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Comparison of different rock phosphate based nutrient sources on chrysanthemum (*Dendranthema grandiflorum* L.) in low pH soils

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Abstract

Phosphorus (P) management is very important for flower crops. A field experiment was conducted in an acid soil to evaluate the effect of different phosphorus sources on soil properties, growth and yield of Chrysanthemum (*Dendranthema grandiflorum* L.). Three different sources at two levels (RDP at 100 and 50%) with ten treatments in three replications were arranged in simple RCBD. Phosphorus was applied through fertilizer (T₃ to T₆); phosphorus-enriched compost (PEC- T₇ and T₈); and P-rich organic manure (PROM- T₉ and T₁₀) and they were compared with absolute control and FYM alone. Recommended doses of nitrogen and potassium were applied to T₃ to T₁₀; and recommended dose of FYM was applied to T₅ to T₁₀ treatments. The results revealed that use of organic-P sources significantly improved growth and yield attributes. Among the treatments, the treatment PROM-100 recorded the highest plant height (49.88 cm), number of primary branches (19.91), plant spread area (1244.06 cm²), flower diameter (4.59 cm), number of flowers per plant (223.33) and flower yield per plant (446.67 g), outperforming both chemical fertilizers and P-enriched compost. The enhanced performance of PROM is attributed to its sustained P release, improved nutrient uptake and positive interaction with organic matter in acidic soil. Notably, supplementation of half of the recommended-P through PEC-50 or PROM-50 recorded on par yields with T₅ (POP). Similarly, growth and yield parameters were also found on par with each other. Thus, the study indicated that the chrysanthemum flower yields can be enhanced with the application of PROM and PEC. Moreover, the present yield levels can also be achieved even at 50% of RDP through PROM or PEC application.

Keywords: Phosphorus, prom, low pH soils, soil fertility, chrysanthemum

1. Introduction

Fertilizers and manures are key nutrient sources for crops. Manure contains phosphorus mostly in organic and form. Only some of this phosphorus is immediately available to crops; the rest remains in the soil for future use through mineralization. Fertilizers provide nutrients in readily available forms, offering a concentrated and consistent nutrient source. Phosphorus is a fundamental element for plant nutrition and is vital for various physiological processes. Its importance cannot be overstated and adequate phosphorus levels are crucial for optimal plant growth and flowering. Ensuring adequate phosphorus levels in agricultural soils will be critical for sustaining crop yields and to meet raising global food demand (Greeshma Reddy *et al.*, 2017) [4]. Inorganic phosphate is largely not available for plant uptake due to its high reactivity with metal ions causing chemical fixation (Vijay *et al.*, 2018) [17]. Thus, its deficiency can significantly affect both growth and metabolism in plants.

The most commonly used P-fertilizers namely; di-ammonium phosphate (DAP), single super phosphate (SSP) etc. are manufactured mainly from rock phosphate (RP) minerals. They can be blended to match crop needs, preventing nutrient accumulation and ensuring optimal growth. In contrast, rock phosphate offers a cost-effective alternative to expensive commercial phosphorus fertilizers, particularly for acid soils where its direct application can be effective (Nagaraja *et al.*, 1997) [10]. Rock phosphate generally contains 18 to 32% depending upon its grade. But RP is found to be of limited value in neutral to alkaline soils due to its low solubility in these conditions.

Application of RP, in combination with phosphate-solubilizing bacteria (PSB), organic acids and farm yard manure (FYM) could enhance phosphorus availability and contribute to sustainable crop growth and profitability (Nagaraja *et al.*, 2016)^[11]. Organic acids produced by micro-organisms in manure help solubilize phosphorus compounds.

Chrysanthemum (*Dendranthema grandiflora*. L) - Queen of East; with golden yellow colour flower belongs to the family Asteraceae. Chrysanthemum ranks next to rose in the international flower market due to its vast range of shapes, sizes, colours and long-lasting floret life. The origin of the chrysanthemum is in Northern hemisphere, chiefly in Europe and Asia. Some claim that it originated in China. Chrysanthemum is a native of Northern Hemisphere. In India, chrysanthemum is mainly grown in Karnataka, Tamil Nadu, West Bengal, Madhya Pradesh and Himachal Pradesh. Applying P-enriched compost and physically mixed organic P manures can significantly increase plant growth and crop yield. Application of P-enriched compost helps to supply this vital nutrient in a slow-release form, improving soil fertility and enhancing nutrient availability over time. This can also lead to better root development, increased flower size and more vigorous plant growth (Moharana and Biswas, 2022)^[9]. Additionally, the compost adds organic matter to the soil, improving its structure and moisture retention, which further supports healthy plant development (Raj *et al.*, 2012)^[12]. Overall, using P-enriched compost in chrysanthemum cultivation can boost plant performance, leading to more robust and visually appealing blooms while promoting sustainable soil management practices (Nagaraja *et al.*, 2018)^[17].

