



Study the Impact of Vermicompost, Zinc and Iron on the Performance of Hybrid Maize (*Zea mays* L.)

Hanuman Prasad Pandey^{1*}, A. K. Sachan¹, R. K. Pathak¹, U. S. Tiwari¹,
R. K. Pandey¹ and Ritu Pandey²

¹Department of Soil Science and Agricultural Chemistry, C.S. Azad University of Agriculture and Technology, Kanpur, U.P. 208002, India.

²Department of Textile and Clothing, C.S. Azad University of Agriculture and Technology, Kanpur, U.P. 208002, India.

Authors' contributions:

This work was carried out in collaboration among all authors. Authors HPP, AKS, UST participate of conceptualize. Authors HPP, UST performed formal analysis. Author HPP investigate and field work. Authors HPP, RKP, UST and AKC described of methodology. Authors AKS and RP participate of validate. Authors HPP and UST performed Visualization the study. Authors HPP and UST wrote the original draft. Authors RP and RKP wrote, review and edited the final manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i430424

Editor(s):

(1) Dr. Muhammad Shehzad, the University of Poonch Rawalakot, Pakistan.

Reviewers:

(1) Mulue Girmay Gebreslasie, Kyushu University, Japan.

(2) Chiruciu Irina-Adriana, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania .
Complete Peer review History: <http://www.sdiarticle4.com/review-history/67274>

Received 03 February 2021

Accepted 06 April 2021

Published 09 April 2021

Original Research Article

ABSTRACT

A field experiment was conducted on student instructional farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. during *kharif* season 2019 and 2020, the present experiment having 32 treatments replicated thrice in factorial randomized block design on same laid out at same location. Hybrid maize variety Pioneer 3377 was sown at 60 × 20 cm (row×plant) during both the years, Soil application of Zinc (5.0 kg) and Iron (10 kg) along with 2.5 tonne vermicompost ha⁻¹ gave significant increase (except plant population) in plant population m⁻² (9.23 & 9.26), Plant height (195cm & 198 cm), number of cobs plant⁻¹ (1.80 & 1.82), number of cobs m⁻² (18 & 18) over control during 2019 and 2020.

*Corresponding author: E-mail: hanuman16794@gmail.com;

Keywords: Hybrid maize; iron; vermicompost; zinc.

1. INTRODUCTION

Maize (*Zea mays L.*) is one of the most important cereal crop, next to rice and wheat and is used as a food for human and feed for animals. This crop has been developed into a multi dollar business in countries viz. Thailand, Taiwan, Singapore, Malaysia, USA, Canada and Germany, because of its potential as a value added product for export and a good food substitute. Maize is gaining immense importance on account of its potential uses in manufacturing starch, plastics, rayon, adhesive, dye, resins, boot polish etc. and due to this large uses it is rightly called a Miracle crop and also known as 'Queen of cereals' due to its high potential yield. In India maize is primarily a *kharif* crop which is sown just before monsoon starts. This crop usually grows well under temperatures varying from 22^o C to 30^o C, although it can tolerate temperatures as high 35^o C. This crop is affected by frost, so it is grown where at least 5 frost free months are available in the year. It requires at least 50 to 90 mm of rainfall. It is not recommended to cultivate this crop in the areas where rainfall is more than 100 mm. Maize or corn can be cultivated successfully in variety of soils ranging from clay loam to sandy loam to black cotton soil. For better yield of maize, soils should consider good organic matter content having high water holding capacity. Well drained soils with pH of 5.5 to 7.0 are preferred for maize farming. Soil test is recommended to find out deficiency of any nutrient values in the soil, any deficiency can be covered by adding good organic matter or compost at the time of land preparation. Maize crop is usually cultivated in India, during the seasons June-July, September-October, January-February. For seed production, sowing in November-December is suitable since seed maturity will not coincide with rainy season.

Zinc and iron are essential micronutrients for human health and deficiency of these micronutrients leads to malnutrition and diseases. Cereals are staple food in most developing countries of Asia and Africa, where they may contribute as much as 75 percent of the dietary energy. Dietary deficiency of essential micronutrients such as zinc (Zn) and iron (Fe) affects more than two billion people's worldwide mostly pregnant women and children below the age of five year, who suffer from severe acute malnutrition. According to World Health organisation reports 3 billion peoples worldwide

are suffering from micronutrients deficiency and 2.5 billion populations of the world are suffering from Zinc deficiency and 1.6 billion populations suffer from Iron deficiency. Biofortification is the process of creating micronutrient denser staple food crops with increased bioavailable concentrations through agronomic intervention or genetic selection [1].

Biofortification works for twin objective of increasing the concentration of the micronutrients in the grains and simultaneously improving the bioavailability of micronutrients in the grains to alleviate the micronutrient deficiency in human beings and also animals. It is a potential cost-effective and sustainable agronomic way to enrich the micronutrient content of food grains. It is an upcoming strategy for dealing the deficiencies of micronutrients in the developing world.

