EFFECT OF DIFFERENT LEVELS OF FERTILIZERS IN COMBINATION WITH BIOFERTILIZERS ON AVAILABLE NUTRIENT STATUS OF SOIL IN *KHARIF* MAIZE

ABSTRACT

A field experiment entitled **"Effect of different levels of fertilizers in combination with biofertilizers on available nutrient status of soil in *kharif* maize"** was conducted at Agriculture College Farm, Bapatla, during both *kharif* 2020 and 2021. The experiment was laid out in randomized block design (RBD) with seven treatments and replicated thrice. The treatments consisted of 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. The results revealed that available macro nutrients (nitrogen, phosphorus and potassium) and micronutrients (zinc, iron, manganese and copper) of maize. During *kharif* in two years of study significantly higher available nitrogen was recorded with 125 % RDF (T_3) it was on par with 100% RDF + VAM + *Azospirillum* + PSB (T_5) and 100% RDF + VAM (T_4). Higher available phosphorus and potassium were recorded in the treatment T_5 that received 100% RDF +VAM + *Azospirillum* + PSB and it was on par with treatment which received 75 % RDF + VAM + *Azospirillum* + PSB (T_7), 125 % RDF (T_3) and 100% RDF + VAM (T_4) at knee high, tasseling and harvest stage of maize. However, micronutrient status was higher with application of 100% RDF +VAM + *Azospirillum* + PSB but non-significant at all the growth stages of maize during both the years of study. Present study highlights the need of use of biofertilizers along with inorganic fertilizers improved nutrient availability and increased fertility status of soil and productivity.

Key words: Available nutrients status, Biofertilizers, Recommended dose of fertilizers and Soil health.

INTRODUCTION

Maize *(Zea mays* L.) is one of the important cereal crops next only to wheat and rice in the world. In India, it ranks fourth after rice, wheat and sorghum. Maize is principal staple food in many countries, particularly in the tropics and subtropics and it is being consumed both as food and fodder and also required by the various industries. The crop has high genetic yield potential hence, it is called Miracle crop and "Queen of Cereals. It is a nutrient exhaustive crop than other cereals and absorbs large quantity of nutrients from the soil during its different growth stages. Maize responds well to fertilizer but under field conditions due to over reliance on nitrogenous fertilizers and no or negligible used of organic manure its yield potential is difficult to exploit. biofertilizers not only help to provide balanced nutrient but also support sustainable production due to their pivotal role in soil health enhancement.

Biofertilizers are products containing live or latent microorganisms that are capable of mobilizing nutrients from unavailable form to available form through biological processes. Proper use of biofertilizers and inorganics help in maintaining the fertility of agricultural soils. *Azospirillum* are free living bacteria which colonize near the root zone and enhance the available nitrogen in the soil by N fixation, whereas phosphate solubilizing bacteria (PSB) solublize the unavailable phosphorus in the soil and make it available for the plants (Kachari and Korla, 2009). *Vesicular Arbuscular Mycorrhizae* (VAM) help in the development of stronger root system, increase root surface area, improve growth (Zandavalli *et al*., 2004). The use of nitrogen fixing microbes will help in reducing the dependence on urea, while phosphorus solubilizing microbes will increase the availability of P from relatively unavailable pools, thus use of integrated source of nutrients will help in curtailing over dependence on inorganic fertilizers alone for nutrient supply to maize. Application biofertilizers along with inorganic fertilizers improved available soil nutrient status.

Soil fertility is influenced by the biofertilizers, which play an important role in fixing atmospheric nitrogen, solubilizing insoluble form of phosphorous, potash and mobilizes the immobile nutrients in soil. These processes enhance the nutrient status of soil. In this study, microbial consortium consisting of biofertilizers *viz*., nitrogen fixing, P solubilizer bacteria and VAM were used.

