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Impact of rock phosphate levels and biostimulants on growth, yield and productivity of cowpea under organic conditions in Sikkim

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Abstract

A field experiment on different treatment combinations of rock phosphate levels and bio-stimulants on growth and yield of cowpea under the organic production system in Sikkim in the *kharif* seasons of 2024-25 and 2025-26 at the College of Horticulture, Bermiok. Ten treatment combinations i.e., 100 kg rock phosphate (RP)/ha with 5% seaweed extract, 100 kg RP/ha with 5% Panchagavya, 100 kg RP/ha with 5% humic acid, 150 kg RP/ha with 5% seaweed extract, 150 kg RP/ha with 5% Panchagavya, 150 kg RP/ha with 5% humic acid, 200 kg RP/ha with 5% seaweed extract, 200 kg RP/ha with 5% Panchagavya, 200 kg RP/ha with 5% humic acid and the control, were laid out in RBD and replicated thrice. A basal dose of 20 t/ha of farmyard manure was given for all the plots. Treatment 200 kg RP/ha with 5% seaweed extract significantly improved various growth parameters, including plant height (136.17 cm), number of branches per plant (8.87), and number of leaves per plant (15.37). Application of 200 kg RP/ha with 5% panchagavya recorded the highest pod yield (5.31 t/ha) and crop productivity (58.37 kg/ha/day), which were significantly superior to the rest of the treatments. In the case of phenolic content, 200 kg RP/ha with 5% humic acid resulted in the highest total phenol content (16.85 mg GAE/g), which was closely followed by 200 kg RP/ha with 5% seaweed extract. Overall, 200 kg RP/ha with 5% panchagavya emerged as the best treatment for enhancing growth, yield, and productivity of cowpea under the organic production system in Sikkim.

Keywords: Bio-stimulants, cowpea, growth, organic production, rock phosphate, yield

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is a type of bean that comes under the family Leguminosae, rich in high protein content (approximately 25%) and certain vitamins (Thiamine, Riboflavin, Niacin, etc.) (Anuja and Vijayalakshmi, 2014) ^[1]. Though it is believed to have originated in Africa, the crop is grown worldwide. Africa is the leading producer, followed by Brazil, India, Myanmar, the West Indies, and Australia. In India, cowpea is cultivated in almost every part of the country. Andhra Pradesh is the top cowpea producer of the country. Other major states growing cowpea include Maharashtra, West Bengal, Rajasthan, Tamil Nadu and Odisha (Raja and Singh, 2022) ^[2]. Cowpea is consumed in both fresh and dry forms. Its fresh immature pods and tender leaves are consumed, and in the dry type, the dried pods are harvested and consumed as legumes (Mekonnen *et al.*, 2022) ^[3]. Mostly, it is grown in the kharif season (July to August) and is used for human consumption and as a fodder crop.

Sikkim, the first fully organic state in the world, prohibits the use of any kind of synthetic agro-inputs like fertilisers, pesticides, growth regulators, etc. in crop production. The state has low crop production levels due to various reasons, including imbalanced nutrient management practices and inadequate supply of nutrients to crops. Growers of the state lack awareness regarding different kinds of organic inputs (like rock phosphate, bio-stimulants, biofertilizers) and their uses (Singh *et al.*, 2022) ^[4]. The soils of the state are mostly acidic due to high rainfall and deficient in phosphorus, thus reducing phosphorus availability to plants. Rock phosphate is a mineral-based phosphorus source containing about 15-35% P₂O₅ and a certain amount of calcium,

thus neutralising soil acidity to some extent while supplying phosphorus. Biostimulants like seaweed extract, panchagavya and humic acid reportedly improve plant growth and quality and resilience against various biotic and abiotic stresses (Bhupenchandra *et al.*, 2022) ^[5]. With an objective to boost the production of cowpea in organic conditions, the investigation was carried out to identify the appropriate combination of rock phosphate and biostimulant for enhancing growth, yield and productivity of cowpea in Sikkim conditions.

Material and Methods

The experiment was carried out in the *kharif* seasons of 2024-25 and 2025-26 at the College of Horticulture, Bermiok, CAU (Imphal), Sikkim, to study the effect of rock phosphate (RP) levels and biostimulants on growth, yield and productivity of cowpea under organic conditions in Sikkim. The experimental site lies at an altitude of 867 meters above mean sea level, at 27° 23.2' 36.3" N latitude and 88° 46.8' 92.7" E longitude. The experiment was laid out in a randomised block design with three replications. Ten treatments *i.e.*, 100 kg RP/ha with 5% seaweed extract (T₁), 100 kg RP/ha with 5% panchagavya (T₂), 100 kg RP/ha with 5% humic acid (T₃), 150 kg RP/ha with 5% seaweed extract (T₄), 150 kg RP/ha with 5% panchagavya (T₅), 150 kg RP/ha with 5% humic acid (T₆), 200 kg RP/ha with 5% seaweed extract (T₇), 200 kg RP/ha with 5% panchagavya (T₈), 200 kg RP/ha with 5% humic acid (T₉), and the control (T₁₀) were laid in the experimental plots. Cowpea seeds of variety Kashi Nidhi (an early maturing variety of IIVR, Varanasi) were sown on 6th May during both seasons of the investigation, at a spacing of 45 cm x 10 cm. Compost @ 20 t/ha was applied in all treatments at the final land preparation. Rock phosphate was applied according to the treatment at the time of final land preparation. Foliar application of different biostimulants (Panchagavya, humic acid, seaweed extract) was done at 15, 30 and 45 days after sowing (DAS). Thinning and gap-filling operations were done to maintain the optimum plant population. Observations

