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Influence of organic manures, inorganic fertilizers and foliar application of zinc on growth, yield and economics of maize (*Zea mays* L.)

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Abstract
A field experiment was conducted during *Kharif* season of 2021 at Crop Research Farm (CRF), Department of Agronomy, SHUATS, Prayagraj (U.P) to investigate the influence of organic manures, inorganic fertilizers and foliar application of zinc on growth, yield and economics of maize. The treatments consisted of organic manure and inorganic fertilizer in combinations and foliar zinc application, whose effect is observed on maize (var. BISCO-UJALA). The experiment was laid out in randomized block design with ten treatments replicated thrice. Study revealed that application of 50% N through Vermicompost + 50% N through inorganic fertilizers recorded significantly higher plant height (221.08 cm), number of leaves per plant (14.53), plant dry weight (198.29 g), number of cobs per plant (1.60), number of grains per cob (416.73), grain yield (8.18 t/ha), Stover yield (18.70 t/ha) and harvest index (29.34%) as compared to other treatment combinations. The higher gross return (INR 130880.00/ha), net return (INR 83182.30/ha) and B:C ratio (2.74) was recorded with the application of 50% N through vermicompost + 50% N through inorganic fertilizers as well.

Keywords: Maize, organic manures, inorganic fertilizers, foliar zinc, growth, yield, economics.

Introduction
Maize (*Zea mays* L.) is considered to be one of the world's most important cereal crops due to its broad utility as a food, feed, and fodder. Maize is classified into different groups/types on the basis of endosperm of kernels like dent corn, popcorn, waxy corn, flint corn, pod corn and sweet corn etc. Among which dent corn (*Zea mays indenata*), sometimes known as "grain corn," is the most common form of maize grown commercially in large scale. Maize is cultivated on 185 million hectares of area in 160 countries, with a total production of 1018 million tonnes at an average productivity of 5.49 tonnes per hectare. The United States of America (USA) is the world's largest producer of maize, accounting for about 35% of global production. The overall area under maize cultivation in India is 9.43 million hectares (2018-19), with a total production of 30 million tonnes at an average productivity of 2.43 tonnes per hectare. Karnataka (15%) and Uttar Pradesh (15%) have the highest area under maize production among Indian states, followed by Maharashtra (10%), Rajasthan (9%), Madhya Pradesh (8%), Bihar (7%), Telangana (6%), Gujarat (5%), and Tamil Nadu (4%).
In the modern agronomic approach application of inorganic fertilizers is done imperatively to boost the yield of crop considering limited amount of nutrients and minerals supplied by soil. These external inorganic fertilisers result into faster vegetative growth and improves crop grain yield but finally results in agricultural intensification, soil degradation and ecological imbalance. The demands of high production cannot be met at the cost of soil deterioration and ecological imbalance. Thus reduction in dependency of chemical fertilizers has become necessary to sustain soil fertility, and to maintain soil health. Supplementing the plant nutrients through organic and inorganic combinations for crop production, not only save fertiliser costs, but also serve as the final answer for restoring lost agricultural soil fertility. In India production of crops using only organic source of nutrient had led to inadequate food grain production for the population. The growing need of food cannot be achieved unless a pre-eminent management practices is constructed. Meanwhile, the essential micronutrients deficiencies in plant, soil and humans should not be overlooked. Maize is known to be very sensitive to Zn deficiency which has become a worldwide nutritional constraint for crop production, especially cereals. Zinc has a significant impact on essential plant life activities such as nitrogen metabolism, chlorophyll production, photosynthesis, and stress tolerance.

Zinc being a highly reactive element forms an insoluble complex when applied in soil delaying its release into the soil solution for absorption. Hence a suitable nutrition administration strategy might be another way to improve nutrient absorption and utilisation. Among the many ways, foliar application has been proven to be effective and efficient in increasing crop productivity. The combination of all of these high-yielding and sustainable production technologies can help the country generate a food surplus while also reducing worries about soil health, environmental pollution, pesticide toxicity, and sustainability of agricultural production.

Considering the above facts, the present investigation entitled "Influence of organic manures, inorganic fertilizers and foliar application of zinc on growth, yield and economics of maize" was conducted to study and construct a pre-eminent nutrient management practices for maize under eastern Uttar Pradesh conditions.

Materials and Methods

A field experiment was conducted during *Kharif season* of 2021 at Crop Research Farm (CRF), Department of Agronomy, SHUATS, Prayagraj (UP). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), medium in organic carbon (0.48%), medium in available Nitrogen (278.93 kg/ha), low in available Phosphorous (19.03 kg/ha) and medium in available Potash (238.1 kg/ha).