This organic source of nutrients has been under attention in recent years. Lazcano et al. [2] tested the response of 4 sweet corn hybrids to vermicompost and reported that the treatment significantly improved plant growth, marketable yield and the quality of ears. However, the level of improvement varied with the hybrid. They concluded that the different response of hybrids to the vermicompost represents a complex interaction between organic amendments and plants. In Iran, because of lime originated soils and high pH, the efficiency of chemical fertilizers, especially phosphorus fertilizers and micronutrients containing fertilizers, is very low after adding to soil.

Keeping in view of significance of zinc, iron in mitigating malnutrition and increasing the yield potential of crop, the present investigation has been undertaken at the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India to evaluate the effect of zinc, iron and vermicompost on plant population, plant height and cobs of hybrid maize (*Zea mays L.*).

2. MATERIALS AND METHODS

2.1 Study Site

A field experiment was conducted at field no. 6 Student's Instructional Farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during the *Kharif* season 2019 and

2020. The experimental field was well drained with uniform topography and assured source of water supply through tube well. The farm is situated in the alluvial belt of the indo gangetic plain of central U.P., India.

2.2 Geographical Location

District Kanpur Nagar is situated in subtropical and semi-arid zone and lies between the parallel of 25°26' and 26°58' north latitude and 79°31' and 80°34' east longitude with an elevation of 125.9 m from sea level in the alluvial belt of Indo-gangetic plains of central Uttar Pradesh.

2.3 Soil Status

The soil was moist and well drained and uniform plane topography, water supply through tubewell. The farm is situated in the alluvial belt of the indo gangetic plain of central U.P., India. The soil of the experimental field was alluvial in origin sandy loam in texture slightly alkaline in reaction having pH 8.20 and 8.21, electrical conductivity 0.360 and 0.361 dsm^{-1} , low in organic carbon percentage in soil is 0.422 and 0.423%, and available nitrogen (207 and 207.50 kg ha^{-1}), medium in available phosphorus (13.60 and 13.62 kg ha^{-1}) and available potassium (142 and 142.01 kg ha^{-1}), deficient in sulphur (15.60 and 15.61 kg ha^{-1}) and DTPA-extractable Zinc (0.530 and 0.528 mg kg^{-1}) and Iron (3.76 and 3.74 mg kg^{-1}).

2.4 Experimental Details

The experiment was laid out in factorial randomized block design and replicated thrice. There are three factors comprises different levels of nutrients factor -1st two levels (No vermicompost and 2.5 tonne vermicompost ha^{-1}), factor 2nd four levels of Zinc (No Zn, 2.5 Kg Zn, 5.0 Kg Zn, and 7.5 Kg Zn ha^{-1}), factor 3rd four levels of Iron (No Fe, 5.0 Kg Fe, 10 Kg Fe and 15 Kg Fe ha^{-1}) comprising 32 treatment combinations i.e. $M_0 Z_n_0 Fe_0$ (Control), $M_0 Z_n_0 Fe_1$ (Fe @ 5 kg ha^{-1}), $M_0 Z_n_0 Fe_2$ (Fe @ 10 kg ha^{-1}), $M_0 Z_n_0 Fe_3$ (Fe @ 15 kg ha^{-1}), $M_0 Z_n_1 Fe_0$ (Zn @ 2.5 kg ha^{-1}), $M_0 Z_n_1 Fe_1$ (Zn @ 2.5 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_0 Z_n_1 Fe_2$ (Zn @ 2.5 $\text{kg} + \text{Fe} @ 10 \text{ kg ha}^{-1}$), $M_0 Z_n_1 Fe_3$ (Zn @ 2.5 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$), $M_0 Z_n_2 Fe_0$ (Zn @ 5.0 kg ha^{-1}), $M_0 Z_n_2 Fe_1$ (Zn @ 5.0 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_0 Z_n_2 Fe_2$ (Zn @ 5.0 $\text{kg} + \text{Fe} @ 10 \text{ kg ha}^{-1}$), $M_0 Z_n_2 Fe_3$ (Zn @ 5.0 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$), $M_0 Z_n_3 Fe_0$ (Zn @ 7.5 kg ha^{-1}), $M_0 Z_n_3 Fe_1$ (Zn @ 7.5 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_0 Z_n_3 Fe_2$ (Zn @ 7.5 $\text{kg} + \text{Fe} @ 10 \text{ kg}$