recorded during the investigation were plant height (cm) at harvest, number of branches per plant, number of leaves per plant, and pod length (cm). For each treatment plot-wise pod yield of cowpea (kg/plot) was recorded, which was later converted into pod yield (t/ha). Crop productivity (kg/ha/day) was calculated by dividing pod yield by the total duration of the crop. The total crop duration was 105 days during the experimentation. The total phenolic content of the pods was determined using the modified Folin–Ciocalteu assay, with gallic acid employed as the reference standard following the method described by Pakade *et al.* (2013) ^[6] and Ralepele *et al.* (2021) ^[7]. The total phenolic content was expressed as gallic acid equivalents (GAE) in mg per g of extract. Data were statistically analysed using OPSTAT, HAU, Hissar at 5% probability to draw a valid conclusion statistically.

Results and Discussion

The data on various growth and yield parameters are presented in Table 1 and graphically in Figure 1, 2, and 3. The tallest plant was observed under T₈ (156.73 cm), which showed a significant superiority over all treatments. Treatment T₉ recorded the maximum number of branches per plant (12.23) and was found statistically superior among all treatments, except T₈ (11.27). The highest number of leaves per plant was registered under T₈ (18.50), which were closely followed by T₉ (17.60). An adequate supply of phosphorus to plants improves cell division, energy transfer (ATP), and photosynthesis, thus resulting in better roots and early shoot development (Molla, 2024) ^[8]. The presence of phytohormone auxin in Panchagavya could have promoted plant growth by stimulating cell division and cell elongation in axillary buds. Additionally, the application of Panchagavya may stimulate the endogenous synthesis of natural auxins within the plant, resulting in early and vigorous vegetative growth (Kumar *et al.* 2023 ^[9]; Raja *et al.* 2022 ^[2]). Better growth response in cowpea under T₈ (200 kg RP/ha with 5% panchagavya) could be the result of these synergistic effects.

Tables 1: Influence of different levels of rock phosphate and biostimulants on growth, yield, productivity and total phenol content in cowpea (pooled data of two years)

Treatments	Plant height (cm)	No. of branches per plant	No. of leaves per plant	Pod length (cm)	Pod yield (t/ha)	Crop productivity (kg/ha/day)	Total phenol content (mg GAE/g)
T ₁	95.30	7.70	9.80	26.68	2.57	24.51	15.62
T ₂	113.13	6.10	7.17	27.22	3.47	33.06	15.42
T ₃	103.77	6.37	9.17	27.55	2.15	20.44	15.48
T ₄	101.80	7.27	10.73	30.27	4.20	39.96	16.60
T ₅	103.10	8.23	10.17	29.33	3.87	36.83	15.33
T ₆	100.50	9.73	14.67	28.82	3.60	34.24	15.44
T ₇	136.17	8.87	15.37	26.80	4.80	45.67	16.65
T ₈	156.73	11.27	18.50	29.93	5.31	50.58	16.64
T ₉	120.67	12.23	17.60	27.57	4.97	47.32	16.85
T ₁₀	84.23	5.12	7.40	25.34	2.22	22.10	14.42
CD (P =0.05)	17.96	1.10	1.83	N/A	0.61	5.81	0.947
Sem	5.94	0.36	0.61	0.87	0.20	1.92	0.313
Sed	8.40	0.52	0.86	1.23	0.29	2.72	0.443
CV	8.98	7.30	8.35	5.31	8.75	8.76	3.392

N.B.: 100 kg RP/ha with 5% seaweed extract (T₁), 100 kg RP/ha with 5% panchagavya (T₂), 100 kg RP/ha with 5% humic acid (T₃), 150 kg RP/ha with 5% seaweed extract (T₄), 150 kg RP/ha with 5% panchagavya (T₅), 150 kg RP/ha with 5% humic acid (T₆), 200 kg RP/ha with 5% seaweed extract (T₇), 200 kg RP/ha with 5% panchagavya (T₈), 200 kg RP/ha with 5% humic acid (T₉), and the control (T₁₀)

