

# Original Research Article

**EFFECT OF DIFFERENT LEVELS OF FERTILIZERS IN COMBINATION WITH AND BIOFERTILIZERS application Impact ON AVAILABLE MACRONUTRIENTS STATUS OF SOIL IN KHARIF MAIZE**

## ABSTRACT

A field experiment entitled "Effect of different levels of fertilizers in combination with biofertilizers on available macro nutrient status of soil in kharif maize" was conducted at Agriculture College Farm, Bapatla, during both kharif Kharif of 2020 and 20-21. The experiment was laid out in randomized block design (RBD) with seven treatments and replicated thrice. The treatments consisted of T<sub>1</sub>- Control; T<sub>2</sub>- 100% RDF; T<sub>3</sub>- 125% RDF; T<sub>4</sub> - 100% RDF + Vesicular Arbuscular Mycorrhizae (VAM); T<sub>5</sub>- 100% RDF + VAM + Azospirillum + phosphate solubilizing bacteria (PSB); T<sub>6</sub>- 75 % RDF + VAM; T<sub>7</sub>- 75 % RDF + VAM + Azospirillum + PSB. The results revealed that available macronutrients (nitrogen, phosphorus, and potassium) of maize during the study. The results revealed that available nitrogen during during kharif Kharif of 2020-21 was in two years of study significantly ( $P < 0.05$ ) higher available nitrogen was recorded with 125 % RDF (T<sub>3</sub>) it that was on par with T<sub>6</sub> (100% RDF + VAM + Azospirillum + PSB (T<sub>6</sub>) and T<sub>4</sub> (100% RDF + VAM (T<sub>4</sub>). Higher available phosphorus and potassium were recorded in the treatment T<sub>5</sub> that received 100% RDF + VAM + Azospirillum + PSB and it was on par with treatment which received 75 % RDF + VAM + Azospirillum + PSB (T<sub>7</sub>), 125 % RDF (T<sub>3</sub>) and 100% RDF + VAM (T<sub>4</sub>) at knee high, tasselling, and harvest stage of maize. Present study highlights the need of use of the biofertilizers have to be applied side-by-side along with inorganic fertilizers improved to improve nutrient availability and increased the fertility status of soil and productivity.

**Keywords:** Biofertilizers, Fertilizers levels, Available Macro nutrients status, Biofertilizers, Recommended dose of fertilizers and Soil health.

## INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops next only to wheat and rice in the world. In India, it ranks fourth after rice, wheat, and sorghum. Maize is the 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-nutrient-exhaustive crop than other cereals and absorbs a large quantity-number of nutrients from the soil during its different growth stages. Maize responds well to fertilizer but under field conditions, due to over-over-reliance on nitrogenous fertilizers and no or negligible use of organic manure, its yield potential is difficult to exploit. biofertilizers not only help to provide balanced nutrients 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-free-living bacteria which that colonize near the root zone and enhances the available nitrogen in the soil by N-fixation, whereas phosphate solubilizing bacteria (PSB) solubilize 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 a stronger root system, increase root surface area, and improve growth (Zandavalliet al., 2004). The use of nitrogen-nitrogen-fixing microbes will help in reducing the dependence on urea, while phosphorus-phosphorus-solubilizing microbes will increase the availability of P from relatively unavailable pools, thus the

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use of ~~the~~ integrated source of nutrients will help in curtailing ~~over-over~~ dependence on inorganic fertilizers alone for nutrient supply to maize. Application of 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 forms of phosphorous, potash, and ~~mobilizes-mobilizing~~ the immobile nutrients in ~~the~~ soil. These processes ~~can~~ enhance the nutrient status of ~~the~~ soil. In this study, ~~a~~ microbial consortium consisting of biofertilizers viz., ~~nitrogen-nitrogen~~-fixing, P solubilizer bacteria, and VAM were used.

## MATERIAL AND METHODS

### Site Description

The field experiment ~~were~~ was carried out during ~~the both Kharif Kharif~~ seasons of 2020-2021 at Agricultural College Farm, Bapatla. Geographically located at an altitude of 5.49 m above ~~mean~~ sea level, 15°54' North latitude, 80°30' East longitude, and about 8 km away from ~~the~~ Bay of Bengal. It is located in ~~the~~ 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<sup>-1</sup>), medium in organic carbon (5.4 g kg<sup>-1</sup>), medium in available nitrogen (283 kg ha<sup>-1</sup>), medium in available phosphorus (42.5 kg ha<sup>-1</sup>), high in potassium (426 kg ha<sup>-1</sup>) in initial soil characters of the experimental field.

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### 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<sub>1</sub>- Control; T<sub>2</sub>- 100% RDF; T<sub>3</sub>- 125% RDF; T<sub>4</sub> - 100% RDF + Vesicular Arbuscular Mycorrhizae (VAM); T<sub>5</sub>- 100% RDF + VAM + *Azospirillum* + phosphate solubilizing bacteria (PSB); T<sub>6</sub>- 75 % RDF + VAM; T<sub>7</sub>- 75 % RDF + VAM + *Azospirillum* + PSB. RDF for maize 200:60:50 kg ha<sup>-1</sup> N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O through applied Urea, SSP, and MOP and biofertilizers like VAM -12.5 kg ha<sup>-1</sup>, *Azospirillum* -5 kg ha<sup>-1</sup> and PSB -5 kg ha<sup>-1</sup> through applied vermicompost.

