

## Foliar Application of Seaweed Extract and Micronutrients on Plant Growth and Yield of Strawberry (*Fragaria X ananassa* Duch) CV. Winter Dawn

### ABSTRACT

The review summarizes the findings from recent studies, assessing the impact of foliar application of seaweed extracts and micronutrients on strawberry plants. Improvements in growth parameters, nutrient uptake, TSS, and yield attributes were observed. The study also determines whether adding seaweed extracts and micronutrients to strawberry growth methods can improve plant performance in general and fruit yield in particular. Minerals, amino acids, and plant growth regulators are among the bioactive substances found in seaweed extracts that have been shown to have a positive impact on a number of plant physiological functions. Furthermore, vitamin shortages might result in decreased growth and yield because they are essential to the plant's metabolic processes. The combination of micronutrients and seaweed extract has synergistic effects that offer a promising way to boost the general health and yield of strawberry crops.

**Keywords:** - Seaweed extract, Micronutrients, Growth Parameters, TSS

### INTRODUCTION

Strawberry (*Fragaria × ananassa*) is one of the most delicious fruit of the world which attained a prime position in the world fruit market as fresh fruit with in the processing industries. All the cultivated varieties of strawberry are octaploid ( $2n=8\times=56$ ) in nature and belongs to the family Rosaceae. It is short day plant, native from France in 17th century and the two American diploids *Fragaria × chiloensis* and *Fragaria × virginiana* are considered as its progenitors. Strawberry is perennial, stoloniferous herbs which spread via stolons or runners. The strawberry have a type of aggregate fruit botanically. In India, many strawberry cultivars were introduced in early 1960. Primarily strawberry was growing in temperate zone of the country. However, it can also be cultivated under sub-tropical climate, even at higher altitudes of tropical climate. In India its main centers of cultivation are Nainital (district) and Dehradun in Uttrakhand, Mahabaleshwer (Maharashtra), Kashmir Valley, Bangalore and Kalimpong (West Bengal). In recent years, strawberry is being cultivated successfully in plains of Maharashtra around Pune, Nashik and Sangli towns. In Rajasthan strawberry is getting popularity for the cultivation in Jhadol and Mavali (Udaipur), Nimbaheda (Chittorgarh), Mandalgarh (Bhilwara) and Jhalawar. The strawberry plants are strongly affected by the environmental factors like temperature, photoperiod and light intensity **Kumar et al., (2021)**.

The chemical composition of strawberry is ascorbic acid (64.0 mg), water (91.75 g), protein (0.61 g), fat (0.37 g), carbohydrate (7.02 g), fiber (2.3 g), calcium (14.0 mg), potassium (166 mg/100 g) and vitamin-A (27 IU). Ellagic acid is a naturally occurring plant phenol. It has been found to inhibit the cancer disease and asthma by the regular consumption of the fruit **Kumar et al., (2021)**.

Strawberries reproduce sexually via seed; they can also reproduce asexually using their stolons, or runners, which grow several cm away from the 'mother' plant before rooting into the ground at the nodes and developing a new crown. Several weeks later, the stolon deteriorates and the new flowers, leaves, and stolon (**Almaliotis et al., 2002**).

The availability of micronutrient like iron, zinc and boron to the plant at less than pH 6.5. Boron is absorbed in  $H_3BO_4$  form. Next to zinc, boron is widely deficient nutrient. It is a micronutrient mobile in soil and immobile in the plant. Availability of boron in soil is reduced on account of calcareousness, salinity or sodicity, over liming. Very little is known about mineral of B in soils. Boron plays many important roles in plant metabolism. Zn absorbed by the plant in  $Zn^{2+}$  form. Zn is very most important micro-nutrient of global concern, and highly deficient micro-nutrient of equal magnitude on both acid as well as alkaline soils. zinc is an immobile micro-nutrient in the plants. The availability of zinc in soil is adversely affected by soil calcareousness, high phosphorus content, salinity or sodicity, over liming etc. Iron absorbed by plant in  $Fe^{2+}$  form. It is one of the micronutrients becomes extremely mobile under waterlogged conditions and it is highly immobile in the plant. In acid soils, soluble iron could fix phosphates which are aggravated further by high water table and water logging. Whereas on alkaline calcareous soils, lime induced Fe chlorosis is perhaps the most researched nutritional disorder in citrus. Availability of iron becomes less available in soils having beyond pH 7.8. High available iron could induce manganese-deficiency. **Chandrakar et al., 2019** studies on nutritionally, strawberry contains low calorie carbohydrate and a potential source of vitamin-C and fibers.

