The Pharma Innovation

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Evaluate the response of different levels of zinc, iron and organic manure on yield attributing parameters of hybrid maize (*Zea mays* L.)

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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 maximum increase in yield attributing characterstics viz. cob length (19.25cm & 19.80 cm), cob girth (13.60cm & 13.95 cm), number of grain row cob^{-1}(17 & 17), number of grain row^{-1} (33 & 35), test weight (24.10 gm & 24.30 gm) in comparison to all the treatments during 2019 and 2020.

1. Introduction

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat in the world's agricultural economy, both as a food for human and as feed for livestock. It is known as ''*queen of cereals*'' because of its maximum yield potential among the cereals and expanded use in different agro-industries. It is recognized as a leading commercial crop of great economic value. Maize is used as a staple food for humans, feed for livestock and raw material for industry. It has high nutritional value as it contains about 62.3% starch, 10.4 % protein, 4.6% oil, 1.8% fibre, 4.3% sugar, 10.4% aluminizes and 1.3% ash. Maize protein "Zein" is rich source of trytophane and lysine, the two most essential amino acids. Being highly cross pollinated, maize has become highly polymorphic through the course of natural and domesticated evolution and thus contain enormous genetic variability. Maize is also capable against salinity stress (Akbari et al. 2009). In the USA 75% of the starch produced by the wet milling is used in hydrolyzed products, mainly sweeteners; and the rest is as industrial starch. Various alcoholic beverages and industrial products are produced by maize distillery and fermentation industries. The fermentation of maize starches has made it an important feedstock for ethanol which is being used as a biofuel; a mixture of 10% ethanol and 90% gasoline is called 'gasohol'.

Exploitive agriculture involving modern production technology with the introduction of high yielding sweet corn, coupled with use of high analysis fertilizers lead to deficiency of micronutrients, particularly zinc and iron.In future, it may emerge as an alarming situation in the intensively cultivated areas. About half of the world's population suffers from micronutrient malnutrition, including iron, zinc and iodine which are mainly associated with low dietary intake of micronutrients in diets with less diversity of food. Recent reports indicate that nearly 5,00,000 children under 5 years of age die annually because of Zn and Fe deficiencies. Iron and zinc are essential minerals for humans. Deficiencies in both contribute to severe cases of malnutrition.

Among the micronutrients, zinc deficiency is most common in the world (Alloway, 2004) [2]. Worldwide incidence of zinc deficiency in soils is becoming more important due to its impact on human health (Singh *et al*., 2005) [20]. Zinc deficiency in Indian soils is expected to increase from 42 percent in 1970 to 63 per cent in 2025 due to continuous depletion of soil fertility. Zinc plays an important role in chlorophyll formation, carbohydrate metabolism and protein synthesis.

Iron is one of the micronutrients for normal plant growth. Although Fe is the fourth most abundant element in the earth's crust, it is the third most limiting nutrient for plant growth (Zuo and Zhang, 2011). Fe is involved in many important compounds and physiological processes in plants. It is required for the activity of ALA synthase, which catalyzes the first identified step of the tetrapyr role biosynthetic pathway leading to chlorophyll formation and therefore, it is indirectly responsible for much of the green color of growing plants. Iron plays an important role in electron transfer in photosynthesis, respiration, nitrogen fixation as well as in DNA synthesis. Khurana *et al*. (2002) [10] observed spectacular response of maize to zinc and iron application. Balanced and optimum use of fertilizers plays a vital role in increasing the yield of cereals (Asghar *et al*., 2010) [4]. Supplementation of micronutrients through foliar results in better nutrient balance in plants (Patra *et al*., 1995) [14]. Proper method of nutrient application can be another approach for better uptake and utilization of Zn. Amongst the different methods; the foliar spray of micronutrients is efficient for enhancement of crop productivity (Savithri *et al.,* 1999) [18]. The process of adding vitamins or minerals to the crops in order to improve their overall nutrient content is called as fortification. It is two types, genetic biofortification and agronomic fortification. Enhancing of a particular nutrient by addition of fertilizer to soil or to foliage in appropriate form, time and growth stages of the crop is known as agronomic fortification which is a simple and rapid solution to the problem. Reddy *et al.* (2019) [16] observed that 150 kg nitrogen ha^{-1} + 25 kg $ZnSo_4$ resulted in significant increase the yield, yield attributes like cob length, cob weight, cob $plant^{-1}$, number of grain rows cob^{-1}, test weight and harvest index ha^{-1} was significantly superior to the plots viz. zero application of both nitrogen and zinc. Maralian Habib (2012) [11] reported that higher seed yield was obtained by using Zn, Fe + Zn chelate and urea fertilizer. 1000 seed weight and ear length increased by foliar application of fertilizer when compared with the control.Foliar application of Zn, increased seed yield, 1000 seed weight, ear length, Zn, Cu and Mn concentration. Keeping in view the significance of zinc, iron and vermicompost in yield attributing parameters of hybrid maize present investigation was undertaken at the C.S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh.