MATERIAL AND METHODS

Site Description

The field experiment were 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 soil micronutrients *viz*; iron (6.81 mg kg^{-1}), manganese (5.43

mg kg^{-1}), copper (1.37 mg kg^{-1}) and zinc (0.58 mg kg^{-1}) in initial soil characters of the experimental field.

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, SSP and MOP and biofertilizers like VAM -12.5 kg ha^{-1}, *Azospirillum* -5 kg ha^{-1} and PSB -5 kg ha^{-1} through applied vermicompost.

Collection and Preparation of Soil Samples: Initial soil samples were collected from the entire field randomly and made into composite samples, from the composite sample representative sample was taken by quartering method. Plot wise surface (0-15) soil samples were collected at knee high, tasseling and at harvest stages of maize. The soil samples were air dried in shade, ground and screened through 2mm sieve and used for laboratory analysis. These soil samples were further estimation of available soil nutrient status. Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit (Subbiah and Asija, 1956). Available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965). Available potassium in the samples was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer (Jackson, 1973). Available zinc, iron, manganese and copper in the soils were determined in DTPA extract, using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Available macronutrients

Available nitrogen

Data pertaining to the soil available nitrogen (Table-1) indicated that various levels of fertilizers and biofertilizer treatments imposed on maize crop have shown significant effect on available nitrogen at all the growth stages of maize during both the years of study. Significantly higher soil available nitrogen was recorded in the treatment T_3 *i.e.*, 125% RDF (372, 361, 349 kg ha^{-1} and 383, 366, 351 kg ha^{-1}) in *kharif*, 2020 and 2021, respectively at knee high, tasseling and harvest stages of maize crop and it was on par with the treatments T_5 (100% RDF + VAM + *Azospirillum* and PSB) (349, 338, 319 kg ha^{-1} and 357343, 317 kg ha^{-1}) and T_4 (100% RDF+VAM) (338, 327, 314 kg ha^{-1} and 346, 332, 316 kg ha^{-1}) and these were significantly superior over other treatments during both the years of study. The lowest available nitrogen was recorded with the treatment T_1 *i.e.*, control (262, 234, 204 kg ha^{-1} in 2020 and 269, 239, 206 kg ha^{-1} in 2021) which received no fertilizers at all the three stages of crop growth. The moist soil conditions might have helped the mineralization of soil nitrogen and greater multiplication of soil microbes, which could convert organically bound nitrogen into readily available form leading to building up of higher available nitrogen. Combined application of biofertilizers and inorganic fertilizers increased the available nitrogen in soil. The important characteristic of *Azospirillum* is that they excrete ammonia in the rhizosphere in the presence of root exudates. This might be ascribed to fixation of nitrogen by *Azospirillum.* The increase in availability of nitrogen in the plots where biofertilizers were applied could also be attributed to positive relation between the added and native microorganisms in the soil that mineralized the organic matter (Ponmurugan and Gopi, 2006). The role of *Azospirillum* and phosphobacteria in enhancing the availability of nitrogen in the soil was reported by Ram *et al*. (2011).

