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Effect of organic acid coated phosphatic fertilizer on soil P status, yield and quality of Brinjal

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Abstract

A field experiment was conducted during Rabi, 2019 which is laid out in Randomized Block Design (RBD) with ten treatments and three replications. The treatments comprised of T₁: NK+ P as uncoated DAP, T₂: NK + P as FA coated DAP (5%), T₃: NK + P as FA coated DAP (10%), T₄: NK + P as FA coated DAP (15%), T₅: NK + P as FA coated DAP (20%), T₆: NK + P as HA coated DAP (5%), T₇: NK + P as HA coated DAP (10%), T₈: NK + P as HA coated DAP (15%), T₉: NK + P as HA coated DAP (20%), T₁₀: Control. Urea and MOP were used as the source of Nitrogen and potassium respectively. The results from the field experiment revealed that the available P in the soil, the yield of Brinjal(CO₂) and the economic returns are varying according to the change in coating concentration and type of organic acids. There is no significant difference in anthocyanin content and Titrable acidity of Brinjal fruits but slight improvement is found in ascorbic acid content. Significantly higher yield was obtained in T₉ [NK + P as HA coated DAP (20%)] and lowest yield was recorded for T₁₀, T₆ and T₁. Humic acid coated treatments found better in yield and available soil P status compared to Fulvic acid coated treatments.

Keywords: Humic acid, Fulvic acid, Brinjal, Di Ammonium Phosphate, Soil available phosphorus, yield

Introduction

Phosphorus is the main element required for the plant's growth. P is important for root growth and act as an energy source. DAP is the most widespread phosphate fertilizer because of its high analysis and good physical properties. Phosphorus commonly limits plant growth in deficient condition. The main reason for this deficiency is rapid dissolution and fixation of nutrients in the soil. For reducing P losses and to improve phosphorus use efficiency (PUE), gradual release of P is essential. Gradual release can be promoted by coating P fertilizer. Coating with organic or inorganic polymers is most common. To prevent the accumulation of undesirable synthetic residues in the soil that occurs due to inorganic polymer coating, organic polymers act as a promising coating material since they are easily degradable and non-toxic to the environment.

Humic acids (HA) and Fulvic acids (FA) are natural biostimulants and which will improve the growth of plants. The coating of fertilizers using organic acids will help in improving the fertilizer efficiency and also it will reduce the fertilizer losses. Paramasivan *et al.* (2015) [20] who studied the effect of Humic acid on yield, profitability and nutrient uptake in Brinjal reported that the Humic acid application has increased the yield, profitability and nutrient uptake in Brinjal. Ugur *et al.* (2013) [25] reported that Humic acid application was found to be effective on yield. Karakurt *et al.* (2009) [14] studied that increasing soil and foliar HA concentrations resulted in a significant enhancement in mean fruit weight of pepper. Similarly Humic acids acts as a soil conditioner and improves the ability of soil to hold more nutrients which are available to plant (Iqbal and Mastorakis, 2014) [13]. Foliar application of Fulvic acid at different levels on plant growth, fruit quality and yield of tomato led to a significant increase in plant height, fresh and dry weight (Suh *et al.* 2014) [23]. Application of Fulvic acid at different levels improves the quality parameters *viz.*, Fruit antioxidant activity, total phenolic, carbohydrate, capsaicin and carotenoid contents in pepper.

Hence keeping the above points the present study was undertaken to standardize organic acid coating (Humic acid, Fulvic acid) for phosphatic fertilizer to improve the yield, quality as well as P use efficiency in Brinjal.

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Materials and methods

Field experiment was conducted during winter season (October – November) in the Farmer's field at Thondamuthur, Coimbatore, Tamil Nadu. The experimental site is geographically located at 10.99° N latitude and 76.83° E longitude at an altitude of 315 m above MSL. In the four rainfall seasons, Coimbatore received 859.50mm rainfall which is 27.5% more than 50 year's average rainfall. The mean maximum and minimum temperatures were 32.5°C and 21°C, respectively. The initial soil samples were collected from the experimental field and analyzed the initial physico chemical properties. The texture of the soil was sandy loam. The soil was low in available N, high in available P, and high in available K.