2. Materials and Methods

The field experiment was conducted in a farmer's field at Holehonnur, Shivamogga. The experimental site was situated at 13° 59' 45" N (Latitude) and 75° 41' 00" E (Longitude), altitude of 569 MSL and falls under Southern Transition Zone (Zone 7) of Karnataka. The Chrysanthemum (var. Poornima yellow) was grown under open field conditions. The rooted chrysanthemum cuttings were planted at a distance of 45 cm × 30 cm apart after adding well decomposed FYM at 25 t ha⁻¹. The recommended dose of 150:100:100 kg N: P₂O₅: K₂O per hectare was applied in the form of urea, diammonium phosphate (DAP) and Muriate of potash (MOP). However, nitrogen was applied in three split equal doses, the first as a basal dose and the remaining doses after 30 and 45 days after planting. All the standard crop production practices for Chrysanthemum were followed as per the standard Horticulture package of practices. Data were recorded in terms of different plant parameters viz., plant height (cm), plant spread (cm) in North-South and East-West direction, number of primary and secondary branches per plant, days taken for bud initiation, days to 50% flowering, flower diameter (cm), number of flowers per plant, yield of flower per hectare (t ha⁻¹). The cultivars were planted in three replications, and five plants were selected in each replication for making observations. The data collected were analysed statistically using Randomised Complete Block Design.

- **Plant height (cm):** The plant height was measured by meter scale from ground level to the highest tip of the main stem. The height was measured for all the five plants in each plot which was tagged and later an average was calculated.
- **Plant spread (cm²):** The spread of the plant was recorded by measuring the plant canopy in two mutually perpendicular directions with the help of a meter scale. The spread was measured for all the five plants in each plot

which was tagged and later an average was calculated.

- **Number of primary branches:** Total number of primary branches coming out from the main stem was counted and recorded. This was done for all tagged plants in each treatment. Later on, their average was calculated.
- **Number of secondary branches:** The number of secondary branches on primary branches was counted for randomly selected plants at 60 and 75 DAT. The averages were worked out and expressed in number.
- **Days taken to bud initiation:** To record the first flower bud appearance, the plants were observed critically and after its emergence the flower buds were tagged. Days taken for flower bud appearance were noted from transplanting date to flower bud appearance date.
- **Days taken to 50% flowering:** Number of days taken by the half of the plants for flowering in each plot from the date of planting was recorded and average was calculated.
- **Flower diameter (cm):** Fully matured and well-opened flowers were collected from randomly selected plants. The diameter of each flower was measured using a meter scale and the average was calculated and expressed in centimetres.
- **Number of flowers per plant (g):** The number of flowers produced by the five randomly selected plants were counted at each harvest till the final harvest. They were summed up and the average number of flowers produced by a plant over a total crop period was calculated with respect to each treatment.
- **Flower yield per plant (g):** The flowers harvested at regular intervals from the five randomly selected plants were weighed and expressed in grams.
- **Flower yield per plot (kg):** The flowers harvested at regular intervals from each plot were weighed and expressed in kilograms.
- **Flower yield per hectare (q ha⁻¹):** The flowers harvested at regular intervals from each plot were weighed and expressed in kilograms. The average yield per hectare was calculated and expressed as q ha⁻¹.

3. Results and Discussion

Vegetative parameters

The data on plant height, primary branches and secondary branches at different stages are presented in Table 1 and Figure 1. The plant height increased with time in all the treatments. All the fertilized plots showed higher growth than the absolute control (T₁) and FYM alone applied plots (T₂). Among them, the least growth was observed in fertilizer only applied plots (T₃ and T₄) compared to the combined application of fertilizer and FYM. The plant height at later stages (45, 60 and 75 DAT) indicated that the treatments receiving PEC (T₇ and T₈) and PROM (T₉ and T₁₀) recorded significantly higher growth than the conventional fertilizer (DAP) applied plots. In general, all the treatments receiving 100% RDP recorded higher growth than 50% RDP applied plots. It was interesting to note that the plant height at 75 DAT in T₅ (RDP-100) was found on par with the treatments T₈ (PEC-50) and T₁₀ (PROM-50) receiving only 50% RDP.