Among various micro-nutrients, iron (Fe) and zinc (Zn) plays an important role in promoting vegetative growth, flowering, yield and quality of strawberry fruits (**Chaturvedi et al., 2005**). Iron has many important functions in plant growth and development, such as involvement in the biosynthesis of chlorophyll, respiration, chloroplast development and improves the performance of photosystems. It is an essential part of many enzymes. Iron also participates in the oxidation process that releases energy from sugars and starches and in responses that convert nitrate to ammonium in plant. It plays an essential role in nucleic acid metabolism (**Eskandari, 2011; Havlin et al., 2014**). Zinc also plays an important role in photosynthesis and related enzymes resulting in increasing sugar and decreasing acidity. (**Mahnaz et al., 2010**) claimed that  $ZnSO_4$  as a source of zinc had a positive effect in increasing leaf area, length and diameter of petiole, fresh and dry shoot ratio, yield, TSS, acidity and Vitamin-C of strawberry plant.

## **MATERIALS AND METHODS**

### **DATA ANALYSIS:**

The data was analysed using OPSTAT.

The details of the various materials used and methods adopted in carrying out the experiment are presented below:

### **EXPERIMENTAL SITE:**

The present investigation entitled “**Effect of different concentration of seaweed extract and micronutrients on plant growth, yield and quality of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter Dawn**” was carried out during the year 2023-2024 in the Department of Horticulture, Sam Higginbottom University of Agriculture Technology & Sciences Prayagraj in the months of October 2023 to February 2024. The experiment was conducted on strawberry cv. Winter Dawn. All the facilities necessary for cultivation, including labour were made in the department.

### **Layout and treatment combination**

Studies on effect of seaweed extract and micronutrients on growth and yield of strawberry was carried out on cv. Winter Dawn during 2023-24 at Horticulture Research Farm of Naini Agricultural Institute, SHUATS, Prayagraj, (Uttar Pradesh). The experiment was laid out in RBD viz. Treatments at 13 levels viz. T0: control, T1: SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.2%, T2: SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.4%, T3: SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, T4: SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%, T5: SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.2%, T6: SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.4%, T7: SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, T8: SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%, T9: SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.2%, T10: SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.4%, T11: SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, T12: SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. The transplanting was done on 28/10/2023 in field condition.

### **CLIMATE:**

The Prayagraj District comes under subtropical belt in the southeast of U.P. which experience extremely hot summer and fairly cold winter. During the winter months (Dec.-Jan) temperature falls 2-5°C or even low, while in summer months (May-June) it reaches as high as 49°C. Hot blowing winds are regular feature during the summers and an occasional spell of frost may be during winters. Most of the rainfall is received in the middle of July to end of September after

which the intensity of rainfall decreases. The mean annual rainfall is about 850-1100mm. However, occasional precipitation is also not uncommon during winter months.

## **RUNNING STATUS -**

### **1. Growth Parameter**

- Plant Height (cm)
- Plant Spread (cm)
- Chlorophyll Content

### **2. Leaf Parameter**

- Number of leaves per plant
- Leaf area (sq. cm)
- Petiole length (cm)

### **3. Flower Parameter**

- Days taken to flower

### **4. Fruit Parameter**

- Berry weight (g)
- Berry Length (cm)
- Berry diameter (mm)

### **5. Yield Parameter**

- Total Yield per plant (kg) (Yield/ha)

### **6. Quality Parameter**

- Total Soluble Solids (Brix)
- Vitamin C content (mg/100 g of fresh fruit)
- Total sugar (%)

### **7. Economics**

- Cost of cultivation (Rs)

## **RESULTS AND DISCUSSIONS**

During the present investigation, observations on various plant characteristics were recorded to evaluate the “**Effect of different concentration of seaweed extract and micronutrients on plant growth, yield and quality of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter**”

**Dawn**". The tabulated data were statistically analyzed with a view to find out the significant effect of different factors which are present in the appendix 1. The data present in the tabular forms shows the relevant standard error of mean deviation S. ( $\pm$ ) and the critical difference (C.D) at 5% level of significance, wherever necessary. The results emanating from the present studies are presented under appropriate heading:

**TABLE 1: Effect of different concentration of seaweed extract and micronutrients on plant height (cm) of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter dawn**

Treatment No.	Treatments details	Plant height (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
T0	Control	7.20	10.47	16.50	20.97
T1	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	8.43	15.46	20.36	27.86
T2	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	8.57	17.29	24.86	27.85
T3	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	8.67	16.95	24.14	27.80
T4	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	9.12	18.17	27.21	30.30
T5	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	8.63	14.80	24.98	29.90
T6	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	8.07	15.49	23.98	27.22
T7	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	8.07	15.43	24.28	27.66
T8	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	9.19	18.31	27.35	31.15
T9	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	8.64	16.89	23.10	27.95
T10	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	8.32	16.00	24.20	28.11
T11	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	9.23	18.57	27.46	31.25
T12	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	9.31	18.68	27.57	32.31
	<b>F-Test</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
	<b>S.Ed.</b>	<b>0.189</b>	<b>0.328</b>	<b>0.820</b>	<b>0.879</b>
	<b>CD at 0.5%</b>	<b>0.390</b>	<b>0.677</b>	<b>1.692</b>	<b>1.815</b>
	<b>CV</b>	<b>2.701</b>	<b>2.459</b>	<b>4.131</b>	<b>3.780</b>

**At 30 days** after transplanting, maximum plant height (cm) (9.31) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum plant height (cm) (7.20) was found recorded in T<sub>0</sub> Control respectively

**At 60 days** after transplanting, maximum plant height (cm) (18.68) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum plant height (cm) (10.47) was found recorded in T<sub>0</sub> Control respectively.

**At 90 days** after transplanting, maximum plant height (cm) (27.57) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum plant height (cm) (16.50) was found recorded in T<sub>0</sub> Control respectively.

**At 120 days** after transplanting, maximum plant height (cm) (32.31) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Followed by, SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% and SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% .Where as the minimum plant height (cm) (20.97) was found recorded in T<sub>0</sub> Control respectively.

The increase in plant spread of strawberry might be due to Zn + B + Fe might have stimulated cell division and cell elongation resulting in increased plant spread would have increased in the treated plants. These results were in close agreement with the findings of **Bakshi et al., (2013 a), Bakshi et al., (2013 b) and Singh et al., (2015)** in strawberry.

**TABLE 2: Effect of different concentration of seaweed extract and micronutrients on plant spread (cm) of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter dawn**

Treatment No.	Treatments details	Plant spread (cm)			
		30	60	90	120

		<b>DAT</b>	<b>DAT</b>	<b>DAT</b>	<b>DAT</b>
T0	Control	9.54	13.79	17.31	26.64
T1	SWE 1ml/l+(ZnSO4, H3BO3, FeSO4) 0.2%	11.40	21.18	27.79	33.64
T2	SWE 1ml/l+(ZnSO4, H3BO3, FeSO4) 0.4%	10.76	21.03	26.94	30.57
T3	SWE 1ml/l+(ZnSO4, H3BO3, FeSO4) 0.6%	11.07	20.94	24.08	31.10
T4	SWE 1ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%	12.14	24.20	29.46	36.12
T5	SWE 3ml/l+(ZnSO4, H3BO3, FeSO4) 0.2%	12.03	20.52	24.72	32.05
T6	SWE 3ml/l+(ZnSO4, H3BO3, FeSO4) 0.4%	11.19	20.94	26.68	33.83
T7	SWE 3ml/l+(ZnSO4, H3BO3, FeSO4) 0.6%	11.08	22.36	24.64	31.60
T8	SWE 3ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%	12.26	24.83	29.68	36.24
T9	SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.2%	11.22	22.40	25.38	31.95
T10	SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.4%	11.07	21.45	24.97	33.10
T11	SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.6%	12.44	25.28	30.00	37.14
T12	SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%	12.54	25.42	31.10	37.01
<b>F-Test</b>		<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S.Ed.</b>		<b>0.179</b>	<b>0.372</b>	<b>0.741</b>	<b>0.896</b>
<b>CD at 0.5%</b>		<b>0.370</b>	<b>0.767</b>	<b>1.528</b>	<b>1.849</b>
<b>CV</b>		<b>1.918</b>	<b>2.082</b>	<b>3.440</b>	<b>3.309</b>

**At 30 days after transplanting**, maximum plant spread (cm) (12.54) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%. Where as the minimum plant spread (cm) (9.54) was found recorded in T<sub>0</sub> Control respectively.