The field experiment was laid out in Randomized Block Design (RBD) and consisted of ten treatments and replicated thrice. The treatments comprised of T₁: NK+ P as uncoated DAP, T₂: NK + P as FA coated DAP(5%), T₃: NK + P as FA coated DAP (10%), T₄: NK + P as FA coated DAP (15%), T₅: NK + P as FA coated DAP (20%), T₆ NK + P as HA coated DAP (5%), T₇: NK + P as HA coated DAP (10%), T₈: NK + P as HA coated DAP (15%), T₉: NK + P as HA coated DAP (20%), T₁₀: control. Urea and Muriate of potash (MOP) were used as the Nitrogen and potassium source respectively.

The coating of fertilizers was done using oil (vegetable oil). Subsequently mix the fertilizer and limited amount of oil with Humic acid and Fulvic acid separately by physical mixing. Then the fertilizers were dried in hot water bath for several hours until the moisture was removed completely. The dried material was used for the experiment. The Brinjal (CO₂) seedlings were raised in the nursery for transplanting. Thoroughly the main field was ploughed and ridges and furrows were formed at a spacing of 60 cm. The furrows were irrigated and 25-30 days old seedlings were transplanted at 60 cm apart on the ridges. The plots received normal cultural practices such as weeding, irrigation and plant protection and were performed from time to time. All the cultural operations were carried out based on Crop Production Guide (CPG) – Government of Tamilnadu. The growth and yield parameters were recorded.

Nitrogen and Potassium was applied in the form of Urea and MOP as per the fertilization schedule for Brinjal. Phosphorus was applied in the form of HA and FA coated DAP. Recommended dose of fertilizer for Brinjal (As per STCR recommendation) is 127:37:100 kg NPK ha⁻¹. The fertilizer was applied as per the fertilization schedule at different growth stages. The crop was kept weed free with four hand weeding's. Irrigations were given as and when required. Better crop growth was ensured with the help of timely plant protection sprays which were followed by recommended cultural operations whenever required.

The total yield from each of the treatment plots were calculated and expressed in kg. The total fruit yield was calculated by converting the per plot fruit yield on hectare basis and expressed in t ha⁻¹. Five plants in each plot other than guard row were randomly selected and tagged for recording observations on growth and yield parameters. Observations like number of fruits per plant, fruit length girth, fruit weight, and yield per plot were recorded. From the yield, gross returns can be calculated and this can be used for the calculation of benefit cost ratio. The soil samples were analysed for available P at different stages of Brinjal by using Olsen's extractant (Olsen *et al.*, 1954)^[18].

The quality parameters were tested in laboratory. For the estimation of anthocyanin 10g fruit sample was separated and

samples were extracted with 10mL of ethanolic HCl. Extract was filtered and used for estimation. The absorbance of extracts clarified by filtration was measured at 535nm. Results were expressed as mg cynidin-3-glucoside equivalent per 100 g of FW.

Ascorbic acid content was determined by titration with an oxidizing agent namely indophenol dye. 10 g of fresh fruit taken in pestle and mortar blended with 4% oxalic acid. Pipette out the 10mL of this solution into a 250 mL conical flask and titrate against standard indophenol dye till a permanent pink color is obtained. (Miller, 1998)^[17].

The titrable acidity in the fruit sample is estimated by macerating the fruit sample and add 20-30 mL of water and few drops of phenolphthalein indicator then titrate against 0.1N NaOH. Endpoint is the appearance of pink colour. (Horwitz, 1975)^[11].

The data on the various characters recorded were statistically analysed under randomized block design as suggested by Gomez and Gomez (2010). Wherever the treatment differences were found to be significant (F-test), critical differences were worked out at five per cent probability level (P = 0.05) and the treatment differences that were found not to be significant was denoted NS (Non-significant) in the respective tables.

Results and discussions

Effect of organic acid (HA, FA) coated Di ammonium phosphate on yield and soil available P are summarized in Table 1, Table 2 respectively.