ha^{-1}), $M_0 Z_n_3 Fe_3$ (Zn @ 7.5 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$), $M_1 Z_n_0 Fe_0$ (V.C @ 2.5 tonne ha^{-1}), $M_1 Z_n_0 Fe_1$ (V.C @ 2.5 tonne + Fe @ 5.0 kg ha^{-1}), $M_1 Z_n_0 Fe_2$ (V.C @ 2.5 tonne + Fe @ 10.0 kg ha^{-1}), $M_1 Z_n_0 Fe_3$ (V.C @ 2.5 tonne + Fe @ 15.0 kg ha^{-1}), $M_1 Z_n_1 Fe_0$ (V.C @ 2.5 tonne + Zn @ 2.5 kg ha^{-1}), $M_1 Z_n_1 Fe_1$ (V.C @ 2.5 tonne + Zn @ 2.5 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_1 Z_n_1 Fe_2$ (V.C @ 2.5 tonne + Zn @ 2.5 $\text{kg} + \text{Fe} @ 10 \text{ kg ha}^{-1}$), $M_1 Z_n_1 Fe_3$ (V.C @ 2.5 tonne + Zn @ 2.5 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$), $M_1 Z_n_2 Fe_0$ (V.C @ 2.5 tonne + Zn @ 5.0 kg ha^{-1}), $M_1 Z_n_2 Fe_1$ (V.C @ 2.5 tonne + Zn @ 5.0 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_1 Z_n_2 Fe_2$ (V.C @ 2.5 tonne + Zn @ 5.0 $\text{kg} + \text{Fe} @ 10 \text{ kg ha}^{-1}$), $M_1 Z_n_2 Fe_3$ (V.C @ 2.5 tonne + Zn @ 5.0 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$), $M_1 Z_n_3 Fe_0$ (V.C @ 2.5 tonne + Zn @ 5.0 kg ha^{-1}), $M_1 Z_n_3 Fe_1$ (V.C @ 2.5 tonne + Zn @ 7.5 $\text{kg} + \text{Fe} @ 5 \text{ kg ha}^{-1}$), $M_1 Z_n_3 Fe_2$ (V.C @ 2.5 tonne + Zn @ 7.5 $\text{kg} + \text{Fe} @ 10 \text{ kg ha}^{-1}$), $M_1 Z_n_3 Fe_3$ (V.C @ 2.5 tonne + Zn @ 7.5 $\text{kg} + \text{Fe} @ 15 \text{ kg ha}^{-1}$) in factorial RBD with 3 replications on same location.

2.5 Agronomic Practices

2.5.1 Field Preparation

Field preparation was started after harvesting of *rabi* crop with an object for optimum moisture condition. For proper germination of seed optimum moisture is required in the experimental field. The experimental field was ploughed once with soil turning plough followed by two cross harrowing. After each operation, planking was done to level the field and to obtain the fine tilth. Finally layout was done and plots were demarcated with small sticks and rope with the help of manual labour in each block.

2.5.2 Application of fertilizers

The crop was fertilized as per treatment. The recommended dose of nutrient i.e. N, P, and K was applied @ 150: 80 : 60 kg ha^{-1} respectively.

2.5.3 Time and method of fertilizer

Half does Nitrogen and total phosphorus, potash, zinc and Iron were applied as basal dressing. Remaining dose of nitrogen was applied through top dressing after knee-high stage. Well decompose Vermicompost applied @ 2.5 t ha^{-1} at the time of sowing.

2.5.4 Seed and sowing

20 kg seed ha^{-1} maize variety Pioneer-3377 was used and sowed on 11 July 2019 and 14th July

Table 1. Composition of nutrient applied

S. No.	Nutrient applied	Source	Nutrient content
1	Nitrogen	Urea	46% N
2	Phosphorus	DAP	18% N and 46% P ₂ O ₅
3	Potassium	MOP	60% K ₂ O
4	Zinc	ZnSO ₄ .7H ₂ O	21% Zn and 11-18% S
5	Iron	FeSO ₄ .7H ₂ O	19% Fe and 10.5% S
6.	Organic Manure	Vermicompost	0.50-1.5 % N, 0.10-0.30 % P and .0.15-0.56 % K

2020. Row to row and plant to plant distance remain 60 and 20 respectively. Seeds were sown about 5-6 cm depth.

2.5.5 Intercultural operations

Weeding and hoeing were done with khurpi and hand hoe after germination. All the agronomic practices including plant protection measures etc. were adopted as and when needed. Weeding was started from the first week of August and continued till the harvest of crops in order to save the crop from birds, parrots and enemies in the crop.

2.5.6 Irrigation

Tube-well was the source of irrigation. Irrigation was provided in the crop as and when required.

2.5.7 Harvesting

The crop was harvested at the proper stage of maturity as determined by visual observations. Half meter length on either end of each plot and two borders rose from each side as borders were first removed from the field to avoid error. The crop in the net plot was harvested for calculation on yield data. Produce was tied in bundles and weighted for biomass yield. Threshing of produce of each net crop was done by manually.

2.6 Observations Recorded

The observations were recorded as per the procedure described below. For this purpose 5 plants were selected randomly in each net plot and were tagged with a level for recording various observations on growth and yield parameters, at each sampling interval five plants were uprooted for destructive sampling from two rows on either side between border and net plot earmarked for the purpose.

2.6.1 Plant height (cm)

Plant height was recorded at harvesting stage from the base of the plant to the tip of the last

leaf before tasseling and up to the uppermost visible ligule after tasseling. The observations were taken from the five earmarked plants and expressed in cm.

