Original Research Article

IMPACT OF BIOFERTILIZERS AND INORGANIC FERTILIZERS ON MICRO NUTRIENT CONTENT AND UPTAKEOF MAIZE

ABSTRACT

A field experiment entitled**"Impact biofertilizers and inorganic fertilizers on micro nutrient content and uptake of maize"** was conducted clay loam soils at Agriculture College Farm, Bapatla, during both *kharif*2020 and 2021. The aim of this study was to see the effect of different levels of fertilizers along with biofertilizers on micro nutrient content and uptake by maize crop.The results indicated that application of 100% RDF +VAM + *Azospirillum* + PSBrecorded highest micronutrient content and lowest recorded with the control, but non significantly influenced by the imposed treatments at kneehigh, tasseling and harvest stage(straw and grain). The application of 100% RDF +VAM + *Azospirillum* + PSB recorded significantly highest iron, manganese, copper and zinc uptake at kneehigh, tasseling and harvest stage (grain and straw)of maize crop.The results revealed thatapplication of biofertilizers along with inorganic fertilizers significantlyincreasedplant nutrient content and uptake of maize crop. It is concluded that integrated use of biofertilizers and inorganic fertilizers improves the nutrient content and uptake of maize crop.

Key words: Biofertilizers, Fertilizer levels,Micronutrient content and Uptake.

1.INTRODUCTION

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. In India, maize is the third most important food crops after rice and wheat. Maize in India, contributes nearly 9 % in the national food basket. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil,

protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. Maize is cultivated both in temperate and tropical regions of the world. The full yield potential of maize crop can be exploited through adoption of hybrids with better nitrogen management practices.

The combined application of inorganic fertilizers and biofertilizers significantly increased micro nutrient content and uptake in *kharif* maize, in straw and in grain. This might be due to combined application of inorganicfertilizers and biofertilizers enhance root growth and cell multiplication leading to more absorption of nutrients from deeper layers of soil ultimately resulting in increased micro nutrient content and uptake. The application of biofertilizers (PSB, *Azospirillum* and VAM) plays a vital role in solubilization of various inorganic and organic phosphates added to the soil. It may also release soluble phosphorus into the soil through the decomposition of phosphorus from organic compounds. Chen (2006) states that the use of microbial inoculation can reduce the dosage of inorganic fertilizer, increase the nutrient content that can be absorbed from the soil, increase crop productivity and improve the quality of land sustainably.

Biofertilizers shows thea dynamic and positive effect on crop yield and nutrient uptake by the plant from the soil. There is a difference in biofertilizer performance among different crops out of which climate, soil biodiversity, soil fertility and soil C:N ratio are major contributing factors it. Thus, the need biofertilizers for nutrient content and uptake is an important factor in many soils. The aim of this experiment was to examine the role of biofertilizers in combination with inorganic fertilizers on nutrient content and uptake of maize (Selvakumar *et al*., 2012).

2.MATERIAL AND METHODS

2.1 Site Description

The field experiment was carried out during both *kharif* seasons of 2020-2021 at Agricultural College Farm, Bapatla. Geographically located at an altitude of 5.49 m above mean sea level, $15^{o}54'$ North latitude, $80^{0}30'$ East longitude and about 8 km away from Bay of Bengal.It is located in Krishna agro-climatic zone of Andhra Pradesh. The experimental soil was clay loam in texture, slightly alkaline in reaction (pH 7.56), non- saline (0.64 dS m^{-1}), medium in organic carbon (5.4 g kg^{-1}), medium in available nitrogen (283 kg ha^{-1}), medium in available phosphorus (42.5 kg

ha^{-1}), high in potassium (426 kg ha^{-1}) and medium in sulphur (14.3 mg kg^{-1}) and sufficient in all micronutrients (6.81, 5.43, 1.37 and 0.58) (Fe, Mn, Cu and Zn).