The primary branches and secondary branches were significantly higher in PROM applied plots. However, the treatments receiving PEC (T₇ and T₈) and PROM (T₉ and T₁₀) applied treatments had higher number of primary branches at later stages of 60 and 75 DAT. In general, all the treatments receiving 100% RDP recorded higher primary branches than 50% RDP applied

plots. Similar to plant height, the primary branches at 75 DAT in T₅ (RDP-100) were found on par with the treatments PEC-50 and PROM-50, which received only half of the recommended fertilizer. In general, all the treatments receiving 100% RDP recorded higher primary and secondary branches than 50% RDP applied plots. Similar to plant height, number of branches, the plant spread area also increased steadily with time across all treatments, with further increase in spread area. Among the fertilizer treatments, PEC -100 and PROM-100 showed higher spread area compared to conventional fertilizers (T₅). In general, the treatments receiving 100% RDP showed significantly higher spread area than the 50% RDP applied plots. Similar to plant height and number of branches, the spread area of chrysanthemum in RDP-100 was found on par with PEC-50 and PROM-50.

The above results clearly demonstrate the critical role of plant nutrition in enhancing plant development (Kumar, 2014) [5]. The variations in different Chrysanthemum growth parameters may be attributed to the amount of nutrients added and their sources (Manzoor *et al.*, 2006; Nagaraja *et al.*, 2016) [7, 11]. It was also evidenced by substantial increase in all the growth parameters in fertilized treatments compared to absolute control (T₁) and FYM (T₂) treatments. These results further confirm the importance of plant nutrition with fertilizers (Reddy *et al.*, 2020) [19]. The superiority of PROM and enriched compost treatments can be attributed to their ability to provide a sustained release of phosphorus along with organic matter, which improves root proliferation, nutrient uptake and overall vegetative growth. The application of FYM might have enhanced microbial activity and soil physical conditions, thereby facilitating better utilization of nutrients (Shivakumar *et al.*, 2010; Reddy *et al.*, 2020) [16, 19]. Phosphorus plays a pivotal role in cell division, photosynthesis, and energy transfer, which translates into increased plant height and branching and which ultimately contribute to greater canopy expansion (Shreekanth *et al.*, 2018) [17].

Effect of P- enriched organic manures on yield

Days taken for bud initiation and 50% flowering

The application of phosphorus significantly reduced the time taken for flower bud initiation (Figure 2). The days taken for flower bud initiation in the absolute control (T₁) was longest while, lesser number of days was recorded in T₉ plots (PROM-100). It was also observed that phosphorus application both at 50 and 100% were found on par with all the P sources at their respective levels. The treatments applied with 100% RDP recorded significantly lesser number of days compared to treatments with 50% RDP. Among different P sources, PROM and PEC-based treatments reduced the number of days taken for bud initiation.

The data on 50% flowering indicated that the chrysanthemum took maximum duration in the absolute control (T₁) while, the minimum duration was recorded in

T₉ (PROM-100). Application of phosphorus significantly hastened flowering (T₃ to T₁₀) compared to unfertilized treatments (T₁ and T₂). Treatments supplied with RDP-100 levels recorded early flowering than those with RDP-50 levels indicating the importance of adequate phosphorus availability in reducing the duration of flowering. It suggests the effectiveness in ensuring a more sustained and readily available P supply for

better reproductive development (Bohra and Kumar, 2014) [1].

The reduction in days for bud initiation and for flowering with phosphorus application can be attributed to its importance in reproductive phase of chrysanthemum. Its role in energy transfer, enzyme activation and nucleic acid synthesis is known to accelerate physiological processes related to flowering (Kumari *et al.*, 2014) [5]. Moreover, the application of organic P sources through PROM and PEC would not only supply phosphorus substantially but also enhances microbial activity and root growth, creating favourable conditions for early transition from vegetative to reproductive phase (Reddy *et al.*, 2020) [19]. These results are in the line with the findings in Calendula and in chrysanthemum (Shashidhar and Gopinath, 2005) [14].

