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M Chandra NaikDepartment of crop physiology,
College of Agriculture, UAS,
Raichur, Karnataka, India**Amaregouda A**Department of crop physiology,
College of Agriculture, UAS,
Raichur, Karnataka, India**Meena MK**Department of crop physiology,
College of Agriculture, UAS,
Raichur, Karnataka, India**Ramesh YM**Department of crop physiology,
College of Agriculture, UAS,
Raichur, Karnataka, India

Physiological assessment of iron and zinc biofortification on growth and yield parameters of sweet corn

M Chandra Naik, Amaregouda A, Meena MK and Ramesh YM

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Abstract

Field experiment was carried out during *kharif* 2017 and 2018 in black soil at farmer field at Kumarnahally village, Huvina hadagali Tq, Bellary District representing the Northern Dry Zone (Zone-II) which is located at latitude of 15.04' N, longitude of 75.94' E and 561 meters which is above mean sea level to study the physiological assessment of iron and zinc biofortification on growth and yield parameters of sweet corn (*Zea mays* L. *Saccharata*) to evaluate and analysis of sweet corn through biofortification to achieve higher growth and yield parameters. Pooled data both years indicated that seed treatment with ZnSO₄ @ 0.5 % + FeSO₄ @ 0.5 % and foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded significantly higher total dry matter (196.3, 203.8 and 200.1 g plant⁻¹ at 30, 60 DAS and at harvest, respectively) and also higher photosynthetic rate (17.2, 33.5 and 32.7 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest respectively). Similarly Fresh cob yield was noticed with seed treatment by ZnSO₄ @ 0.5 % & FeSO₄ @ 0.5 % and foliar spray of ZnSO₄ @ 1.0 % & FeSO₄ @ 1.0 % which was on par with seed treatment with ZnSO₄ @ 0.5 % + foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % during the year 2017, 2018 and pooled data.

Keywords: Sweet corn, growth and yield parameters

Introduction

Maize is called “Queen of Cereals” because of its productive potential compared to any other cereal crop. In India, maize occupies an area of 9.2 m ha, production of 23.6 million tonnes with the productivity of 2564 kg/ha. In Karnataka, it is cultivated in an area of 1.34 million ha with a production of 3.91 million tonnes and the productivity of 2921 kg/ha (Anon., 2017) [3]. Sweet corn (*Zea mays* L. *saccharata*) is a vegetable crop grown for human consumption throughout the world. The U.S, Mexico, Nigeria, Indonesia, Hungary, South Africa, Peru, Guinea, France and Thailand were the top ten sweet corn producing countries (FAO, 2017) [6]. The U.S. was the highest sweet corn producer by mass produced, 4.09 million metric tons, and by area harvested, 243,790 ha (FAO, 2017) [6]. Sweet corn (*Zea mays* L. *saccharata*) also known as sugar corn, is a hybridized variety of maize (*Zea mays* L.) specifically bred to increase the sugar content. Sweet corn is introduced to India from United States of America. It has a sugary rather than a starchy endosperm with a creamy texture. The low starch level makes the kernel wrinkled rather than plumpy. The modern sweet corn varieties are classified as “normal sugary” (Su); “sugary enhanced” (Se) and “shrunk” (Sh₂), which are also called as “super sweet”. These differ in sweetness and ratio of conversion of sugar to starch. All these varieties are most popular while “super sweet” is commercially used because it is very sweet with minimum conversion of sugar to starch. The sweet corn contains relatively good amount of calcium (Ca), phosphorus (P), iron (Fe) and potassium (K). It contains a higher proportion of sitosterol (47%). Due to high oil content, flavor and color develop in processed sweet corn. Sweet corn is rich in thiamine, riboflavin, niacin, vitamin B₆ and vitamin A as major vitamins. Lipoxigenase and peroxidase enzymes are directly associated with off-flavor and other quality deteriorations. In sweet corn, aroma develops due to dimethyl sulphide (DMS) and hydrogen sulphide (H₂S).