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**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 ~~a~~ quartering method. ~~Plot~~ Plot-wise surface (0-15) soil samples were collected at ~~knee-knee~~-high, tasseling, and at harvest stages of maize. The soil samples were air dried in ~~the~~ shade, ground, and screened through ~~a~~ 2mm sieve and used for laboratory analysis. These soil samples were further estimation of available soil nutrient status. Available nitrogen was estimated by ~~the~~ alkaline permanganate method by using ~~a~~ macro Kjeldahl distillation unit (Subbiah and Asija, 1956). Available phosphorus in the soil samples was extracted with 0.5 M NaHCO<sub>3</sub> buffered at pH 8.5 and the phosphorus in the extract was estimated by ~~the~~ ascorbic acid method using ~~a~~ 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 ~~a~~ flame photometer (Jackson, 1973).

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## RESULTS AND DISCUSSION

### Available macronutrients

#### Available nitrogen

~~Data pertaining to the soil available nitrogen~~ The results (Table-1) indicated that various levels of fertilizers and biofertilizer treatments imposed on maize crops have shown ~~a~~ significant ( $P < 0.05$ ) effect on available nitrogen at

all the growth stages of maize during both the years of study. Significantly ( $P < 0.05$ ) higher soil available nitrogen was recorded in the treatment T<sub>3</sub> i.e., 125% RDF (372, 361, 349 kg ha<sup>-1</sup> and 383, 366, 351 kg ha<sup>-1</sup>) in Kharif/Kharif, 2020- and 2021, respectively at knee high, tasseling, and harvest stages of maize crop and it was on par with the treatments T<sub>5</sub> (100% RDF + VAM + *Azospirillum* and PSB) (349, 338, 319 kg ha<sup>-1</sup> and 357.343, 317 kg ha<sup>-1</sup>) and T<sub>4</sub> (100% RDF+VAM) (338, 327, 314 kg ha<sup>-1</sup> and 346, 332, 316 kg ha<sup>-1</sup>) and these were significantly ( $P < 0.05$ ) superior over other treatments during both the years of study. The lowest available nitrogen was recorded with the treatment T<sub>1</sub> control i.e., control (262, 234, 204 kg ha<sup>-1</sup> in 2020 and 269, 239, 206 kg ha<sup>-1</sup> in 2021) which received no fertilizers at all the three stages of crop growth. Combined The combined application of biofertilizers and inorganic fertilizers increased the available nitrogen in the 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 the fixation of nitrogen by the *Azospirillum*. The increase in the availability of nitrogen in the plots where biofertilizers were applied could also be attributed to the positive relationship 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

At all growth stages of maize, among the different treatments applied, the treatment that received 100% RDF + VAM + *Azospirillum* and PSB (T<sub>5</sub>) (62.08, 58.69, 53.53 kg ha<sup>-1</sup> and 64.11, 60.07, 55.65 kg ha<sup>-1</sup>) recorded significantly ( $P < 0.05$ ) highest available phosphorus in soil and it was on par with the treatments T<sub>7</sub> (75% RDF + VAM + *Azospirillum* and PSB) (59.95, 55.67, 50.26 kg ha<sup>-1</sup> and 62.01, 57.97, 52.93 kg ha<sup>-1</sup>), T<sub>4</sub> (100% RDF+VAM) (57.24, 52.56, 48.19 kg ha<sup>-1</sup> and 59.30, 55.27, 50.23 kg ha<sup>-1</sup>) and T<sub>3</sub> (125% RDF) (55.28, 51.24, 47.17 kg ha<sup>-1</sup> and 47.17, 57.33, 48.61 kg ha<sup>-1</sup>) at knee high, tasseling, and harvest stages of maize crop (Table-2). These were significantly ( $P < 0.05$ ) superior over to other treatments during both the years of study. The lowest available phosphorus was recorded with the treatment T<sub>1</sub> control i.e., control (39.52, 35.33, 31.35 kg ha<sup>-1</sup> in 2020 and 41.59, 37.54, 32.15 kg ha<sup>-1</sup> in 2021) which received no fertilizers at all the three stages of crop growth. The results revealed that available soil phosphorus significantly ( $P < 0.05$ ) increased with the 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. Amending soil with biofertilizers and inorganic fertilizers helps in enhancing the P concentration in solution through the mineralization of organic P and solubilization of native soil P compounds by producing organic acids (Roy *et al.*, 2017).

