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Influence of compost coated and blended phosphatic fertilizers on chemical composition and economics of maize (*Zea mays* L.) in *Alfisols*

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Abstract
A field evaluation was taken up to study the effect of compost coated and blended phosphatic fertilizers on chemical composition and economics of maize in *Alfisols* at College of Agriculture, V. C. Farm, Mandya during *kharif* 2020. The investigation included eight treatments that include 100, 75 and 50 per cent of compost coated DAP (T_3, T_4 and T_5, respectively) and compost blended rock phosphate (T_6, T_7 and T_8, respectively) along with recommended dose of nitrogen and potassium, keeping 100% RDF (using uncoated DAP) as check which was laid out in Randomized Complete Block Design which are replicated three times. Results indicated that application of 75 per cent RDP through compost coated DAP with recommended dose of N and K (T_4) recorded higher nutrient content in keernel and stover *viz.*, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients at harvest, respectively. This resulted in higher kernel and stover yield combined with gross returns and B:C ratio (3.02) indicating the application of 75 per cent RDP through compost coated DAP is optimum for obtaining higher yield and net returns.

Keywords: Phosphorus, coated, blended, returns, nutrient

1. Introduction
Phosphorus (P) is the second most crucial primary nutrient, following nitrogen. It plays a vital role as a structural component in cell membranes, chloroplasts, and mitochondria and is also a key constituent of sugar phosphates such as adenosine diphosphate, adenosine triphosphate, nucleic acids, and phospholipids. While phosphorus is highly mobile within plants, it remains immobile in soil. A long-standing issue in soil science is its fixation as iron and aluminum phosphates in acidic soils and calcium phosphates in alkaline soils (Sanders *et al.*, 2012) [9].
This long-standing issue leads to very low phosphorus use efficiency of applied P-fertilizers in the soil, even with the implementation of best management practices for crop production, resulting in poor crop growth and yield. The complexity of the problem stems from phosphorus's low total content in the soil, its highly insoluble nature, the inaccessibility of native phosphorus compounds for plant uptake, and the transformation of readily available phosphorus from manures and fertilizers into unavailable forms when added to the soil. Consequently, phosphorus is often regarded as the most researched but least understood element due to its unique characteristics.
The depletion of global rock phosphate (RP) reserves is becoming a significant challenge for maintaining phosphorus fertilizer supply, which is crucial for global food security in the 21st century. Approximately 90% of the world's phosphorus comes from non-renewable RP sources, with around 60% used as fertilizer in crop production. Therefore, it is essential to develop eco-friendly strategies to enhance phosphorus availability and improve phosphorus use efficiency in farming systems. One promising approach is the use of coated phosphatic fertilizers.
These new-generation fertilizers are coated with natural or semi-natural, environmentally friendly macromolecules, designed to release plant nutrients gradually to match crop demand. This technology not only improves nutrient use efficiency but also provides a mechanism to

reduce the environmental risks associated with excessive and indiscriminate fertilizer use (Shaviv, 1999) [11]. Coated or controlled-release phosphatic fertilizers offer several advantages over traditional water-soluble fertilizers, such as reducing fertilizer usage, controlling the rate of nutrient release, and improving phosphorus transformation and use efficiency for crops.

Maize (*Zea mays* L.) is an incredibly versatile crop, known for its ability to adapt to various agro-climatic conditions. It is cultivated globally on 197 million hectares, producing 1,147.6 million tons, with an average productivity of 5.8 tons per hectare (Anon., 2019 a) [1]. As a staple food for many in developing countries, maize provides around 30% of the food calories for over 4.5 billion people worldwide. In India, maize is grown across diverse agro-climatic regions, covering 9.56 million hectares, with a production of 28.56 million tons and a productivity of 3.07 tons per hectare (Anon., 2020) [3]. In Karnataka, maize is cultivated on 1.29 million hectares, yielding 3.73 million tons with a productivity of 2.89 tons per hectare (Anon., 2019 b) [2]. Specifically, in the Mandya district of Karnataka, maize is grown on 3,903 hectares, producing 15,978 tons with a productivity of 4.308 kg per hectare (Anon., 2020) [3]. Given these facts, a study was undertaken to evaluate the efficiency of using coated and blended phosphatic fertilizers in agriculture, with maize as the test crop grown in *Alfisols*.

