Effect of compost coated and blended phosphatic fertilizers on growth, yield and nutrient uptake by maize under *Alfisols in India*

ABSTRACT

During *kharif* 2020 a field experiment was conducted at College of Agriculture, V. C. Farm, Mandya, India to study the effect of compost coated and blended phosphatic fertilizers on growth, yield and nutrient uptake of maize. There were eight treatments that include 100, 75 and 50 per cent of compost coated DAP (T_3, T_4 and T_5, respectively) and compo blended rock phosphate (T_6, T_7 and T_8, respectively) along with recommended dose of nitrogen and potassium, keeping 100% recommended dose of fertilizers (using uncoated DAP) as check. The experiment was laid out in Randomized Complete Block Design with three replications. The results revealed higher growth parameters *viz.,* plant height (222.75 cm), no. of leaves plant^{-1} (12.98 plant^{-1}), leaf area (6387.55 cm^2 plant^{-1}) and total dry matter accumulation plant^{-1} (167.20 g plant^{-1}) were recorded with application of 75 per cent RDP through compost coated DAP with recommended dose of N and K (T_4) which was on par with T_7, T_3 and T_6, respectively. Similarly, significantly higher yield parameters like cob length (21.87 cm), cob girth (20.76 cm), no. of rows cob^{-1} (16.56 cob^{-1}), no. of kernels row^{-1} (36.03 row^{-1}) and test weight (35.73 g) were recorded in T_4 when compared to T_2, T_5 and T_8, respectively. Kernel and stover yield (82.19 and 91.44 q ha^{-1}, respectively) was observed to be higher in T_4 coupled with higher uptake of N, P, K, Ca, Mg, S, Fe, Mn, Cu and Zn which clearly indicated that application of 75% RDP through compost coated DAP is optimum for obtaining higher growth, yield and nutrient uptake by maize.

Key words: Blended, coated, growth, maize, yield.

1. INTRODUCTION

Phosphorus (P) is the second most important primary nutrient element after nitrogen. It is a structural component of cell membranes, chloroplasts, mitochondria and constituent of sugar phosphates *viz.,* Adenosine diphosphate (ADP), Adenosine triphosphate (ATP), nucleic acid, phospholipids, *etc*. Phosphorus is highly mobile in plants and immobile in soil. *Alfisols* are base rich soils (>35%) with clay enriched argillic horizon and having evidence of clay illuviation. The fixation of phosphorus as iron and aluminum phosphates in acid soils and calcium phosphates in alkaline soils and *Alfisols* is defined as a historical problem of soil science (Sanders *et al.,* 2012)[12]. This historical problem corresponds to very low P use efficiency (PUE) of applied P-fertilizer in the soil system even after employing the best management practices for crop production resulting in poor growth and yield of the crop. Complex nature arises because of its low total soil phosphorus content, highly insoluble nature, unavailability of the native phosphorus compounds for plant uptake and transformation of readily available phosphorus present in manures and fertilizers into unavailable forms when they are added to soil. Henceforth, phosphorus is regarded as the most studied, but least understood element because of its unique character.

The depletion of global rock phosphate (RP) reserves is emerging as one of the major challenges to regulate P fertilizer supply for global food security in the 21st century. Globally, around 90 per cent of the P is mined from non-renewable RP and approximately 60 per cent of it is used in cropping as fertilizer. Thus, care should be given to the development of eco-friendly strategy to improve the P availability and P use efficiency in farming systems. Coated phosphatic fertilizers is an innovative option to improve phosphorus use efficiency and sustained release of P in the soil.

The coated phosphatic fertilizers is one such new generation fertilizer that are coated with natural or semi-natural, environmentally friendly macromolecule material which is designed to release plant nutrients in a steady manner so as to synchronize the release with crop demand. This technology not only helps in improving the nutrient use efficiency but also suggests a suitable mechanism to reduce environmental hazards posed by indiscriminate and excessive use of fertilizers (Shaviv, 1999)[14]. In general, coated phosphatic fertilizers or control release fertilizers exhibit numerous preferences over the traditional water-soluble fertilizers, for example, savings in huge quantities of fertilizers, reducing the rate of release of fertilizer nutrients and thus supplying nutrients to crops for longer period of growth and thus enhance yield and use efficiency of the fertilizer.