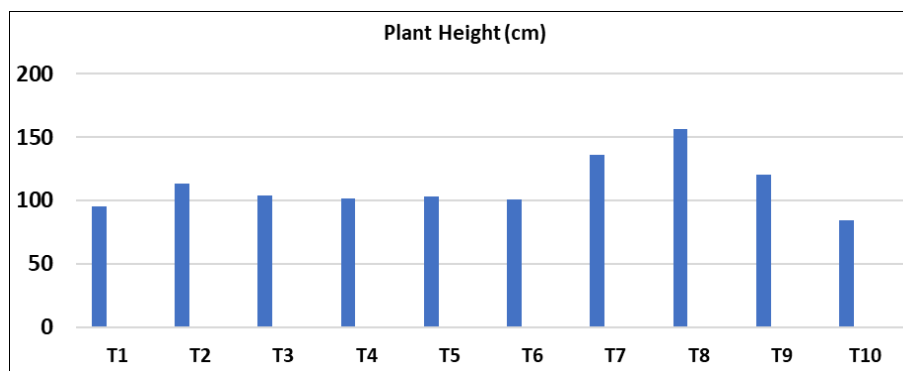


Fig 1: Impact of different treatments on the plant height of cowpea

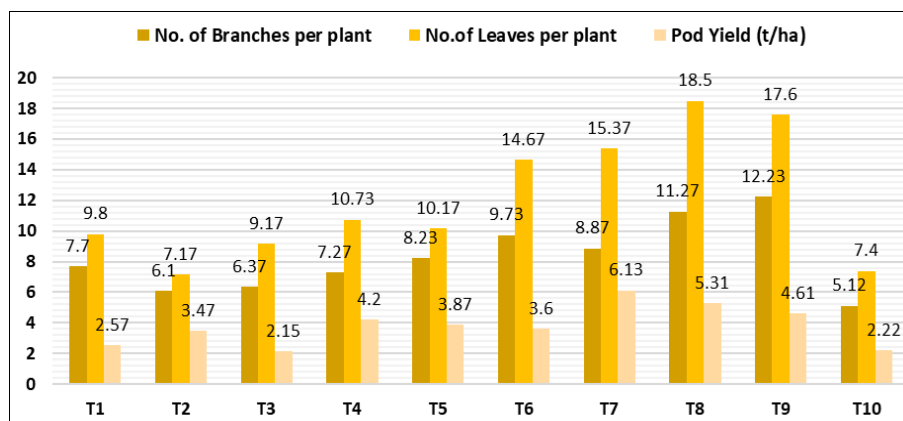


Fig 2: Effect of different treatments on the parameters like number of branches per plant, number of leaves per plant, and pod yield of cowpea.

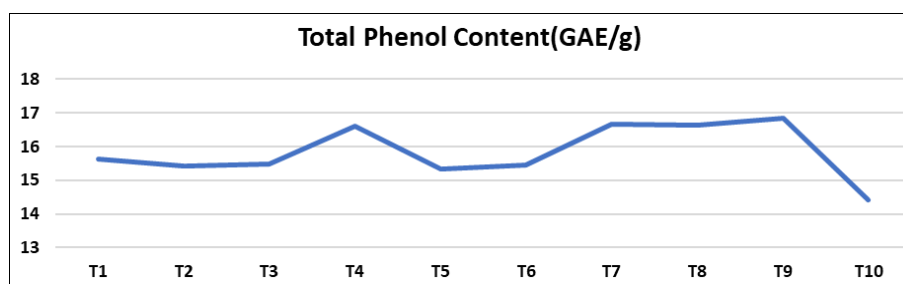


Fig 3: Effect of different treatments on the total phenolic content of cowpea.

The pod length was not significantly influenced by the application of various treatments. However, treatment T₈ (5.31 t/ha) significantly enhanced pod yield among all treatments. In the case of crop productivity, T₈ (50.58 kg/ha/day) gave the highest among all treatments, which is statistically superior to all treatments. Marked improvement in pod length, pod yield and crop productivity in cowpea due to application of T₈ (200 kg RP/ha with 5% panchagavya) might be attributed to better growth and development in the crop. Similar results were also reported by Kurakula *et al.* (2021) ^[10], in which the application of seaweed extract *Ascophyllum nodosum* solution (2%) significantly improved yield over the control. Aliyu *et al.* (2007) ^[11] observed marked enhancement in growth and yield of cowpea with increasing dose of RP up to 75 kg/ha. Treatment T₉ (16.85 GAE/g) markedly increased total phenolic content in cowpea, which was statistically at par with T₈ (16.64 GAE/g), T₇ (16.65 GAE/g) and T₄ (16.60 GAE/g). De Jesus *et al.* (2023) ^[12] found that the foliar application of humic acid 12ml/l at cowpea under a dry region significantly increased total phenol content, which helps plants to survive under stress conditions. Also, Conselvan *et al.* (2017) ^[13] observed that humic substances prominently increased the phenol content in crops.

Conclusion

Based on the above findings, it can be concluded that the application of 200 kg Rock phosphate per hectare in combination with 5% panchagavya is the most effective treatment for improving growth, yield, crop productivity of cowpea and its total phenolic content under the organic production system in Sikkim.

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