Available phosphorus

Close perusal of the data pertaining to available phosphorus in soil (Table-2) revealed that irrespective of the year of study, the available phosphorus at all the growth stages of maize crop were significantly influenced by the combined application of biofertilizers and inorganics. At all growth stages of maize, among the different treatments applied, the treatment that received 100% RDF + VAM + *Azospirillum* and PSB (T_5) (62.08, 58.69, 53.53 kg ha^{-1} and 64.11, 60.07, 55.65 kg ha^{-1}) recorded significantly highest available phosphorus in soil and it was on par with the treatments T_7 (75% RDF+ VAM + *Azospirillum* and PSB) (59.95, 55.67, 50.26 kg ha^{-1} and 62.01, 57.97, 52.93 kg ha^{-1}), T_4 (100% RDF+VAM) (57.24, 52.56, 48.19 kg ha^{-1} and 59.30, 55.27, 50.23 kg ha^{-1}) and T_3 (125% RDF) (55.28, 51.24, 47.17 kg ha^{-1} and 47.17, 57.33, 48.61 kg ha^{-1}) at knee high, tasseling and harvest stages of maize crop. These were significantly superior over other treatments during both the years of study. The lowest available phosphorus was recorded with the treatment T_1 *i.e.*, control (39.52, 35.33, 31.35 kg ha^{-1} in 2020 and 41.59, 37.54, 32.15 kg ha^{-1} in 2021) which received no fertilizers at all the three stages of crop growth. The results revealed that available soil phosphorus significantly increased with combined application of biofertilizers and inorganic fertilizers. The use of biofertilizer with chemical fertilizer can play an important role in improving P availability. The increase in soil P content might be due to the P-solubilizing potential of the isolates in biofertilizer. This may be attributed to the production of organic acids and solubilization of inorganic insoluble phosphates by microorganisms. The potential role of soil microorganisms for increasing the amount of available P by phytase activity has also been reported by Richardson (2001). Amending soil with biofertilizers and inorganic fertilizers helps in enhancing the P concentration in solution through mineralization of organic P and solubilization of native soil P compounds by producing organic acids (Roy *et al*., 2017).

Available Potassium

Data pertaining to the soil available potassium (Table-3) indicated that combined application of inorganics and biofertilizers have shown significant effect on available potassium at all the three growth stages of maize during both the years of study. The results revealed that significantly the highest available potassium in soil was recorded in the treatment T_5 (100% RDF + VAM +*Azospirillum* and PSB) (493, 475, 457 kg ha^{-1} and 500, 482, 460 kg ha^{-1}) and it was on par with the treatments T_7 (75% RDF+ VAM + *Azospirillum* and PSB) (484, 463, 445 kg ha^{-1} and 488, 467, 448 kg ha^{-1}), T_3 (125% RDF) (483, 453, 436 kg ha^{-1} and 486, 457, 439 kg ha^{-1}) and T_4 (100% RDF+VAM) (476, 446, 426 kg ha^{-1} and 479, 450, 429 kg ha^{-1}) at knee high, tasseling and harvest stages of maize crop. These were significantly superior over other treatments during both the years of study. The lowest available potassium was recorded with the treatment T_1 *i.e*., control (389, 363, 332 kg ha^{-1} in 2020 and 391, 365, 335 kg ha^{-1} in 2021) which received no fertilizers at all the three stages of crop growth. The present study indicated that application of biofertilizers along with inorganic fertilizers increased the available potassium content in soil. This may be due to variety of soil microbes which can release soluble potassium from potassium-bearing minerals. These microbes release organic acid, which quickly dissolves rock and chelate ions, releasing K ions into the soil (Friedrich *et al.*, 2004). It has been shown that *Bacillus mucilaginosus* and *Bacillus edaphicus* can generate polysaccharide and carboxylic acids, such as tartaric acid and citric acid, to solubilize K compounds (Lin *et al.,* 2002). The presence of indigenous potassium-solubilizing microbes might have increased the concentration of available soil potassium. In addition, the organic acids released during decomposition of manures mobilize the native or non-exchangeable forms of potassium and charge the soil solution with potassium ions, so that it will be readily available. The results were in close conformity with Thakur *et al*. (2010) and Pande *et al*. (2013).