Micronutrient deficiency is the fifth major global challenge to human health. Iron and zinc deficiency the most common and widespread, afflicting more than half of the human population (Subhanulla Khan and Rahmen, 2017) [10]. Worst hit are the developing countries of

Corresponding Author:**M Chandra Naik**Department of crop physiology,
College of Agriculture, UAS,
Raichur, Karnataka, India

Asia and Africa (Gómez *et al.*, 2010) ^[7]. More than 2 billion people suffer from iron deficiency alone, and the estimates of zinc deficiency are also close and deficiency of iron and zinc, also known as 'Hidden hunger', results in poor growth and compromised psychomotor development of children, reduced immunity, fatigue, irritability, weakness, hair loss, wasting of muscles, sterility, morbidity and even death in acute cases

This situation is largely attributed to the high consumption of cereal based foods, rice, wheat and maize. Edible parts (endosperms) of modern cereal cultivars are inherently poor in Iron and zinc concentration in whole grain. Apart from the cereals inherent inability to accumulate high iron and zinc, one major reason for their low accumulation in edible parts is the cultivation of cereals on zinc-deficient soils, particularly in developing countries like India (Alloway, 2015) ^[11]. The Green Revolution is also considered to have contributed to the prevalence of these micronutrient deficiencies in soils because it promoted the use of high-yielding varieties, large-scale irrigation, and macronutrient fertilizers. It is considered that high yielding varieties led to the dilution effect of micronutrients due to increased 100 kernel weights. The existence of a negative relationship between irrigation and iron and zinc uptake and a similar negative relationship between phosphorus and iron and zinc uptake (Saha *et al.*, 2013) ^[9] also lead to lower the accumulation of these micronutrients in the grains. Since the edible parts of the cereals and pulses are poor in iron and zinc, thus heavy dependence of people from developing countries on these foods results in the development of large-scale iron and zinc malnutrition.

The recommended daily allowance (RDA) of iron is 13 mg per day for children, 17 mg per day for adult, 7 mg per day for children and 12 mg per day for adult similarly, zinc is necessary but in India mostly people have monotonous diets which relies on cereals that are deficient in micronutrients, iron and zinc (Anonymous, 2010) ^[2]. In India, consumption of rice as staple food provides daily per capita iron content (14.93 mg) which is less than RDA. The malnutrition problem is expected to increase further with the increase of population as the poor masses in the developing countries like India only depends on cereal meals *i.e.*, rice and it cannot afford to balance their diet with vegetables, milk, meat and fruit supplements (Poletti *et al.*, 2004) ^[8].

Cereal crops are inherently very low in grain Fe and Zn concentrations and growing them on potentially Zn and Fe deficient soils, further reduces Fe and Zn concentration in grain (Cakmak *et al.*, 2010) ^[4]. Thus, bio-fortification of

cereal crops with Fe and Zn is a high priority global issue. Iron- containing plant haemoglobins are another promising target for altering Fe content in plant-based foods. Plant haemoglobin is similar to the human haemoglobin, with Fe binding capacity and is most commonly found in nodulating legumes (Kundu *et al.*, 2003).

Materials and Method

Field experiment was carried out during *kharif* 2017 and 2018 in black soil at farmer field at Kumarnahally village, Huvina hadagali Tq, Bellary District representing the Northern Dry Zone (Zone-II) which is located at latitude of 15.04' N, longitude of 75.94' E and 561 meters above Mean Sea Level. Laboratory studies were carried out in the Department of Crop Physiology, College of Agriculture, University of Agricultural Sciences, Raichur.

The soil is black with optimum pH (8.34) and electrical conductivity was normal (0.108 dsm⁻¹). The nitrogen content in the soil was low (248.0 kg ha⁻¹), whereas the phosphorous was medium (43.0 kg ha⁻¹) and the potash was high (386.0 kg ha⁻¹). The organic carbon content was medium (0.45%) besides, zinc (0.85 mg/kg⁻¹) content found to be slightly below the normal, iron (0.87 mg/kg⁻¹).