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 $kgha^{-1}$), 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.

Table 1: Treatment details

S. No.	Treatments	
1	$(M_0 Zn_0 Fe_0)$	Control
2	$(M_0 Zn_0 Fe_1)$	Fe @ 5 kg ha^{-1}
3	$(M_0 Zn_0 Fe_2)$	Fe @ 10 kg ha^{-1}
4	$(M_0 Zn_0 Fe_3)$	Fe @ 15 kg ha^{-1}
5	$(M_0 Zn_1 Fe_0)$	Zn @ 2.5 kg ha^{-1}
6	$(M_0 Zn_1 Fe_1)$	Zn @ 2.5 kg ha^{-1} + Fe @ 5 kg ha^{-1}
7	$(M_0 Zn_1 Fe_2)$	Zn @ 2.5 kg ha^{-1} + Fe @ 10 kg ha^{-1}
8	$(M_0 Zn_1 Fe_3)$	Zn @ 2.5 kg ha^{-1} + Fe @ 15 kg ha^{-1}
9	$(M_0 Zn_2 Fe_0)$	Zn @ 5.0 kg ha^{-1}
10	$(M_0 Zn_2 Fe_1)$	Zn @ 5.0 kg ha^{-1} + Fe @ 5 kg ha^{-1}
11	$(M_0 Zn_2 Fe_2)$	Zn @ 5.0 kg ha^{-1} + Fe @ 10 kg ha^{-1}
12	$(M_0 Zn_2 Fe_3)$	Zn @ 5.0 kg ha^{-1} + Fe @ 15 kg ha^{-1}
13	$(M_0 Zn_3 Fe_0)$	Zn @ 7.5 kg ha^{-1}
14	$(M_0 Zn_3 Fe_1)$	Zn @ 7.5 kg ha^{-1} + Fe @ 5 kg ha^{-1}
15	$(M_0 Zn_3 Fe_2)$	Zn @ 7.5 kg ha^{-1} + Fe @ 10 kg ha^{-1}
16	$(M_0 Zn_3 Fe_3)$	Zn @ 7.5 kg ha^{-1} + Fe @ 15 kg ha^{-1}
17	$(M_1 Zn_0 Fe_0)$	V.C @ 2.5 ton ha^{-1}
18	$(M_1 Zn_0 Fe_1)$	V.C @ 2.5 ton ha^{-1} + Fe @ 5.0 kg ha^{-1}
19	$(M_1 Zn_0 Fe_2)$	V.C @ 2.5 ton ha^{-1} + Fe @ 10.0 kg ha^{-1}
20	$(M_1 Zn_0 Fe_3)$	V.C @ 2.5 ton ha^{-1} + Fe @ 15.0 kg ha^{-1}