Number of flowers per plant and flower diameter

The phosphorus management significantly influenced both the number of flowers and flower diameter represented in Table 2. The number of flowers per plant ranged from 124.86 to 223.33 and its size ranged from 4.13 to 4.59 cm. Among different P-treatments, application at 100% RDP through PEC and PROM recorded significantly higher number of flowers than conventional DAP fertilizer treatments (T₅; RDP-100). Similar effects were seen even w.r.t. flower size in terms of its diameter. It was also observed that P- application at 100% rates had significantly higher number of flowers corresponding to their 50%. Similarly, application of PEC and PROM at 100% recorded larger flowers than conventional DAP treatments (T₃; DAP-100). It was also observed that application of PEC and PROM at 50% showed recorded on par number of flowers per plant and flower size with RDP-100 treatments (T₅).

The superiority of these treatments may be attributed to the sustained slow release of phosphorus from PEC and PROM. Improved nutrient availability and root activity could be the reason for larger flower and higher yield (Greeshma Reddy *et al.*, 2017) [4]. The addition of organics is also known to enhance microbial activity, reduce P fixation and thus, ensure continuous P- supply (Nagaraja, 1997) [10]. Thus, P- supply to plants improve flower quality and yield (De and Dhiman, 1998) [3].

Flower yield of chrysanthemum

The phosphorus management had significantly influenced the flower yield, data presented in Table 2. Application of phosphorus along with nitrogen and potassium increased the flower yield in terms of yield per plant, per plot and per hectare significantly. However, the sources of phosphorus and its levels influenced the flower yield to a greater extent. Among different P- treatments application of 100% RDP through PEC and PROM recorded significantly higher flower yield. Use of conventional-P along with FYM reduced flower yield. Application of phosphorus at 50% had lesser flower yield corresponding to their 100% application. The positive response of different yield components with fertilization in this study corroborates with research findings of Shirale *et al.* (2014); Shivakumar *et al.* (2010) [15, 16]. Adequate phosphorus nutrition plays a vital role in energy transfer, floral primordia development and assimilate partitioning, which directly influence flower size and number (Bohra and Kumar, 2014) [1].

Table 1: Effect of different sources of phosphorus on chrysanthemum growth parameters

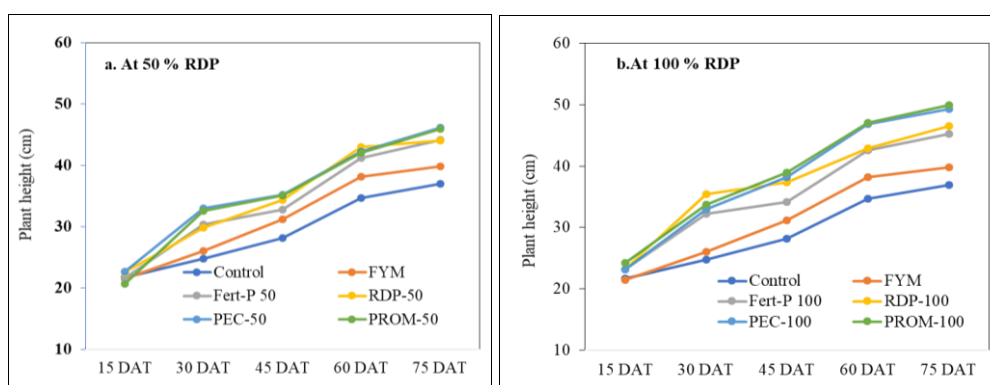
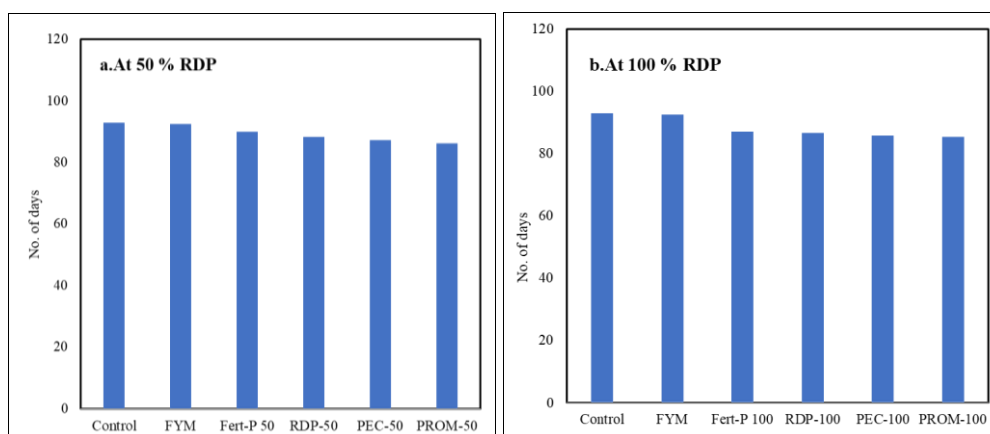
Treatments*	Plant height (cm)	Number of Primary branches	Number of Secondary branches	Plant spread (Area cm ²)	Days for bud initiation	Days for 50% flowering
T ₁ -Absolute control	36.97	10.62	16.67	493.77	92.90	121.08
T ₂ - FYM only	39.83	12.73	19.65	571.44	92.53	119.96
T ₃ - 100% RDP Through fertilizer	45.26	15.14	24.13	858.48	87.04	115.94
T ₄ - 50% RDP Through fertilizer	44.18	15.21	22.65	759.64	89.94	116.54
T ₅ -100% RDP Through fertilizer + Rec. FYM	46.50	16.93	26.29	1045.54	86.54	114.29
T ₆ -50% RDP Through fertilizer + Rec. FYM	44.04	15.52	23.05	757.83	88.29	116.21
T ₇ -100% RDP through PEC + Rec. FYM	49.33	17.95	28.28	1228.81	85.72	110.62
T ₈ -50% RDP through PEC + Rec. FYM	46.15	16.94	26.22	1016.08	87.25	112.76
T ₉ -100% RDP through PROM + Rec. FYM	49.88	19.91	29.12	1244.06	85.41	109.37
T ₁₀ -50% RDP through PROM + Rec. FYM	45.95	16.93	26.17	990.31	86.21	111.52
S. Em ±	1.10	0.58	0.67	49.47	0.72	0.71
CD ($p = 0.05$)	3.26	1.73	1.99	146.99	2.15	2.13