2.6.2 Plant Population m⁻²

The total number of plants in each meter square area was counted at harvesting stage.

2.6.3 Number of cobs plant⁻¹

Total number of cobs from the individual plant was counted at maturity stage.

2.6.4 Number of cobs m⁻²

Average number of cobs m⁻² was recorded by counting the cobs per plant and counted the number of plants per meter square and mean was recorded.

2.7 Statistical Analysis

The experiment was laid out in factorial randomized block design and replicated thrice. The data on various characters studied during the course of investigation were statistically analyzed for factorial randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were analyzed statistically using the methods advocated by Chandel [3].

3. RESULTS

3.1 Effect of Organic Manure, Zinc and Iron on Plant Population m⁻² of Hybrid Maize

The plant population of hybrid maize was recorded m⁻² before harvesting and the data are presented in table 2, during 2019 and 2020.

3.1.1 Effect of organic manure

The data in respect to plant population/m² were embodied in table 2 did not reach to the level of significance in either of the year indicating that organic manure did not affect the plant population. The highest plant population m⁻² 9.10 and 9.26 m⁻² was recorded with the application of organic manure and 9.03 and 9.19 with no organic during 1st year and 2nd year, respectively.

3.1.2 Effect of zinc

It is visualized from the data given in table 2 that mean plant population m⁻² was increased with the increasing levels of zinc over control during both the years but the increase in plant population was found non-significant during both the years.

Maximum plant population 9.37 and 9.50 m⁻² was recorded during 1st year and 2nd year, respectively. However, application of 7.5 kg zinc ha⁻¹ showed a slight decrease in plant population over 5.0 kg zinc ha⁻¹ during both the years.

3.1.3 Effect of iron

It is apparent from the data given in table 2 revealed nonsignificant variations in plant population m⁻² with the application of discrete levels of Iron over control during both the years. Maximum plant population 9.15 m⁻² and 9.38 m⁻² was recorded with the application of 10 kg Iron ha⁻¹ during 1st year and 2nd year, respectively. It is obvious from the data that plant population/m² was increased with the increasing levels of iron upto 10 kg ha⁻¹ and further non-significant decreased with increasing dose of iron 15 kg ha⁻¹ during both the years.

3.1.4 Interactions Effect

An appraisal of the data given in table 2 revealed that likewise organic manure, zinc and iron, their interactions (Zn × Fe), (Zn × O.M), (Fe × O.M), (Zn × Fe × O.M) also increased the plant population m⁻² but the increase in plant population found non significant during both the years. Maximum plant population 9.60 m⁻² and 9.80 m⁻² was recorded with 5 kg zinc ha⁻¹, 10 kg Iron ha⁻¹ and 2.5 tonne vermicompost ha⁻¹ and minimum at control during 1st year and 2nd year, respectively.

3.2 Effect of Organic Manure, Zinc and Iron on Plant Height (cm) of Hybrid Maize

The data in regard to plant height was recorded before harvest of crops in centimeters during 2019 and 2020 that were presented in Table 3.

3.2.1 Effect of organic manure

It is obvious from the data given in Table 3 that plant height in centimeters increased significantly with the application of organic manure over without organic manure during both the years. Plant height of hybrid maize increased from 174.7 and 177.9 to 183.3 and 187.0 cm with the application of organic manure during experimentation.

3.2.2 Effect of zinc

Effect of different levels of zinc on plant height given in Table 3 showed significant increase in plant height over control during both the years. It is clear from the data that plant height significantly increased upto 5 kg zinc ha⁻¹ and further decreased non-significantly with increasing dose of zinc at 7.5 kg ha⁻¹ during both the years. Maximum mean plant height 183.6 cm and 186.3 cm was recorded with the application of 5 kg zinc ha⁻¹ and minimum 173.2 cm and 178.0 cm at control during 2019 and 2020, respectively.

3.2.3 Effect of Iron

The data given in Table 3 clearly revealed that plant height in centimeters significantly increased with the application of iron upto 10 kg ha⁻¹ over control and further decreased nonsignificantly. Maximum plant height 183.2 cm and 186.7 was recorded with 10 kg iron ha⁻¹ and minimum 175.0 and 176.2 at control during 1st and 2nd year, respectively.

3.2.4 Interaction effect

The effect of interaction between Zn × Fe, Zn × O.M, Fe × O.M, Zn × Fe × O.M on plant height in centimeters given in table 3 showed significant influence in plant height during both the years. Maximum plant height 195.0 cm and 198.0 cm plant⁻¹ was recorded with 2.5 tonne vermicompost, 5 kg zinc and 10 kg Iron ha⁻¹ and minimum at control during both the years.