21	(M_1 Zn_1 Fe_0)	V.C @ 2.5 ton ha^{-1}+ Zn @ 2.5 kg ha^{-1}
22	(M_1 Zn_1 Fe_1)	V.C @ 2.5 ton ha^{-1}+ Zn @ 2.5 kg ha^{-1}+ Fe @ 5 kg ha^{-1}
23	(M_1 Zn_1 Fe_2)	V.C @ 2.5 ton ha^{-1}+ Zn @ 2.5 kg ha^{-1}+ Fe @ 10 kg ha^{-1}
24	(M_1 Zn_1 Fe_3)	V.C @ 2.5 ton ha^{-1}+ Zn @ 2.5 kg ha^{-1}+ Fe @ 15kg ha^{-1}
25	(M_1 Zn_2 Fe_0)	V.C @ 2.5 ton ha^{-1}+ Zn @ 5.0 kg ha^{-1}
26	(M_1 Zn_2 Fe_1)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}+ Fe @ 5 kg ha^{-1}
27	(M_1 Zn_2 Fe_2)	V.C @ 2.5 ton ha^{-1}+ Zn @ 5.0 kg ha^{-1}+ Fe @ 10 kg ha^{-1}
28	(M_1 Zn_2 Fe_3)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}+ Fe @ 15kg ha^{-1}
29	(M_1 Zn_3 Fe_0)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}
30	(M_1 Zn_3 Fe_1)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}+ Fe @ 5 kg ha^{-1}
31	(M_1 Zn_3 Fe_2)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}+ Fe @ 10 kg ha^{-1}
32	(M_1 Zn_3 Fe_3)	V.C @ 2.5 ton ha^{-1} + Zn @ 5.0 kg ha^{-1}+ Fe @ 15 kg ha^{-1}

* Recommended dose of NPK @ 150:80:60 was applied uniformly to each treatment.

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.

Table 2: Composition of nutrient applied

S. No.	Nutrient applied	Source	Nutrient content
1	Nitrogen	Urea	46% N
2	Phosphorus	DAP	18% N and 46% P_2O_5
3	Potassium	MOP	60% K_2O
4	Zinc	$ZnSO_4.7H_2O$	21% Zn and 11-18% S
5	Iron	$FeSO_4.7H_2O$	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

2.5.3 Time and method of fertilizer: Half does N_2 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 11July 2019 and 14th July 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. Watching 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 Length of the cob (cm): for recording the cob length five plants were taken and the length of cob was measured from base to tip of each cob. The average of five cobs was reported in centimeters.

2.6.2 Girth of the cob (cm): for recording the cob girth five plants were taken and the girth were measured at bottom, middle and tip of cob and the mean was expressed as cob girth in centimetres.

2.6.3 Number of grain rows per cob: for recording the number of grains per cob five plants were taken and counted the number of grain per cob and mean were recorded.

2.6.4 Number of grains per row: The number of grains per row from selected five plants was counted and mean was recorded.

2.6.5 Test weight (gram): The random sample was drawn from grains of each net plot, thereafter 1000 grains were counted and weighed and reported as 1000 grain weight in gram.

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 (1990) [6].

3. Results
3.1 Effect of organic manure, zinc and iron on cob length (cm) of hybrid maize
Data in regard to effect of organic manure, zinc, iron and their

interactions on cob length (cm) of hybrid maize was depicted in table 3 during 2019 and 2020.

3.1.1 Effect of organic manure
Data in respect to the effect of organic manure on cob length (cm) given in the table 3 revealed significantly increase in cob length over no organic during both the years. Increase in cob length of hybrid maize was recorded maximum 17.39 and 17.79 with the application of 2.5 tonne vermicompost and minimum 16.91 and 17.64 with no organic application during 1st and 2nd year, respectively.

3.1.2 Effect of Zinc
At a glance over the data given in table 3 It is visualize from the data that cob length (cm) of hybrid maize was increased significantly at all the levels of zinc over control during both the years. Maximum increase in cob length was observed with the application of 5 kg zinc ha^{-1} during both the years.

3.1.3 Effect of Iron
Data depicted in the table 3 revealed that likewise zinc, application of different levels of iron also enhances the length of cob with the increasing levels of iron significantly during both the years. Maximum cob length 17.86 and 18.45 cm was noted with the application of 10 kg Fe ha^{-1} and minimum 15.88 and 16.33 cm at control during 1st and 2nd year, respectively.

3.1.4 Effect of interactions
Interaction effect of O.M X Zn, O.M X Fe, Zn X Fe, O.M X Zn X Fe depicted in table 3 influenced linearly and non significantly cob length of hybrid maize during both the years. Maximum length of cob of hybrid maize was recorded 19.25 and 19.80 with the application of 2.5 tonne vermicompost + 5 kg Zn + 10 Kg Fe ha^{-1} and minimum 14.25 and 14.78 at control ($M_0Fe_0Zn_0$) during 1st and 2nd year, respectively.