#### Available Potassium

The results revealed that a significantly ( $P < 0.05$ ) the highest available potassium in the soil was recorded in the of treatment T<sub>5</sub> (100% RDF + VAM + Azospirillum and PSB) (493, 475, 457 kg ha<sup>-1</sup> and 500, 482, 460 kg ha<sup>-1</sup>) and it was on par with the treatments T<sub>7</sub> (75% RDF + VAM + Azospirillum and PSB) (484, 463, 445 kg ha<sup>-1</sup> and 488, 467, 448 kg ha<sup>-1</sup>), T<sub>3</sub> (125% RDF) (483, 453, 436 kg ha<sup>-1</sup> and 486, 457, 439 kg ha<sup>-1</sup>) and T<sub>4</sub> (100% RDF + VAM) (476, 446, 426 kg ha<sup>-1</sup> and 479, 450, 429 kg ha<sup>-1</sup>) at knee high, tasseling, and harvest stages of maize crop. These were significantly ( $P < 0.05$ ) superior over to other treatments during both the years of study (Table-3). The lowest available potassium was recorded with the treatment T<sub>1</sub> i.e., control (389, 363, 332 kg ha<sup>-1</sup> in 2020 and 391, 365, 335 kg ha<sup>-1</sup> in 2021) which received no fertilizers at all the three stages of crop growth. This may be due to a variety of soil microbes which that 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). The presence of indigenous potassium-solubilizing microbes might have increased the concentration of available soil potassium. In addition, the organic acids released during the 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).

## 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 biofertilizers as good organic amendments in the soil for enhanced improvement of soil chemical properties. The application of biofertilizers has beneficial effects on maintaining the soil nutrients status of the soil as it increases the available macronutrients (nitrogen, phosphorus, and potassium) of the soil and improved soil health.

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**Comment [es1]:** MUST BE UPDATED as zero% (0 out of 12) of the listed references were published in the past five years. The percentage has to increase to 30-40%. The old reference indicates less interest in the study field.

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Table 1. Effect of different levels of fertilizers in combination with biofertilizers on available nitrogen(kg<sub>ha</sub><sup>-1</sup>) at different stages of maize [growth](#).

Treatments	Kharif(2020)			Kharif (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T <sub>1</sub> : Control	262	234	204	269	239	206
T <sub>2</sub> : 100% RDF	309	294	277	316	299	281
T <sub>3</sub> : 125% RDF	372	361	349	383	366	351
T <sub>4</sub> : 100% RDF + VAM	338	327	314	346	332	316
T <sub>5</sub> : 100% RDF + VAM+ <i>Azospirillum</i> + PSB	349	338	319	357	343	317
T <sub>6</sub> : 75% RDF + VAM	299	278	247	309	283	253
T <sub>7</sub> : 75% RDF + VAM + <i>Azospirillum</i> + PSB	313	297	278	320	302	281
<b>SEm (±)</b>	11.3	11.4	11.8	12.5	11.4	11.8
<b>CD (P=0.05)</b>	35	35	36	38	35	36
<b>CV (%)</b>	6.2	6.5	7.2	6.6	6.4	7.2

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

Treatments	Kharif (2020)			Kharif (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T <sub>1</sub> : Control	39.52	35.33	31.35	41.59	37.54	32.15
T <sub>2</sub> : 100% RDF	51.35	47.26	43.62	53.38	49.36	44.34
T <sub>3</sub> : 125% RDF	55.28	51.24	47.17	57.33	53.31	48.61
T <sub>4</sub> : 100% RDF + VAM	57.24	52.56	48.19	59.30	55.27	50.23
T <sub>5</sub> : 100% RDF + VAM+ <i>Azospirillum</i> + PSB	62.08	58.69	53.53	64.11	60.07	55.65
T <sub>6</sub> : 75% RDF + VAM	49.38	45.02	42.62	51.49	47.46	43.44
T <sub>7</sub> : 75% RDF + VAM + <i>Azospirillum</i> + PSB	59.95	55.67	50.26	62.01	57.97	52.93
<b>SEm (<math>\pm</math>)</b>	2.46	2.63	2.54	2.45	2.44	2.36
<b>CD (P=0.05)</b>	7.57	8.12	7.81	7.54	7.53	7.28
<b>CV (%)</b>	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 ( $\text{kg}\cdot\text{ha}^{-1}$ ) at different stages of maize growth.

Treatments	Kharif (2020)			Kharif (2021)		
	Kneehigh	Tasseling	Harvest	Kneehigh	Tasseling	Harvest
T <sub>1</sub> : Control	389	363	332	391	365	335
T <sub>2</sub> : 100% RDF	445	423	403	449	425	405
T <sub>3</sub> : 125% RDF	483	453	436	486	457	439
T <sub>4</sub> : 100% RDF + VAM	476	446	426	479	450	429
T <sub>5</sub> : 100% RDF + VAM + <i>Azospirillum</i> + PSB	493	475	457	500	482	460
T <sub>6</sub> : 75% RDF + VAM	439	417	387	443	420	386
T <sub>7</sub> : 75% RDF + VAM + <i>Azospirillum</i> + PSB	484	463	445	488	467	448
<b>SEm (<math>\pm</math>)</b>	16.5	16.6	16.8	16.0	16.5	15.9
<b>CD (P=0.05)</b>	49	51	52	49	51	49
<b>CV (%)</b>	6.3	6.6	7.0	6.0	6.6	6.6