Maize (*Zea mays* L.) is one of the most versatile emerging crops having greater adaptability under varied agro-climatic conditions. Globally, it is cultivated over an area of 197 m ha with production of 1,147.6 m t and a productivity of 5.8 t ha^{-1} (Anon., 2019 a)[3]. Besides, it is a staple food for poor people in most of the developing countries and in the world, it provides about 30 per cent of the food calories for more than 4.5 billion people. In India, it is grown under diverse agro climatic situations covering an area of 9.56 m ha with 28.56 m t production and 3.07 t ha^{-1} productivity (Anon., 2020)[5]. While, in Karnataka maize is cultivated in an area of 1.29 m ha with a production of 3.73 m t with productivity of 2.89 t ha^{-1} (Anon., 2019 b)[4]. In Mandya district of Karnataka, maize is grown in an area of 3,903 ha with a production of 15,978 t and productivity of 4.308 kg ha^{-1} (Anon., 2020)[5]. Hence considering the above facts, an attempt has been made to evaluate the efficiency of usage of coated and blended phosphatic fertilizers in agriculture by using maize as a test crop in *Alfisols*.

2. MATERIALS AND METHODS

The experiment was conducted at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya, India during *Kharif* 2020. Soil of the experimental site was classified as *Alfisols* with red loamy sand with neutral soil reaction (7.15), electrical conductivity (0.12 dSm^{-1}) and organic carbon content (4.64 g kg^{-1}) was found to be low. The available nitrogen (310.23 kg ha^{-1}), phosphorus (28.63 kg P_2O_5 ha^{-1}) and potassium (276.72 kg K_2O ha^{-1}) was medium. The investigation was carried out in Randomized Complete Block Design with eight treatments and replicated thrice.

Treatment details include

T_1: Absolute control
T_2: RDF (150:75:40 NPK kg ha^{-1})
T_3: 100% RDP through compost coated DAP
T_4: 75% RDP through compost coated DAP

T_5 50% RDP through compost coated DAP
T_6: 100% RDP through compost blended RP
T_7: 75% RDP through compost blended RP
T_8: 50% RDP through compost blended RP

Note: RDF: Recommended dose of fertilizers, RD N and K: Recommended dose of nitrogen and potassium, RDP: Recommended dose of phosphorus, RP: Rock phosphate

In the present experiment, maize (*Zea mays* L.) variety MAH-14-05 was grown as the test crop. The land was prepared by ploughing with tractor drawn disc plough followed by disc harrowing and passing cultivator twice to bring the soil to fine tilth.

Layout of the experiment was done with gross plot and net plot size of 5.4 m × 3.6 m and 4.2 m × 2.4 m, respectively. A distance of 0.5 m between two plots and 0.6 m was set to differentiate the replications. The bund height of 30 cm was raised in the space available between replications and plots. The recommended FYM (10 t ha^{-1}) was applied uniformly to all the treatments two weeks before sowing except for control plot. After layout of experiment, recommended quantity of zinc sulphate (10 kg ha^{-1}) were applied. Furrows at an interval of 60 cm were opened using furrow openers attached to bullock pair. Basal dose of RDF [1/2rd N (50 %) and 50, 75, 100 per cent of compost coated or blended P and 100 percent K] was applied to each treatment and mixed with soil. Urea, di-ammonium phosphate (DAP), Rock phosphate and muriate of potash (MOP) were used as sources of N, P and K, respectively. Seeds were dibbled at 30 cm spacing (2 seeds per hill). The remaining 1/2rd dose of nitrogen was top dressed in two equal splits, one at 30 DAS and another at 45 DAS in the form of urea. First irrigation was given on the day of sowing and subsequent irrigations were given as and when required by the crop using ridges and furrow method.

