***Original Research Article***

**Effect of Phosphorus Levels and Bio-Organics on Yield and Nutrient Uptake of Rice Variety ADT- 43**

**Abstract:**

A field experiment was conducted in 2017 to evaluate the effects of varying phosphorus levels and bio-organic amendments on the yield performance and nutrient uptake of the rice variety ADT-43 in India. Rice productivity is often constrained by limited phosphorus availability and inefficient nutrient management practices. Although chemical fertilizers are widely used to address nutrient deficiencies, their long-term use poses environmental concerns and economic challenges. In this context, bio-organic inputs such as green manure and phosphate-solubilizing bacteria (PSB) have gained attention as sustainable alternatives for improving nutrient availability and enhancing crop productivity. The results of the study demonstrated a significant increase in both grain and straw yields, as well as improved uptake of nitrogen, phosphorus, and potassium (68.86, 10.87, and 22.66 kg ha⁻¹, respectively), following the application of phosphorus, bio-organics, or their combination, compared to the untreated control. The percentage increase in grain and straw yield ranged from 5% to 26% and 23% to 40%, respectively. Yield values varied notably across treatments, with maximum grain and straw yields of 4279 kg ha⁻¹ and 6540 kg ha⁻¹, respectively, recorded under the combined application of 100% phosphorus (50 kg P₂O₅ ha⁻¹), green manure at 6.25 t ha⁻¹, and PSB. However, the study did not specify statistical significance thresholds such as *p*-values or confidence intervals, which are essential for validating the reliability and reproducibility of the reported differences.

**Key words:** Phosphorus, Bio-Organics, Green Manure, FYM, PSB, Rice Yield and Nutrient Uptake.

**Introduction:**

“Rice is the staple food for about 50 per cent of the world’s population   
(72.7 billion) that resides in Asia, where in 90 per cent of the world’s rice is grown and consumed” (Papademetriou, M. K. 2000). “It is an important staple food that provides 66 to 70 per cent body calorie intake of the consumers” (Barah and Pandey, 2005). “In Tamil Nadu, rice cultivation spreads over an area of 20 lakh hectares with a total production of 52 lakh tonnes” (Anonymus, 2012). “Phosphorus is the second major nutrient for plant growth as it is an integral part of different bio-chemical constituents like nucleic acids, nucleotides, phospholipids, phosphoprotiens and phosphate compound as “energy currency” within plants. It not only plays an essential role in energy transfer and metabolic regulation, but also an important structural constituent of many molecules, such as nucleotides, phospholipids and sugar phosphate/phospho sugars” (Lime *et al.,* 2003). “Phosphatic fertilizers occupy an important place, its insufficient supply, slow mobility of applied phosphorus and its marked fixation results in low crop recoveries (around 20%), which calls for ways and means for its judicious use. Farmyard manure or compost and use of blue green algae in wetland rice are the common practices” (Begum *et al*., 2009). “Phosphate solubilizing bacteria (PSB) solubilize and mineralize the residual or fixed phosphorus, increases phosphorus availability in the soil and also the overall phosphate use efficiency” (Chhonkar and Tilak, 1997). Indian farmers are unable to afford the heavy expenditure on chemical fertilizers however, it is imperative to use technologies such as phosphorus management in an integrated manner for its increased use efficiency. The present investigation was carried out with a view to evaluate the effect of phosphorus levels and bio-organic sources on growth and yield of wetland rice.

**Materials and Methods:**

The field experiment was conducted during 2017 in a farmer’s field at Puthur village, Kollidam taluk, Nagapattinam district, Tamil Nadu, to evaluate the effect of phosphorus levels and bio-organic inputs on the yield and nutrient uptake of rice variety ADT-43. The study was laid out in a factorial randomized block design (FRBD) with two factors and three replications. The first factor consisted of five levels of phosphorus: control (0% RDP), 25% RDP, 50% RDP, 75% RDP, and 100% RDP (50 kg P₂O₅ ha⁻¹). The second factor included three bio-organic treatments: no bio-organics (control), farmyard manure (FYM) at 12.5 t ha⁻¹ + phosphate-solubilizing bacteria (PSB), and green manure (GM) at 6.25 t ha⁻¹ + PSB. The recommended dose of fertilizers (RDF) applied was 100-50-50 kg N-P₂O₅-K₂O ha⁻¹. Half of the recommended nitrogen and the full dose of potassium were applied as basal, and the remaining nitrogen was applied in two equal splits at active tillering and panicle initiation stages. Phosphorus was applied according to the treatment levels. The soil at the experimental site was sandy clay loam in texture with a pH of 8.17, low in organic carbon (0.51%) and available nitrogen (240.0 kg ha⁻¹), and medium in available phosphorus (21.0 kg ha⁻¹) and potassium (260.5 kg ha⁻¹). Twenty-five-day-old seedlings of rice variety ADT-43 were transplanted at a spacing of 15 cm × 15 cm. The required quantities of FYM + PSB and GM + PSB were applied basally as per the respective treatments. All recommended agronomic practices were followed uniformly for all treatments to raise a healthy crop. The data recorded on yield and related parameters were analyzed statistically using the analysis of variance (ANOVA) method as described by Gomez and Gomez (1984).

