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Effect of Phosphorus Biofertilizers along with Inorganic Fertilizers on Nutrient Content of Maize

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the response of maize to phosphorus levels and phosphorus biofertilizers.
Study Design: The experiment was laid out in randomized block design with nine treatments replicated thrice.
Place and Duration of Study: Agricultural College Farm, Bapatla during *kharif*, 2019.
Methodology: The experimental soil was slightly alkaline in reaction (7.63), medium in organic carbon (0.6 %), medium in available nitrogen (354 kg ha^{-1}), high in available phosphorus (55.32 kg ha^{-1}) and available potassium (402 kg ha^{-1}).The treatments comprised of T_1- Control (without P), T_2 - 100% Recommended Dose of Phosphorus (RDP), T_3 - 100% RDP + PSB @ 1 L ha^{-1}, T_4 - 100%

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RDP + VAM @ 12.5 kg ha^{-1}, T_5 - 75% RDP + PSB @ 1 L ha^{-1}, T_6 -75% RDP + VAM @ 12.5 kg ha^{-1}, T_7 – PSB @ 1 L ha^{-1}, T_8 –VAM @ 12.5 kg ha^{-1}, T_9 - PSB @ 1 L ha^{-1} + VAM @ 12.5 kg ha^{-1}. The plant samples were analysed for N, P, K, S and micronutrients by the following standard methods.

Results: The results of the experiment indicated that P, S and Zn were significantly influenced by the imposed treatments whereas N, K, Fe, Mn and Cu were not significantly influenced. The highest nutrient content was recorded in the treatment with the application of 100% RDP + VAM@ 12.5 kg ha^{-1} (T_4).

Conclusion: The combined application (inorganic fertilizer + biofertilizer) proved significantly superior over control and biofertilizers alone in improving the nutrient content in maize.

Keywords: Phosphorus; PSB; VAM; Maize.

1. INTRODUCTION

Maize (*Zea mays* L.) is a commercial crop on which many agro-based industries depend for raw materials. For optimum plant growth, nutrients must be available in sufficient and balanced quantities. Phosphorus (P) is the most limiting nutrient after N for crop yields and is essential for maize growth and development. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction [1]. Adequate supply of phosphorus result in rapid growth and early maturity and improves the quality of vegetative growth. Large quantities of chemical fertilizers are used to replenish soil N and P resulting in high costs and environmental contamination.

Biofertilizer is a natural input that can be applied as a complement to, or as a substitute of chemical fertilizer in sustainable agriculture [2]. Biological phosphate fertilizers containing beneficial bacteria and fungi increased soluble phosphate, which can be absorbed by plants easily. Conversion of the insoluble forms of P to an accessible form by plants (ortho-phosphate) is an important trait of phosphate-solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF). Phosphate solubilizing microorganisms are more effective in mineralizing the organic phosphates in soil and increase the phosphorus availability by lowering soil pH and producing organic acids [3].

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif*, 2019-2020 at Agricultural College Farm, Bapatla. The experiment was laid out in RBD with nine treatments replicated thrice. The experimental soil was slightly alkaline in reaction (7.63), medium in organic carbon (0.6 %), medium in available nitrogen (354 kg ha^{-1}), high in available phosphorus (55.32 kg ha^{-1}) and available potassium (402 kg ha^{-1}).The treatments comprised of T_1- Control (without P), T_2 - 100% Recommended Dose of Phosphorus (RDP), T_3 - 100% RDP + PSB @ 1 L ha^{-1}, T_4 - 100% RDP + VAM @ 12.5 kg ha^{-1}, T_5 - 75% RDP + PSB @ 1 L ha^{-1}, T_6 -75% RDP + VAM @ 12.5 kg ha^{-1}, T_7 – PSB @ 1 L ha^{-1}, T_8 –VAM @ 12.5 kg ha^{-1}, T_9 - PSB @ 1 L ha^{-1} + VAM @ 12.5 kg ha^{-1}. Well decomposed farmyard manure @ 5 t ha^{-1} was applied before sowing. A common dose of nitrogen @ 200 kg ha^{-1} was applied in the form of urea in four equal splits *i.e* 1/4 as basal, 1/4 at knee high, 1/4 at tasseling and 1/4 at 60 DAS(Days After Sowing). Recommended dose of P_2O_5 @ 60 kg and 45 kg ha^{-1} was applied as per the treatments as basal just before sowing. A common dose of 50 kg K_2O $ha^{-1}$was applied as muriate of potash in two equal splits as half at basal and remaining half at tasseling stage. Farmyard manure was mixed with biofertilizers *viz.,* PSB @ 1 L ha^{-1} and VAM @ 12.5 kg ha^{-1} as per the treatments. Plant samples were collected at knee high, tasseling and harvest stages. The samples were analysed for N, P, K, S and micronutrients by the following standard methods as mentioned below.