Yield attributes

The maximum number of fruits per plant was observed in T₉ (NK + P as HA coated DAP (20%)) with values of 48. This was followed by T₈ (NK + P as HA coated DAP (15%)) which recorded 45.1. and then T₃ (NK + P as FA coated DAP (10%)) attain a value of 44.5. Similar findings were reported by Arancon *et al.* (2006)^[4], who explained peppers treated with humic acids extracted from organic source produced significantly more fruits and flowers. Shafeek (2016)^[22] studied in cucumber, indicated that the application of Humic acid increases the number of fruits per plant and also there is an increment in N%, Protein% and TSS%. Farahi *et al.* (2013)^[9] explained about the improvement of fruit number in strawberry.

The fruit length showed some differences between treatments. The minimum fruit length was observed in control (T₁₀) which recorded 7.6cm and the maximum fruit length was noted in T₉ (20% HA Coated DAP) which recorded 8.3 cm. This was followed by T₆ (5% HA Coated DAP) and T₄ (15% FA coated DAP) which attain a value of 8.1 cm. The results are in line with the reports of Azarpour *et al.* (2012)^[5] who explained that foliar application of HA treatments positively affect that fruit length and width, fruit number per plant in brinjal. Manas *et al.*, (2014)^[16] explained that the maximum fruit length registered in pepper plants which received the foliar application of HA+Zn+B

The results of the current study shows that maximum fruit girth was observed in T₉ which recorded 17.2cm this was followed by T₈ (16.4 cm) then T₅ (20% FA coated DAP), which recorded 16.3cm. Similar findings were given by Azarpour *et al.* (2012)^[5]. Also, Yildirim, who explained that foliar and soil HA treatments improves the fruit diameter in tomato. Salman (2005)^[21] given that application of Humic acid increased the fruit diameter in watermelon.

According to the data observed on fruit weight showed that T₉ has got the maximum fruit weight followed by T₈ and T₅. This recorded 83.4g, 76.8g and 74.9g respectively. The fruit weight was minimum (59.9g) in the treatment control followed by T₁ (uncoated DAP). El-Nemr (2015) [21] studied the responses of eggplants with different foliar concentrations of some bio-stimulators which show that humic acid application has improved the fruit weight. Similar results were reported by Azarpour *et al.* (2012) [5]. Karakurt *et al.* (2009) [4] observed that the fruit weight of pepper was enhanced by the application of Humic acid. Humic acid improve the fruit weight by activating hormones like auxin and cytokinin (Huang, Yuan *et al.* 2009) [12]. Humic acid holds many elements which increase the availability of trace minerals and consequently affected plant growth and yield (Hartwigson and Evans, 2000) [10]. El-kenawy (2017) [6] observed that fulvic acid application in Thompson seedless grape increased the yield.

Among the 10 treatments T₉ (20% HA coated DAP) surpassed other treatments by achieving the highest fruit yield

per hectare (31.18 t ha⁻¹) and which was superior to the next best treatment T₈ (15% HA coated DAP) which recorded 30.43 t ha⁻¹. The lowest fruit yield was observed in T₁₀ (control) which reported the value 17.92 t ha⁻¹. Compared to uncoated DAP, HA coating at 20% in DAP recorded 14.88% increase in yield followed by HA coating at 15% in DAP (12.12% increase in yield). Similar findings were observed by Paramasivan *et al.* (2015) [20] in Brinjal, who studied the influence of Humic acid yield of Brinjal and results found that highest fruit yield and total dry matter production were recorded in 75% RDF of NPK with 10kg of Humic acid applied as soil application and 0.2% foliar application.

The results revealed that the organic acid coated DAP fertilizer has brought variations in yield attributes of Brinjal. The different concentrations of Humic acid and Fulvic acid helps in growth and yield of plant. 20% Humic acid coated DAP fertilizers followed by 15% HA coated DAP showed the highest yield *ie.* 14.88% and 12.12% increase in yield, respectively over uncoated DAP.

Table 1: Effect of Organic acid coated DAP fertilizer on yield attributes of brinjal (*Solanum melongena* L.)