Treatment details

In this study, seed treatment and foliar application of iron and zinc with their combinations of treatments in three replications are listed below.

1. Application of recommended dose of FYM is common for all the treatments except control
2. Stage of treatment imposition is seed treatment at the time of sowing and foliar spray at 55 and 65 days after sowing (pre and post flowering stages)

Various growth parameters, yield parameters were collected at 30, 60 DAS and at harvest were correlated with quality parameters and micronutrient composition of seeds and correlation studies were made between cob yield and its attributes. The values of correlation coefficient (r) were calculated and tested for their significance as per the procedure outlined by Panse and Sukhatme (1967). The standard error of mean (S.Em \pm) was worked out and the critical difference at 5 per cent level of significance was calculated wherever the results were found significant. Graphs and plates have been used to project the important results. The data recorded on growth, morphological, physiological, yield and yield parameters. General view of the experiment is presented in plate 1



Plate 1: Influence of seed treatment and foliar spray of iron and zinc on total dry matter production of sweet corn



Plate 2: Influence of seed treatment and spray of iron and zinc on cob formation of sweet corn

Table 1: Influence of seed treatment and foliar spray of iron and zinc on total dry matter production at different growth stages of sweet corn

Treatments	Total dry matter production (g plant ⁻¹)								
	30 DAS			60 DAS			At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T ₁ -Seed treatment with ZnSO ₄ @ 0.5 %	23.4	24.6	24.0	122.8	126.4	124.6	148.8	153.2	151.0
T ₂ - Seed treatment with FeSO ₄ @ 0.5 %	22.5	23.6	23.0	118.8	121.9	120.3	144.5	148.4	146.5
T ₃ - Foliar application of ZnSO ₄ @ 1.0 %	23.3	24.3	23.8	132.7	135.8	134.2	166.9	171.2	169.1
T ₄ - Foliar application of FeSO ₄ @ 1.0 %	20.9	22.0	21.5	114.4	117.2	115.8	140.0	143.5	141.8
T ₅ - Seed treatment with ZnSO ₄ @ 0.5 % + seed treatment with FeSO ₄ @ 0.5 %	25.4	26.7	26.1	139.1	142.7	140.9	174.9	179.5	177.2
T ₆ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ 1.0 %	26.9	28.0	27.4	149.0	153.1	151.1	183.3	188.3	185.8
T ₇ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	23.7	24.9	24.3	136.0	13.5	137.8	171.1	175.5	173.3
T ₈ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 %	26.4	27.7	27.1	141.6	145.2	143.4	175.1	179.6	177.4
T ₉ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	23.9	25.3	24.6	128.8	132.2	130.5	159.9	164.1	162.0
T ₁₀ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	30.9	32.4	31.6	157.2	159.3	158.5	193.2	198.3	195.7
T ₁₁ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0%	26.9	28.0	27.5	153.6	157.5	155.0	186.1	190.8	169.2
T ₁₂ - Seed treatment with ZnSO ₄ @ 0.5 % + seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	31.9	33.5	32.7	163.2	167.4	165.3	196.3	203.8	200.1
T ₁₃ - Control	19.3	20.3	19.8	109.6	112.5	111.0	130.1	133.5	131.8
S. Em (±)	0.93	1.93	1.40	4.58	5.73	13.46	3.52	3.22	1.54
C.D. @ 5%	2.71	5.62	4.08	13.37	16.73	39.3	10.27	9.41	4.62

During 2017, 2018 and pooled results noticed that with seed treatment by ZnSO₄ @ 0.5 % + FeSO₄ @ 0.5 % and foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded significantly higher total dry matter (31.9, 163.2 and 196.3, g plant⁻¹ during 2017, 33.5, 167.4 and 203.8 g plant⁻¹ during 2018 and 32.7, 165.3 and 200.1 g plant⁻¹ from pooled was recorded at 30, 60 DAS and at harvest, respectively). Which was on par with seed treatment with ZnSO₄ @ 0.5 % + foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded (30.9, 157.2 and 193.2 g plant⁻¹, 32.4, 159.3 and 198.3 g plant⁻¹ and 31.6, 168.5 and 195.7 g plant⁻¹ at 30, 60 DAS and at harvest, respectively) as compared to control (19.3, 109.6 and 130.1 g plant⁻¹, 20.3, 112.5 and 133.5 plant⁻¹ and 19.8, 111.0 and 131.8 g plant⁻¹, at 30, 60 DAS and at harvest respectively Table 1.