Nutrient	References
N	Piper, [4]
P	Piper, [4]
K	Muhr *et al*. [5]
S	Chesnin and Yein, [6]
Micronutrients	Lindsay and Norvell [7]

3. RESULTS AND DISCUSSION

The data recorded on different nutrient contents in maize plants at various stages of crop growth indicated that the treatmental effects were significant only on phosphorus and sulphur contents while the other nutrients were not significantly influenced.

3.1 Phosphorus Content

Perusal of data revealed that the treatment that received 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4)

recorded significantly highest P content at knee high (0.37%), tasseling (0.30%) and harvest in kernel (0.24%) and stover (0.074%), followed by 100% RDP + PSB @ 1 L ha^{-1} (T_3) with P content values at knee high (0.35%), tasseling (0.29%) and at harvest stage (0.069 % and 0.23 % in stover and kernel, respectively).

The significantly lowest P content was recorded in control (without P) (T_1) at knee high (0.22 %), tasseling (0.19%) and at harvest stage (0.047% and 0.15% in stover and kernel, respectively). Phosphorus concentration was found to be significantly higher in maize plants treated with inorganic P and biofertilizers compared to the control plants. As a treatment result, P uptake was significantly increased in kernel and stover. Phosphorus concentration tended to increase as phosphorus fertilizer levels were increased. Increasing phosphorus level from 0 up to 60 kg, P_2O_5 ha^{-1} significantly increased phosphorus % in maize kernel and stover [8]. The phosphorus content was higher due to reduced activity phosphorus complexing agents, which leads to higher availability of phosphorus to plants. Similar results were reported by Mahesh *et al.* [9]. Reddy and Singh [10] stated that inoculation of P solubilizing bacteria in the presence of rock phosphate significantly increased the available P content of wheat and maize plants as compared to the control. This may be explained as the application of biofertilizers could make such nutrients more available for plants. Mahfouze and Sharaf - Eldin [11], found that phosphorus solvent bacteria have the ability to produce organic acids that increasing solubility and availability of phosphorus to plant.

3.2 Sulphur Content

Sulphur content in maize at different stages revealed that the treatment with 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4) recorded significantly highest sulphur content at knee high (0.235%), tasseling (0.212%) and harvest in kernel (0.330%) and stover (0.092%), which was followed by 100% RDP + PSB @ 1 L ha^{-1} (T_3) with values at knee high (0.231%), tasseling (0.203%) and at harvest stage (0.088 % and 0.310% in stover and kernel, respectively). Application of P fertilizer may result in increased S mobilization and availability in soil and hence, increased concentration in plants. Naagar and Meena [12] reported that inoculation with PSB significantly increased S-content in grain and straw of cluster beans over uninoculated control.

3.3 Zinc Content

The maximum zinc content (41.88, 35.37, 27.83 and 24.02 mg kg^{-1}) at knee high, tasseling, stover and kernel at harvest stage was recorded in control (without P) (T_1) followed by PSB@ 1 L ha^{-1}+VAM@ 12.5 kg ha^{-1}(T_9) (38.63, 33.26, 27.03 and 22.07 mg kg^{-1}).The minimum zinc content (31.76, 26.53, 21.55 and 16.84 mg kg^{-1}) was recorded with 100% Recommended Dose of Phosphorus (RDP) (T_2). Zinc content was significantly decreased with increasing in the P levels. Phosphorus applications have been reported to negatively affect the shoot and even grain Zn concentration in cereal crops [13]. In addition, complex interactions of P with cations such as Fe and especially Zn are known to occur. Chahal and Ahluwalia [14] indicated that

Table 1. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on phosphorus content (%) of maize

