinc on no. of leaves per plant at 30,60,90 DAT

The maximum no. of leaves at (30 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (7.3), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (7.1). Whereas minimum was recorded in treatment T_0 (4.5) which consisted of water spray as shown in Table 2.

The maximum no. of leaves at (60 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (21.3), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (21.0). Whereas minimum was recorded in treatment T_0 which consisted of water spray was (15.2).

The maximum no. of leaves at (90 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (27.4), followed by concentration of Zn and Fe (0.4+0.6) i.e., treatment T_7 (26.9). Whereas minimum was recorded in treatment T_0 which consisted of water spray was (20.2).

Effect of iron and zinc on growth parameters on plant spread and no. of fruits per plant at 90 DAT

The maximum plant spread at (90 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 (27.2), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 (26.9). Whereas minimum plant

Table 2. Effect of iron and zinc on growth

		Plant Height (cm)			No. of leaves per plant			Plant spread (cm)	No. of fruits per plant
Treatments	**Combinations**	**30 DAT**	**60 DAT**	**90 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**90 DAT**	**90 DAT**
T0	Water Spray	5.4	12.0	16.9	4.5	15.2	20.2	23.2	12.1
T1	Zn(0.2)+Fe(0.2)	6.8	14.0	20.8	6.5	19.6	25.0	26.0	18.0
T2	Zn(0.4)+Fe(0.4)	7.3	14.8	21.7	6.8	20.6	26.0	26.6	19.1
T3	Zn(0.6)+Fe(0.6)	8.1	15.4	22.1	7.3	21.3	27.4	27.2	20.4
T4	Zn(0.2)+Fe(0.4)	7.0	14.3	21.1	6.5	19.9	25.3	26.1	18.4
T5	Zn(0.2)+Fe(0.6)	7.6	15.0	21.8	6.9	20.9	26.5	26.7	19.7
T6	Zn(0.4)+Fe(0.2)	6.4	13.7	20.1	6.2	19.1	24.3	25.6	17.0
T7	Zn(0.4)+Fe(0.6)	7.8	15.1	21.9	7.1	21.0	26.9	26.9	20.0
T8	Zn(0.6)+Fe(0.4)	7.1	14.5	21.4	6.7	20.3	25.8	26.3	18.8
T9	Zn(0.6)+Fe(0.2)	6.5	13.9	20.4	6.4	19.4	24.7	25.9	17.6
T10	Zn(0.2)	5.7	12.8	17.2	4.9	16.7	22.0	24.3	14.1
T11	Zn(0.4)	5.9	12.8	17.5	5.0	17.2	22.6	24.6	15.0
T12	Zn(0.6)	6.0	13.1	17.9	5.2	17.7	22.9	24.9	15.4
T13	Fe(0.2)	6.1	13.2	18.4	5.5	18.1	23.1	25.2	16.0
T14	Fe(0.4)	6.2	13.3	19.3	5.7	18.4	23.4	25.3	16.3
T15	Fe(0.6)	6.3	13.6	19.9	6.0	18.8	23.8	25.6	16.8
F-test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd (±)		**0.05**	**0.10**	**0.25**	**0.12**	**0.27**	**0.21**	**0.52**	**0.47**
$C.D_{0.05\%}$		**0.15**	**0.30**	**0.72**	**0.34**	**0.77**	**0.60**	**1.50**	**1.37**
CV%		**1.33**	**1.30**	**2.17**	**3.38**	**2.43**	**1.48**	**3.51**	**4.77**