2.2 Experimental design and treatments

The experiment was laid out in randomized block design (RBD) with seven treatments and replicated thrice. The experimental treatment details are as following T_1- Control; T_2- 100% RDF;T_3- 125% RDF; T_4 – 100% RDF + VAM; T_5- 100% RDF +VAM + *Azospirillum* + PSB; T_6- 75 % RDF + VAM; T_7- 75 % RDF + VAM + *Azospirillum* + PSB. RDF for maize 200:60:50 kg ha^{-1} N, P_2O_5 and K_2O through applied Urea, Single super phosphate and Muriate of potash and biofertilizers like VAM -12.5 kg ha^{-1}, *Azospirillum* -5 kg ha^{-1} and PSB -5 kg ha^{-1} through applied vermicompost. The popular hybrid of maize Pioneer 3396 was chosen for the study.

2.3 Collection and Preparation of plant Samples: Plant samples of maize was collected from five randomly selected plants at knee high, tasseling and harvest stage. The samples were first dried in shade and then in hot air oven at 65 ^oC. The plant samples were ground in willey mill and stored in labeled brown paper bags for analysis. The grain samples were also processed and stored in similar fashion.

2.4 Methods used for plant analysis:

Di-acid extract was prepared as per the method outlined by Jackson (1973). It was carried out using a 9:4 mixture of HNO_3: $HClO_4$. The pre digestion of sample was done by using 10ml of HNO_3 g^{-1} sample. Iron,manganese, copper and zincin the diacid extract were determined using atomic absorption spectrophotometer as per the specifications mentioned by Lindsay and Norvell (1978). From the chemical analytical data, uptake of each nutrient was calculated as shown below.

2.5 Micronutrient uptake by maize crop

From the chemical analytical data, uptake of the micro nutrients at knee high, tasseling and harvest of the maize crop was calculated and expressed by using the formulae.

$$\text{Micronutrient uptake (g ha}^{-1}) = \frac{\text{Nutrient content (mg kg}^{-1}) \text{ x dry weight in kg ha}^{-1}}{1000}$$

3.RESULTS AND DISCUSSION

3.1. Micronutrient Content

3.1.1 Iron Content

The results revealed that, different levels of fertilizers and biofertilizer treatments applied to maize had shown a non significant influence on iron content (Table-1). Irrespective of the growth stages of maize and during both the years of study, application of 100% RDF + VAM + *Azospirillum* and PSB (T_5) (106.37, 92.16, 58.48, 46.84 mg kg^{-1}in 2020 and 113.07, 100.15, 60.15, 47.77 mg kg^{-1}in 2021) recorded numerically higher iron content at knee high, tasseling and harvest (stover and grain) stages of maize crop growth, respectively. The lowest iron content was recorded with the treatment T_1 *i.e.*, control (74.12, 65.32, 36.81, 31.94 mg kg^{-1}in 2020 and 80.55, 70.16, 38.19, 28.70 mg kg^{-1}in 2021). This might be due to application biofertilizer and inorganics slightly increased iron content at all the stages of crop growth. There was no significant influence on micronutrient contents with combined application of inorganics along with biofertilizers. Similar results were observed with Goutami and Rani (2016). Irrespective of the year of the study, the Fe content in maize decreased with the growth stages from knee high to harvest stage.

3.1.2 Manganese Content

Numerically, higher manganese content values were recorded in application of 100% RDF + VAM + *Azospirillum* and PSB (T_5) (49.77, 45.37, 29.40, 16.18 mg kg^{-1}in 2020 and 52.77, 46.42, 31.43, 16.73 mg kg^{-1}in 2021) at knee high, tasseling and harvest (stover and grain) stages of maize crop growth, respectively (Table-2). The lowest manganese content was recorded with the treatment T_1 *i.e.*, control (34.34, 31.11, 18.53, 10.16 mg kg^{-1}in 2020 and 37.08, 32.42, 19.37, 10.86 mg kg^{-1}in 2021).The results of the present study revealed that the combined application of biofertilizers and inorganic fertilizers recorded the highest manganese content compared to control. There was no significant influence on micronutrient contents with combined application of inorganics along with biofertilizers. Similar results were observed by Goutami and Rani (2016). Irrespective of the year of study, the Mn content in maize straw decreased with the advancement of crop growth from knee high to harvest indicating the dilution effect (Debiprasad *et al.*, 2010). The wide variation in Mn

concentration between straw and grain might be due to the slow movement of Mn from straw to grain as reported by Duhan and Singh (2002).

