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EVALUATION OF THE EFFECT OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON THE GROWTH, YIELD AND QUALITY OF SPRING MAIZE (*ZEA MAYS* L.)

Kishlay Anand, Vivek Pandey*, Sant Sharan Tripathi, Shiva Mohan, Sandeep Kumar Diwakar, Devraj Singh and Sharvan Kumar
Faculty of Agriculture, Invertis University, Bareilly-243123, (U.P.), India
*Corresponding author email: vivekpanday831996@gmail.com
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ABSTRACT

A field experiment on maize (*Zea mays* L.) was carried out at the Instruction Farm of Invertis University Bareilly, Uttar Pradesh, India during *spring* season 2024. The soil of the experimental field was sandy loam in texture, low in organic carbon and available nitrogen, but medium in available phosphorus and available potassium having slightly alkali pH (7.2) with an electrical conductivity of 0.317. The experiment was arranged in a randomized block design having 8 treatments *viz;* T_1- Control, T_2- 100 % Recommended dose of fertilizer (RDF), T_3- 100 % RDF + @ 2.5 kg/ha $ZnSO_4$, T_4- 75 % RDF + Vermicompost (VC) @ 1.5 t/ha, T_5 -75 % RDF +VC @ 1.5 t/ha + NPK consortia, T_6- 50 % RDF + VC @ 3.0 t/ha + NPK consortia, T_7- 50 % RDF + Poultry manure (PM) @ 2.5 t/ha + NPK consortia, T_8- 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ with three replication. The experimental results revealed that among the integrated nutrient management practices, application of 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ had the maximum plant height (218.6 cm), number of physiological active leaves/plant (12.85) and dry matter accumulation (268.2 g/plant) at harvest stage. However, significantly maximum grains/rows (14.3), grains rows/cob (32.9), grains/cob (471.5), test weight (218.4 g), grain yield (64.4 q/ha), stover yield (117.9 q/ha), biological yield (182.3 q/ha), protein content (9.59 %) and protein yield (618.3 kg/ha) was recorded under the application of 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ than other treatments.
***Keywords*: ** Integrated nutrient management, Poultry manure, Vermicompost, NPK consortia and Protein yield.

Introduction

Maize is placed in 3rd position among the cereals in terms of its importance, after rice and wheat in India and contributes nearly 9 % to the nation food basket (Hasanain *et al.,* 2021). In India maize is grown in an area about 10.74-million-hectare (M ha) with a production about 35.67 Metric Ton (MT) accounting about nearly 3% of total world population and productivity of 3.3 t/ha (Anonymous, 2023). The indiscriminate and continuous use of chemical fertilizers, especially nitrogenous ones, has led to several issues such as reduced nutrient use efficiency, environmental pollution, disturbed the physio-chemical properties of soil, impaired the ground water quality that causes health hazard in changing climate scenario, greenhouse gas emission and increased cost of cultivation (Zhang *et al.,* 2012). Chemical fertilizers cannot be totally avoided due to their high nutrient content and ease of use. To increase crop production, it's important to apply nutrients wisely, including organic sources, bio-fertilizers and micronutrients. Integrated nutrient management practices aim to minimize nutrient losses due to leaching, runoff, volatilization, emission and immobilization, thereby enhancing nutrient use efficiency, so it an eco-friendly and sustainable strategy that combines the use of chemical fertilizers, organic manures and biofertilizers to enhance soil fertility, optimize plant nutrient supply and improve crop growth (Haque and Ali, 2020). INM not only ensures balanced nutrient availability throughout the crop growth period but also contributes to improved soil physical, chemical and biological properties, resulting in higher productivity and better crop quality. Moreover, the integration of organic and biological sources of nutrients promotes better nutrient cycling, reduces dependency on chemical inputs, and supports sustainable agricultural systems. Under the farmer's field condition, the imbalance use of nutrients due to excess application of macro nutrient and neglecting use of micro nutrient cause the poor growth and productivity of maize. Micronutrients are actively involved in numerous physiological and metabolic functions of plant beginning from cell formation, respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation etc. Zinc deficiency is a widespread issue occurring both crops and human beings. Nearly 50% of the world's soils, which used for cereal production, are affected due to zinc deficient Among the cereal crops, maize is particularly susceptible to zinc deficiency. Zinc plays a crucial role in synthesis of chlorophyll, protein and facilitates the efficient utilization of nitrogen and phosphorus in plants by acting as an activator of key enzymes such as dehydrogenase and proteinase. Moreover, it is a component of tryptophan, a precursor to the auxin hormone (Badiyala and Chopra, 2011). Zinc application improves maize productivity and also contributes to enhancing soil fertility. Therefore, suitable combination of chemical fertilizer and organic manure culture need to be developed for particular cropping system and soil.