Table 3: Effect of organic manure, zinc and iron on cob length (cm) of hybrid maize.

		1st year					2nd year				
		Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
M_0	Fe_0	14.25	15.52	16.52	16.24	15.63	14.78	16.06	17.09	17.01	16.23
	Fe_1	15.24	16.60	17.76	17.46	16.76	15.81	17.18	18.38	18.30	17.41
	Fe_2	16.00	17.43	18.70	18.50	17.65	16.60	18.03	19.35	19.20	18.29
	Fe_3	16.00	17.32	18.65	18.40	17.59	16.40	17.90	19.20	19.00	18.12
	Mean	15.37	16.71	17.90	17.65	16.91	15.89	17.29	18.50	18.37	17.64
M_1	Fe_0	14.70	15.98	17.00	16.90	16.14	15.01	16.32	17.31	17.12	16.44
	Fe_1	15.72	17.09	18.28	18.20	17.32	16.06	17.46	18.61	18.40	17.63
	Fe_2	16.50	17.44	19.25	19.10	18.07	16.86	18.33	19.80	19.50	18.62
	Fe_3	16.30	17.80	19.10	19.00	18.05	16.70	18.25	19.70	19.30	18.48
	Mean	15.80	17.07	18.40	18.30	17.39	16.15	17.59	18.85	18.58	17.79

	Zn_0	Zn_1	Zn_2	Zn_3	Zn_0	Zn_1	Zn_2	Zn_3
Mean of the mean Zn	15.58	16.89	18.15	17.97	16.02	17.69	18.68	18.47

	Fe_0	Fe_1	Fe_2	Fe_3	Fe_0	Fe_1	Fe_2	Fe_3
Mean of the mean Fe	15.88	17.04	17.86	17.82	16.33	17.52	18.45	18.30

Factors	1st year		2nd year	
	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.271	0.769	0.303	0.924
Zinc	0.383	1.083	0.428	1.210
Iron	0.383	1.083	0.428	1.210
(O.M) X Zinc	0.542	NS	0.605	NS
(O.M) X Iron	0.542	NS	0.605	NS
Zinc X Iron	0.766	NS	0.856	NS
(O.M) X Zinc X Iron	1.083	NS	1.210	NS

3.2 Effect of organic manure, zinc and iron on cob girth (cm) of hybrid maize
The effect of organic manure, zinc, iron and their interactions on cob girth is presented in table 4 for both the years.

3.2.1 Effect of organic manure
It is visualized from the data embodied in the table 4 show slight increase in cob girth of hybrid maize with the application of 2.5 tonne vermicompost ha^{-1} over control (no organic) but the increase in cob girth was found non-significant during both the years. Maximum cob girth 12.66 and 13.15 cm was noted with 2.5 tonne vermicompost ha^{-1} and minimum 12.30 and 12.51 cm at control (no organic).

3.2.2 Effect of zinc
It is obvious from the data given in the table 4 that it shows narrower and non-significant variation with the application of different rates of zinc during both the years. Maximum cob girth 12.92 and 13.26 cm was noted with the application of 5 kg zinc ha^{-1} which was slightly decreased with the increasing levels of zinc upto 7.5 kg ha^{-1} during both the years.

3.2.3 Effect of iron
It is apparent from the data that cob girth varied from 11.93 to 12.70 and 12.33 to 13.18 cm with the use of different rates of iron maximum at 10 kg Fe ha^{-1} and minimum at control during 1st and 2nd year, respectively. It was also observed that cob girth decreased nonsignificantly over the application of 10 kg iron ha^{-1} during both the years.