Treatment	Knee high	Tasseling	Harvest	
			Stover	Kernel
T_1: Control (without P)	0.22	0.19	0.047	0.15
T_2: 100% Recommended Dose of Phosphorus (RDP)	0.32	0.27	0.064	0.21
T_3: 100% RDP + PSB @ 1 L ha^{-1}	0.35	0.29	0.069	0.23
T_4: 100% RDP + VAM @ 12.5 kg ha^{-1}	0.37	0.30	0.074	0.24
T_5: 75% RDP + PSB @ 1 L ha^{-1}	0.28	0.24	0.058	0.19
T_6: 75% RDP + VAM @ 12.5 kg ha^{-1}	0.30	0.25	0.061	0.20
T_7: PSB@ 1 L ha^{-1}	0.23	0.21	0.050	0.17
T_8: VAM@ 12.5 kg ha^{-1}	0.25	0.22	0.052	0.18
T_9: PSB@ 1 L ha^{-1} + VAM@ 12.5 kg ha^{-1}	0.27	0.23	0.055	0.20
S.Em (±)	0.02	0.018	0.003	0.013
CD (P = 0.05%)	0.06	0.052	0.009	0.039
C.V (%)	11.91	12.38	9.26	11.42

Table 2. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on sulphur content (%) of maize

Treatment	Knee high	Tasseling	Harvest	
			Stover	Kernel
T_1: Control (without P)	0.176	0.126	0.063	0.220
T_2: 100% Recommended Dose of Phosphorus (RDP)	0.214	0.191	0.085	0.300
T_3: 100% RDP + PSB @ 1 L ha^{-1}	0.231	0.203	0.088	0.310
T_4: 100% RDP + VAM @ 12.5 kg ha^{-1}	0.235	0.212	0.092	0.330
T_5: 75% RDP + PSB @ 1 L ha^{-1}	0.206	0.187	0.079	0.250
T_6: 75% RDP + VAM @ 12.5 kg ha^{-1}	0.207	0.190	0.082	0.260
T_7: PSB@ 1 L ha^{-1}	0.181	0.140	0.072	0.230
T_8: VAM@ 12.5 kg ha^{-1}	0.188	0.143	0.075	0.240
T_9: PSB@ 1 L ha^{-1} + VAM@ 12.5 kg ha^{-1}	0.194	0.146	0.077	0.270
S.Em (±)	0.010	0.008	0.010	0.020
CD (P = 0.05%)	0.030	0.023	0.014	0.050
C.V (%)	8.36	7.60	10.47	11.46

Table 3. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on zinc content (mg kg^{-1}) of maize

Treatment	Knee high	Tasseling	Harvest	
			Stover	Kernel
T_1: Control (without P)	41.88	35.37	27.83	24.02
T_2: 100% Recommended Dose of Phosphorus (RDP)	31.76	26.53	21.55	16.84
T_3: 100% RDP + PSB @ 1 L ha^{-1}	32.72	28.26	22.51	18.02
T_4: 100% RDP + VAM @ 12.5 kg ha^{-1}	34.36	29.32	23.43	18.69
T_5: 75% RDP + PSB @ 1 L ha^{-1}	35.43	30.88	24.04	19.19
T_6: 75% RDP + VAM @ 12.5 kg ha^{-1}	36.10	31.26	24.55	19.61
T_7: PSB@ 1 L ha^{-1}	37.35	32.09	25.19	20.41
T_8: VAM@ 12.5 kg ha^{-1}	37.60	32.80	26.21	20.82
T_9: PSB@ 1 L ha^{-1} + VAM@ 12.5 kg ha^{-1}	38.63	33.26	27.03	22.07
S.Em (±)	1.72	1.27	1.21	1.31
CD (P = 0.05%)	5.16	3.82	3.64	3.91
C.V (%)	8.23	7.11	8.51	11.32

Zn concentration in all the plant parts of the maize were significantly and progressively decreased with the increasing rates of P application. Itelima et al. [15] stated that chemical fertilizers were more mobile, soluble and immediately available to plants than biofertilizers that need time to excrete acids for increasing the availability of essential nutrient element to plants. However, application of combined chemical and bio-fertilizers stimulate the concentration as well as uptake by maize plant. Bio-fertilizers play several roles for activates the beneficial bacteria and improve the soil fertility by increasing its available nutrients to meet the plant requirements.

4. CONCLUSION

The nutrient content (P and S) of maize at knee high, tasseling and harvest stage were significantly higher in the treatment that received 100% RDP + VAM @ 12.5 kg ha^{-1} (T_4) and it is on par with 100% RDP + PSB@ 1 L ha^{-1} (T_3). The Zn content was significantly higher with no phosphorus application and it is lower in 100% Recommended Dose of Phosphorus (RDP) (T_2). The nutrient content of N, K, Fe, Mn and Cu of maize at knee high, tasseling and harvest stage were not significantly influenced by the increasing levels of phosphorus along with biofertilizers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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