T.no	Treatments	Average fruit weight (g)	Number of fruits per plant (Nos.)	Fruit length (cm)	Fruit girth (cm)	Fruit Yield (t ha ⁻¹)
T ₁	NK+ P as Uncoated DAP	65.6	37.7	8.1	614.6	27.14
T ₂	NK+ P as FA coated DAP (5%)	69.5	39.0	7.9	14.9	28.35
T ₃	NK+ P as FA coated DAP (10%)	72.6	44.5	8.0	15.3	28.12
T ₄	NK+ P as FA coated DAP (15%)	74.6	42.0	8.1	15.6	28.74
T ₅	NK+ P as FA coated DAP (20%)	74.9	43.6	7.9	16.3	29.66
T ₆	NK+ P as HA coated DAP (5%)	66.3	37.8	8.1	15.5	26.69
T ₇	NK+ P as HA coated DAP (10%)	74.6	41.8	7.8	16.2	29.49
T ₈	NK+ P as HA coated DAP (15%)	76.8	45.1	8.0	16.4	30.43
T ₉	NK+ P as HA coated DAP (20%)	83.4	48.0	8.3	17.2	31.18
T ₁₀	Control	59.9	29.5	7.6	13.5	17.92
	SEd	1.22	0.94	0.191	0.350	0.465
	CD (P = 0.05)	2.56	1.98	NS	0.736	0.976

All treatments received 127:37:100 kg N:P₂O₅:K₂O ha⁻¹ as per soil test based recommendation
N as Urea, P as Coated DAP and K as MOP

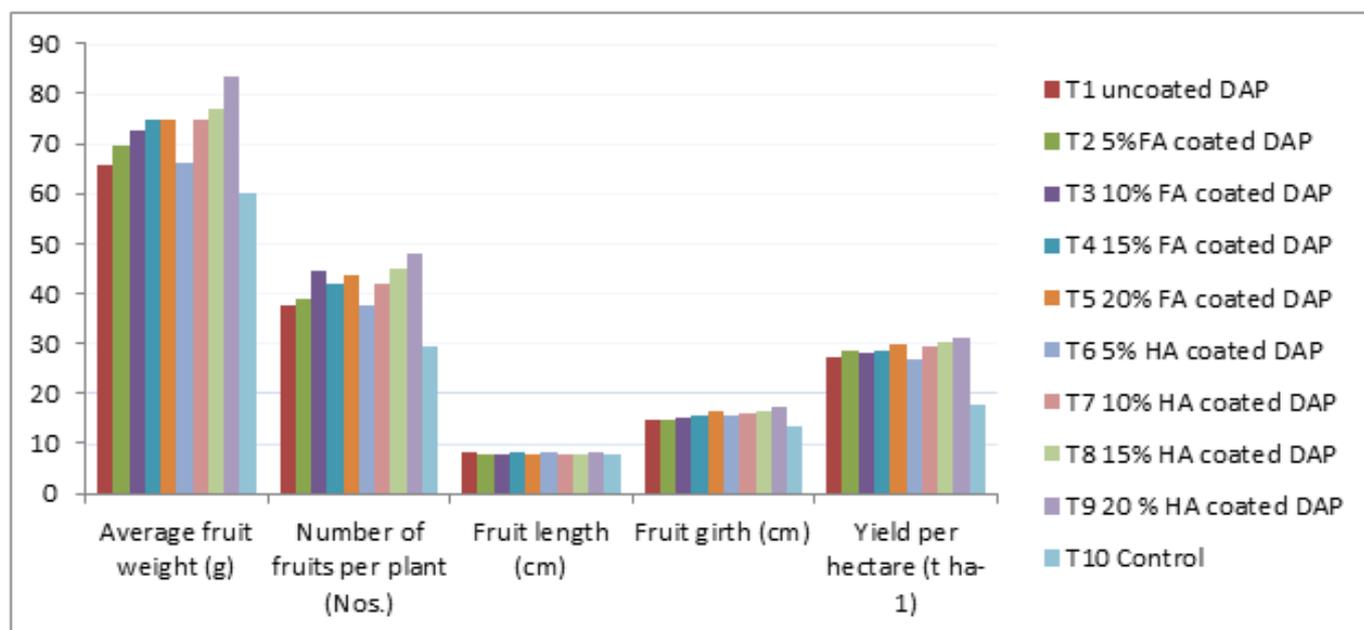


Fig 1: Deviation of yield attributes with respect to treatment

Benefit cost ratio**Table 2:** Deviation of Benefit cost ratio with respect to treatments