Table 2. Biofortification effect of organic manure, zinc and iron on plant population m⁻² of hybrid maize

		1 st year					2 nd year				
		Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean
M ₀	Fe ₀	8.50	8.60	9.20	9.10	8.85	8.50	8.70	9.30	9.20	8.92
	Fe ₁	8.60	8.70	9.50	9.40	9.05	8.70	8.80	9.50	9.40	9.10
	Fe ₂	8.80	9.00	9.50	9.40	9.17	8.90	9.10	9.60	9.50	9.27
	Fe ₃	8.70	8.90	9.40	9.30	9.07	8.80	9.00	9.60	9.50	9.22
	Mean	8.65	8.80	9.40	9.30	9.03	8.97	8.90	9.50	9.40	9.19
M ₁	Fe ₀	8.70	8.80	9.00	9.20	8.92	8.80	8.90	9.10	9.00	8.95
	Fe ₁	8.90	9.00	9.30	9.40	9.15	9.00	9.10	9.50	9.40	9.25
	Fe ₂	9.10	9.20	9.60	9.60	9.37	9.20	9.30	9.80	9.70	9.50
	Fe ₃	8.00	9.10	9.50	9.30	8.97	9.10	9.20	9.60	9.50	9.35
	Mean	8.67	9.02	9.35	9.40	9.10	9.02	9.12	9.50	9.40	9.26

Mean of the mean Zn	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₀	Zn ₁	Zn ₂	Zn ₃
		8.66	8.91	9.37	9.35	9.00	9.01	9.50

Mean of the mean Fe	Fe ₀	Fe ₁	Fe ₂	Fe ₃	Fe ₀	Fe ₁	Fe ₂	Fe ₃
		8.88	9.10	9.15	9.02	8.93	9.17	9.38

Factors	1 st year		2 nd year	
	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.253	NS	0.341	NS
Zinc	0.358	NS	0.482	NS
Iron	0.358	NS	0.482	NS
(O.M) X Zinc	0.506	NS	0.681	NS
(O.M) X Iron	0.506	NS	0.681	NS
Zinc X Iron	0.715	NS	0.964	NS
(O.M) X Zinc X Iron	1.012	NS	1.363	NS

3.3 Effect of Organic Manure, Zinc and Iron on Number of Cobs Plant⁻¹ of Hybrid Maize

Data pertaining to the number of cobs plant⁻¹ are presented in Table 4 in years 2019 and 2020.

3.3.1 Effect of organic manure

Data discussed on the number of cobs plant⁻¹ given in Table 4 showed the increase significantly in the number of cobs plant⁻¹ with the application of 2.5 tonne vermicompost ha⁻¹ over no organic treatment during both the years. Maximum number of cobs 1.70 and 1.72 was recorded with 2.5 tonne ha⁻¹ vermicompost and minimum 1.40 and 1.41 at control during 1st and 2nd year, respectively.

3.3.2 Effect of zinc

At a glance over the data given in table 4 revealed significant increase in number of cobs plant⁻¹ at different levels of zinc over control during both the year. Highest number of cobs

1.63 and 1.63 plant⁻¹ was recorded with the application of 5 kg zinc ha⁻¹ and minimum 1.45 and 1.48 plant⁻¹ at control during 1st and 2nd year, respectively. It was also depicted that the number of cobs plant⁻¹ increased significantly upto 5 kg zinc ha⁻¹ and further increased dose of zinc 7.5 kg ha⁻¹ non significant decrease in number of cobs per plant during both the years.

3.3.3 Effect of iron

Data in regard to the number of cobs plant⁻¹ given in the Table 4 showed that application of different levels of iron significantly increased the number of cobs per plant over control during both the year. It is also obvious from the data that the number of cobs per plant increased with the application upto 10 kg Fe ha⁻¹ and further increase of iron dose upto 15 kg ha⁻¹ reduced the number of cobs plant⁻¹ non significantly during both the years. Highest number of cobs 1.60 and 1.63 was recorded with 10 kg Fe ha⁻¹ and minimum 1.47 and 1.48 cobs plant⁻¹ at control during 1st and 2nd year, respectively.

3.3.4 Interaction effect

Data in regard to interaction effects of organic manure, zinc and iron presented in table 4 showed non-significantly increase the number of cobs plant⁻¹ during both the years. Highest number of cobs 1.80 and 1.82 was recorded with the application of 2.5 tonne vermicompost + 5.0 Kg Zinc + 10 kg Iron ha⁻¹ and minimum 1.20 and 1.22 at control (No organic + No Zinc + No iron) during 1st and 2nd year, respectively.

3.4 Effect of Organic Manure, Zinc and Iron on Number of Cobs m⁻² of Hybrid Maize

Data in regard to number of cobs m⁻² were embodied in Table 5 during 2019 and 2020.

3.4.1 Effect of organic manure

Data furnished in table 5 showed significant increase in number of cobs m⁻² with the application of organic manure (2.5 tonne vermicompost ha⁻¹) over no organic during both the years. Mean number of cobs m⁻² 15.81 and 15.87 was recorded with 2.5 tonne vermicompost ha⁻¹ and minimum 13.87 and 13.93 at without organic during 1st and 2nd year, respectively.