Weed management was done through application of Atrazine 50% WP @ 6.5 g L^{-1} at two days after planting. Inter-cultivation practice was done at 35 and 60 DAS with the help of bullock drawn harrow. Hand weeding was done at 30 and 60 DAS to keep the plots devoid of weeds. Five plants were randomly selected from each net plot and labelled to take growth parameters at different growth stages *viz.*, 30, 60, 90 DAS and at harvest of the crop. After reaching the physiological maturity the crop was harvested according to the treatments from all the plots. From the net plot the cobs and stover were harvested separately from each plot. Kernel and stover were sun dried and weighed separately after threshing. The yields obtained were expressed in quintals ha^{-1}. The data was statistically analysed by following the method of Gomez and Gomez, 1984[9].

2.1 Preparation of compost coated and blended phosphatic fertilizers

Two different sources of phosphorus like DAP and Rock phosphate were selected for coating and blending with compost, respectively. Compost coated DAP and blended rock phosphate were prepared by coating and blending fertilizer with compost in different ratios *i.e.,* 5:1, 10:1 and 10:1.5 proportions. Slightly wet DAP granules were taken in a circular plastic basin and coating material was sprinkled and mixed with compost. The fertilizer granules were subjected to swirling movement by rotating basin circularly. The process was repeated twice or thrice until the satisfactory visual coating was obtained. For blending rock phosphate with compost, rock phosphate powder was mixed thoroughly with the coating material. Compost coating or blending with either DAP or Rock phosphate in 5:1 ratio is used for the experiment. The coated DAP granules or blended rock phosphate were air dried in shade and were used in the treatment implication (Figure 1).

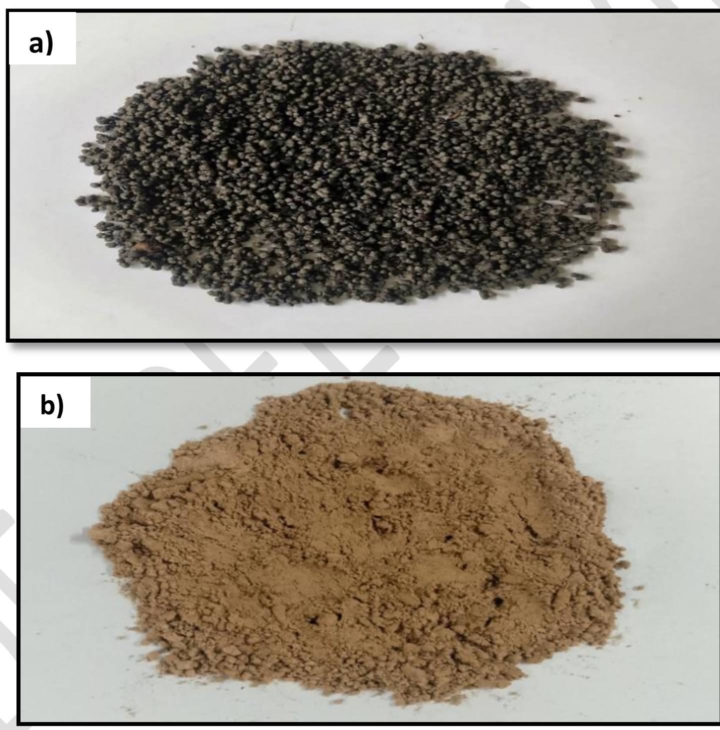

Figure 1: a) Compost coated DAP, b) Compost blended rock phosphate

3. RESULT AND DISCUSSION

3.1 Plant height

Compost coated and blended phosphatic fertilizers showed significant effect on plant height (Table 1). At harvest, maximum plant height was registered in treatment receiving 75 per cent

RDP through compost coated DAP with recommended dose of N and K (T_4-222.75 cm) and was observed to be on par with T_7 (216.33 cm) and T_3 (212.25 cm), respectively. The lower plant was recorded in absolute control (T_1- 60.05 cm).