**At 60 days after transplanting**, maximum plant spread (cm) (25.42) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%. Where as the minimum plant spread (cm) (13.79) was found recorded in T<sub>0</sub> Control respectively.

**At 90 days after transplanting**, maximum plant spread (cm) (31.10) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%. Where as the minimum plant spread (cm) (17.31) was found recorded in T<sub>0</sub> Control respectively.

**At 120 days after transplanting**, maximum plant spread (cm) (37.01) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.8%. Followed by SWE 5ml/l+(ZnSO4, H3BO3, FeSO4) 0.6%, T<sub>8</sub> SWE 3ml/l+(ZnSO4, H3BO3, FeSO4) 0.8% and SWE 1ml/l+(ZnSO4, H3BO3, FeSO4)

0.8%. Where as the minimum plant spread (cm) (26.64) was found recorded in T<sub>0</sub> Control respectively.

The increase in plant spread of strawberry might be due to Zn + B + Fe might have stimulated cell division and cell elongation resulting in increased plant spread would have increased in the treated plants. These results were in close agreement with the findings of **Bakshi et al., (2013 a), Bakshi et al., (2013 b) and Singh et al., (2015)** in strawberry.

**TABLE 3: Effect of different concentration of seaweed extract and micronutrients on number of leaves per plant of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter dawn**

Treatment No.	Treatments details	Number of leaves per plant			
		30 DAT	60 DAT	90 DAT	120 DAT
T0	Control	5.35	12.38	20.19	30.08
T1	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	6.34	19.66	24.93	34.69
T2	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	6.24	19.53	26.43	34.64
T3	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	6.16	19.60	29.13	33.75
T4	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	7.04	21.16	31.15	40.86
T5	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	6.49	19.12	26.78	32.36
T6	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	6.41	19.68	28.43	34.91
T7	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	6.26	19.47	26.99	33.11
T8	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	7.11	22.73	31.84	41.37
T9	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	6.49	20.12	27.47	34.59
T10	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	6.43	20.26	26.93	33.72
T11	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	7.17	22.83	32.52	43.35
T12	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	7.31	24.64	34.66	45.43
<b>F-Test</b>		<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S.Ed.</b>		<b>0.124</b>	<b>0.743</b>	<b>0.708</b>	<b>1.250</b>
<b>CD at 0.5%</b>		<b>0.256</b>	<b>1.533</b>	<b>1.461</b>	<b>2.579</b>
<b>CV</b>		<b>2.333</b>	<b>4.527</b>	<b>3.067</b>	<b>4.208</b>

**At 30 days after transplanting**, maximum Number of leaves per plant (7.31) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Number of leaves per plant (5.35) was found recorded in T<sub>0</sub> Control respectively.

**At 60 days after transplanting**, maximum Number of leaves per plant (24.64) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. followed by with SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% and SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% Where as the minimum Number of leaves per plant (12.38) was found recorded in T<sub>0</sub> Control respectively.

**At 90 days after transplanting**, maximum Number of leaves per plant (34.66) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. followed by withy SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.6%, T<sub>8</sub> SWE 3ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% and SWE 1ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% Where as the minimum Number of leaves per plant (20.19) was found recorded in T<sub>0</sub> Control respectively.

**At 120 days after transplanting**, maximum Number of leaves per plant (45.43) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Number of leaves per plant (30.08) was found recorded in T<sub>0</sub> Control respectively.

The increase in number of leaves per plant as results of ZnSO<sub>4</sub> + Boron + FeSO<sub>4</sub> application might be due to fact that activity of micronutrients at shoot meristem resulting is more system of nucleoprotein responsible for increasing leaf initiation and expansion. Similar observations on number of leaves per plant due to micronutrients were also reported by **Chaturvedi et al., (2005), Bakshi et al., (2013. a) Bakshi et al., (2013, b) and Singh et al., (2015)** in strawberry.