Material and Methods

The field experiment was conducted at the Instruction Farm (at a latitude of 28° 29' North and longitude of 79° 49' East with an elevation of 252 m above mean sea level) of Invertis University Bareilly, Uttar Pradesh, India during *spring* season 2024 on sandy loam soil. The soil of the experimental field was low in organic carbon (0.32 %) and available nitrogen (181.6 kg/ha), but medium in available phosphorus (13.2 kg/ha) and potassium (118.1 kg/ha) having slightly alkali pH (7.2) with an electric conductivity of 0.317. Experimental field was moist, well- drained with uniform topography. The experiment was arranged in a randomized block design having 8 treatments *viz;* T_1- Control, T_2- 100 % RDF, T_3- 100 % RDF + @ 2.5 kg/ha $ZnSO_4$, T_4- 75 % RDF +VC @ 1.5 t/ha, T_5 -75 % RDF +VC @ 1.5 t/ha + NPK consortia, T_6- 50 % RDF + VC @ 3.0 t/ha + NPK consortia, T_7- 50 % RDF + PM @ 2.5 t/ha + NPK consortia, T_8- 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ with three replication. The Variety, Dekalb 9208 was sown on 02/02/2024 using seeds @ 22 kg/ha at 5 cm depth in flat bed method with spacing of 60 × 20 cm row × plant spacing. In experimental field, poultry manure (PM) @ 2.5 t/ha (on dry weight basis) was applied as per treatments by spreading uniformally in the plots and thoroughly mixing up to the top 15 cm soil depth, before one week of sowing. The experimental soil was fertilized as per treatments, after laying out of the. The recommended amount of nutrient (150:60:40 kg/ha) were applied through urea, NPK (12:32:16), and muriate of potash as per respective treatments. The amounts of NPK present in the various sources used in experimentation is given in Table 1. The maize seeds at 22 kg/ha used for sowing was inoculated with NPK consortia, as per treatments. For the inoculation of NPK consortia 10 % jaggery slurry was prepared by boiling the jaggery solution. The culture of various bio-fertilizers each @ 20 ml/kg seeds was mixed in the cooled jaggery slurry. The required quantity of seeds was thoroughly mixed with the solution for uniform coating over the seeds; the inoculated seeds were dried in shade and subsequently used for sowing in respective treatments during the experimental years.

Table 1 : NPK content present in the various sources of fertilizers/manure

S. No	Source	N (%)	P_2O_5 (%)	K_2O (%)
1.	Poultry Manure	2.94	2.7	1.5
2.	Vermi Compost	2.43	1.36	2.12
3.	Urea	46	-	-
4.	NPK	12	32	16
5.	MOP	-	-	60

Plant height was recorded with the help of a meter scale, dry matter accumulation was recorded in each plot, two plants form the sample rows (second row from both north and west side of the plot) was cut from the ground surface with the help of sickle at all the stages of crop growth and sun dried for 2-3 days. After sun drying, these plants were dried at 65±5^{0}C temperature at until a constant weight was achieved and the average weight was expressed in gram per plant. The yield attributes viz; Cobs/plant, grains/rows, grains rows/cob, grains/cob and test weight (g) were recorded according to standard procedure. After the harvesting of border rows the grain yield, stover yield and biological yield were recorded in kg/plot in each net plot and express as q/ha, protein content in grains was determined by modified- Kjeldahl method by using the formula as,