3.2 Number of leaves plant^{-1}

According to results obtained, compost coated and blended phosphatic fertilizers application could improve the number of leaves in plan maximum number of leaves were observed in T_4 (12.98 plant^{-1}) which was significant over T_2 (10.78 plant^{-1}), T_5 (10.96 plant^{-1}) and T_8 (10.87 plant^{-1}) and the least leaf count was noticed in absolute control (8.07 plant^{-1}) (Table 1).

3.3 Leaf area per plant (cm^2 plant^{-1})

Leaf area was also significantly influenced by the application of compost coated and blended phosphatic fertilizers (Table 1). At harvest, significantly higher leaf area was recorded in T_4 (6387.55 cm^2 plant^{-1}) and was on par with 75 per cent RDP through compost blended RP (T_7- 6368.80 cm^2 plant^{-1}), 100 per cent RDP through compost coated DAP (T_3- 6151.84 cm^2 plant^{-1}), 100% RDP through compost blended RP (T_6- 6023.97 cm^2 plant^{-1}). Significantly lower leaf area was observed in control (T_1- 3413.97 cm^2 plant^{-1}).

3.4 Total dry matter accumulation (g plant^{-1})

Treatment receiving 75 percent RDP through compost coated DAP with recommended dose of N and K (T_4-167.20 g plant^{-1}) recorded significantly higher dry matter production compared to control (80.37 g plant^{-1}), T_2 (146.57 g plant^{-1}), T_5 (149.68 g plant^{-1}) and T_8 (147.88 g plant^{-1}) and was on par with rest of the treatments (Table 1).

Compost layer around fertilizer grain reduced the adsorption and precipitation of phosphorus in soil. Also attached cationic ions which cause precipitation of P fertilizer was reduced due to anionic surface of humic substances which enhanced the P availability to plant and as a result the growth of crop enhanced (Ai *et al.,* 2009) [2]. While less growth and productivity in uncoated DAP was due to less P availability to crop and also due to adsorption and precipitation. Similar results were also reported by Noor *et al*. (2017)[11], Ashenafi *et al.* (2023)[6], Santhi *et al.* (2023))[13], Adetayo *et al.* (2023)[1], Mohan and Malarvizhi (2020)[10].

Table 1. Effect of compost coated and blended phosphatic fertilizers on growth parameters of maize

	Treatment	Plant height (cm)	No. of leaves $plant^{-1}$	Leaf area (cm^2 $plant^{-1}$)	Total dry matter accumulation (g $plant^{-1}$)
T_1	Absolute control	60.05	8.07	3413.97	80.37
T_2	RDF (150:75:40 NPK kg ha^{-1})	185.47	10.78	5344.01	146.57
T_3	100% RDP through compost coated DAP	212.25	12.80	6151.84	162.30
T_4	75% RDP through compost coated DAP	222.75	12.98	6387.55	167.20
T_5	50% RDP through compost coated DAP	188.85	10.96	5683.33	149.68
T_6	100% RDP through compost blended RP	212.33	12.47	6023.97	159.60
T_7	50% RDP through compost blended RP	216.33	12.86	6368.80	165.85
T_8	50% RDP through compost blended RP	187.73	10.87	5470.00	147.88
	S.Em±	**7.58**	**0.48**	**148.74**	**3.87**
	CD @ 5 %	**23.00**	**1.45**	**451.16**	**11.75**

Note: RDF: Recommended dose of fertilizers, RD N and K: Recommended dose of nitrogen and potassium, RDP: Recommended dose of phosphorus, RP: Rock phosphate

3.5 Yield parameters

The application of compost coated and blended phosphatic fertilizers had the positive and significant effect on the yield parameters of the crop (Table 2). Application of 75 percent RDP through compost coated DAP with recommended dose of N and K (T_4) recorded significantly higher cob length (21.87 cm), cob girth (20.76 cm), number of rows per cob (16.56), number of kernels per row (36.03) and test weight (35.73 g) and was observed to be on par with treatment receiving 75 per cent RDP through compost blended RP with recommended dose of N and K (T_7), 100 per cent RDP through compost coated DAP with recommended dose of N and K (T_3) and 100 per cent RDP through compost blended RP with recommended dose of N and K (T_6). The lower yield parameters was registered in absolute control (T_1) (Table 2).