2. Materials and Methods

The experiment was conducted at the College of Agriculture, Vishweshwaraiah Canal Farm, Mandya, located in Region III and Agro-Climatic Zone VI (Southern Dry Zone) of Karnataka, at 12° 34' North latitude and 76° 49' East longitude, with an altitude of 705 meters above mean sea level during the Kharif season of 2020. The soil at the experimental site was red loamy sand with a neutral pH of 7.15, electrical conductivity of 0.12 dSm^{-1}, and low organic carbon content (4.64 g kg^{-1}). 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}) were found to be at medium levels. The experiment was conducted using a Randomized Complete Block Design (RCBD) with eight treatments, replicated three times. The treatments included three levels of compost-coated DAP: 100%, 75%, and 50% of the recommended dose of phosphorus (RDP) (T_3, T_4, and T_5, respectively); three levels of compost-blended rock phosphate: 100%, 75%, and 50% of RDP (T_6, T_7, and T_8, respectively); c100% of the recommended dose of fertilizers (RDF) through conventional fertilizers with FYM (T_2); and an absolute control (T_1). The maize (*Zea mays* L.) variety MAH-14-05 was used as the test crop. The land was prepared by ploughing with a tractor-drawn disc plough, followed by disc harrowing and two passes with a cultivator to achieve a fine tilth. The layout of the experiment was prepared with a gross plot size of 5.4 m × 3.6 m and a net plot size of 4.2 m × 2.4 m. A spacing of 0.5 m between plots and 0.6 m between replications was maintained. A 30 cm-high bund was constructed between the replications and plots. The recommended amount of FYM (10 t ha^{-1}) was uniformly applied to all treatments two weeks before sowing, except for the control plot. Following the layout, zinc sulphate (10 kg ha^{-1}) was applied to all plots. Furrows, spaced 60 cm apart, were made using furrow openers attached to a bullock pair. A basal dose of the recommended fertilizer [half of the nitrogen (50%) and 50%, 75%, or 100% of compost-coated phosphorus, along with 100% of potassium] was applied to each treatment and mixed with the soil. Urea, di-ammonium phosphate (DAP), rock phosphate, and muriate of potash (MOP) were used as sources of nitrogen, phosphorus, and potassium, respectively. Seeds were dibbled at 30 cm spacing, with 2 seeds per hill. The remaining half of the nitrogen dose was top-dressed in two equal splits at 30 days after sowing (DAS) and 45 DAS, using urea. The first irrigation was applied on the day of sowing, followed by subsequent irrigations as required, using the ridges and furrows method. Inter-cultivation was carried out at 35 and 60 DAS with a bullock-drawn harrow, and hand weeding was done at 30 and 60 DAS to keep the plots weed-free. Five plants were randomly selected from each net plot and labelled to take growth parameters at different growth stages 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 collected samples were digested and analysed for primary, secondary and micronutrients. The data was statistically analysed by following the method of Gomez and Gomez, 1984 [7].

2.1 Preparation of compost coated and blended phosphatic fertilizers

Two phosphorus sources, DAP and rock phosphate, were chosen for coating and blending with compost, respectively. Compost-coated DAP and compost-blended rock phosphate were prepared by mixing the fertilizers with compost in different ratios: 5:1, 10:1, and 10:1.5. To coat the DAP, slightly damp granules were placed in a circular plastic basin, and the coating material was sprinkled and mixed with compost. The granules were then swirled by rotating the basin in a circular motion. This process was repeated two or three times until a satisfactory visual coating was achieved. For blending, rock phosphate powder was thoroughly mixed with the compost. A 5:1 ratio of compost to either DAP or rock phosphate was used in the experiment. The coated DAP granules and blended rock phosphate were air-dried in the shade and later used for treatment application (Fig. 1).