**TABLE 4: Effect of different concentration of seaweed extract and micronutrients on petiole length (cm) of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter dawn**

Treatment No.	Treatments details	Petiole length (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
T0	Control	4.09	6.19	7.16	9.41
T1	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	5.41	7.47	9.41	12.29
T2	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	5.08	7.17	8.56	10.36
T3	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	4.66	7.23	9.14	11.35
T4	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	6.63	8.07	10.16	13.14

T5	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	5.22	7.18	8.79	12.53
T6	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	4.71	7.50	8.56	12.43
T7	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	5.58	8.29	9.76	12.01
T8	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	6.83	8.28	11.14	13.24
T9	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	4.85	6.86	8.28	12.21
T10	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	5.87	7.87	9.87	12.23
T11	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	7.02	8.61	12.24	13.45
T12	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	7.07	8.77	12.51	14.42
<b>F-Test</b>		<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S.Ed.</b>		<b>0.201</b>	<b>0.192</b>	<b>0.234</b>	<b>0.233</b>
<b>CD at 0.5%</b>		<b>0.416</b>	<b>0.396</b>	<b>0.483</b>	<b>0.480</b>
<b>CV</b>		<b>4.390</b>	<b>3.074</b>	<b>2.964</b>	<b>2.330</b>

**At 30 days after transplanting**, maximum Petiole length (cm) (7.07) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Petiole length (cm) (4.09) was found recorded in T<sub>0</sub> Control respectively.

**At 60 days after transplanting**, maximum Petiole length (cm) (8.77) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Petiole length (cm) (6.19) was found recorded in T<sub>0</sub> Control respectively.

**At 90 days after transplanting**, maximum Petiole length (cm) (12.51) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Petiole length (cm) (7.16) was found recorded in T<sub>0</sub> Control respectively.

**At 120 days after transplanting**, maximum Petiole length (cm) (14.42) was recorded in T<sub>12</sub> SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8%. Where as the minimum Petiole length (cm) (9.41) was found recorded in T<sub>0</sub> Control respectively.

The increase in petiole length of strawberry might be due to Zn + B + Fe might have stimulated cell division and cell elongation resulting in increased plant spread would have increased in the treated plants. These results were in close agreement with the findings of **Bakshi et al., (2013 a), Bakshi et al., (2013 b) and Singh et al., (2015)** in strawberry.

**TABLE 5: Effect of different concentration of seaweed extract and micronutrients on Days to first flowering, Days to first fruiting, Number of flower per plant, Number of fruit per plant, Fruit weight (gm) of Strawberry (*Fragaria x ananassa* Duch.) cv. Winter dawn.**

<b>Treat ment No.</b>	<b>Fruit weight (gm)</b>	<b>Number of fruit per plant</b>	<b>Number of flower per plant</b>	<b>Days to first fruiting</b>	<b>Days to first flowering</b>
T0	15.16	10.18	23.83	61.98	54.13
T1	22.93	15.63	27.5	58.27	49.76
T2	22.95	16.43	30.43	54.77	46.62
T3	22.3	15.32	29.95	53.42	45.76
T4	25.79	17.07	33.07	52.01	43.76
T5	22.3	16.03	29.44	53.43	45.55
T6	23.96	15.96	28.83	55.94	47.79
T7	22.03	15.44	27.1	58.76	50.1
T8	25.64	17.32	33.44	49.78	41.63
T9	22.03	15.29	27.97	55.89	47.44
T10	22.33	16.54	26.35	54.24	45.61
T11	26.12	17.4	33.71	56.45	48.2
T12	27.12	18.43	34.64	46.34	39.81
<b>F-Test</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S.Ed.</b>	<b>0.342</b>	<b>0.49</b>	<b>0.631</b>	<b>1.161</b>	<b>1.158</b>
<b>CD at 0.5%</b>	<b>0.706</b>	<b>1.011</b>	<b>1.302</b>	<b>2.396</b>	<b>2.39</b>
<b>CV</b>	<b>1.812</b>	<b>3.766</b>	<b>2.6</b>	<b>2.598</b>	<b>3.042</b>

The increase in fruit weight, number of fruit/plant, number of flower/plant, days to first fruiting, days to first flowering of strawberry might be due to Zn + B + Fe might have stimulated cell division and cell elongation resulting in increased plant spread would have increased in the treated plants. These results were in close agreement with the findings of **Yadav et al., (2017)** in banana, **Bakshi et al., (2013 a)**, **Bakshi et al., (2013 b)**, **Mehraj et al., (2015)**, **Singh et al., (2015)**, in strawberry.