3.5.1 Kernel and stover yield

Kernel and stover yield of maize varied significantly with the application of compost coated and blended phosphatic fertilizers along with recommended dose of nitrogen and potassium. The results indicated that, kernel yield (82.19 q ha^{-1}) and stover yield (91.44 q ha^{-1}) recorded in treatment receiving RD N and K + 75% RDP through compost coated DAP (T_4) which was significantly higher than that recorded in T_1(23.35 & 38.95 q ha^{-1}), T_2 (69.92 & 76.89 q ha^{-1}), T_5 (70.20 & 77.55 q ha^{-1}) and T_8 (70.13 & 73.30 q ha^{-1}) and on par with rest of the treatments. Lower kernel and stover yield were noticed in control (T_1- 23.35 & 38.95 q ha^{-1}) which received no fertilizers (Table 2).

The increase in yield of maize might be attributed to the supply of readily soluble form of nutrients which are supplied through urea, MOP and slow releasing source *i.e.,* compost coated DAP and compost blended RP and thus releasing the nutrients in slow and sustained manner that has helped in getting higher growth and yield. Compost blended with RP made it to dissolve easily and release of P required for the growth and yield of crop. The results corroborates with the findings of Bhattacharya *et al.* (2004)[7], Ashenafi *et al.* (2023)[6], Santhi *et al.* (2023))[13], Adetayo *et al.* (2023)[1] and Yadav *et al.* (2009)[16].

Table 2. Effect of compost coated and blended phosphatic fertilizers on yield parameters kernel yield and stover yield of maize

Treatment		Cob length(cm)	Cob girth (cm)	No. of rows cob^{-1}	No. of kernels row^{-1}	Test weight (g)	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1	Absolute control	6.20	11.00	10.33	12.40	18.69	23.35	38.95
T_2	RDF (150:75:40 NPK kg ha^{-1})	17.92	16.89	12.92	29.98	29.67	69.92	76.89
T_3	100% RDP through compost coated DAP	20.73	20.07	15.57	34.50	34.42	79.50	88.63
T_4	75% RDP through compost coated DAP	21.87	20.76	16.56	36.03	35.73	82.19	91.44
T_5	50% RDP through compost coated DAP	18.29	17.18	13.60	30.37	30.27	70.20	77.55
T_6	100% RDP through compost blended RP	20.67	19.48	15.48	34.22	34.35	78.83	87.17
T_7	50% RDP through compost blended RP	21.73	20.16	16.35	35.80	35.72	81.10	89.53
T_8	50% RDP through compost blended RP	18.11	16.97	13.12	30.12	30.13	70.13	73.30
S.Em±		**0.74**	**0.73**	**0.59**	**1.24**	**1.28**	**2.79**	**3.16**
CD @ 5 %		**2.26**	**2.23**	**1.80**	**3.77**	**3.89**	**8.46**	**9.59**

Note: RDF: Recommended dose of fertilizers, RD N and K: Recommended dose of nitrogen and potassium, RDP: Recommended dose of phosphorus, RP: Rock phosphate

3.6 Nutrients uptake by maize

3.6.1 Primary nutrients uptake

Significantly higher total N, P and K uptake was recorded in T_4 (228.63, 33.87 and 223.99 kg ha^{-1}, respectively) which was on par with 75 per cent RDP through compost blended RP with recommended dose of N and K *i.e.*, T_7 (221.73, 31.52 and 211.53 kg ha^{-1}, respectively). Whereas, lower uptake of N, P and K was recorded in T_1 (21.18, 5.05 & 45.79 kg ha^{-1}) (Figure 2).