The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The treatments consisted of organic manure (*viz*., Poultry manure, Goat/sheep manure, Vermicompost) in combination (*viz*., 50% N through Organic manure + 50% N through Inorganic Fertilizers, 75% N through Organic manure + 25% N through Inorganic Fertilizers and 100% N through Organic manure + 0% N through Inorganic fertilizers) and foliar zinc application (*viz*., Zinc 0.5% at 25 DAS, Zinc 1.0% at 45 DAS), whose effect is observed on Maize (var. BISCO-UJALA). The experiment comprises of ten possible treatment combination of above mentioned factor, *viz.*, T_1: 50% N through poultry manure + 50% N through Inorganic fertilizers T_2: 75% N through poultry manure + 25% N through Inorganic fertilizers, T_3: 100% N through poultry manure + 0% N through Inorganic fertilizers, T_4: 50% N through Goat/sheep + 50% N through Inorganic fertilizers, T_5: 75% N through Goat/sheep + 25% N through Inorganic fertilizers, T_6: 100% N through Goat/sheep + 0% N through Inorganic fertilizers, T_7: 50% N through Vermicompost + 50% N through Inorganic fertilizers, T_8: 75% N through Vermicompost + 25% N through Inorganic fertilizers, T_9: 100% N through Vermicompost + 0% N through Inorganic fertilizers, T_{10}: Control (RDF), observation on growth, yield and economics were recorded during the field experiment.

Result and Discussion

Growth

On analysing the data pertaining to growth parameters, it is understood that, significantly higher plant height (221.08 cm), maximum number of leaves per plants (14.73) and higher plant dry matter production was recorded in treatment with application of 50% N through Vermicompost + 50% N through Inorganic fertilizers.

The increase in plant height, number of leaves and plant dry weight could be attributed to the fact that the increase in plant growth reduces the quantity of light available to individual plants, especially lower leaves, due to increased shade. The plant tends to grow taller as the mutual shadowing increases, Rajesh *et al.* (2011) [7] reported similar findings. The individual plants could have effectively utilized the available nutrient resources for plant growth, and thus enhanced the number of leaves production. The improvement in number of leaves might have increased the photosynthetic efficiency of maize and have induced to produce more plant dry matter. Similarly findings were recorded by Chandrashekar *et al*. (2000) [3] and Sujatha M, (2007) [8].

Yield attributes

According to the yield characteristics data that was collected and analysed at harvest and thereafter, maximum number of cobs per plant (1.22), maximum number of grains per cob (416.73), higher cob length (21.49 cm) and seed index (24.63g) was recorded in treatment with the application of 50% N through vermicompost + 50% N through Inorganic fertilizers.

The higher performance of yield attributes might be due to zinc as it is proven to increase pollen viability and significant effect pollen formation and fertilization, hence higher grains number are direct index of pollen viability, whereas the prolong nutrient supplied by the inorganic and inorganic sources led to better translocation of photosynthates in form of grain resulting in better yield attributes. Similar findings was reported by Kannan *et al.* (2013) [5].

Yield

The ultimate purpose of a field experiment is to develop superior crop management strategies that result in increased production. After analysing the data collected during the field experiment, it was discovered that treatments with the application of 50% N through Vermicompost + 50% N through Inorganic fertilizers had a significant increases in grain yield (8.18 t/ha), Stover output (19.70 t/ha), and harvesting index (29.34 percent) compared to other treatment combination.

The appropriate use of inorganic and organic sources has a positive impact on plant metabolism and development, resulting in increased grain output. The results were identical to those of B.S. Manojgowda (2021) [6] where Vermicompost in combination with inorganic fertilizers considerably boosted grain production of Finger millet.

Economics

The economic return of maize was analyzed after harvesting the crop based on market pricing (OCT-2021), the result indicated a growing trend in yield across treatments. However, maximum gross returns (INR 130880.00 /ha), net returns (INR 83182.30 /ha) and benefit cost ratio (2.74) was evaluated in treatment with the application of 50% N through Vermicompost + 50% N through inorganic fertilizers.

Table 1: Growth and yield attributes of maize as influenced by organic manures, inorganic fertilizers and foliar application of zinc.