3.1.3 Copper Content

Irrespective of the growth stages of maize during both the years of the study, application of 100% RDF + VAM + *Azospirillum* and PSB (T_5) (18.15,14.76,12.68,7.23 mg kg^{-1}in 2020 and 20.22,15.62,12.96,7.55 mg kg^{-1}in 2021) at knee high, tasseling and harvest (stover and grain) stages of maize crop growth, respectively(Table-3). The lowest copper content was recorded with the treatment T_1 *i.e*., control (10.47,9.41,7.06,5.05 mg kg^{-1}in 2020 and 13.69,10.50,8.67,4.52 mg kg^{-1}in 2021).The results of the present study revealed that the combined application of biofertilizers and inorganic fertilizers recorded numerically higher copper content compared to control. There was no significant influence on micronutrient contents with combined application of inorganics along with biofertilizers. Similar results were observed by Goutami and Rani (2016).Irrespective of the year of the study, the Cu content in maize decreased with the growth stage from knee high to tasseling stage. When compared to Cu content in grain and straw at harvest was higher in all treatments.

3.1.4 Zinc Content

The higher zinc content values were recorded in 100% RDF + VAM + *Azospirillum* and PSB (T_5) (43.43, 37.15, 34.26, 31.60 mg kg^{-1}in 2020 and 45.85, 39.52, 34.74, 31.82 mg kg^{-1}in 2021) at knee high, tasseling and harvest (stover and grain) stages of maize crop growth, respectively(Table-4). The lowest zinc content was recorded with the treatment T_1 *i.e*., control (29.18, 26.84, 24.42, 21.25 mg kg^{-1}in 2020 and 31.07, 27.93, 24.63, 22.33 mg kg^{-1}in 2021) which received no fertilizers at knee high, tasseling and harvest (stover and grain) stages of maize crop growth. Increase in concentration of zinc with application of inorganics along with the biofertilizers was probably due to chelation of zinc with organic ligands, which might have enhanced the availability of zinc and its absorption by the plants. Zinc content was slightly increased but non significantly influenced by the treatments.Irrespective of the year of study, the Zn content in maize decreased with the growth stage from knee high to tasseling due to dilution effect and the Zn content in grain was lower when compared to straw. The decreased zinc content with the advancement of crop growth, could be due to the highest utilization of zinc in the synthesis of some growth promoting hormones and in the reproductive processes of plants which were vital for grain formation.

3.2 Micro Nutrient Uptake

3.2.1 Iron Uptake

Significantly higher Fe uptake was recorded in the treatment T_5 that received 100% RDF + VAM + *Azospirillum* and PSB (182.18, 655.19, 493.98, 287.29 g ha^{-1} in 2020 and 205.00, 720.16, 519.62, 311.43 g ha^{-1} in 2021) and it was on par with the treatments T_7, T_3 and T_4 at knee high, tasseling and harvest (straw and grain) stages of maize during 2020 and 2021, respectively (Table-5). The recommended dose of fertilizer T_2 (100% RDF) (123.69, 528.83, 365.44, 211.70 g ha^{-1} in 2020 and 141.48, 575.00, 385.06, 225.82 g ha^{-1} in 2021) was on par with T_3, T_4,T_6 and T_7 at knee high, tasseling and harvest (straw + grain) stages of maize crop, respectively. The lowest iron uptake was recorded with the treatment (T_1)control (73.74, 293.80, 192.06, 106.34 g ha^{-1} in 2020 and 84.09, 322.52, 206.53, 110.60 g ha^{-1} in 2021).The increase in the uptake of cationic micronutrients with application of organic manures and biofertilizers along with inorganic fertilizers might be due to release of micronutrients on mineralization or production of organic acids during their decomposition which aids in solubilization of insoluble micronutrient compounds in soil or due to supply of natural chelating agents which makes more availability and uptake of micronutrients (Barik *et al*., 2006). The chelatingaction of released organic compounds prevent the micronutrient cations from fixation,precipitation, oxidation,leaching and increase their availability and uptake by plants.Thisisinaccordance withresultsofGogoi*et al*.(2010).The application of biofertilizer increased the uptake of both macro and micro nutrients. It was observed that biofertilizer application had enhanced plant nutrients uptake. The results are in close agreement with the findings of Mohammadi *et al*. (2020) who demonstrated the ability of biofertilizers in increasing nutrient availability and uptake.