During 2017 results noticed that with seed treatment by ZnSO₄ @ 0.5 % + FeSO₄ @ 0.5 % and foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded significantly higher

photosynthetic rate (17.2, 37.8 and 31.9 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest, respectively during 2017, 17.8, 39.4 and 33.5 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest, respectively during 2017 and pooled data indicated that 17.5, 38.6 and 32.7 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest respectively. Which was on par with seed treatment with ZnSO₄ @ 0.5 % + foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded (16.9, 36.2 and 30.9 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest, respectively during 2018, 17.6, 38.2 and 32.2 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest, respectively during 2018 and pooled data of both the years indicated that 17.3, 37.2 and 31.6 μ mol CO₂ m⁻² s⁻¹ at 30, 60 DAS and at harvest, respectively compared with all other treatments. However, the control treatment recorded significantly lower photosynthetic rate 11.7, 24.5 and 19.3 μ mol CO₂ m⁻² s⁻¹ respectively, at 30, 60 DAS and at harvest Table 2.

Table 2: Influence of seed treatment and foliar spray of iron and zinc on photosynthetic rate at different growth stages of sweet corn

Treatments	Photosynthetic rate ($\mu\text{ mol CO}_2\text{ m}^{-2}\text{ s}^{-1}$)								
	30 DAS			60 DAS			At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T ₁ - Seed treatment with ZnSO ₄ @ 0.5 %	13.9	14.6	14.2	29.1	31.5	30.3	23.4	24.6	24.0
T ₂ - Seed treatment with FeSO ₄ @ 0.5 %	13.1	13.7	13.4	28.3	30.4	29.3	22.5	23.6	23.0
T ₃ - Foliar application of ZnSO ₄ @ 1.0 %	13.7	14.3	14.0	30.4	32.7	31.5	23.3	24.3	23.8
T ₄ - Foliar application of FeSO ₄ @ 1.0 %	12.4	12.8	12.6	26.5	28.1	27.3	20.9	22.0	21.5
T ₅ - Seed treatment with ZnSO ₄ @ 0.5 % + seed treatment with FeSO ₄ @ 0.5 %	14.2	14.7	14.5	30.3	36.0	33.3	25.4	26.7	26.1
T ₆ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ 1.0 %	16.3	16.9	16.6	34.6	37.2	35.9	26.9	28.0	27.4
T ₇ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	14.1	14.7	14.4	31.0	34.6	32.8	23.7	24.9	24.3
T ₈ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 %	15.8	16.4	16.1	33.6	36.5	35.0	26.4	27.7	27.1
T ₉ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	13.9	14.6	14.3	31.5	34.2	34.6	23.9	25.3	24.6
T ₁₀ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	16.9	17.6	17.3	36.2	38.2	37.2	30.9	32.4	31.6
T ₁₁ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0%	16.1	16.8	16.5	35.1	37.7	37.2	26.9	28.0	27.5
T ₁₂ - Seed treatment with ZnSO ₄ @ 0.5 % + seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	17.2	17.8	17.5	37.8	39.4	38.6	31.9	33.5	32.7
T ₁₃ - Control	11.7	12.2	11.9	24.5	27.3	25.9	19.3	20.3	19.8
S. Em (\pm)	0.98	1.23	1.07	1.20	1.48	0.74	0.93	1.94	1.42
C.D. @ 5%	2.87	3.60	3.12	NS	NS	NS	2.71	5.62	4.08

DAS=Days after sowing NS= Non significant

Table 3: Influence of seed treatment and foliar spray of iron and zinc on fresh cob yield (with skin) of sweet corn