Sl.no	Treatment	Gross returns (lakh/ha)	Net Returns (lakh/ha)	BC Ratio
1	NK+ P as Uncoated DAP	6.11	4.7	4.44
2	NK+ P as FA coated DAP (5%)	6.39	4.99	4.61
3	NK+ P as FA coated DAP (10%)	6.33	4.94	4.56
4	NK+ P as FA coated DAP (15%)	6.46	5.07	4.64
5	NK+ P as FA coated DAP (20%)	6.67	5.27	4.77
6	NK+ P as HA coated DAP (5%)	6.01	4.62	4.33
7	NK+ P as HA coated DAP (10%)	6.63	5.23	4.74
8	NK+ P as HA coated DAP (15%)	6.81	5.39	4.82
9	NK+ P as HA coated DAP (20%)	7.01	5.59	4.93
10	Control	6.24	4.94	4.77

All treatments received 127:37:100 kg N:P₂O₅:K₂O ha⁻¹ as per soil test based recommendation
N as Urea, P as Coated DAP and K as MOP

The application of 20% HA coated DAP (T₉) fetched significantly higher net returns and benefit cost ratio (4.93) over the rest of treatments (Table 2). The second best treatment was 15% HA coated DAP which recorded a benefit cost ratio of 4.82, this might be due to achieved higher productivity as well as lower cost of cultivation leading to higher economic returns in Brinjal. These results are in close conformity with the findings of Paramasivan *et al.* (2015) [20] and Abd *et al.* (2005) [1].

Soil available phosphorus

Coated phosphatic fertilizers regulate release of phosphorus in the soil. Also net fertilizer P efficiency, dry matter production, P uptake, and net fertilizer release efficiency were better in coated fertilizers. Lubkowski (2014) [15] studied the use of biodegradable chitosan to coated fertilizer granules with an inert, impermeable layer in facilitated controlled release properties. As the layer thickness increases the degree of release decreases. Teixeira *et al.*, (2016) [24] observed that use

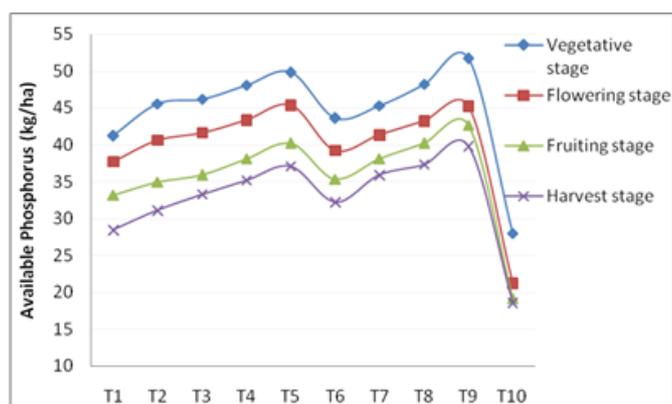
of organic acid coating facilitated the slow release of phosphorus fertilizers and improves the P availability in maize crop. Coating with humic acids reduced the water solubility of the P fertilizers, increased the agronomic efficiency (AE) of P led to higher values of apparent P recovery by maize. Erro *et al.*, (2016) [8] studied about improvement of phosphorus use efficiency using humic substances. And it was concluded that humic substances can improve the phosphorus efficiency.

The initial soil available P of the experimental field was high. The available P in soil showed significant variation in different growth stages of Brinjal. T₉ (20% HA coated DAP) showed highest soil available P compared to other treatments (39.82 kg/ha) this was followed by T₈ (15% HA coated DAP) which was on par with T₅ (20% FA coated DAP). The least available in soil was obtained in the treatment T10 (control) followed by T₁ (uncoated DAP). The results were confirmed with the findings of Wu and Liu (2008) [26] and Teixeira *et al.*, (2016) [24].