3.2.2 Manganese Uptake

Among all the treatments, the highest Mn uptake in plant was recorded in the treatment T_5*i.e.*,100% RDF + VAM +*Azospirillum* and PSB (85.24, 325.54, 249.40, 101.96 g ha^{-1} in 2020 and 95.78, 336.45, 272.94, 109.91 g ha^{-1} in 2021) and it was on par with the treatments T_7, T_3 and T_4 at knee high, tasseling and harvest (straw and grain) stages of maize during *kharif*, 2020 and 2021, respectively(Table-6). The recommended dose of fertilizer T_2 (100% RDF) (55.31, 249.74, 187.56, 75.36 g ha^{-1} in 2020 and 64.22, 263.71, 197.17, 82.62 g ha^{-1} in 2021) was on par with T_3, T_4, T_6 and T_7 at knee high, tasseling and harvest (straw + grain) stages of maize crop. The lowest manganese uptake was recorded with the treatment T_1 *i.e.*, control (34.16, 135.43, 91.59, 39.35 g ha^{-1} in 2020

and 38.70, 149.03, 104.75, 43.88 g ha^{-1} in 2021).Application of inorganics in combination with biofertilizers might had increased the availability of Mn in soil thereby increased plant nutrient uptake. Similar results were observed by Krishnaveni (2010). It was observed that biofertilizer application had enhanced plant nutrients uptake. On the other hand, Mn uptake was gradually increased with advancement of stage of crop. Since drymatter production, yield and nutrient content were maximum or higher at harvest therefore significantly higher nutrient uptake is obvious (Amit *et al*., 2018).

3.2.3 Copper Uptake

The results revealed that Cu uptake at different stages of maize was significantly influenced by different treatments imposed during both the years study(Table-7). The highest Cu uptake by the plant was recorded in the treatment T_5*i.e*., 100% RDF + VAM + *Azospirillum* and PSB (31.62, 106.45, 108.03, 45.64 g ha^{-1} in 2020 and 37.18, 114.13, 112.90, 49.88 g ha^{-1} in 2021) and it was on par with T_7, T_3 and T_4 at knee high, tasseling and harvest (straw+ grain) stages of maize during *kharif*, 2020 and 2021, respectively. The recommended dose of fertilizer T_2 (100% RDF) (20.06, 80.07, 84.73, 28.01 g ha^{-1} in 2020 and 24.90, 86.23, 87.40,35.34 g ha^{-1} in 2021) was on par with T_3, T_4, T_6 and T_7 at knee high, tasseling and harvest (straw + grain) stages of maize crop. The lowest copper uptake was recorded with the treatment (T_1) control (10.41, 38.95, 37.50, 17.11 g ha^{-1} in 2020 and 14.07, 50.39, 46.57, 18.55 g ha^{-1} in 2021).Application of inorganics in combination with biofertilizers are high which might had increased the availability of Cu in soil thereby increased plant nutrient uptake. Copper uptake was gradually increased with vegetative phase to harvest. When absorbed during the vegetative phase it helps in synthesizing the chlorophyll necessary for photosynthesis and promotes rapid leaf, stem and root growth which stimulates micronutrient absorption and assimilation of nutrients. The increased absorption of micronutrient cations also might be due to complexing properties of organics which prevent precipitation, fixation of these nutrients and keep them in soluble form (Madhavi *et al*.,2008).