3.4.2 Effect of Zinc

Data in regard to number of cobs m⁻² presented in table 5 showed significantly increase in number of cobs m⁻² upto the level of 5 kg Zinc ha⁻¹ during both the years. Maximum increase number of cobs m⁻² was recorded with the application of 5 kg ha⁻¹ over control during both the year, highest number of cobs m⁻² 15.87 and 16.25 was recorded with the application of 5.0 kg zinc ha⁻¹ and minimum 13.50 and 13.50 during 1st and 2nd year, respectively.

3.4.3 Effect of iron

The data depicted in table 5 showed significantly increase in cobs m⁻² with the each incremental doses of iron over control during both the years. No. of cobs m⁻² increased due to each incremental levels of iron during both the years. Application of iron 10 kg ha⁻¹ showed maximum number of cobs m⁻² 15.87 and 15.87 during 1st and 2nd year, respectively.

3.4.4 Interaction effect

Interaction effects of organic manure, zinc and iron given in table 5 showed a non-significant increase in the number of cobs m⁻² during both

the years. Maximum number of cobs m⁻² 18.00 and 18.00 was recorded with application of 2.5 tonne vermicompost + 5.0 kg Zinc + 10 kg Iron ha⁻¹ and minimum 12.00 and 12.00 at control (M₀Zn₀Fe₀) during 1st and 2nd year, respectively.

4. DISCUSSION

Data pertaining to plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² present in Table 2 to 5 clearly revealed that application of different levels of organic manure, zinc and iron significantly over its control except plant population during both the years.

Addition of organic manure as vermicompost showed its superiority to accelerating plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² over without application of organic manure during both the years.

Vermicompost is a rich source of macro and micro nutrient and growth hormones which not only supply essential nutrients to the soil but also in addition improvement in the physical, chemical and biological properties of soil was improved. The improved physicochemical nature and slow release of nutrients over a longer period with use of organic source might be responsible for better crop growth of hybrid maize with the application of vermicompost. These results corroborate the finding of Badiyala and Chopra [4], Khatik et al. [5] and Wailare and Kesarwani [6].

Application of zinc 5.0 Kg ha⁻¹ showed the highest increase in plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² and beyond this level yield attributing parameters slightly declined during both the years.

The significant response of zinc is may be due to its stimulatory effect on most of the physiological and metabolic process of plant and because field soil was low in zinc status and its early supply correct the deficiency and considerably improve the crop growth. The finding of this investigation confirmed the observation of earlier worker Asif et al. [7], Chaudhary et al. [8] and Ehsanullah et al. [9].

Plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² were also influenced with the application of different levels of iron during both the years. Maximum increase in yield attributing parameters was recorded with

application of 10 Kg iron ha⁻¹ and then above 10 Kg ha⁻¹ tends to decline during both the years.

Improvement may be due to the fact that iron is a constituent of the electron transport enzymes like cytochromes and ferredoxin are actively involved in photosynthesis and mitochondrial respiration.It

is also a constituent of the enzyme catalase and peroxidase which catalyse the breakdown of H₂O₂ into H₂O and O₂, preventing H₂O₂ toxicity all the physiological process proved instrumental in increasing yield attributing parameters with application of iron. Improvement in yield attributing parameters with the application of iron

Table 3. Biofortification effect of organic manure, zinc and iron on Plant height (cm) of hybrid maize

		1 st year					2 nd year				
		Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean
M ₀	Fe ₀	168.0	169.0	171.0	170.0	169.5	171.0	173.0	174.0	173.0	172.7
	Fe ₁	170.0	173.0	179.0	176.0	174.5	173.0	175.0	182.0	181.0	177.7
	Fe ₂	173.0	176.0	182.0	181.0	178.0	178.0	180.0	185.0	183.0	181.5
	Fe ₃	172.0	175.0	181.0	180.0	177.0	176.0	178.0	182.0	183.0	179.7
	Mean	170.7	173.2	178.2	176.7	174.7	174.5	176.5	180.7	180.0	177.9
M ₁	Fe ₀	172.0	175.0	178.0	177.0	175.5	177.0	179.0	182.0	181.0	179.7
	Fe ₁	174.0	177.0	189.0	188.0	182.0	179.0	183.0	192.0	191.0	186.2
	Fe ₂	179.0	186.0	195.0	194.0	188.5	186.0	189.0	198.0	195.0	192.0
	Fe ₃	178.0	185.0	194.0	193.0	187.5	184.0	186.0	196.0	194.0	190.0
	Mean	175.7	180.7	189.0	188.0	183.3	181.5	184.2	192.0	190.2	187.0
Mean of the mean Zn	Zn ₀	Zn ₁	Zn ₂	Zn ₃		Zn ₀	Zn ₁	Zn ₂	Zn ₃		
		173.2	177.0	183.6	182.3		178.0	180.2	186.3	185.1	
Mean of the mean Fe	Fe ₀	Fe ₁	Fe ₂	Fe ₃		Fe ₀	Fe ₁	Fe ₂	Fe ₃		
		172.5	178.2	183.2	182.2		176.2	182.0	186.7	183.9	