Table 3: Effect of Organic acid coated DAP fertilizer on soil available phosphorus

Tr.no	Treatments	Vegetative stage	Flowering stage	Fruiting stage	Harvest stage
T ₁	NK+ P as Uncoated DAP	41.2	37.7	33.2	28.41
T ₂	NK+ P as FA coated DAP (5%)	45.6	40.64	34.92	31.11
T ₃	NK+ P as FA coated DAP (10%)	46.2	41.68	35.88	33.27
T ₄	NK+ P as FA coated DAP (15%)	48.1	43.33	38.11	35.22
T ₅	NK+ P as FA coated DAP (20%)	49.8	45.4	40.2	37.11
T ₆	NK+ P as HA coated DAP (5%)	43.60	39.21	35.36	32.22
T ₇	NK+ P as HA coated DAP (10%)	45.3	41.33	38.11	35.89
T ₈	NK+ P as HA coated DAP (15%)	48.2	43.22	40.2	37.32
T ₉	NK+ P as HA coated DAP (20%)	51.69	45.23	42.66	39.82
T ₁₀	Control	27.98	21.22	19.12	18.58
	SEd	1.11	0.96	0.80	0.44
	CD (P = 0.05)	2.32	2.01	1.68	0.93

All treatments received 127:37:100 kg N:P₂O₅:K₂O ha⁻¹ as per soil test based recommendation
N as Urea, P as Coated DAP and K as MOP

**Fig 2:** Available phosphorus at different stages of growth of brinjal with respect to treatments

Quality parameters

Anthocyanin content (mg 100 g⁻¹)

The results showed that there is no significant difference in the anthocyanin content with respect to treatments. Among the treatments highest anthocyanin content was reported in in T₉ (11.56 mg 100 g⁻¹) which was followed by T₈ (11.48 mg 100 g⁻¹). Similar results were given by Alcija *et al.* (2019).

Ascorbic acid content (mg 100 g⁻¹)

There is slight increase in ascorbic content of Brinjal with respect to treatments. The highest ascorbic content was

obtained in T₉ which recorded a value of 16.68 mg 100 g⁻¹ followed by T₈ (16.65 mg 100 g⁻¹). Similar results were reported by in tomato.

Titration acidity (%)

There is no significant difference between treatments. Titration acidity value is a generically made character of fruit which might not be vary with the different concentrations of organic acid coated phosphate fertilizers. The values of Titration acidity ranged from 0.26 to 0.31%. Similar results were reported by in tomato.

Table 4: Effect of HA&FA coated phosphatic fertilizers on quality parameters in Brinjal variety CO2

Tr. No.	Treatments	Anthocyanin content (mg 100 g ⁻¹)	Ascorbic acid content (mg 100 g ⁻¹)	Titration acidity (%)
T ₁	NK+ P as Uncoated DAP	11.43	16.34	0.29
T ₂	NK+ P as FA coated DAP (5%)	11.21	16.42	0.28
T ₃	NK+ P as FA coated DAP (10%)	11.32	16.36	0.29
T ₄	NK+ P as FA coated DAP (15%)	11.28	16.41	0.31
T ₅	NK+ P as FA coated DAP (20%)	11.35	16.48	0.28
T ₆	NK+ P as HA coated DAP (5%)	11.43	16.47	0.27
T ₇	NK+ P as HA coated DAP (10%)	11.31	16.52	0.29
T ₈	NK+ P as HA coated DAP (15%)	11.48	16.65	0.30
T ₉	NK+ P as HA coated DAP (20%)	11.56	16.68	0.28
T ₁₀	Control	11.1	16.32	0.26
	SEd	0.27	0.011	0.012
	CD (P = 0.05)	NS	0.0227	NS

All treatments received 127:37:100 kg N: P₂O₅:K₂O ha⁻¹ as per soil test based recommendation

N as Urea, P as Coated DAP and K as MOP

Conclusion

Over all conclusions drawn from the field experiment is that slowing the release of fertilizer P into the soil by organic acid coated phosphatic fertilizers can markedly increase yield and soil available phosphorus. Among the coated fertilizers Humic acid coated DAP fertilizer excelled in yield as well as soil available P status. Also, the application of 20% HA coatd DAP fetched significantly higher net returns and benefit cost ratio. Hence, the present study revealed that organic acid coated phosphate fertilizer can be safely used within the applied concentrations with a positive effect on yield parameters like number fruits per plant, fruit length, fruit girth, fruit weight, yield per plot and yield per hectare, improvement in soil available P status, ascorbic acid content and also in economic returns. Application of 20% HA coated DAP can be recommended for the better fruit yield of brinjal, Benefit cost ratio, and available soil P status.

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