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Effect of phosphorus and zinc along with biofertilizer on plant height, drymatter and quality of maize

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ABSTRACT

A field experiment was carried out to study the performance of various treatments of phosphorus and zinc along with biofertilizer on maize and the experiment was aaducted of at Agricultural College Farm, Bapatla during *rabi* season of 2023-2024. The experiment was laid out in randomized block design (RBD) with nine treatments replicated thrice. The results indicated that the application of various levels of inorganic phosphorus, zinc fertilizer along with phosphorus biofertilizer, had a significant impact on plant height and dry matter accumulation at different stages whereas, protein content in the kernel was found to be non-significant. Higher dry matter, plant height and protein content of kernel was found with the treatment 100% RDP + PSB + VAM along with 25 or 50 kg $ZnSO_4$ ha^{-1}.

Key Words: *Biofertilizer, Phosphorus, Maize and Zinc*

Maize (*Zea mays* L.) the one of the most adaptable developing crop. It has a broad range of adaptation under various agro-climatic conditions. Due to its largest potential yield, maize is referred to as the "queen of cereals" internationally. It is an important feed and food crop which ranks third after wheat and rice in India and World.

Phosphorus (P) is second most important nutrient among primary nutrients. It is called as 'key to life' as being the main component of energy metabolism (Nieder and Benbi, 2003). Phosphorus is mainly present in soil as inorganic form namely iron (Fe) and aluminium (Al) phosphate predominantly in acid soil while calcium (Ca) phosphate dominantly present in neutral to alkaline soil. This is the major cause of non availability of phosprorus to plants. Large amounts of total P are present in the majority of soils, but P deficit results from their low solubility.

Zinc is vital to several physiological processes, including hormone control, protein synthesis, and enzyme activation. Insufficient zinc in maize can result in lower yields, stunted growth, and heightened disease susceptibility. One of the most common deficiency symptom in maize is 'white bud' which is due to low level of zinc than optimum. Because of its paramount significance in maize, it is considered as the indicator plant for Zn deficiency. Thus, for the best possible maize yield and quality, it is essential to guarantee sufficient zinc availability (Suganya *et al*., 2020).

Studies on the influence of biofertilizer of PSB and VAM on soil P and Zn and their transformations have been started recently. Therefore, it is very important to look into the consequences of P and Zn interaction on development and results of yield of maize. The interaction of soil P and Zn as influenced after applying the P and Zn fertilizers, in addition to P biofertilizers and their influence on the development and performance of maize, are not well documented. Hence, the present study was planned to know the effects of P and Z are maize.

MATERIAL AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla with winner 8352 hybrid of maize during *rabi* season is 2023-24 in clay loam soil. The experiment was carried out in randomized block design with nine treatments replicated thrice. The crop was sown under a spacing of 60 cm x 10 cm. Well decomposed farmyard manure @ 10 t ha^{-1} was applied 15 days before sowing. Recommended dose of nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Recommended dose of nitrogen @ 220 kg ha^{-1} was applied in three equal splits as band placement (1/3rd each at the time of sowing, knee high and tasseling stages). Whereas, phosphorus was applied as per the treatments after one week of sowing as band placement. Entire recommended dose of potassium @ 80 kg ha^{-1} was applied as band placement along with nitrogen and phosphorus after one week of sowing. Farmyard manure was mixed with biofertilizers *viz.,* PSB @ 1.25 L ha^{-1} and VAM @ 12.5 kg ha^{-1} as per the treatments and applied uniformly according to the treatment.

Treatments were T_1: 100% RDP, T_2: 100% RDP + PSB + VAM, T_3: 100% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}, T_4: 100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}, T_5: 75% RDP, T_6: 75% RDP + PSB + VAM, T_7: 75% RDP+ PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}, T_8: 75% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1} and T_9: PSB + VAM.

Plant height was recorded at knee high, tasseling and harvesting stages with the help of a wooden scale and was measured from ground level to the tip of the top most leaf before tasseling and to the tip of tassel after tasseling at harvest stage of every five tagged plants in the respective plots and expressed in cm. For dry matter accumulation, five plants from each plot were collected randomly at different stages (Knee high, tasseling stage and at harvest) of crop period. The samples were cut from ground level and were dried in shade first and then dried in a hot-air oven at 65°C till they attained constant weight. Sample dry weights were summed up to arrive mean dry matter per plant in individual treatment. The mean dry weight was multiplied by the number of plants m^{-2} and expressed in kg ha^{-1}. The nitrogen content from the kernel samples was estimated by Micro Kjedahl method and N content was multiplied by 6.25 to get per cent crude protein.