Treatments	Fresh cob yield (g plant ⁻¹)			Fresh cob yield (q ha ⁻¹)			% yield increase over control
	2017	2018	Pooled	2017	2018	Pooled	
T ₁ - Seed treatment with ZnSO ₄ @ 0.5 %	195.4	199.3	197.3	150.6	158.7	154.6	2.91
T ₂ - Seed treatment with FeSO ₄ @ 0.5 %	193.6	197.4	195.5	150.3	158.4	154.3	2.72
T ₃ - Foliar application of ZnSO ₄ @ 1.0 %	197.0	200.9	198.9	154.8	170.6	164.5	8.53
T ₄ - Foliar application of FeSO ₄ @ 1.0 %	192.0	195.9	193.9	150.1	158.2	154.1	2.60
T ₅ - Seed treatment with ZnSO ₄ @ 0.5 % + seed treatment with FeSO ₄ @ 0.5 %	199.9	203.9	201.9	158.2	163.1	159.0	5.60
T ₆ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ 1.0 %	198.3	202.3	200.3	160.2	168.7	164.5	8.75
T ₇ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	199.4	203.3	201.4	157.7	166.4	162.1	7.40
T ₈ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 %	200.4	204.4	202.4	160.0	169.0	164.5	8.75
T ₉ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of FeSO ₄ @ 1.0%	202.1	206.1	204.1	157.5	165.7	161.6	7.12
T ₁₀ - Seed treatment with ZnSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	206.0	210.1	208.1	168.2	179.0	173.6	13.54
T ₁₁ - Seed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0%	199.8	203.8	201.8	157.6	169.7	163.9	8.42
T ₁₂ - Seed treatment with ZnSO ₄ @ 0.5 % + feed treatment with FeSO ₄ @ 0.5 % + foliar application of ZnSO ₄ @ 1.0 % + foliar application of FeSO ₄ @ 1.0 %	224.0	228.1	226.0	174.6	184.0	179.3	16.29
T ₁₃ - Control	144.3	147.2	145.7	146.1	154.0	150.1	-
S. Em (\pm)	6.54	7.74	6.98	5.16	5.03	4.08	-
C.D. @ 5%	19.09	22.59	20.37	15.1	14.7	11.9	-

Fresh cob yield per ha of sweet corn as influenced by seed treatment and foliar application with ZnSO₄ and FeSO₄ and their interactions during individual years as well as pooled data presented in (Table 3 and plate 1).

Results noticed that with seed treatment by ZnSO₄ @ 0.5 % + FeSO₄ @ 0.5 % + foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded significantly higher fresh cob yield (174.6, 184.0 and 179.3 q ha⁻¹ during the year 2017, 2018 and pooled analysis data respectively). There was 16.29 per cent yield increase over control followed by (13.54 per cent) compared with all other treatments. Which was on par with seed treatment with ZnSO₄ @ 0.5 % + foliar spray of ZnSO₄ @ 1.0 % + FeSO₄ @ 1.0 % recorded fresh cob yield (168.2, 179.0

and 173.6 q ha⁻¹ during both the year 2017, 2018 and pooled analysis data, respectively), compared with all other treatments. However, the control treatment recorded significantly lower fresh cob yield (146.1, 154.0 and 150.1 q ha⁻¹ was recorded during the year 2017, 2018 and pooled analysis data respectively).

Among the different foliar nutrition and different growth stages with seed treatment and foliar spray with ZnSO₄ and FeSO₄ at 2 stages (pre flowering and post flowering) improved the cob characteristics compared to other treatments (Plate 1). This significant effect of seed treatment and foliar nutrition on cob characteristics, number rows per cob, number of kernels per row, test weight, cob length and girth might be

due to the improved leaf dry matter production, higher photosynthetic rate, chlorophyll content with the application of foliar nutrition at early stages. This may result in improvement of the grain size of the plants.