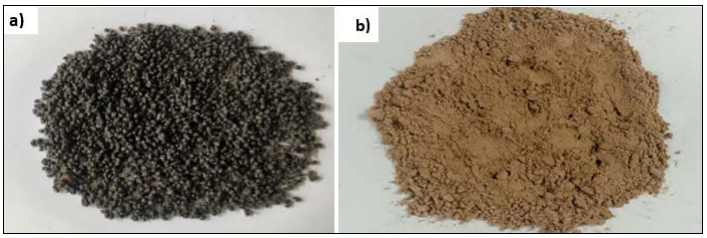

Fig 1: a) Compost coated DAP, b) Compost blended rock phosphate

3. Results and Discussion

3.1 Kernel and Stover yield

The kernel and stover yields of maize showed significant variation with the application of compost-coated and blended phosphatic fertilizers, along with the recommended doses of nitrogen and potassium. The highest kernel yield (82.19 q ha^{-1}) and stover yield (91.44 q ha^{-1}) were recorded in the treatment that received the recommended dose of nitrogen and potassium (RD N and K) combined with 75% RDP through compost coated DAP. This yield were significantly higher than those recorded in T_1 (23.35 and 38.95 q ha^{-1}), T_2 (69.92 and 76.89 q ha^{-1}), T_5 (70.20 & 77.55 q ha^{-1}), and T_8 (70.13 and 73.30 q ha^{-1}), and were comparable to the other treatments. The lowest kernel and stover yield were observed in the control (T_1: 23.35 and 38.95 q ha^{-1}), which did not receive any fertilizers (Figure 1).

3.2 Chemical composition of maize

3.2.1 Primary nutrients

Significantly higher total N, P and K content in kernel and stover was recorded in T_4 (1.28, 0.20, 1.19 and 1.17, 0.16 and 1.38 per cent, 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 (1.26, 0.19, 1.14 and 1.15, 0.15, 1.33 per cent, respectively). Whereas, lower N, P and K content in kernel and stover was recorded in T_1 (0.38, 0.09, 0.61 and 0.21, 0.03, 0.81 per cent) (Table 1).

3.2.2 Secondary nutrients

Data pertaining to content of secondary nutrients in kernel and stover indicated that, significantly higher total calcium, magnesium and sulphur content of 0.41, 0.21, 0.16 and 0.35, 0.15, 0.14 per cent, respectively was recorded in T_4 which was on par with T_7 (0.35, 0.19, 0.15 and 0.28, 0.14, 0.13 per cent). Lower Ca, Mg and S content was recorded in T_1 (0.14, 0.08, 0.09 and 0.10, 0.04, 0.07 per cent, respectively) (Table 2).

3.2.3 Micronutrients

Lower Fe, Mn, Zn and Cu content was recorded in control (66.30, 52.30, 8.21, 25.36 and 39.46, 35.56, 4.78, 16.66 per cent, respectively) which increased to 98.00, 73.20, 15.13, 50.53 and 72.50, 59.14,10.21,30.87, per cent, 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 (Table 3).

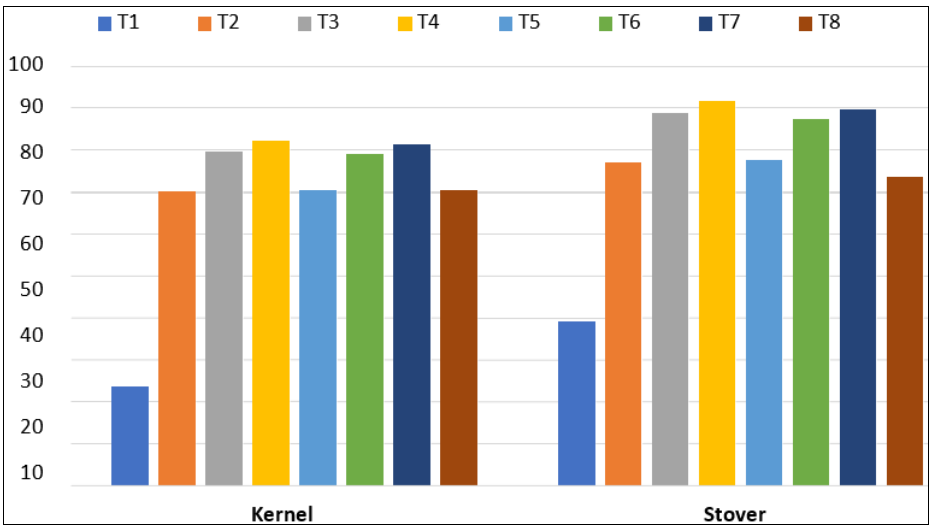

Fig 2: Effect of compost coated and blended phosphatic fertilizers on kernel and stover yield of maize

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

Table 1: Effect of compost coated and blended phosphatic fertilizers on N, P and K content of maize