3.2.4 Zinc Uptake

Among the different treatments applied, the treatment T_5 that received 100% RDF +VAM + *Azospirillum* and PSB (74.99, 266.58, 290.77, 201.37 g ha^{-1} in 2020 and 83.73, 286.71, 301.62, 209.66 g ha^{-1} in 2021) and it was on par with the treatments T_7, T_3 and T_4 at knee high, tasseling and harvest (straw and grain) stages of maize during the 2020 and 2021, respectively.The recommended

dose of fertilizerT_2 (100% RDF) (48.59, 211.57, 222.32, 149.27 g ha^{-1} in 2020 and 55.14, 228.67, 227.93, 157.98 g ha^{-1} in 2021) was on par with T_3, T_4, T_6 and T_7at knee high, tasseling and harvest (straw + grain) stages of maize crop,respectively.The lowest zinc uptakewas recorded with the treatment T_1 *i.e.*, control (29.03, 124.23, 129.39, 82.32 g ha^{-1} in 2020 and 32.43, 131.91, 132.71, 90.23 g ha^{-1}in 2021).Increased cationic micronutrient uptake at higher level of fertilizers and biofertilizers could be due to the reason that release of NH_4^+ and K^+ into soil solution in higher quantities may release cations including micronutrients from soil exchange complex and help in root exchange and thus might increase their availability, concentration and uptake.Increased accumulation of nutrients especially nitrogen, phosphorus, potash and zinc in vegetative parts was might be due to improved metabolism and led to greater translocation of these nutrients to reproductive structures of the crop. The increased photosynthetic efficiency, which favoured drymatter production and nutrient concentration in plants, seems to be the major factor responsible for higher nutrient uptake. These results are in close conformity with Kumar *et al.* (2018).

4.Conclusion

The combined application of biofertilizers and inorganic fertilizers significantly increased nutrient content and uptake at different growth stages of maize crop. The split application of inorganic fertilizers increased plant nutrient content and uptake of maize.The additional effect of improvement in plant nutrition status might be due to biofertilizers and inorganic dose which in combination gave better result in integrated treatments. The increased nutrient uptake could be due to higher drymatter accumulation at different stages of crop growth as uptake being the product of nutrient content and drymatter accumulation.

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Table 1. Effect of different levels of fertilizers in combination with biofertilizers on iron content(mg kg^{-1}) at differentgrowth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	74.12	65.32	36.81	31.94	80.55	70.16	38.19	28.70
T_2: 100% RDF	91.82	79.53	48.83	40.14	98.79	86.21	50.65	40.48
T_3: 125% RDF	103.83	89.26	53.67	43.47	107.13	96.10	53.94	44.13
T_4: 100% RDF + VAM	100.77	86.64	51.95	41.19	106.00	92.97	52.95	42.11
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	106.37	92.16	58.48	46.84	113.07	100.15	60.15	47.77
T_6: 75% RDF + VAM	87.62	75.59	47.79	35.80	95.56	81.25	48.43	39.46
T_7: 75% RDF + VAM + *Azospirillum* + PSB	104.10	90.18	55.47	44.43	111.76	97.84	56.47	45.16
SEm (±)	6.94	5.79	4.25	3.24	7.16	6.55	4.34	3.73
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.58	12.12	14.59	13.85	12.18	12.72	14.58	14.35