Fresh cob yield ha^{-1} is an ultimate end product of many yield-contributing components, physiological and morphological processes taking place in plants during growth and development. Fresh cob yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink (grains) and also on plant growth and development during early stages of crop growth. This may be attributed to fulfillment of the demand of the crop by higher assimilation and translocation of photosynthates from source (leaves) to sink (grains) through supply of required micro nutrients by foliar spray.

In the present investigation, it is clear that foliar application of micronutrients increased the grain yield compared to control where only recommended dose of fertilizers was applied. Among the different treatments, seed treatment and foliar spray of ZnSO_4 and FeSO_4 @ 0.5 and 1.0 per cent at different growth stages (pre and post flowering) increased grain yield by 16.29 % (T_{12}) followed by 13.54% (T_{10}) per cent respectively as compared to control T_{13} (no seed treatment and foliar application with ZnSO_4 and FeSO_4). Similar results were noticed by Fakeerappa *et al.* (2017) the seed treatment and foliar application of micronutrients with ZnSO_4 and FeSO_4 1.0 per cent recorded high fresh cob (313.7q ha^{-1}) and fodder yield (616.6 q ha^{-1}) respectively. It might be due to foliar spray of micronutrients (zinc and iron) are essential for several enzymes that regulate the metabolic activities in plants. They involve in auxin production, transformation of carbohydrates and regulation of sugars in plants. Especially zinc and iron involved in synthesis of growth promoting hormones and reproductive process of many plants which are vital role for grain formation. Interaction effect of enriched ZnSO_4 and FeSO_4 @ 20 and 40 DAS was recorded higher yield in sweet corn

Summary and conclusion

- The total dry matter production was recorded significantly higher in (T_{12}) seed treatment with ZnSO_4 @ 0.5 % + FeSO_4 @ 0.5 % and foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 %) as compared to control.
- The leaf area and leaf area index was increased up to 65 DAS and declined thereafter. The total leaf area and leaf area index was found to be greater in the treatment (T_{12}) seed treatment with ZnSO_4 @ 0.5 % + FeSO_4 @ 0.5 % and foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 %) over rest of the treatments.
- The photosynthesis rate progressively increased from 55 to 75 DAS and declined thereafter at harvest. There was considerable variability among the treatment under study for photosynthesis rate. Significantly highest rate of photosynthesis was recorded in (T_{12}) seed treatment with ZnSO_4 @ 0.5 % + FeSO_4 @ 0.5 % and foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 %) followed by (T_{10}) seed treatment with ZnSO_4 @ 0.5 % + foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 %) as compared to control.
- The foliar spray of Zn and Fe influenced the cob length, number of rows per cob, number of seeds per row and cob weight differed significantly among all the treatments. The significantly higher yield and yield

parameters were noticed in (T_{12}) seed treatment with ZnSO_4 @ 0.5 % + FeSO_4 @ 0.5 % and foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 %) than rest of the treatments.

- The fresh cob yield and other yield contributing characters significantly influenced by seed treatment and foliar spray of Zn and Fe among various treatments. The treatment (T_{12}) seed treatment with ZnSO_4 @ 0.5 % + FeSO_4 @ 0.5 % and foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 % recorded higher production of fresh cob weight 179.3 q ha^{-1} (16.29 %) over control followed by (T_{10}) 173.6 q ha^{-1} (13.54 %) as compared to control.

Conclusion

The micro nutrients (Zn and Fe) played a vital role in balancing internal mechanism of plant growth and development by interacting with key metabolic processes. Thereby optimizing the source-sink relationship in the plant and stimulate the translocation of photo-assimilates to the sink *i.e.*, seeds.

Based on the information recorded from the present investigation, it can be concluded that Zn and Fe treatments differ in their response to source sink manipulation and the ultimate aim of this experiment was to increase the grain yield and quality parameters by increasing better seed and filling percentage. Therefore, among the various seed treatment with ZnSO_4 @ 0.5 % + foliar spray of ZnSO_4 @ 1.0 % + FeSO_4 @ 1.0 % *i.e.*, 55 DAS and at 65 DAS were more effective for enhancing the grain yield and quality of sweet corn.

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