**Result and Discussion:**

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

**Yield Attributes:**

“The yield attributing characters *viz*., panicle length, number of panicles m-2, number of grains panicle-1 and 1000 grains weight increased significantly with soil application of 100% P (50 kg P2O5 ha-1), 6.25 t ha-1 of green manure along with PSB (table 1). Over all phosphorus application improved nutritional environment of rhizosphere, as well as plant system as evident from greater uptake of nutrients and ultimately metabolic and photosynthetic activity resulting in better development of yield attributes” (Yosef Taber, 2013). Combined application of PSB + GM was noticed with better yield attributes. This might be due to the fact that organic materials are expected to supply more nutrients essential to fulfill the demand of rice and also the inoculation of PSB increased the availability of phosphate by converting insoluble to soluble form of and P gave a constant supply of phosphorus throughout the crop growth. Further, PSB are known to excrete plant growth substances, which might contribute in better yield attributes. These results confirmed the findings of Yadav *et al.* (2013).

**Grain Yield and Straw Yield:**

The grain and straw yield of rice were significantly improved due to application of phosphorus or bio-organics or both over control. The per cent increase in rice grain and straw yield ranged from 5 to 26 and 23 to 40, respectively. The grain and straw yield of rice ranged from 184 to 1469 kg ha-1 and 992 to 2034 kg ha-1, respectively. The highest grain yield (4279 kg ha-1) and straw yield (6540 kg ha-1) of rice was observed with soil application of 100% P (50 kg P2O5 ha-1) and 6.25 t ha-1 of green manure + PSB over control(table 2). Ishizuka (1971) opined that phosphorus plays an important role in the translocation of assimilates to the panicles and also as a constituent of protoplasm. This explains the reason for the increased grain yield and yield attributes. Increased yield attributes, grain and straw yield of rice may be ascribed to combined application of bio-organics with inorganic P which might enhanced soil microbial population resulting better root proliferation and its ability, nutrients availability and their uptake, ultimately led to the better dry matter production and its distribution in the crop. These results substantiate the findings of Meena *et al.* (2015). “the application of 75 % RDP may be recommended for rice grown in P accumulated soil under Nizamabad condition. With respect to time of P application, the split application also be followed successfully in rice crop without any adverse effect on grain yield of rice grown in P accumulated soil”(Archana *et al.,* 2017).

**Rice Nutrition:**

“Nutrient content and uptake (N, P and K) in rice was significantly improved upon addition of phosphorus and bio-organics over control. The highest N, P and K were noticed with table 3 (T15-50 kg P2O5 ha-1 + green manure @ 6.25 t ha-1 + PSB). Nutrient uptake increased with the advancement growth of stage attributed mainly to higher DMP. The percent increase in nutrient uptake over control in rice grain and straw due to bio-organics application. The increase in the uptake of nutrients with increasing dose of NPK seems because of greater availability of these nutrients and prolific root system developed due to balanced application of nutrients, resulting better absorption of nutrients” (Brar *et al.*, 1995). Result supports the findings of Srivastava *et al.* (2014). “Phosphorus has been reported to play a vital role in the transformation of ammonical ions into protein molecules and thereby increases the nitrogen uptake and protein synthesis. Consequently, in the present study, its application at adequate levels (100% RDP) affected uptake of phosphorus ion and increased the phosphorus content in rice grain and straw”. (Nicol, 1934) Higher phosphorus uptake is attributed to consistent availability of phosphorus in soil throughout crop growth stages. In the present study, it is confirmed by significant positive linear relationship between phosphorus uptake and available phosphorus in soil. It is noticed that 87 to 96 per cent variation in P uptake is caused by available P in soil. It shows that higher P availability and their uptake is key for realizing higher yield in the later stage. The results are in accordance with findings of Ali *et al.* (2005). Farmyard manure helped in the proliferation of BGA and PSB and supplied considerable N and P from it’s own and also through the process of N fixation and P solubilisation. Hence, increased nutrients availability in soil led to better uptake by rice.(Jemila *et al.,* 2017) concluded that “the use of complex fertilizer sources (20 : 20 : 0 or 15 : 15 : 15) along with PSB @ 2 kg/ha can be recommended for release and mobilization of insoluble and fixed forms of P and subsequently for increasing the availability of other nutrients, which in turn is an important fertility parameter that is essential for maximising the yield of rice crop in the rice growing soils”