Treatment	N(%)		P(%)		K(%)	
	Kernel	Stover	Kernel	Stover	Kernel	Stover
T_1	0.38	0.21	0.09	0.03	0.61	0.81
T_2	0.83	0.69	0.13	0.10	0.92	1.09
T_3	1.18	0.96	0.19	0.15	1.05	1.28
T_4	1.28	1.17	0.20	0.16	1.19	1.38
T_5	0.98	0.77	0.14	0.11	0.99	1.14
T_6	1.13	0.89	0.18	0.14	1.07	1.25
T_7	1.26	1.15	0.19	0.15	1.14	1.33
T_8	0.87	0.72	0.13	0.10	0.95	1.12
S.Em±	0.04	0.03	0.006	0.005	0.04	0.05
CD @ 5 %	0.12	0.10	0.02	0.01	0.12	0.15

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

Table 2: Effect of compost coated and blended phosphatic fertilizers on Ca, Mg and S content of maize

Treatment	Ca(%)		Mg(%)		S(%)	
	Kernel	Stover	Kernel	Stover	Kernel	Stover
T_1	0.14	0.10	0.08	0.04	0.09	0.07
T_2	0.20	0.15	0.11	0.10	0.10	0.09
T_3	0.39	0.26	0.19	0.13	0.15	0.13
T_4	0.41	0.30	0.21	0.15	0.16	0.14
T_5	0.23	0.18	0.13	0.11	0.11	0.10
T_6	0.30	0.25	0.18	0.12	0.14	0.12
T_7	0.35	0.28	0.19	0.14	0.15	0.13
T_8	0.21	0.16	0.12	0.10	0.10	0.09
S.Em±	0.01	0.01	0.006	0.005	0.005	0.004
CD @ 5 %	0.03	0.03	0.02	0.01	0.02	0.01

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

3.3 Economics

Economics is one of the most important criteria for acceptance or wider adoption of any technology.

3.3.1 Cost of cultivation (Rs. ha^{-1})

The cost of cultivation of maize ranged from Rs. 24,876 to Rs. 44,886. Application of RD N and K + 100% RDP through compost coated DAP recorded higher cost of cultivation (Rs 44,886 ha^{-1}) followed by other treatments.

3.3.2 Gross and net return (Rs. ha^{-1})

Application of RD N and K + 75% RDP through compost coated DAP recorded higher gross return and net return (Rs 1,32,429 and 88,603 ha^{-1}, respectively) followed by RD N and K + 75% RDP through compost blended RP (Rs 1,30,603 and 87,182 ha^{-1}) compared to other treatments and lowest was recorded in the absolute control (Rs 38,920 and 14,404 ha^{-1}) respectively.

3.3.3 B: C ratio

Higher B: C ratio of 3.02 was recorded in T4 (RD N and K + 75% RDP through compost coated DAP) followed by T7 (3.01), T6 (2.86) and T3 (2.85). Lower B: C ratio of 1.56 was obtained in the absolute control.