For statistical analysis Fisher's method of analysis of variance was followed for analysis and interpretation of the data as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Plant height

The current study was focused on evalution of the plant height of maize crop at the knee high, tasseling stage and at harvest and presented in the table 1 and figure 1. At knee high stage, tasseling stage and at harvest. Among all the treatments significantly the highest plant height was recorded in treatment T_4 (100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) with 78.3 cm, 227 cm and 240 cm, respectively, followed by T_3 (100% RDP + PSB + VAM + 25 kg $ZnSO_4$) 77.3 cm, 225 cm and 237 cm plant height, respectively, T_2 (100% RDP + PSB + VAM) with 72.4 cm, 216 cm, 225 cm plant height, respectively, T_7 (75% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) with 72.2 cm, 223 cm, 229 cm plant height, respectively and T_8 (75% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) with 71.7 cm, 220 cm, 230 cm plant height, respectively and these treatments were found on par with each other. The lowest plant height with 56.5 cm, 182 cm and 189 cm was recorded in T_9 (PSB + VAM) at knee high, tasseling stage and at harvest of crop, respectively.

The observed increase in growth parameters, such as plant height, in the above mentioned treatments can be attributed to the addition of biofertilizer and inorganic fertilizers. These additions enhanced the physical, chemical, and biological qualities of the soil, resulting in increased nutrient availability and ultimately benefiting plant development. This enhancement could also be ascribed to specific growth-promoting compounds released by the biofertilizers, which in turn may have resulted in improved root development, enhanced water movement, and increased uptake and deposition of nutrients. These results were consistent with the findings of Parmar and Sindhu (2013) and Archana *et al*. (2013).

Drymatter accumulation

The data presented in the table 1.0 and figure 2 on dry matter production showed that P and Zn fertilizers had a significant impact on dry matter production during the knee high, tasseling stage and at harvest of the maize.

At knee high stage the highest dry matter production was observed in the treatment with T_4 (100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (1757 kg ha^{-1}) followed by T_3 (100% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (1725 kg ha^{-1}), T_7 (75% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (1587 kg

Table 1 : Effect of phosphorus, zinc and biofertilizer on plant height, drymatter accumulation and protein content of maize

Treatments	Plant height (cm)			Dry matter accumulation ($kg\ ha^{-1}$)			Protein content (%)
	Knee high	Tasseling	Harvest	Knee high	Tasseling	Harvest	
T_1 : 100% RDP	64	200	204	1397	9992	14463	10
T_2 : 100% RDP +PSB+ VAM	72.4	216	225	1574	10500	15794	10.2
T_3 : 100% RDP +PSB+ VAM + 25 kg $ZnSO_4\ ha^{-1}$	77.3	225	237	1725	11886	17914	10.3
T_4 : 100% RDP +PSB+ VAM + 50 kg $ZnSO_4\ ha^{-1}$	78.3	227	240	1757	11738	17837	10.4
T_5 : 75% RDP	60.3	193	195	1253	8566	13493	9.6
T_6 : 75% RDP +PSB+ VAM	65.6	209	210	1467	10167	15380	10.1
T_7 : 75% RDP +PSB+ VAM + 25 kg $ZnSO_4\ ha^{-1}$	72.2	223	229	1587	10625	16004	10.2
T_8 : 75% RDP +PSB+ VAM + 50 kg $ZnSO_4\ ha^{-1}$	71.7	220	230	1578	10814	16089	10.1
T_9 : PSB+ VAM	56.5	182	189	1103	7752	12813	9.5
S.Em (±)	2.9	8	10.31	80	508	745	0.4
CD (P = 0.05)	8.6	25	30.91	240	1524	2234	NS
CV (%)	7.2	7	8.2	9	9	8	7.2

ha^{-1}), T_8 (75% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (1578 kg ha^{-1}) and T_2 (100% RDP + PSB +VAM) (1574 kg ha^{-1}). These treatments were on par with each other and significantly superior over other treatments. While the lowest amount of dry matter production was observed with the treatment T_9 (1103 kg ha^{-1}) where only PSB and VAM were applied without any inorganic phosphorus or zinc fertilizers.