Protein content (%) = Nitrogen content in grain (%) × 5.85 (correction factor)

Protein yield of the grain was measured by multiplying the average protein content of grain with grain yield/ha and expressed as kg/ha. This gave the total protein yield/ha and as per given formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in grain (\%)} \times \text{grain yield (kg/ha)}}{100}$$

The mean of data was analyzed through Analysis of Variance (ANOVA) techniques for randomized block design and presented at 5 % level of significance ($<P = 0.05$).

Result and Discussion

Growth and development of maize

The data is presenting in table 2. The effect of different integrated nutrient management practices on various growth parameters *viz*., plant height, number of physiological active leaves/plant and dry matter accumulation (g/plant) at knee high stage, tasseling stage and at harvest. The plant height and number of physiological active leaves/plant did not have any significant different at knee high stage, which varied from 73.2 to 80.4 cm and 7.71 to 8.78 minimum to maximum plant height and number of physiological active leaves/plant under control and 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$, respectively. While, 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ had significantly maximum plant height 218.6 and 223.3 cm over T_1, T_4 and T_6 at tasseling T_1 at harvesting stage, respectively. However, 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ had significantly maximum number of physiological active leaves/plant 11.48 to 9.03 over T_2 and T_6 at tasseling T_2, T_4 and T_6 at harvesting stage, respectively. This might be attributed to better integration of chemical fertilizers with poultry manure and biofertilizer, however, poultry manure and biofertilizers enhances the uptake of N and P for the plants which results in more synthesis of chlorophyll in the leaves. Similar results were also resulted by (Pandey *et al.,* 2023). Dry matter accumulation (g/plant) was significantly ($p<0.05$) affected by different INM practices. The result presented in table 2 showed that the application of 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ (T_8) gave significantly higher dry matter of 24.82 g/plant, at knee high stage compared to 75 % RDF+ VC @ 1.5 t/ha and unfertilized treatment, while at tasseling and harvest stage (160.22 and 268.17 g/plant) was noted under T_8 being *at par* with T_3 T_7 during tasseling and T_2, T_3 and T_7 at harvest, respectively. However, T_8 had ~ 8.3 %, ~12.3 % and ~8.2 % more dry matter produces than 100 % RDF applied plots. Similar results were also reported by (Kolawole Edomwonyi and Samson Uduzei, 2009).

Yield attributes, yield and quality

The data is presenting in table 3. The effect of different integrated nutrient management practices on various yield attributes *viz*., cobs/plant, grains/rows, grains rows/cob, grains/cob, test weight (g), grain, stover and biological yield (q/ha), protein content (%) and protein yield (kg/ha) have significant different, except number of cobs/plant and test weight (g). Cobs/plant varied from 1.01 to 1.07 minimum to maximum under control to 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$, respectively. The significantly maximum number of grains/rows (14.3), grains rows/cob (32.9) and grains/cob (471.5) were noticed under T_8, being statically *at par* with treatments T_2, T_3 and T_7 with grains/rows and grains/cob, while in case of grains rows/cob it was significantly superior over all the treatments except T_1. Test weight (g) did not have any significant different which varied from 206.1 to 218.4 minimum to maximum under control and 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$, respectively. Application of 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ had significantly maximum grain yield of 64.4 q/ha, stover yield of 117.9 q/ha and biological yield of 182.3 q/ha which being statistically *at par* with T_3 in grain yield and biological yield but in case of stover yield it was *at par* under T_3 and T_7. The improvement in yield attributing characters and yield may be due to replacement of 50 % RDF through poultry manure and biofertilizers, use of 50 % chemical fertilizer supplied the nutrient particularly nitrogen at initial stage of plant growth with a half dose of chemical fertilizers supplied the plant nutrients in adequate proportion at all the crop growth while, poultry manure show beneficial effect after their proper decomposition and mineralization, its supply available nutrient direct to the plant and conserve moisture at later stage through slow and steady release of nutrients and biofertilizer increase the availability of nutrient near the root zone. Similar results also reported by (Yadav *et al*., 2016). The maximum protein content was registered under the treatments T_8, being *at par* with T_3, T_5. Protein yield was significantly superior over all other treatments. The minimum to maximum protein yield was received control (231.6 kg/ha) to 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ (618.3 kg/ha).