**Table 1: Effect of phosphorus levels and bio-organics on yield attributes and yields of rice at harvest stage**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Bio-org levels**    **Phosphorus levels** | **Panicle**  **Length(cm)** | **Panicles/m2** | **Grains/**  **Panicle** | **1000 grain**  **Weight** | **Grain yield** | **Straw yield** |
| P0-Control | 15.5 | 380.3 | 97.7 | 13.1 | 3691 | 5671 |
| P1-25% | 16.3 | 417.4 | 104.9 | 13.7 | 3832 | 5768 |
| P2-50% | 17.0 | 434.7 | 109.0 | 14.2 | 3857 | 5965 |
| P3-75% | 17.2 | 451.5 | 114.7 | 14.8 | 4038 | 5988 |
| P4-100% | 18.0 | 473.7 | 123.0 | 15.3 | 4455 | 6281 |
| Mean | 16.8 | 431.4 | 109.8 | 14.2 | 3974 | 6540 |

SED 0.15 3.99 1.18 0.13 36.25 55.53

CD 0.3 8.1 2.4 0.27 74 113

(p=0.05)

Table 2. Effect of application of different levels of phosphorus and bio organics on grain and straw yield of rice (kg ha-1)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bio-org.  levels**  **P levels** | **Grain yield** | | | | **Straw yield** | | | |
| **OM0** | **OM1** | **OM2** | **Mean** | **OM0** | **OM1** | **OM2** | **Mean** |
| P0-Control | 3511 | 3695 | 3691 | 3632 | 4653 | 5645 | 5768 | 5355 |
| P1-25% | 3768 | 3792 | 3832 | 3797 | 5755 | 5822 | 5965 | 5847 |
| P2-50% | 3886 | 3934 | 3857 | 3879 | 5859 | 6113 | 5988 | 5986 |
| P3-75% | 3924 | 3965 | 4038 | 3975 | 6175 | 6325 | 6281 | 6260 |
| P4-100% | 4117 | 4265 | 4455 | 4279 | 6361 | 6517 | 6540 | 6472 |
| Mean | 3841 | 3922 | 3974 | 3912 | 5760 | 6084 | 6108 | 5984 |
|  | **P** | **BO** | **P × BO** |  | **P** | **BO** | **P × BO** |  |
| SED | 20.93 | 16.21 | 36.25 |  | 32.06 | 24.83 | 55.53 |  |
| CD (p=0.05) | 42 | 33 | 74 |  | 65 | 50 | 113 |  |

Table: 3 Effect of application of different levels of phosphorus and bio organics on rice grain NPK (kg ha-1)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bio-org. levels**  P levels | **Nitrogen uptake** | | | | **Phosphorus uptake** | | | | **Potassium uptake** | | | |
| **OM0** | **OM1** | **OM2** | **Mean** | **OM0** | **OM1** | **OM2** | **Mean** | **OM0** | **OM1** | **OM2** | **Mean** |
| P0-Control | 40.26 | 43.00 | 44.13 | 42.46 | 6.96 | 7.72 | 7.67 | 7.45 | 10.43 | 13.10 | 13.16 | 12.23 |
| P1-25% | 45.20 | 48.06 | 51.50 | 48.25 | 7.87 | 8.13 | 8.44 | 8.15 | 13.90 | 15.10 | 16.50 | 15.16 |
| P2-50% | 53.13 | 54.92 | 55.53 | 54.52 | 8.82 | 8.87 | 9.05 | 8.91 | 17.82 | 17.97 | 17.20 | 17.66 |
| P3-75% | 56.25 | 59.53 | 61.93 | 59.23 | 9.16 | 9.21 | 9.61 | 9.33 | 18.60 | 19.60 | 20.06 | 19.42 |
| P4-100% | 63.13 | 63.73 | 68.86 | 66.50 | 9.96 | 10.34 | 10.87 | 10.39 | 20.84 | 21.46 | 22.66 | 21.64 |
| Mean | 51.75 | 54.44 | 56.39 | 54.19 | 8.55 | 8.85 | 9.13 | 8.84 | 16.31 | 17.44 | 17.91 | 17.22 |
|  | **P** | **BO** | **P × BO** |  | **P** | **BO** | **P × BO** |  | **P** | **BO** | **P × BO** |  |
| SED | 0.29 | 0.22 | 0.50 |  | 0.04 | 0.03 | 0.08 |  | 0.09 | 0.77 | 0.16 |  |
| CD (p=0.05) | 0.59 | 0.46 | 1.03 |  | 0.09 | 0.07 | 0.16 |  | 0.19 | 0.14 | 0.33 |  |