**TABLE 6: Effect of different concentration of seaweed extract and micronutrients on TSS, Acidity, Ascorbic acid, Specific gravity, pH.**

<b>Treatment No.</b>	<b>TSS 0Brix</b>	<b>Acidity (%)</b>	<b>Ascorbic acid (mg/100g)</b>	<b>Specific gravity</b>	<b>pH</b>
T0	7.58	0.61	51.17	1.09	3.93
T1	8.16	0.79	54.78	1.31	3.77
T2	8.43	0.86	55.85	1.18	3.75
T3	9.13	0.88	55.03	1.32	3.7
T4	9.23	1.07	57.09	1.35	3.64
T5	8.16	1.05	54.34	1.18	3.73
T6	8.47	0.92	53.54	1.14	3.74
T7	8.48	0.91	55.17	1.23	3.78
T8	9.77	1.1	57.2	1.31	3.47
T9	8.39	0.84	52.3	1.14	3.81
T10	9.07	1.03	55.31	1.29	3.54
T11	10.14	1.18	57.43	1.53	3.37
T12	10.29	1.3	58.41	1.63	3.27
<b>F-Test</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S.Ed.</b>	<b>0.156</b>	<b>0.037</b>	<b>0.533</b>	<b>0.055</b>	<b>0.084</b>
<b>CD at 0.5%</b>	<b>0.322</b>	<b>0.076</b>	<b>1.099</b>	<b>0.114</b>	<b>0.174</b>
<b>CV</b>	<b>2.152</b>	<b>4.655</b>	<b>1.182</b>	<b>5.252</b>	<b>2.82</b>

**TABLE 7: Overall expenditure, profit and B:C ratio.**

<b>Symbols</b>	<b>Treatment Combination</b>	<b>Fruit yield (t ha-)</b>	<b>Total cost of cultivation</b>	<b>Gross return (Rs.ha-1)</b>	<b>Net return (Rs. ha-1)</b>	<b>B:C ratio</b>
T <sub>0</sub>	Control	8.94	419856	895215.5	475359.5	1.12
T <sub>1</sub>	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	13.46	422392.05	2078650.787	1656258.737	3.59
T <sub>2</sub>	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	14.66	424484.25	2184698.76	1760214.51	3.97
T <sub>3</sub>	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	11.67	426576.45	1982144.2	1555567.75	2.93
T <sub>4</sub>	SWE 1ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	15.77	428668.65	2553868.953	2125200.303	4.30
T <sub>5</sub>	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	12.31	423279.75	2076274.333	1652994.583	3.19
T <sub>6</sub>	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	14.98	425371.95	2217902.987	1792531.037	4.07
T <sub>7</sub>	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	9.67	427464.15	1972300.633	1544836.483	2.25
T <sub>8</sub>	SWE 3ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	16.59	429556.35	2575608.707	2146052.357	4.56
T <sub>9</sub>	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.2%	9.24	424180.9	1953804.24	1529623.34	2.13
T <sub>10</sub>	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.4%	14.04	426273.1	2141744.733	1715471.633	3.75
T <sub>11</sub>	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.6%	16.97	428365.3	2635871.287	2207505.987	4.70
T <sub>12</sub>	SWE 5ml/l+(ZnSO <sub>4</sub> , H <sub>3</sub> BO <sub>3</sub> , FeSO <sub>4</sub> ) 0.8%	17.48	430457.5	2899861.187	2469403.687	4.84

## CONCLUSION

From the current investigation, it is concluded that treatment combination T12 : SWE 5ml/l+(ZnSO<sub>4</sub>, H<sub>3</sub>BO<sub>3</sub>, FeSO<sub>4</sub>) 0.8% is the best treatment for growth, yield and fruit quality viz, plant height (cm) (32.31), plant spread (cm) (37.01), number of leaves per plant (45.43) , petiole length (cm) (14.42) , days to first flowering (39.81) , days to first fruiting (46.34), number of flower per plant (34.64), number of fruit per plant (18.43), fruit weight (gm) (27.12),fruit per plant (g) (499.98) , fruit yield t ha<sup>-1</sup> (17.48) , TSS °brix (10.29), juice content (%) (94.59) and pH(3.27) of strawberry.