The highest dry matter production at tasseling stage was observed in the treatment T_3 (100% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (11886 kg ha^{-1}) followed by T_4 (100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (11734 kg ha^{-1}), T_8 (75% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (10814 kg ha^{-1}), T_7 (75% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (10625 kg ha^{-1}) and T_2 (100% RDP + PSB +VAM) (10500 kg ha^{-1}). These treatments were on par with each other and significantly superior over other treatments. While the lowest amount of dry matter production was observed with the treatment T_9 (7752 kg ha^{-1}) where only PSB and VAM were applied without any inorganic phosphorus or zinc fertilizers.

The dry matter production at the harvest of maize followed the same trend as tasseling stage. The highest dry matter production was registered with the treatment T_3 (100% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (17914 kg ha^{-1}) followed by T_4 (100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (17837 kg ha^{-1}), T_8 (75% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1}) (16089 kg ha^{-1}), T_7 (75% RDP + PSB + VAM + 25 kg $ZnSO_4$ ha^{-1}) (16004 kg ha^{-1}) and T_2 (100% RDP + PSB +VAM) (15794 kg ha^{-1}). These treatments were on par with each other and significantly superior over other treatments. While the lowest amount of dry matter production was observed with the treatment T_9 (12813 kg ha^{-1}) where only PSB and VAM were applied without any inorganic phosphorus or zinc fertilizers.

Sufficient phosphorus leads to an increased buildup of photosynthates, resulting in higher production of dry matter. The application rate of P and Zn significantly influenced the total dry matter content. This may be attributed to the increased amount of fertilizer applied to the soil, which promotes plant development, leaf area index and plant height as reported by Jan *et al*. (2013). The application of phosphorous and zinc fertilizers resulted in higher total dry matter yield. This is likely because the application of more phosphorous to the soil enhances the translocation of P into the plant parts, leading to increased dry matter production. Additionally, zinc is involved in protein synthesis and the biosynthesis of

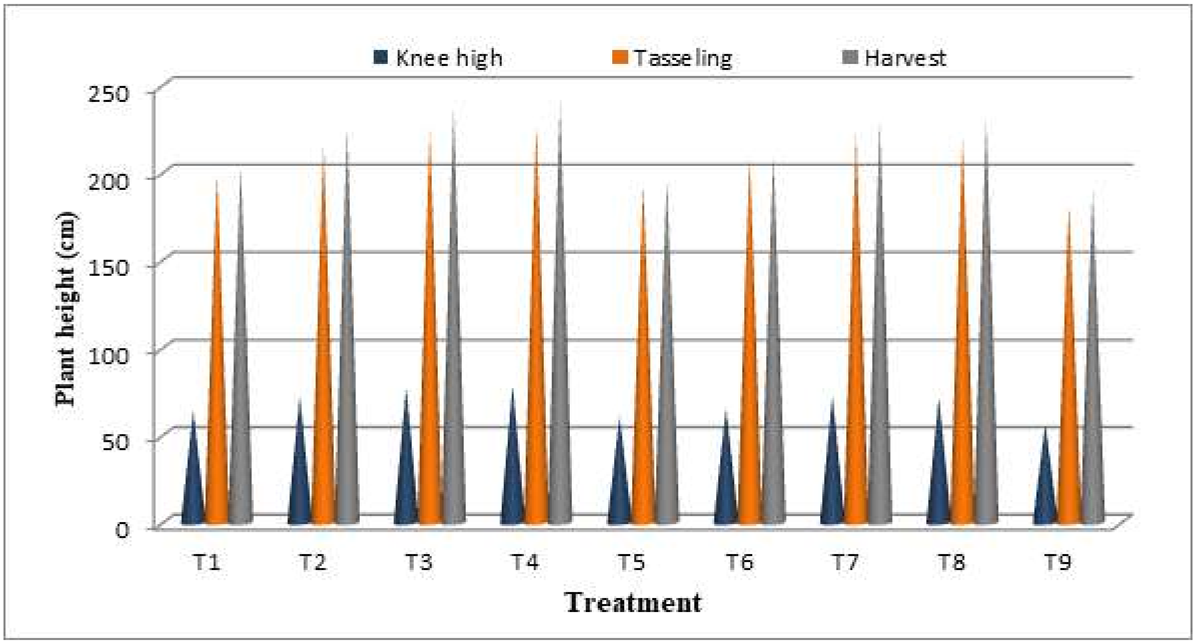

Fig 1 : Effect of phosphorus, zinc and biofertilizer on plant height at knee high, tasseling and at harvest of maize