Available micronutrients

Available Iron

Close examination of data pertaining to soil available iron (Table-4) revealed that available iron at all the stages of maize was non significantly influenced by different levels of fertilizers and biofertilizers during both the years of study. Numerically, higher available iron in soil was recorded in T_5 *i.e.*, 100% RDF+ VAM + *Azospirillum* and PSB (7.54, 7.27, 7.08 mg kg^{-1} and 7.69, 7.38, 7.14 mg kg^{-1}) and lower values (6.70,6.46,6.23 mg kg^{-1} and 6.85,6.55,6.27 mg kg^{-1}) were recorded in T_1 *i.e.*, control at knee high, tasseling and harvest stages of maize during *kharif*, 2020 and 2021, respectively. Critical observation of the data revealed that there was no much influence of inorganics alone or their combination with biofertilizers on available micronutrient status of the soil. However, the treatments received combined application of inorganics with biofertilizers have shown a slight increase in micronutrients, which might be due to formation of chelated forms and enhance mineralization and solubilisation of the native nutrients (Kharache *et al.*, 2013). Increase in available Fe might be due to lowering of pH as a result of decomposition of organics which was known to increase the solubility of metallic elements (Prasad *et al.*, 2010b).

Available Manganese

Data related to available manganese content in soil are presented in the table 5 and revealed that available manganese at all the stages of maize was non significantly influenced by different levels of fertilizers and biofertilizers during both the years of study. Numerically, higher available manganese in soil was recorded in T_5 *i.e.*, 100% RDF+ VAM + *Azospirillum* and PSB (6.44, 6.27, 6.17 mg kg^{-1} and 6.52, 6.39, 6.24 mg kg^{-1}) and lower values (5.30, 5.10, 5.00 mg kg^{-1} and 5.38, 5.17, 5.06 mg kg^{-1}) were recorded in T_1 *i.e.*, control at knee high, tasseling and harvest stages of maize during both *kharif*, 2020 and 2021, respectively. Combined application of inorganics and biofertilizers non significantly influenced available manganese content but slightly increased when compared to control. This might be due to the solubility of Mn under relatively acid and reducing conditions like Fe. Most of the total Mn in soils was found in the Mn - oxide and organic fractions the later are more soluble and therefore, easier to redistribute in plant available forms than the Fe - oxide and residual forms (Das, 2000). However, the available manganese was decreased with advancement of crop stage during both the years. This decrease in Mn might be attributed to the depletion of micronutrients from soil due to crop uptake (Veeranagappa *et al*., 2011a).

Available Copper

The results pertaining to soil available copper (Table-6) revealed that irrespective of the year of study, the available copper status at knee high, tasseling and harvest stages of maize crop was non significantly influenced by the treatments that received inorganics along with the biofertilizers. The higher available copper content in soil recorded with the treatment T_5 *i.e.*, 100% RDF+ VAM + *Azospirillum* and PSB (1.69,1.59,1.55 mg kg^{-1} and 1.77,1.65,1.59 mg kg^{-1}) and lower values (1.32, 1.22, 1.18 mg kg^{-1} and 1.38,1.28,1.22 mg kg^{-1}) were recorded in T_1 *i.e.*, control at knee high, tasseling and harvest stages of maize during both *kharif*, 2020 and 2021, respectively. The enhancement in the available Cu due to the addition of organic substances might be ascribed to their ability to form stable water soluble complexes preventing the reaction with other soil constituents and also increasing the Cu content by releasing it from the native reserves (Gupta *et al*., 1988). Copper has a strong affinity for the nitrogen atom of amino groups and it appeared quite likely that soluble nitrogen compounds like amino acids act as copper carriers in xylem and phloem.

Available Zinc

Close observation of data presented in table 7 indicated that, among the different treatments imposed to *kharif* maize, combined application of inorganics and biofertilizers have shown a non significant effect on available zinc status in soil. Higher available zinc in soil was recorded in T_5 *i.e.*, 100% RDF+ VAM + *Azospirillum* and PSB (0.67, 0.62, 0.60 mg kg^{-1} and 0.73, 0.68, 0.64 mg kg^{-1}) and lower values (0.54, 0.50, 0.47 mg kg^{-1} and 0.59, 0.54, 0.51 mg kg^{-1}) were recorded in T_1 *i.e.*, control at knee high, tasseling and harvest stages of maize during both *kharif*, 2020 and 2021, respectively. Application of 100% RDF+ VAM + *Azospirillum* and PSB (T_5) slightly increased zinc content compared to control (T_1), but non significantly influenced by the treatments. The available Zn decreased with advancement of crop stage during both the years of study. The decrease might be attributed to uptake of Zn by the growing plants. On the other hand, all the available micronutrients were gradually decreased with advancement of crop stage *i.e.,* from knee high to harvest stages of maize. The lowest content was obtained at harvest stage and the highest content was obtained at knee high stage. This might be due to the continuous depletion of nutrients by crop uptake. Similar type of results were noted by Subhalakshmi and Pratapkumarreddy (2017).