Table 2. Effect of different levels of fertilizers in combination with biofertilizers on manganese content (mg kg^{-1}) at different growth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Kneehigh	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	34.34	31.11	18.53	10.16	37.08	32.42	19.37	10.86
T_2: 100% RDF	42.87	38.26	24.99	13.83	45.91	40.27	25.89	14.11
T_3: 125% RDF	46.18	43.11	27.59	15.19	49.49	44.15	28.52	15.64
T_4: 100% RDF + VAM	44.93	41.47	26.90	14.76	47.25	42.50	27.92	14.76
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	49.77	45.37	29.40	16.18	52.77	46.42	31.43	16.73
T_6: 75% RDF + VAM	40.58	36.61	24.39	13.44	42.62	37.66	25.37	13.77
T_7: 75% RDF + VAM + *Azospirillum* + PSB	48.85	44.23	28.38	15.86	51.51	45.23	29.59	16.11
SEm (±)	3.53	2.96	2.11	1.20	3.22	3.12	2.28	1.18
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	13.91	12.79	14.17	14.61	11.95	13.06	14.22	14.05

Table 3. Effect of different levels of fertilizers in combination with biofertilizers on copper content (mg kg^{-1})at different growth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Kneehigh	Tasseling	Harvest		Kneehigh	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	10.47	9.41	7.06	5.05	13.69	10.50	8.67	4.52
T_2: 100% RDF	15.22	12.72	11.61	6.01	17.05	13.22	11.12	6.14
T_3: 125% RDF	16.93	13.30	12.20	6.74	17.76	14.51	12.41	7.16
T_4: 100% RDF + VAM	16.11	12.98	11.59	6.19	17.48	13.77	11.82	6.43
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	18.15	14.76	12.68	7.23	20.22	15.62	12.96	7.55
T_6: 75% RDF + VAM	14.51	11.68	10.55	5.46	15.61	12.32	10.71	5.63
T_7: 75% RDF + VAM + *Azospirillum* + PSB	17.20	14.22	12.47	7.10	18.64	14.85	12.59	7.31
SEm (±)	1.32	1.11	0.96	0.51	1.34	1.14	0.88	0.48
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	14.46	14.32	14.68	13.99	14.52	14.36	14.51	13.52

Table 4. Effect of different levels of fertilizers in combination with biofertilizers on zinc content (mg kg^{-1}) at differentgrowth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	29.18	26.84	24.42	21.25	31.07	27.93	24.63	22.33
T_2: 100% RDF	37.46	31.63	29.76	27.11	39.19	34.13	30.03	27.37
T_3: 125% RDF	40.34	35.95	32.88	29.27	43.18	37.08	33.23	29.55
T_4: 100% RDF + VAM	39.43	34.85	31.87	28.78	41.37	35.82	32.14	28.97
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	43.43	37.15	34.26	31.60	45.85	39.52	34.75	31.82
T_6: 75% RDF + VAM	36.21	31.23	29.74	26.74	37.43	32.36	30.07	26.93
T_7: 75% RDF + VAM + *Azospirillum* + PSB	41.19	36.36	33.58	30.15	43.85	38.35	33.88	31.06
SEm (±)	3.12	2.14	2.23	1.97	3.19	2.24	2.19	2.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	14.13	11.09	12.48	12.27	14.24	11.33	12.36	12.44

Table 5. Effect of different levels of fertilizers in combination with biofertilizers on iron uptake (g ha^{-1}) at different growth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	73.74	293.80	192.06	106.34	84.09	322.52	206.53	110.60
T_2: 100% RDF	123.69	528.83	365.44	211.70	141.48	575.00	385.06	225.82
T_3: 125% RDF	158.09	594.36	426.37	250.91	177.91	650.00	434.68	273.87
T_4: 100% RDF + VAM	157.44	551.95	403.57	246.11	174.65	602.01	420.09	258.82
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	182.18	655.19	493.98	287.29	205.00	720.16	519.62	311.43
T_6: 75% RDF + VAM	102.24	446.31	318.34	183.52	122.90	482.01	328.01	176.90
T_7: 75% RDF + VAM + *Azospirillum* + PSB	170.10	626.01	451.90	269.74	194.33	684.41	468.69	283.45
SEm (±)	8.48	38.46	30.11	13.39	10.29	40.79	33.04	17.40
CD (P=0.05)	26.12	118.51	92.79	41.27	31.72	125.68	101.79	53.63
CV (%)	10.46	12.55	13.55	10.22	11.27	12.19	14.31	12.69