The total uptakes of N, P and K increased in the coated and blended P fertilizers applied treatments because of higher availability of these nutrients and higher biomass yield as compared to uncoated P fertilizer applied treatment. Application of different levels of coated P fertilizers enhances productivity due to its sustained P release. The findings are in confirmation with findings of Chagas *et al*. (2017)[8] and Zafar *et al.* (2020)[17].

3.6.2 Secondary nutrients uptake

Data pertaining to uptake of secondary nutrients indicated that, significantly higher total calcium, magnesium and sulphur uptake of 61.13, 30.98 and 27.96 kg ha^{-1} was recorded in T_4 which was on par with T_7 (53.45, 27.94 and 25.73 kg ha^{-1}). Lower uptake was recorded in T_1 (7.16, 3.43 and 5.95 kg ha^{-1}) (Figure 3).

3.6.3 Micronutrients uptake

Lower Fe, Mn, Zn and Cu uptake was recorded in control (382.54, 322.13, 153.52 and 46.88 g ha^{-1}) which increased to 1582.36, 1231.02, 751.78 and 234.62 g ha^{-1}, respectively in T_4 and was on par with T_7, T_3 and T_6, respectively and significantly higher with rest of the treatments (Figure 4).

The higher uptake of micronutrients in coated treatments as compared to uncoated ones, might be attributed to the coatings of DAP and RP reduced the fixation of various nutrients and reduced the dissolution rate as well as surface area of contact with soil particles, which might have helped to increase availability of these nutrients throughout the growth periods of crop. Similar results were also reported by Singh, (2003)[15] and Santhi *et al.* (2023))[13].

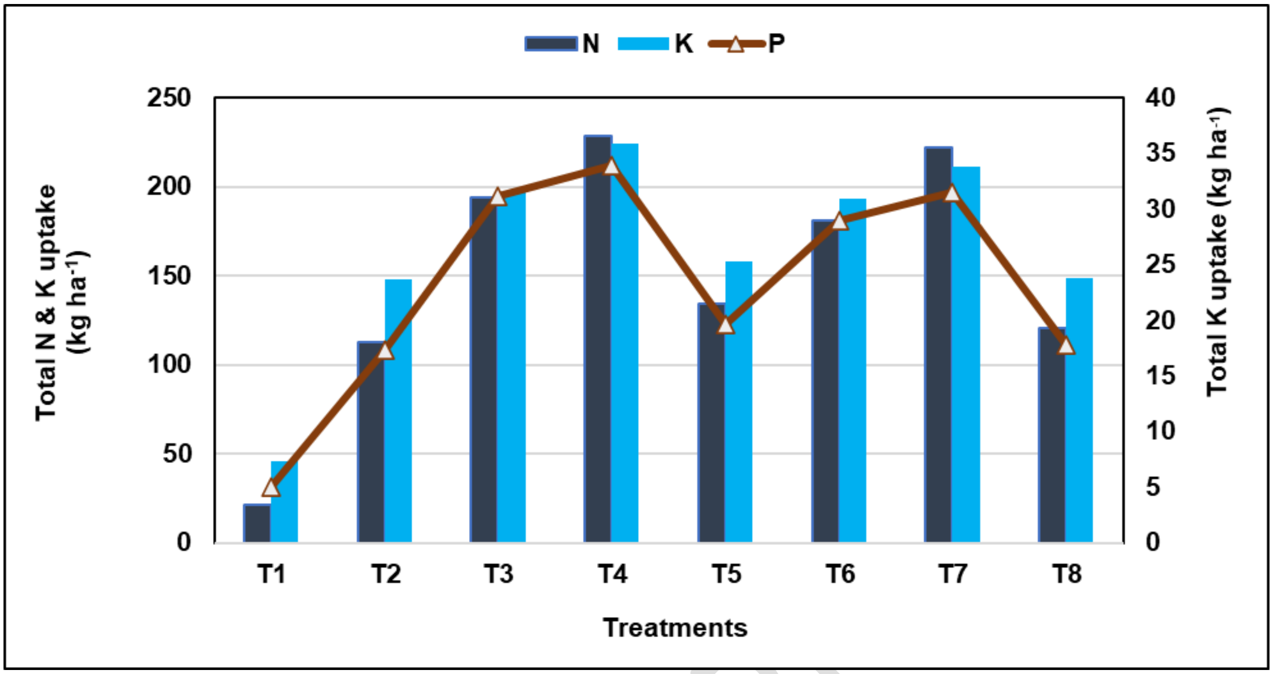

Figure 2: Effect of compost coated and blended phosphatic fertilizers on N, P and K uptake by maize