3.2.4 Effect of interactions

Likewise, individual effects of Organic manure, Zinc, Iron and their interaction also accelerate cob girth when the increasing rate of cob girth was found non-significant during both the years. Maximum cob girth 13.60 and 13.95 cm was recorded with the application of 2.5 tonne vermicompost + 5 kg Zn + 10 Kg Fe ha^{-1} and minimum 11.50 and 11.65 at control (No organic, No Zinc, No Iron) during 1st and 2nd year, respectively. (Table 4)

Table 4: Effect of organic manure, zinc and iron on cob girth (cm) of hybrid maize

		1st year					2nd year				
		Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
M_0	Fe_0	11.50	11.70	11.95	11.70	11.71	11.65	11.95	12.10	12.00	11.92
	Fe_1	11.80	11.90	12.60	12.50	12.20	12.00	12.20	13.00	12.80	12.50
	Fe_2	12.00	12.50	13.25	13.10	12.71	12.35	12.65	13.40	13.30	12.92
	Fe_3	12.00	12.20	13.15	13.00	12.58	12.10	12.45	13.20	13.15	12.72
	Mean	11.82	12.07	12.73	12.57	12.30	12.02	12.31	12.92	12.81	12.51
M_1	Fe_0	11.90	12.10	12.35	12.25	12.15	12.20	12.60	13.20	13.00	12.75
	Fe_1	12.25	12.45	13.00	12.95	12.66	12.65	12.90	13.45	13.30	13.07
	Fe_2	12.40	12.60	13.60	13.45	13.01	12.85	13.20	13.95	13.80	13.45
	Fe_3	12.25	12.35	13.50	13.20	12.82	12.65	13.20	13.80	13.70	13.33
	Mean	12.20	12.37	13.11	12.96	12.66	12.58	12.97	13.60	13.45	13.15

	Zn_0	Zn_1	Zn_2	Zn_3	Zn_0	Zn_1	Zn_2	Zn_3
Mean of the mean Zn	12.01	12.22	12.92	12.76	12.30	12.64	13.26	13.13

	Fe_0	Fe_1	Fe_2	Fe_3	Fe_0	Fe_1	Fe_2	Fe_3
Mean of the mean Fe	11.93	12.43	12.86	12.70	12.33	12.78	13.18	13.03

	1st year		2nd year	
Factors	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.283	NS	0.309	NS
Zinc	0.400	NS	0.437	NS
Iron	0.400	NS	0.437	NS
(O.M) X Zinc	0.565	NS	0.619	NS
(O.M) X Iron	0.565	NS	0.619	NS
Zinc X Iron	0.799	NS	0.875	NS
(O.M) X Zinc X Iron	1.130	NS	1.237	NS

3.3 Effect of organic manure, zinc and iron on number of grain row cob^{-1} of hybrid maize.

The data concern the individual effect of organic manure, Zinc, Iron and their interactions on number of grain row cob^{-1} in table 5 during 2019 and 2020.

3.3.1 Effect of organic manure

It is clear from the data in the given table 5 revealed that application of 2.5 tonne vermicompost ha^{-1} show significantly positive effect on number of grain row cob^{-1} during both the years. Number of grain rows cob^{-1} was observed 14.00 and 14.00 cob^{-1} with the application of vermicompost ha^{-1} over the control during 1st and 2nd year, respectively.

3.3.2 Effect of Zinc

The data furnished in the table 5 revealed that Number of grain row cob^{-1} accelerated significantly with different levels of zinc application over control during both the years. Maximum increase from 11.00 to 14.50 and 11.00 to 14.50 was recorded over control with 5.0 kg Zinc ha^{-1} and during both the years.

3.3.3 Effect of Iron

Data in regard to effect of different levels of iron on number of grain row cob^{-1} given in table 5 revealed significant increases with the incremental dose of Iron upto 10 kg ha^{-1} during both the years. Maximum Number of grain row cob^{-1} 14.00 and 14.25 was noted with the application of 10 kg Fe ha^{-1} and minimum 11.00 and 11.00 at Fe0 during 1st and 2nd year, respectively.

3.3.4 Effect of interactions

A critical observation of the data presented in table 5 revealed that unlike individual effects of organic manure, zinc, iron and their interaction showed nonsignificant increase in number of grain row cob^{-1} during both the year. Number of grain row cob^{-1} varied from 9.0 to 17.0 minimum at control ($M_0Zn_0Fe_0$) and maximum at 2.5 tonne vermicompost and 5 kg Zinc and 10 kg Iron ha^{-1} during 1st and 2nd year, respectively.