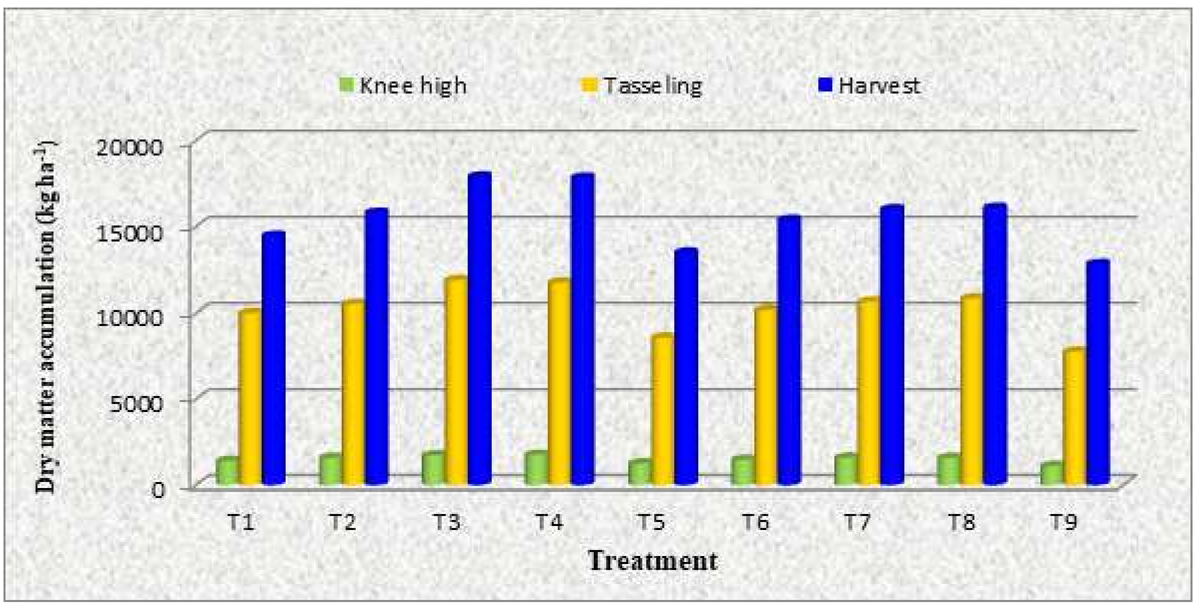

Fig 2 : Effect of phosphorus, zinc and biofertilizer on drymatter accumulation at knee high, tasseling and at harvest of maize

Indole 3-acetic acid, a growth hormone that promotes cell division and elongation. This may have contributed to an increase in plant height, number of leaves, and ultimately, higher dry matter production. The results are consistent with the findings of Potarzycki and Grzebisz *et al*.(2009) and align more closely with the findings of Alam *et al*.(2009).

Protein content

The data presented in the table 1 showed that there was no significance difference among the treatments in terms of protein content in kernels of maize. It was found that highest amount of protein content was reported in the treatment T_4 supplied with 100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1} (10.4%) followed by the treatment T_3 supplied with 100% RDP + PSB + VAM + 50 kg $ZnSO_4$ ha^{-1} (10.3%). While, the lowest amount of protein content was reported in the treatment T_9 (PSB + VAM) (9.5%).

The protein content enhanced with increase in fertilizer application. These findings are similar with those of Kurdikeri *et al*. (1973). Higher amount of protein content at high P_2O_5 levels might be due to enhanced uptake and translocation of nitrate which provide nitrogen for amino acid synthesis. Moreover, P is involved in the synthesis of ATP that is essential in both nitrogen uptake and protein synthesis. These results were in accordance with the findings of Chaudhry and Malik (2000).

The quality and quantity of chemical constituents such tannins, flavonoids, carbohydrates, proteins, steroids, phenols, and alkaloids ware increased by biofertilizers, but under chemical fertilizer and control conditions, all significant phytochemicals were absent from plant cultivation. According to Chandni and Katariya (2018), the application of biofertilizer can improve growth parameters, nutritional content, phytochemicals, and antioxidant activity.

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