Table 6. Effect of different levels of fertilizers in combination with biofertilizers on manganese uptake (g ha^{-1}) at differentgrowth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	34.16	135.43	91.59	39.35	38.70	149.03	104.75	43.88
T_2: 100% RDF	55.31	249.74	187.56	75.36	64.22	263.71	197.17	82.62
T_3: 125% RDF	74.57	293.78	219.08	84.76	84.04	300.81	229.65	95.89
T_4: 100% RDF + VAM	71.69	277.81	204.64	84.20	78.99	289.19	218.93	90.31
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	85.24	325.54	249.40	101.96	95.78	336.45	272.94	109.91
T_6: 75% RDF + VAM	49.36	222.51	163.58	63.20	57.04	231.83	172.97	68.51
T_7: 75% RDF + VAM + *Azospirillum* + PSB	80.04	310.84	230.56	90.36	89.31	317.87	243.63	100.89
SEm (±)	4.42	15.64	15.99	5.93	5.46	15.49	17.65	6.44
CD (P=0.05)	13.61	48.19	49.26	18.29	16.84	47.73	54.39	19.84
CV (%)	11.82	10.31	14.18	13.15	12.97	9.83	14.71	13.05

Table 7. Effect of different levels of fertilizers in combination with biofertilizers on copper uptake (g ha^{-1}) at differentgrowth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	10.41	38.95	37.50	17.11	14.07	50.39	46.57	18.55
T_2: 100% RDF	20.06	80.07	84.73	28.01	24.90	86.23	87.40	35.34
T_3: 125% RDF	26.13	91.58	97.07	40.02	31.06	99.73	100.17	44.21
T_4: 100% RDF + VAM	24.65	86.08	93.35	37.79	29.54	92.75	93.40	40.07
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	31.62	106.45	108.03	45.64	37.18	114.13	112.90	49.88
T_6: 75% RDF + VAM	18.05	69.24	70.46	25.83	21.90	73.29	72.73	29.09
T_7: 75% RDF + VAM + *Azospirillum* + PSB	28.72	99.70	100.01	42.72	33.87	104.86	102.93	45.95
SEm (±)	1.87	6.62	5.54	2.56	2.52	7.05	7.19	3.20
CD (P=0.05)	6.98	20.40	17.08	7.89	7.75	21.73	22.15	9.85
CV (%)	14.09	13.82	11.23	13.09	13.61	13.76	14.17	14.79

Table 8. Effect of different levels of fertilizers in combination with biofertilizers on zinc uptake (g ha^{-1}) at differentgrowth stages of maize

Treatments	*Kharif* (2020)				*Kharif* (2021)			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Straw	Grain			Straw	Grain
T_1: Control	29.03	124.23	129.39	82.32	32.43	131.91	132.71	90.23
T_2: 100% RDF	48.59	211.57	222.32	149.27	55.14	228.67	227.93	157.98
T_3: 125% RDF	63.00	238.04	261.70	181.17	72.16	250.23	268.21	181.51
T_4: 100% RDF + VAM	60.53	228.78	246.16	173.77	67.54	242.50	251.15	176.78
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	74.99	266.58	290.77	201.37	83.73	286.71	301.62	209.66
T_6: 75% RDF + VAM	44.36	184.97	199.27	128.40	50.51	194.37	204.79	133.00
T_7: 75% RDF + VAM + *Azospirillum* + PSB	68.22	253.45	269.77	195.87	77.16	269.16	277.49	195.72
SEm (±)	4.81	12.66	15.22	9.10	5.33	14.45	18.49	11.17
CD (P=0.05)	14.82	39.00	46.89	28.03	16.41	44.54	56.98	34.43
CV (%)	14.93	10.18	11.39	9.80	14.65	10.93	13.48	11.76