Factors	1 st year		2 nd year	
	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.478	1.351	0.480	1.357
Zinc	0.676	1.910	0.679	1.919
Iron	0.676	1.910	0.679	1.919
(O.M) X Zinc	0.956	2.702	0.960	2.713
(O.M) X Iron	0.956	2.712	0.960	1.724
Zinc X Iron	1.351	3.821	1.357	3.837
(O.M) X Zinc X Iron	1.911	5.404	1.919	4.892

Table 4. Biofortification effect of organic manure, zinc and iron on number of cobs plant⁻¹ of hybrid maize

		1 st year					2 nd year				
		Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean
M ₀	Fe ₀	1.20	1.25	1.40	1.35	1.30	1.22	1.30	1.35	1.34	1.30
	Fe ₁	1.25	1.35	1.55	1.50	1.41	1.28	1.34	1.50	1.48	1.40
	Fe ₂	1.30	1.45	1.60	1.55	1.47	1.38	1.48	1.60	1.55	1.50
	Fe ₃	1.30	1.45	1.50	1.45	1.42	1.36	1.42	1.54	1.52	1.46
	Mean	1.26	1.37	1.51	1.46	1.40	1.31	1.38	1.49	1.47	1.41
M ₁	Fe ₀	1.60	1.65	1.69	1.68	1.65	1.62	1.67	1.71	1.70	1.67
	Fe ₁	1.64	1.68	1.74	1.72	1.69	1.66	1.70	1.76	1.74	1.71
	Fe ₂	1.66	1.72	1.80	1.76	1.73	1.68	1.74	1.82	1.81	1.76
	Fe ₃	1.65	1.71	1.79	1.78	1.73	1.67	1.73	1.81	1.79	1.75
	Mean	1.63	1.69	1.75	1.73	1.70	1.65	1.71	1.77	1.76	1.72

Mean of the mean Zn	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₀	Zn ₁	Zn ₂	Zn ₃
	1.45	1.53	1.63	1.59	1.48	1.54	1.63	1.61
Mean of the mean Fe	Fe ₀	Fe ₁	Fe ₂	Fe ₃	Fe ₀	Fe ₁	Fe ₂	Fe ₃
	1.47	1.55	1.60	1.57	1.48	1.55	1.63	1.60

Factors	1 st year		2 nd year	
	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.033	0.092	0.031	0.087
Zinc	0.046	0.131	0.043	0.124
Iron	0.046	0.134	0.043	0.121
(O.M) X Zinc	0.065	NS	0.061	NS
(O.M) X Iron	0.065	NS	0.061	NS
Zinc X Iron	0.092	NS	0.087	NS
(O.M) X Zinc X Iron	0.131	NS	0.123	NS

Table 5. Biofortification effect of organic manure, zinc and iron on number of cobs/m² of hybrid maize

		1 st year					2 nd year				
		Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Mean
M ₀	Fe ₀	12.00	13.00	14.00	13.00	13.00	12.00	13.00	15.00	14.00	13.50
	Fe ₁	12.00	14.00	15.00	14.00	13.75	12.00	14.00	15.00	13.00	13.50
	Fe ₂	13.00	15.00	16.00	15.00	14.75	13.00	15.00	16.00	15.00	14.75
	Fe ₃	13.00	14.00	15.00	14.00	14.00	13.00	14.00	15.00	14.00	14.00
	Mean	12.50	14.00	15.00	14.00	13.87	12.50	14.00	15.25	14.00	13.93
M ₁	Fe ₀	14.00	14.00	15.00	14.00	14.25	14.00	14.00	16.00	15.00	14.75
	Fe ₁	14.00	15.00	17.00	16.00	15.50	14.00	15.00	18.00	17.00	16.00
	Fe ₂	15.00	18.00	18.00	17.00	17.00	15.00	18.00	18.00	17.00	17.00
	Fe ₃	15.00	17.00	17.00	16.00	16.25	15.00	17.00	17.00	16.00	16.25
	Mean	14.50	16.00	16.75	15.75	15.81	14.50	16.00	17.25	16.25	15.87

Mean of the mean Zn	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₀	Zn ₁	Zn ₂	Zn ₃
	13.50	15.00	15.87	14.87	13.50	15.00	16.25	15.12

Mean of the mean Fe	Fe ₀	Fe ₁	Fe ₂	Fe ₃	Fe ₀	Fe ₁	Fe ₂	Fe ₃
	13.62	14.62	15.87	15.12	14.12	14.75	15.80	15.12

Factors	1 st year		2 nd year	
	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.352	0.994	0.350	0.990
Zinc	0.497	1.406	0.495	1.400
Iron	0.497	1.406	0.495	1.412
(O.M) X Zinc	0.703	NS	0.700	NS
(O.M) X Iron	0.703	NS	0.700	NS
Zinc X Iron	0.994	NS	0.990	NS
(O.M) X Zinc X Iron	0.352	0.994	1.400	NS

was also supported to the finding of Al-Issawai and Mahdi [10], Ghasemian et al. [11] and Kadam et al. [12].