Conclusion

The present findings of this research revealed that combined application of different levels of fertilizers and biofertilizers significantly improved available soil nutrient status. The efficacy of biofertilizer as good organic amendments in the soil for enhanced improvement of soil chemical properties. The application of biofertilizers has beneficial effects on maintaining nutrient status of the soil as it increases the available macro nutrients (nitrogen, phosphorus and potassium) and micro nutrients (iron, manganese, copper and zinc) of the soil.

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Table 1. Effect of different levels of fertilizers in combination with biofertilizers on available nitrogen (kg ha^{-1}) at different stages of maize

Treatments	*Kharif* (2020)			*Kharif* (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	262	234	204	269	239	206
T_2: 100% RDF	309	294	277	316	299	281
T_3: 125% RDF	372	361	349	383	366	351
T_4: 100% RDF + VAM	338	327	314	346	332	316
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	349	338	319	357	343	317
T_6: 75% RDF + VAM	299	278	247	309	283	253
T_7: 75% RDF + VAM + *Azospirillum* + PSB	313	297	278	320	302	281
SEm (±)	11.3	11.4	11.8	12.5	11.4	11.8
CD (P=0.05)	35	35	36	38	35	36
CV (%)	6.2	6.5	7.2	6.6	6.4	7.2

Treatments	*Kharif* (2020)	*Kharif* (2021)

Table 2. Effect of different levels of fertilizers in combination with biofertilizers on available phosphorus (kg ha^{-1}) at different stages of maize

	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	39.52	35.33	31.35	41.59	37.54	32.15
T_2: 100% RDF	51.35	47.26	43.62	53.38	49.36	44.34
T_3: 125% RDF	55.28	51.24	47.17	57.33	53.31	48.61
T_4: 100% RDF + VAM	57.24	52.56	48.19	59.30	55.27	50.23
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	62.08	58.69	53.53	64.11	60.07	55.65
T_6: 75% RDF + VAM	49.38	45.02	42.62	51.49	47.46	43.44
T_7: 75% RDF + VAM + *Azospirillum* + PSB	59.95	55.67	50.26	62.01	57.97	52.93
SEm (±)	2.46	2.63	2.54	2.45	2.44	2.36
CD (P=0.05)	7.57	8.12	7.81	7.54	7.53	7.28
CV (%)	7.95	9.24	9.70	7.62	8.21	8.78

Table 3. Effect of different levels of fertilizers in combination with biofertilizers on available potassium (kg ha^{-1}) at different stages of maize

Treatments	*Kharif* (2020)			*Kharif* (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	389	363	332	391	365	335
T_2: 100% RDF	445	423	403	449	425	405
T_3: 125% RDF	483	453	436	486	457	439
T_4: 100% RDF + VAM	476	446	426	479	450	429
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	493	475	457	500	482	460
T_6: 75% RDF + VAM	439	417	387	443	420	386
T_7: 75% RDF + VAM + *Azospirillum* + PSB	484	463	445	488	467	448
SEm (±)	16.5	16.6	16.8	16.0	16.5	15.9
CD (P=0.05)	49	51	52	49	51	49
CV (%)	6.3	6.6	7.0	6.0	6.6	6.6

Treatments	*Kharif* (2020)	*Kharif* (2021)