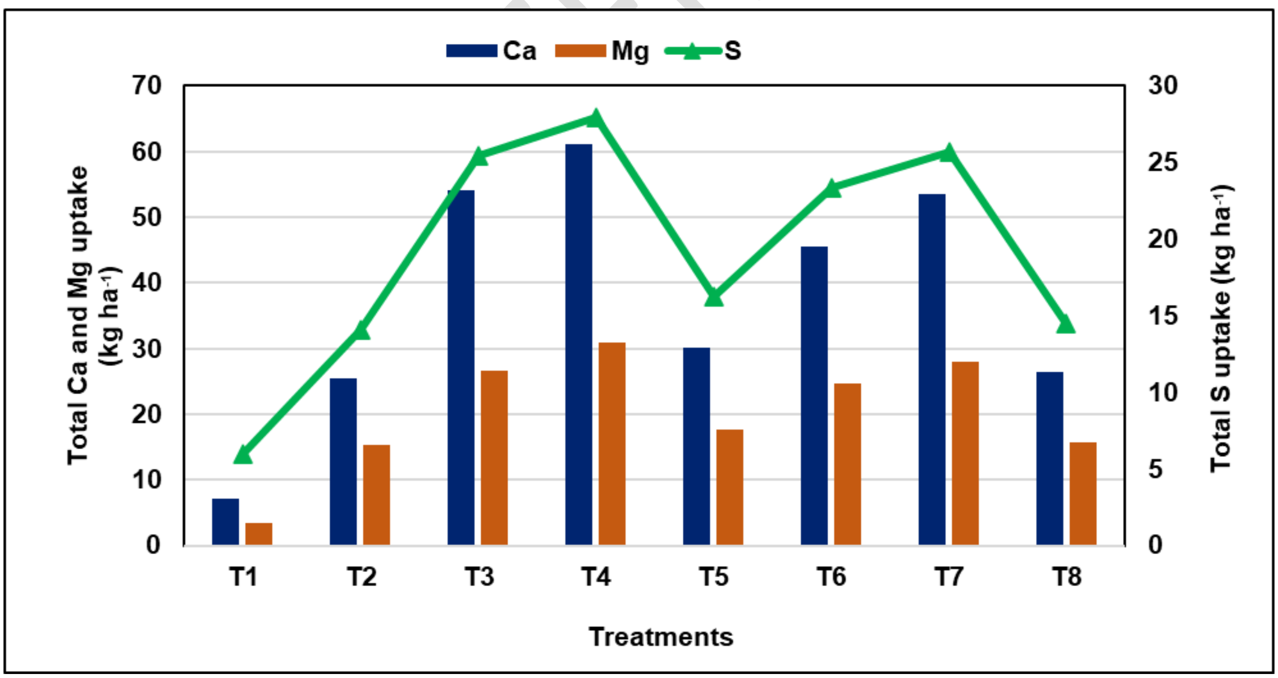

Figure 3: Effect of compost coated and blended phosphatic fertilizers on Ca, Mg and S uptake by maize