Table 5: Effect of organic manure, zinc and iron on number of grain row cob^{-1} of hybrid maize

		1st year					2nd year				
		Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
M_0	Fe_0	9.00	9.00	11.00	11.00	10.00	9.00	9.00	11.00	11.00	10.00
	Fe_1	9.00	11.00	13.00	11.00	11.00	9.00	11.00	13.00	13.00	11.50
	Fe_2	11.00	11.00	15.00	13.00	12.50	11.00	13.00	15.00	13.00	13.00
	Fe_3	11.00	11.00	15.00	11.00	12.00	11.00	11.00	15.00	11.00	12.00
	Mean	10.00	10.50	13.50	11.50	11.37	10.00	11.50	13.00	11.50	11.62
M_1	Fe_0	11.00	11.00	13.00	13.00	12.00	11.00	11.00	13.00	13.00	12.00

	Zn0	Zn1	Zn2	Zn3	Mean	Zn0	Zn1	Zn2	Zn3	Mean
Fe1	11.00	13.00	15.00	15.00	13.50	11.00	13.00	15.00	15.00	13.50
Fe2	13.00	15.00	17.00	17.00	15.50	13.00	15.00	17.00	17.00	15.50
Fe3	13.00	15.00	17.00	15.00	15.00	13.00	15.00	17.00	15.00	15.00
Mean	12.00	13.50	15.50	15.00	14.000	12.00	13.00	15.50	15.00	14.00

Mean of the mean Zn	Zn0	Zn1	Zn2	Zn3	Zn0	Zn1	Zn2	Zn3
	11.00	12.00	14.50	13.25	11.00	12.25	14.50	13.25

Mean of the mean Fe	Fe0	Fe1	Fe2	Fe3	Fe0	Fe1	Fe2	Fe3
	11.00	12.25	14.00	13.50	11.00	12.25	14.25	13.50

	1st year		2nd year	
Factors	SE(m)	C.D at 5%	SE (m)	C.D at 5 %
Organic manure (O.M)	0.249	0.705	0.261	0.737
Zinc	0.353	0.998	0.369	1.043
Iron	0.353	0.998	0.369	1.043
(O.M) X Zinc	0.499	NS	0.522	1.475
(O.M) X Iron	0.499	NS	0.522	NS
Zinc X Iron	0.706	NS	0.738	NS
(O.M) X Zinc X Iron	0.998	NS	1.043	NS

3.4 Effect of organic manure, zinc and iron on number of grain row[-1] of hybrid maize.

Data in regard to the effect of organic manure, zinc, iron and their interaction on number of grains rows[-1] are established in table 6 during 2019 and 2020.

3.4.1 Effect of Organic manure
It is obvious from the data given in the table 6 that significant increase in number of grain row[-1] with the application of 2.5 tonne vermicompost ha^{-1} over no organic treatment during both the years. Application of 2.5 tonne vermicompost influence number of grain row[-1] 23.93 to 26.81 and 24.81 to 28.12 over no organic treatment during the 1st and 2nd year, respectively.

3.4.2 Effect of zinc
It is visualized from the data given in the table 6 revealed significant influenced number of grain row[-1] with application of different levels of zinc over no zinc during both the years. Number of grain row[-1] varied from 20.87 to 29.00 and 21.75 to 30.12 row[-1] lowest at control and highest at 5.0 Kg Zn ha^{-1} during 1st and 2nd year, respectively.

3.4.3 Effect of Iron
Data depicted in the table 6 showed significant influenced in number of grain row[-1] with different doses of iron application during both the years. Maximum Number of grain row[-1] 23.37 and 28.25 row[-1] was recorded with application of 10 Kg iron ha^{-1} and minimum 21.50 and 22.87 row[-1] at Fe0 treatment during 1st and 2nd year, respectively.

3.4.4 Effect of interaction
Interaction effect of O.M X Zn, O.M X Fe, Zn X Fe, O.M X Zn X Fe depicted in table 6 indicating that likewise individual effect of organic manure, zinc and their interaction also accelerated number of grain row[-1] significantly during both the years. Maximum increase in number of grain row[-1] was noted 33.00 and 35.00 with the application of 2.5 tonne Vermicompost, 5.0 Kg Zinc 10 Kg Iron ha^{-1} and minimum 18.00 and 19.00 at control (No organic, Zn0, Fe0) during 1st and 2nd year, respectively.