Treatment	Plant height (cm)	No. of leaves/plant	Plant dry weight (g)	No. of cobs/plant	No. of grains/cob	Seed index (g)
50% N- Poultry manure + 50% N-Inorganic fertilizers	209.89	14.13	190.85	1.46	388.93	24.40
75% N- Poultry manure + 25% N-Inorganic fertilizers	199.68	13.33	183.75	1.20	363.20	24.20
100% N- Poultry manure + 0% N-Inorganic fertilizers	182.33	12.46	177.81	1.00	345.26	24.16
50% N-Goat/sheep manure + 50% N-Inorganic fertilizers	197.67	13.26	188.56	1.20	379.06	24.13
75% N-Goat/sheep manure + 25% N-Inorganic fertilizers	192.66	13.00	178.85	1.00	346.73	24.06
100% N- Goat/sheep manure + 0% N-Inorganic fertilizers	189.71	12.26	172.45	1.00	327.73	24.03

50% N- Vermicompost + 50% N-Inorganic fertilizers	221.08	14.53	198.29	1.60	416.73	24.63
75% N- Vermicompost + 25% N-Inorganic fertilizers	200.08	13.53	186.88	1.13	359.00	24.23
100% N- Vermicompost + 0% N-Inorganic fertilizers	187.89	12.60	185.66	1.00	341.80	24.23
Control (RDF)	191.32	12.93	180.94	1.46	348.06	24.20
S.Em(±)	1.66	0.51	1.96	0.05	7.30	0.54
CD (p=0.05)	4.93	0.45	5.83	0.16	21.71	1.60 (NS)

Table 2: Yield of maize as influenced by organic manures, inorganic fertilizers and foliar application of zinc.

Treatment	Grain Yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
50% N- Poultry manure + 50% N-Inorganic fertilizers	7.57	18.85	28.64
75% N- Poultry manure + 25% N-Inorganic fertilizers	7.21	18.63	27.89
100% N- Poultry manure + 0% N-Inorganic fertilizers	5.96	17.34	25.57
50% N-Goat/sheep manure + 50% N-Inorganic fertilizers	6.95	19.12	26.68
75% N-Goat/sheep manure + 25% N-Inorganic fertilizers	6.25	17.16	26.69
100% N- Goat/sheep manure + 0% N-Inorganic fertilizers	5.12	16.73	23.40
50% N- Vermicompost + 50% N-Inorganic fertilizers	8.18	19.70	29.34
75% N- Vermicompost + 25% N-Inorganic fertilizers	7.29	18.46	28.32
100% N- Vermicompost + 0% N-Inorganic fertilizers	6.12	18.12	25.25
Control (RDF)	6.25	18.26	24.79
S.Em(±)	0.22	0.51	0.73
CD (p=0.05)	0.65	1.51	2.15

Table 3: Total cost of cultivation, Gross returns, Net returns and B: C ratio of maize as Influence by organic manures, inorganic fertilizers and foliar application of zinc.

Treatment	Total cost of cultivation (INR/ha)	Gross return (INR/ha)	Net returns (INR/ha)	B:C ratio
50% N- Poultry manure + 50% N-Inorganic fertilizers	45697.70	121066.67	75368.97	2.65
75% N- Poultry manure + 25% N-Inorganic fertilizers	46548.85	115306.67	68757.82	2.48
100% N- Poultry manure + 0% N-Inorganic fertilizers	47400.00	95253.33	47853.33	2.01
50% N-Goat/sheep manure + 50% N-Inorganic fertilizers	45697.70	111253.33	65555.63	2.43
75% N-Goat/sheep manure + 25% N-Inorganic fertilizers	46548.85	99946.67	53397.82	2.15
100% N- Goat/sheep manure + 0% N-Inorganic fertilizers	47400.00	81866.67	34466.67	1.73
50% N- Vermicompost + 50% N-Inorganic fertilizers	47697.70	130880.00	83182.30	2.74
75% N- Vermicompost + 25% N-Inorganic fertilizers	49548.85	116586.67	67037.82	2.35
100% N- Vermicompost + 0% N-Inorganic fertilizers	51400.00	97386.67	46520.00	1.91
Control (RDF)	39400.00	97386.67	57986.67	2.47

*Data not subjected for statistical analysis

Conclusion

Based on the above experimental findings, it is concluded that application of nutrients in combination of Vermicompost (50% N), inorganic fertilizers (50% N) and foliar zinc (0.5% at 25 DAS + 1.0% at 45 DAS) was found the most suitable combination of fertilizers to be adopted in maize during Kharif season as it was productive, remunerative and economically efficient.

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