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

	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	6.70	6.46	6.23	6.85	6.55	6.27
T_2: 100% RDF	7.27	7.01	6.82	7.42	7.11	6.87
T_3: 125% RDF	7.34	7.09	6.91	7.49	7.20	6.94
T_4: 100% RDF + VAM	7.31	7.06	6.83	7.46	7.16	6.88
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	7.54	7.27	7.08	7.69	7.38	7.14
T_6: 75% RDF + VAM	7.18	6.94	6.71	7.33	7.05	6.76
T_7: 75% RDF + VAM + *Azospirillum* + PSB	7.46	7.22	7.04	7.61	7.33	7.10
SEm (±)	0.31	0.31	0.31	0.31	0.31	0.31
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	7.45	7.57	7.92	7.33	7.46	7.88

Table 5. Effect of different levels of fertilizers in combination with biofertilizers on available manganese (mg kg^{-1}) at different stages of maize

Treatments	*Kharif* (2020)			*Kharif* (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	5.30	5.10	5.00	5.38	5.17	5.06
T_2: 100% RDF	5.72	5.59	5.50	5.81	5.67	5.57
T_3: 125% RDF	6.14	5.93	5.81	6.23	6.02	5.88
T_4: 100% RDF + VAM	5.93	5.74	5.65	6.03	5.85	5.72
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	6.44	6.27	6.17	6.52	6.39	6.24
T_6: 75% RDF + VAM	5.61	5.43	5.37	5.69	5.49	5.44
T_7: 75% RDF + VAM + *Azospirillum* + PSB	6.33	6.11	6.02	6.41	6.23	6.09
SEm (±)	0.25	0.24	0.25	0.25	0.25	0.25
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	7.37	7.38	7.80	7.31	7.42	7.69

Table 6. Effect of different levels of fertilizers in combination with biofertilizers on available copper (mg kg^{-1}) at different stages of maize

Treatments	*Kharif* (2020)			*Kharif* (2021)		
	Kneehigh	**Tasseling**	**Harvest**	**Kneehigh**	**Tasseling**	**Harvest**
T_1: Control	1.32	1.22	1.18	1.38	1.28	1.22
T_2: 100% RDF	1.57	1.48	1.44	1.63	1.56	1.48
T_3: 125% RDF	1.64	1.55	1.51	1.71	1.61	1.55
T_4: 100% RDF + VAM	1.60	1.51	1.47	1.67	1.58	1.51
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	1.69	1.59	1.55	1.77	1.65	1.59
T_6: 75% RDF + VAM	1.50	1.40	1.37	1.56	1.46	1.41
T_7: 75% RDF + VAM + *Azospirillum* + PSB	1.67	1.58	1.52	1.75	1.64	1.56
SEm (±)	0.08	0.08	0.08	0.08	0.08	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	8.43	9.09	9.27	8.22	8.92	9.01

Treatments	*Kharif* (2020)	*Kharif* (2021)

Table 7. Effect of different levels of fertilizers in combination with biofertilizers on available zinc (mg kg^{-1}) at different stages of maize

	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T_1: Control	0.54	0.50	0.47	0.59	0.54	0.51
T_2: 100% RDF	0.59	0.55	0.53	0.64	0.60	0.57
T_3: 125% RDF	0.63	0.59	0.57	0.69	0.64	0.61
T_4: 100% RDF + VAM	0.61	0.58	0.56	0.66	0.62	0.60
T_5: 100% RDF + VAM+ *Azospirillum* + PSB	0.67	0.62	0.60	0.73	0.68	0.64
T_6: 75% RDF + VAM	0.57	0.53	0.51	0.62	0.57	0.55
T_7: 75% RDF + VAM + *Azospirillum* + PSB	0.65	0.62	0.58	0.71	0.67	0.62
SEm (±)	0.03	0.03	0.03	0.03	0.04	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	8.35	8.26	8.22	8.06	9.80	7.66