Table 6: Effect of organic manure, zinc and iron on number of grain/row of hybrid maize

		1st year					2nd year				
		Zn0	Zn1	Zn2	Zn3	Mean	Zn0	Zn1	Zn2	Zn3	Mean
M0	Fe0	18.00	19.00	22.00	21.00	20.00	19.00	20.00	23.00	22.00	21.00
	Fe1	19.00	21.00	28.00	27.00	23.75	20.00	22.00	29.00	28.00	24.75
	Fe2	20.00	24.00	31.00	29.00	26.00	21.00	25.00	31.00	30.00	26.75
	Fe3	20.00	26.00	30.00	28.00	26.00	21.00	27.00	30.00	29.00	26.75
	Mean	19.25	22.50	27.75	26.25	23.93	20.25	23.50	28.25	27.25	24.81
M1	Fe0	21.00	22.00	25.00	24.00	23.00	22.00	24.00	27.00	26.00	24.75
	Fe1	22.00	23.00	31.00	30.00	26.50	23.00	25.00	33.00	31.00	28.00
	Fe2	24.00	29.00	33.00	31.00	29.00	24.00	28.00	35.00	33.00	30.00
	Fe3	23.00	27.00	33.00	33.00	28.75	24.00	27.00	35.00	33.00	29.75
	Mean	22.50	25.25	30.25	29.25	26.81	23.25	26.50	32.00	30.75	28.12

Mean of the mean Zn	Zn0	Zn1	Zn2	Zn3	Zn0	Zn1	Zn2	Zn3
	20.87	23.87	29.00	27.75	21.75	25.00	30.12	29.00

Mean of the mean Fe	Fe0	Fe1	Fe2	Fe3	Fe0	Fe1	Fe2	Fe3
	21.50	25.12	27.50	27.37	22.87	26.37	28.37	28.25

Factors	1st year SE(m)	1st year C.D at 5%	2nd year SE (m)	2nd year C.D at 5 %
Organic manure (O.M)	0.310	0.878	0.323	0.914
Zinc	0.439	1.241	0.457	1.292
Iron	0.439	1.241	0.457	1.292
(O.M) X Zinc	0.621	1.854	0.646	1.985
(O.M) X Iron	0.621	1.869	0.646	1.967
Zinc X Iron	0.878	2.483	0.914	2.585
(O.M) X Zinc X Iron	1.242	NS	1.293	NS

3.5 Effect of organic manure, zinc and iron on test weight (in g) of hybrid maize

The data pertaining to the effects of application of organic manure, zinc and iron alone or in combination on test weight have been furnished in table 7 during 2019 and 2020.

3.5.1 Effect of organic manure

Data in respect to test weight given in table 7 revealed a non significant increase in test weight with the application of organic manure over no organic treatment during both the years. Maximum test weight 23.50 and 23.78 g recorded with the application of 2.5 tonne vermicompost ha^{-1} and minimum 22.78 and 23.22 g at no organic during 1st and 2nd year, respectively.

3.5.2 Effect of zinc

Data in regard to test weight given in table 7 showed narrower and non-significant fluctuation with various levels of zinc application during both the years. Maximum increase in test weight recorded with the application of 5 kg Zinc ha^{-1} after increasing level of zinc upto 7.5 Kg ha^{-1} showed non significant decline effect on test weight during both the years.

Variation in test weight from 22.90 to 23.37 g and from 23.17 to 23.80 g minimum at Zn_0 and maximum at the level of 5 Kg zinc ha^{-1} was recorded during 1st and 2nd year, respectively.

3.5.3 Effect of Iron

It is obvious from the data given in the table 7 revealed that likewise zinc application of different levels of iron also influenced test weight over control during both the years. Application of 10 Kg iron ha^{-1} showed maximum increase in test weight and after that showed non significant decrease in test weight during both the years.

3.5.4 Effect of interactions

It is visualised from the data given in table 7 showed that interaction between O.M X Zn, O.M X Fe, Zn X Fe, O.M X Zn X Fe influenced test weight non significant as applied individually during both the years. Maximum increase in test weight 24.10 and 24.30 g was recorded with the application of 2.5 tonne Vermicompost, 5 Kg Zinc, 10 Kg Iron ha^{-1} and minimum 22.10 and 22.40 g at $M_0Zn_0Fe_0$ during 1st and 2nd years respectively.