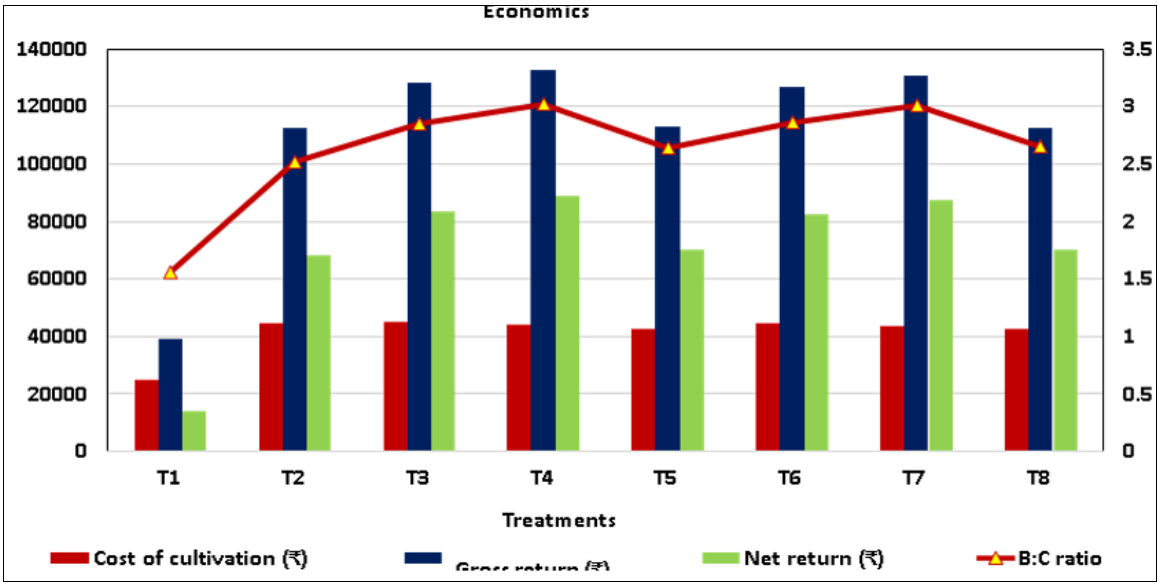

Fig 3: Effect of compost coated and blended phosphatic fertilizers on economics of maize production

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

Table 3: Effect of compost coated and blended phosphatic fertilizers on Fe, Mn, Zn and Cu content of maize

Treatment	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})	
	Kernel	Stover	Kernel	Stover	Kernel	Stover	Kernel	Stover
T_1	66.30	39.46	52.30	35.56	8.21	4.78	25.36	16.66
T_2	80.71	55.56	59.33	43.32	10.67	6.81	41.87	22.33
T_3	95.64	67.77	71.53	57.21	14.24	9.84	50.66	31.66
T_4	98.00	72.50	73.20	59.14	15.13	10.21	50.53	30.87
T_5	85.32	58.42	62.56	47.13	11.35	7.31	48.22	30.38
T_6	94.31	67.13	69.86	55.43	13.94	9.44	49.77	30.39
T_7	97.11	71.30	71.46	57.32	14.37	9.92	48.27	29.47
T_8	83.17	56.35	60.44	46.23	10.84	7.11	48.21	29.05
S.Em±	2.37	1.64	1.78	1.36	0.32	0.22	1.14	0.64
CD @ 5 %	7.20	4.97	5.39	4.12	0.96	0.67	3.46	1.94

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

4. Discussion

The increase in maize yield can be attributed to the balanced supply of readily soluble nutrients from urea and MOP, combined with the slow-release nutrients from compost-coated DAP and compost-blended rock phosphate (RP). These sources provided a steady and sustained nutrient release, which supported better crop growth and yield. The compost-blended RP dissolved more easily, ensuring a gradual release of phosphorus, essential for optimal crop performance. These findings are in line with the results of Bhattacharya *et al*. (2004) [5] and Yadav *et al*. (2009) [13].

The total contents of nitrogen, phosphorus and potassium increased in treatments where coated and blended phosphatic fertilizers were applied, due to higher nutrient availability and greater biomass yield compared to treatments with uncoated P fertilizers. The application of different levels of coated P fertilizers improved productivity by providing a sustained release of phosphorus. These results align with the findings of Chagas *et al*. (2017) [6] and Zafar *et al*. (2020) [14].

The content of micronutrients (Fe, Mn, Cu, and Zn) in maize increased with the application of various coated and blended phosphatic fertilizers (Table 10). This enhancement is likely due to the increased supply of these nutrients in the soil, originating from raw materials used in fertilizer production. Coated DAP and RP reduced nutrient fixation and dissolution rates, improving nutrient availability throughout the crop's growth period. Similar findings were reported by Singh (2003).

Highest net return and B: C ratio was obtained with RD N and K + 75% RDP through compost coated DAP (T_4). This was due to higher grain and straw yield obtained along with lower cost of cultivation. The results were in accordance with Ayalew *et al.* (2011), Sharif *et al.* (2011) [10], Kumar (2017) [8].

5. Conclusion

The present study focused on the synthesis of compost-coated DAP and compost-blended rock phosphate formulations, examining their effects on phosphorus dynamics and post-harvest nutrient status at different levels, using maize as a test crop. The application of coated and blended phosphatic fertilizers led to increased levels of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper and zinc in both kernels and stover. Regardless of the fertilizer source, the higher content of primary, secondary, and micronutrients can be attributed to the release of humic acid from the compost compared to treatments without coating. The advantages of coated and blended phosphatic fertilizers over commercial P fertilizers, including higher nutrient content relative to uncoated DAP, are likely due to the slow release of nutrients that aligns with crop demand. This significantly improved gross and net returns while reducing the cost of maize production.

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7. Declaration of Interests

Authors have declared that no competing interests exist.

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