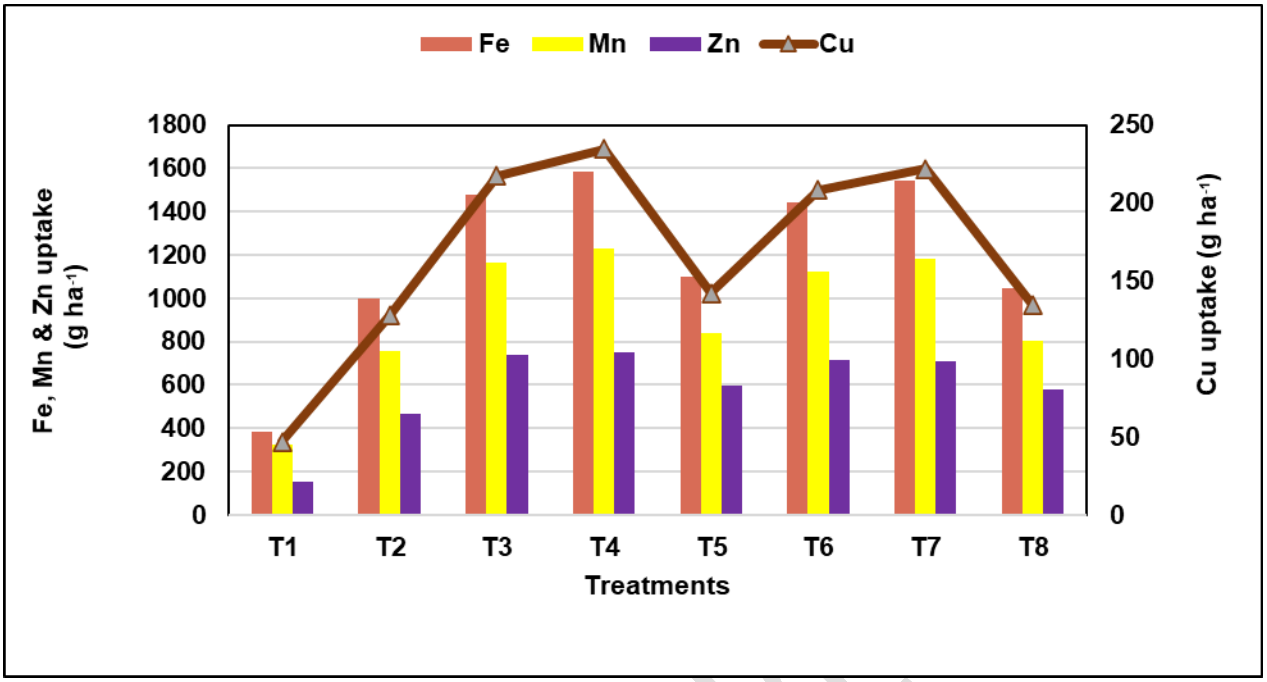

Figure 4: Effect of compost coated and blended phosphatic fertilizers on Fe, Mn, Cu and Zn uptake by maize

Treatment details

T_1: Absolute control
T_2: RDF (150:75:40 NPK kg ha^{-1})
T_3: 100% RDP through compost coated DAP
T_4: 75% RDP through compost coated DAP
T_5 50% RDP through compost coated DAP
T_6: 100% RDP through compost blended RP
T_7: 75% RDP through compost blended RP
T_8: 50% RDP through compost blended RP

Note: RDF: Recommended dose of fertilizers, RD N and K: Recommended dose of nitrogen and potassium, RDP: Recommended dose of phosphorus, RP: Rock phosphate

4. CONCLUSION

The present study highlighted the preparation of compost coated DAP and compost blended rock phosphate fertilizers and testing the efficiency of these fertilizers at different levels by using maize as a test crop. Among the compost coated and blended treatments, application of 75 percent RDP through compost coated DAP with recommended dose of N and K recorded higher growth and yield parameters along with nutrient uptake when compared to rest of the treatments. Moreover, application of 50 per cent RDP through compost coated DAP and 50 percent RDP compost blended RP with recommended dose of N and K was on par with recommended dose of fertilizer application (uncoated) with respect to growth and yield parameters. Thus, compost coated and blended phosphatic fertilizers are superior over uncoated phosphatic fertilizer in achieving higher growth and yield parameters in maize. Further, this holds the potential to be enumerated as an emerging green technology to reduce P losses to the environment, hence check problems of eutrophication and maintain the ecological balance between simultaneous P supply and assimilation by food chain.

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