Likewise organic manure, zinc, iron and their interaction also accelerated yield attributing

parameters during both the years. Combined application of 2.5 tonne vermicompost, 5.0 Kg zinc and 10 Kg iron ha⁻¹ showed higher increase in plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² over M₀Zn₀Fe₀ treatment during both the years is

might be due to balance nutrition of zinc and iron beside supplementing other essential plant nutrients and improved available nutrients to crop for longer period caused better results. These findings are in agreement with those of Solanki et al. [13], Pingoliya et al.[14] and Parasuraman et al. [15].

5. CONCLUSION

The experimental results indicated that, the integrated use of 2.5 tonne vermicompost with 5.0 kg and 10 kg iron ha⁻¹ gave in soil ensures highest growth and development of maize crop viz. plant population m⁻², Plant height (cm), number of cobs plant⁻¹, number of cobs m⁻² as comparison to all the treatments during 2019 and 2020.

ACKNOWLEDGEMENT

The authors duly acknowledge the support of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, and providing funds through CAAST-NC scheme of ICAR, New Delhi.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cakmak I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? *Plant and Soil*. 2008;302(1);1-17.
2. Lazcano C, Revilla P, Malvar RA, Dominguez J. Yield and fruit quality of four sweet corn hybrids (*Zea mays*) under conventional and integrated fertilization with vermicompost. *Journal of the Science of Food and Agriculture*. 2011;91:1244-1253.
3. Chandel SRS. A handbook of agriculture statistics, Achal Prakashan mandir, Pandu Nagar, Kanpur. 1990;843-853.
4. Badiyala D, Chopra P. Effect of zinc and FYM on productivity and nutrient availability in maize (*Zea mays*) - linseed (*Linum usitatissimum*) cropping sequence. *Indian Journal of Agronomy*. 2011;56(2): 88-91.
5. Khatik R, Singh DP, Jain HK, Yadav KK, Chaudhary RS, Bunker RN. Effect of vermicompost and zinc application on growth and yield attribute of maize crop. *Int.J.Curr.Microbiol.App. Sci*. 2019;8(8): 3077-3082.
6. Wailare AT, Kesarwani A. Effect of integrated nutrient management in growth and yield parameters of maize (*Zea mays* L.) as well as soil physico - chemical properties. *Biomedical Journal of Scientific & Technical Research*. 2017;1(2):1-6.
7. Asif M, Saleem MF, Anjum SA, Wahid MA, Bilal MF. Effect of nitrogen and zinc sulphate on growth and yield of maize (*Zea mays* L.). *Journal of Agricultural Research*. 2013;51(4):455 – 464.
8. Chaudhary DG, Parmar JK, Chaudhary S. R, Shinde RD. Influence of potassium, zinc and FYM on growth, yield, nutrient contents and uptake by forage maize (*Zea mays* L.) grown in loamy sand soil. *International Journal of Chemical Studies*. 2017;5 (2):39-42.
9. Ehsanullah, Tariq A, Randhawa AM, Anjum AS, Nadeem M, Naeem M. Exploring the role of zinc in maize (*Zea mays* L.) through soil and foliar application. *University Journal of Agricultural Research*. 2015;3(3):69 - 75.
10. Al-Issawi MH, Mahdi OH. Foliar application of iron and potassium enhances growth and yield of mung bean (*Vigna radiata* L.). *Diyala Agric Sci J*.2016;8:43-55.
11. Ghasemian V, Ghalavand A, Soroosh Zadeh A, Pirzad A. The effect of iron, zinc and manganese on quality and quantity of soybean seed. *J Phytol*.2010;2:73-79.
12. Kadam SR, Bhale VM, Kubade KJ, Deshmukh MR. Effect of Zinc and Iron Fortification on Growth and Developmental Stages of Upland Irrigated Rice (*Oryza sativa* L.) Cultivars. *Int. J. Curr. Microbiol. App. Sci*. 2018;7(1):1950-1958
13. Solanki D, Patel SB, Patel DK, Chaudhary S. Effect of iron and zinc enriched organics on growth, yield attributes and yield of wheat in loamy Sand. *Int J Curr Microbiol App Sci*. 2020;9(6):242-247.
14. Pingoliya KK, Mathur AK, Dotaniya ML, Jajoria DK, Narolia GP. Effect of phosphorus and iron levels on growth and yield attributes of chickpea (*Cicerarietinum* L.) under agro climatic zone a of Rajasthan, India. *Legume Res*. 2014; 37:537-41.
15. Parasuraman P, Prakash R, Chandrasekaran B. Response of hybrid

maize (*Zea mays* L.) to soil and foliar
application of nutrients. Madras

Agricultural Journal. 2008;95(1-6):202–
204.

© 2021 Pandey et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<http://www.sdiarticle4.com/review-history/67274>