Table 7: Effect of organic manure, zinc and iron on test weight (in gram) of hybrid maize

		1st year Zn_0	Zn_1	Zn_2	Zn_3	Mean	2nd year Zn_0	Zn_1	Zn_2	Zn_3	Mean
M_0	Fe_0	22.10	22.30	22.50	22.40	22.32	22.40	22.60	23.00	22.90	22.72
	Fe_1	22.60	22.70	22.90	22.80	22.75	22.90	23.15	23.50	23.45	23.25
	Fe_2	22.90	23.10	23.40	23.10	22.12	23.10	23.45	23.95	23.60	23.52
	Fe_3	22.80	23.00	23.10	22.90	22.95	23.00	23.30	23.85	23.50	23.41
	Mean	22.60	22.77	22.97	22.80	22.78	22.85	23.12	23.57	23.36	23.22
M_1	Fe_0	22.90	23.10	23.40	23.30	23.17	23.20	23.45	23.70	23.60	23.48
	Fe_1	23.20	23.35	23.60	23.50	23.41	23.50	23.65	23.90	24.00	23.76
	Fe_2	23.45	23.85	24.10	23.80	23.80	23.70	23.95	24.30	24.10	24.01
	Fe_3	23.25	23.65	24.00	23.60	23.62	23.60	23.65	24.20	24.00	23.86
	Mean	23.20	23.48	23.77	23.55	23.50	23.50	23.67	24.02	23.92	23.78

	Zn_0	Zn_1	Zn_2	Zn_3	Zn_0	Zn_1	Zn_2	Zn_3
Mean of the mean Zn	22.90	23.13	23.37	23.17	23.17	23.40	23.80	23.64

	Fe_0	Fe_1	Fe_2	Fe_3	Fe_0	Fe_1	Fe_2	Fe_3
Mean of the mean Fe	22.75	23.08	23.46	23.28	23.10	23.50	23.76	23.63

Factors	1st year SE(m)	1st year C.D at 5%	2nd year SE (m)	2nd year C.D at 5 %
Organic manure (O.M)	0.275	NS	0.302	NS
Zinc	0.388	NS	0.427	NS
Iron	0.388	NS	0.427	NS
(O.M) X Zinc	0.549	NS	0.604	NS
(O.M) X Iron	0.549	NS	0.604	NS
Zinc X Iron	0.777	NS	0.854	NS
(O.M) X Zinc X Iron	1.099	NS	1.208	NS

4. Discussion

Data regard to yield attributing parameters mainly cob length (cm), cob girth (cm), number of grain row cob^{-1}, number of grain row^{-1}, test weight (gm) present in table 3 to 7 clearly revealed that application of different levels of organic manure, zinc and iron significantly over its control except cob

girth and test weight during both the years.

Addition of organic manure as vermicompost showed it superiority to accelerating yield attributing parameter 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 (2011) [5] and Wailare and Kesarwani (2017) [22]

Application of zinc 5.0 Kg ha^{-1} showed the highest increase in yield attributing parameters and beyond this level yield attributing parameters slightly declined during both the years. The significant response of zinc in terms of improvement in yield attributing parameters 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 considerable improvement in crop growth. The finding of this investigation confirmed the observation of earlier worker Aruna *et al.* (2006) [3], Ghandali and Dehsorkhi (2017) [7], Paramesh *et al.* (2014) [12] and Reddy *et al.* (2019) [16].

Yield attributing parameters 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 in yield attributing parameters due to application of iron 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. These finding is related to the finding of Ghasenian *et al.* (2010) [8], Hekmant *et al.* (2010) [9] and Sharma *et al.* (2010) [19]

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 yield attributing parameters over $M_0Zn_0Fe_0$ treatment during both the years. Influence in yield attributing parameters with the combined application of organic manure, zinc and iron 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.* (2020) [21], Pingoliya *et al.* (2014) [15] and Parasuraman *et al.* (2008) [13]

5. Conclusion
The experimetal results indicated that, superiority in regard to yield attributing characterstics *viz*, cob length (cm), cob girth (cm), number of grain row cob^{-1}, number of grain row^{-1}, test weight (gm) with 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 as comparison to all the treatments during 2019 and 2020.

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