The highest benefit cost ratio was also found in the same treatment with 1:4.84

## REFERENCES

- Almaliotis D, Velemis D, Bladenopoulou S, Karapetsas N. Leaf nutrient levels of strawberries (cv. Tudla) in relation to crop yield. ISHS. Acta Horticulture 567.IV International Strawberry Symposium. Vol 2. Tempere, Finland 2002.
- Bakshi P, Jasrotia A, Wali VK, Sharma A, Akshi M. Influence of pre-harvest application of calcium and micro-nutrients on growth, yield, quality and shelf-life of strawberry cv "Chandler". Ind. J Agric. Sci. 2013;83:831835.
- Bakshi P, Jasrotia A, Wali VK, Sharma A, Akshi M. Influence of pre-harvest application of calcium and micro-nutrients on growth, yield, quality and shelf-life of strawberry cv Chandler. Ind. J Agric. Sci 2013;83:831835.
- Bakshi, P., Jasrotia, A., Wali, V.K., Sharma, A. and Bakshi, M. (2013).Influence of preharvest application of calcium and micronutrients on growth, yield, quality and shelf-life of strawberry cv. Chandler. Indian J. Agri. Sci., 83(8): 831-835.
- Chandrakar S, Singh P, Panigrahi HK, Paikra Sarita. Effect of foliar spray of calcium and micronutrients on growth parameters, flowering, fruiting and fruit maturity of strawberry (Fragaria x ananassa Duch.) cv. Nabila under net tunnel. Journal of Pharmacognosy and Phytochemistry 2018;7(6):5-10.
- Chaturvedi OP, Singh AK, Tripathi VK, Dixit AK. Effect of zinc and iron on growth, yield and quality of strawberry cv. Chandler. Acta Hort., 2005; 696:237-240.
- Chaturvedi OP, Singh AK, Tripathi VK, Dixit AK. Effect of zinc and iron on growth, yield and

quality of strawberry cv. "Chandler". *Acta. Hort.* 2005;696:237240.

Eskandari H. The importance of iron (Fe) in plant Products and Mechanism of Its uptake by plants. *J Appl. Environ. Biol. Sci.* 2011; 1(10):448-452.

Havlin JL, Tisdale SL, Nelson WL, Beaton JD. Soil fertility and nutrient management: An introduction to nutrient management. (8th Ed). Pearson (pp. 505), Upper Saddle River, New Jersey. U.S.A., 2014.

Kumar Lokesh, HL Bairwa, LN Mahawer, SC Meena, RA Kaushik and RC Choudhary (2021). Response of foliar spray of iron, zinc and boron in strawberry (*Fragaria × ananassa* Duch.) cv. winter dawn. *The Pharma Innovation Journal* 2021; 10(12): 2057-2061

Kumar, S. and Singh,D. (2021). Influence of Micronutrient on Growth, Fruit Yield and Quality of Strawberry (*Fragaria×ananassaDuch.*) cv. Winter Star under Protected Cultivation.*Biological Forum–An International Journal*,13(4):344-348.

Mahnaz A, Saeid E, Enayat T. Interaction of paclobutrazol, boron and zinc on vegetative growth, yield and fruit quality of strawberry (*Fragaria x ananassa Duch.* cv. Selva). *Journal of Biology and Environment Science*, 2010; 4:67-75.

Mehraj H, Hussain MS, Parvin S, Roni MZK, Jamal Uddin AFM (2015) Response of repeated foliar application of boron-zinc on strawberry. *Int. J. Expt. Agric.* 5(1), 21-24.

Singh M, Jamwal M, Sharma N, Kumar R, Wali V. Response of iron and zinc on vegetative and reproductive growth of strawberry (*Fragaria × ananassa Duch.*) cv. Chandler. *Bangladesh J. Bot.* 2015;44(2):337-340.

Singh S, Gautam DK, Singh A. Effect of micronutrient (zinc, boron) and different combination with apsa-80 on growth, yield and quality and economic of strawberry (*Fragaria x ananassa Duch.*). *Research in Environment and Life Sciences* 2015;8(3):416-418.

Yadav Indira, Jitendra Singh, Bharat Meena, Pravin Singh, Sanjay Meena, Shraddha Neware and Patidar D. K. (2017). Strawberry Yield and Yield Attributes after Application of Plant Growth Regulators and Micronutrients on Cv. Winter Dawn. *Chem Sci Rev Lett* 2017, 6(21), 589-594