Conclusion

On the basis of experiment, it may be concluded that with the application of 50 % RDF + PM @ 2.5 t/ha + @ 2.5 kg/ha $ZnSO_4$ in maize seems to be best as they improved the growth, yield attributes, yield and quality of maize. Thus, application of 50 % RDF along with PM and biofertilizer provides a reliable, short-term and sustainable approach for increasing the yield in maize.

Table 2 : Effect of integrated nutrient management on plant height (cm), number of physiological active leaves/plant and dry matter accumulation (g/plant) at different growth stages

Treatments	Plant height (cm) at			Number of physiologically active leaves/plant at			Dry matter accumulation (g/plant) at		
	Knee high stage	Tasselling stage	Harvest	Knee high stage	Tasselling stage	Harvest	Knee high stage	Tasselling stage	Harvest
T_1	73.2	170.1	177.2	7.71	11.48	9.03	19.67	79.12	126.07
T_2	78.8	207.9	213.8	8.12	13.10	10.94	22.92	142.63	247.78
T_3	79.6	213.1	219.9	8.63	13.78	12.61	23.61	155.47	259.81
T_4	76.7	197.3	209.7	8.14	13.61	11.33	20.65	139.53	226.40
T_5	77.1	204.0	211.1	8.35	13.46	12.33	22.96	137.42	235.98
T_6	76.2	201.6	208.7	8.26	13.15	11.30	22.57	138.15	234.02
T_7	79.1	208.8	216.1	8.57	13.50	12.18	23.01	151.42	254.19
T_8	80.4	218.6	223.3	8.78	14.74	12.85	24.82	160.22	268.17
SEm±	1.9	5.4	6.1	0.3	0.42	0.42	0.74	4.83	8.05
CD(P=0.05)	NS	16.6	18.7	NS	1.30	1.28	2.29	14.81	24.68

Table 3: Effect of integrated nutrient management on yield attributing characters, yield and quality of spring maize 2024

Treatments	Cobs /plant	Grains /rows	Grains rows/cob	Grains /cob	Test weight (g)	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Protein content (%)	Protein yield (kg/ha)
T_1	1.01	12.8	23.2	298.0	206.1	27.9	49.0	76.9	8.31	231.6
T_2	1.03	14.1	31.9	452.1	217.8	50.8	90.4	141.2	8.89	451.5
T_3	1.05	14.2	32.6	460.5	218.3	60.2	109.6	169.8	9.52	573.4
T_4	1.02	13.0	31.9	418.7	217.6	47.8	84.6	132.4	8.70	415.7
T_5	1.04	13.9	32.1	444.0	218.0	55.4	99.7	155.0	9.30	515.9
T_6	1.04	13.5	32.0	433.4	217.8	53.0	94.9	148.0	8.99	476.4
T_7	1.05	14.0	32.3	453.2	218.2	58.3	105.5	163.8	9.38	546.6
T_8	1.07	14.3	32.9	471.5	218.4	64.4	117.9	182.3	9.59	618.3
SEm±	0.045	0.31	0.5	6.7	2.7	1.9	4.4	5.8	0.16	3.4
CD(P=0.05)	NS	0.95	1.5	20.6	NS	5.8	13.5	17.9	0.48	10.5

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