Note: *RND and RDK applied to fertilizer treatments (T₃ to T₁₀)

Table 2: Effect of different sources of phosphorus on chrysanthemum flower yield parameters

Treatments*	Number of flowers per plant	Flower diameter (cm)	Flowers yield (g plant ⁻¹)	Flowers yield (g plant ⁻¹)	Flower yield per plot (kg / 6.87 m ²)	Flower yield (ton ha ⁻¹)
T ₁ -Absolute control	124.86	4.13	249.72	249.72	11.17	16.26
T ₂ - FYM only	148.66	4.14	297.33	297.33	11.98	17.43
T ₃ - 100% RDP Through fertilizer	175.66	4.56	351.32	351.32	13.93	20.27
T ₄ - 50% RDP Through fertilizer	163.12	4.47	326.24	326.24	13.48	19.63
T ₅ -100% RDP Through fertilizer + Rec. FYM	197.33	4.58	394.67	394.67	15.69	22.85
T ₆ -50% RDP Through fertilizer + Rec. FYM	166.03	4.47	332.07	332.07	13.51	19.67
T ₇ -100% RDP through PEC + Rec. FYM	220.77	4.53	441.54	441.54	17.12	24.92
T ₈ -50% RDP through PEC + Rec. FYM	195.36	4.45	390.73	390.73	15.48	22.54
T ₉ -100% RDP through PROM + Rec. FYM	223.33	4.59	446.67	446.67	17.22	25.07
T ₁₀ -50% RDP through PROM + Rec. FYM	190.01	4.45	380.02	380.02	15.49	22.54
S. Em ±	5.28	0.12	10.57	10.57	0.46	0.66
CD ($p = 0.05$)	15.70	0.36	31.40	31.40	1.35	1.97

Note: *RND and RDK applied to fertilizer treatments (T₃ to T₁₀)

**Fig 1:** Effect of different sources of phosphorus on plant height of chrysanthemum a) At 50% RDP b) At 100% RDP**Fig 2:** Effect of different sources of phosphorus on days taken for bud initiation of chrysanthemum a) At 50% RDP b) At 100% RDP

Conclusion

The field experiment showed that applying phosphorus sources along with FYM improved soil fertility, plant growth, and flower yield of chrysanthemum compared to using fertilizer or FYM alone. Treatments with PEC and PROM (T₇ to T₁₀) had more residual phosphorus because they released nutrients slowly. The best growth, including plant height, number of branches and plant spread was found in treatment T₉ followed by T₇. Bud initiation and 50% flowering occurred earlier in T₉. This treatment also produced the highest number of flowers per plant, the largest flower size and the highest flower yield. Overall, PROM performed best followed closely by PEC-based treatments.

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