Table 3. Effect of iron and zinc on yield and quality

		Yield/ha	Fruit length (cm)	Fruit weight (g)	Fruit diameter (cm)	TSS
Treatments	**Treatment (%)**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
T0	Water Spray	2.3	3.2	18.6	2.6	6.3
T1	Zn(0.2)+Fe(0.2)	4.5	3.8	24.8	3.0	8.3
T2	Zn(0.4)+Fe(0.4)	5.0	3.9	26.2	3.1	8.6
T3	Zn(0.6)+Fe(0.6)	6.0	4.3	29.3	3.4	9.3
T4	Zn(0.2)+Fe(0.4)	4.7	3.8	25.4	3.0	8.4
T5	Zn(0.2)+Fe(0.6)	5.3	4.0	26.8	3.2	8.8
T6	Zn(0.4)+Fe(0.2)	4.1	3.6	23.8	2.9	8.1
T7	Zn(0.4)+Fe(0.6)	5.4	4.1	27.1	3.3	9.1
T8	Zn(0.6)+Fe(0.4)	4.9	3.9	25.9	3.1	8.5
T9	Zn(0.6)+Fe(0.2)	4.3	3.7	24.2	2.9	8.2
T10	Zn(0.2)	2.9	3.3	20.7	2.7	6.7
T11	Zn(0.4)	3.2	3.3	21.3	2.7	7.3
T12	Zn(0.6)	3.4	3.4	21.8	2.7	7.4
T13	Fe(0.2)	3.6	3.4	22.3	2.8	7.8
T14	Fe(0.4)	3.7	3.5	23.0	2.8	7.9
T15	Fe(0.6)	3.9	3.6	23.4	2.9	8.0
F-test		**S**	**S**	**S**	**S**	**S**
SEd(±)		**0.07**	**0.10**	**0.47**	**0.09**	**0.10**
C.D $_{0.05\%}$		**0.19**	**0.30**	**1.37**	**0.26**	**0.30**
CV%		**8.10**	**4.90**	**3.41**	**5.26**	**2.24**

spread (90 days) was recorded in treatment T_0 which consisted of water spray was (23.2) as shown in Table 2.

The maximum no. of fruits per plant at (30 days) was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (20.4), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (20.0). Whereas minimum no of fruits per plant (30 days) in treatment T_0 which consisted of water spray was (12.1).

Foliar application is based on the principle that the nutrients are quickly absorbed by leaves and transported to different parts of the plant to fulfil the functional requirement of nutrition. Foliar application of the nutrients is obviously an ideal way of evading the problems of nutrient availability. Zinc and boron have important role on pollination; fruit set and yield [9] among the micronutrients.

3.2 Yield Parameters

The maximum yield/ha was observed with the interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (6.0), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (5.4). Whereas minimum yield/ha in treatment T_0 which consisted of water spray was (2.3) as shown in Table 3.

Among various micro-nutrients, iron (Fe) and zinc (Zn) plays an important role in promoting vegetative growth, flowering, yield and quality of strawberry fruits [6].

The maximum fruit length was observed with the interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (4.3 cm), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (4.1 cm). Whereas minimum fruit length in treatment T_0 which consisted of water spray was (3.2 cm).

The maximum fruit weight was observed with interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (29.3 g), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (27.1g). Whereas minimum fruit weight in treatment T_0 which consisted of water spray was (18.6 g).

The maximum fruit diameter was observed with the interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (3.4 cm), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (3.3 cm). Whereas minimum fruit diameter in treatment T_0 which consisted of water spray was (2.6 cm).

The number of fruits per plant, mean fruit weight, diameter and volume of fruit significantly increased with the application of Zinc (0.6%) alone or with Iron (0.4%) in fruit plants. Bhambota et al., [10].

3.3 Quality Parameters

The maximum TSS was observed with the interaction of Zn and Fe (0.6%+0.6%) i.e., treatment T_3 of (9.3^o Brix), followed by concentration of Zn and Fe (0.4%+0.6%) i.e., treatment T_7 of (9.1^o Brix). Whereas minimum TSS in treatment T_0 which consisted of water spray was (6.3^o Brix) as shown in Table 3.

Foliar application of zinc increases fruit size, total soluble solids (TSS) [11] also increasing sugar and decreasing acidity [12].

4. CONCLUSION

Based on the results of the present investigation entitled Effect of Foliar Application of Iron (Fe) and Zinc (Zn) on growth, yield and quality of strawberry (*Fragaria ananassa*) cv. winter dawn. it is concluded that cultivation of strawberry with different concentrations of Zn & Fe found as the best for higher productivity whereas the treatment cv. winter dawn T_3 Zn (0.6%)+Fe (0.6%) showed the best results in terms of vegetative growth, yield, quality. Hence the T_3 Zn (0.6%)+ Fe(0.6%) is best suited for the farmers in terms of growth, yield, quality and net returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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