Conclusion

Rice crop responded well to phosphorus and bio-organics fertilization sandy clay loam in soil. Soil application of phosphorus and bio-organics was found to be better in improving growth and yield of rice through the marked improvement in   
P use efficiency of rice. To maximize rice yield in sandy clay loam soil, application of 100% P (50 Kg P2O5 ha-1) and 6.25 t ha-1 green manure + PSB as soil application may be recommended.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

Disclaimer (Artificial intelligence)

Option 1: I, hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:1.Nil

**References**

1. Ali, M.M., M.S.Mian, A.Islam, J.A.Begum and A.K.M. Ferdous. 2005. Interaction effect of sulphur and phosphorus on wetland rice. *Asian J. Pl. Sci.,* **3(5):** 597-607.
2. Anonymous, 2012. National Horticulture Board, Department of Agriculture, Govt. of India, New Delhi.
3. Archana, K., Reddy, T. P., Anjaiah, T., & Padmaja, B. (2017). Effect of levels of phosphorus and its time of application on soil nutrient status and yield of rice grown on P accumulated soil. *Int J Curr Microbiol Appl Sci*, *4*, 92-9.
4. Barah, B.C. and S. Pandey. 2005. Rainfed rice production systems in Eastern India: An on – farm diagnosis and policy alternatives. *Indian J. Agric. Eco.,* **60(1):** 1110-136.
5. Begum, Z. N. T., Mandal, R. and Islam, M. S. 2009. Effect of blue green algae and urea-N on growth and yield performance of traditional variety of rice. J. Phytol. Res. **22(2):** 211-214.
6. Brar, B.S., N.S. Dhillon and M. Chand. 1995. Effect of farmyard manure application on growth, yield and uptake and availability of nutrients in rice (*Oryza sativa* L.) - wheat (*Triticum aestivum*) rotation. *Indian J. Agric. Sci.,* **65(5):** 350-353.
7. Chhonkar, P.K. and K.V.B.R. Tilak. 1997. Bio-fertilizers for sustainable agriculture: Research gaps and future needs. In Plant Nutrient Needs Supply, Efficiency and Policy Issues: 2000–2025 (Eds. J.S. Kanwar and J.C. Katyal). *National Academy of Agric. Sci.* New Delhi, pp. 52–66.
8. Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research (Ed.) A Willey Inter Science Publication, New York, USA.
9. Ishizuka, Y. 1971. Physiology of rice plant. *Adv. Agron.,* **23:** 241-315.
10. Jemila, C., SALIHA, B. B., & Udayakumar, S. (2017). Evaluating the performance of phosphatic fertilizers on plant nutrients (N, P and K) concentration and uptake by the rice crop. *Research on Crops*, *18*(2).
11. Lime, J.H., I.M. Chung, S. Ryu, M.R. Park and S.J. Yun. 2003. Differential response of rice and acid phosphates activities and isoforms to phosphorus deprivation.*J. Biochem. Mol. Biol.,* **36(6):** 597-602.
12. Meena, R.K., M.P. Neupane and S.P. Singh. 2015. Effect of phosphorus levels and bio-organic sources on growth and yield of rice (*Oryza sativa* L). *Int. J. Agrl. Sci.,* **11(2):** 286-289.
13. Nicol. H. 1934. The derivation of the nitrogen of the crop plants with special reference to associated growth. *Biol. Rev.,* **9:** 383-410.
14. Papademetriou, M. K. (2000). Rice production in the Asia-Pacific region: issues and perspectives. *Bridging the rice yield gap in the Asia-Pacific region*, *220*, 4-25.
15. Srivastava, V. K., Singh, J. K., Bohra, J. S. and Singh, S. P. 2014.Effect of fertilizer levels and organic sources of nitrogen on production of hybrid rice (*Oryza sativa* L.) and soil properties under system of rice intensification. *Indian J. Agron.,* **59(4):** 607-612.
16. Yadav, S.K., Singh, R.P. Yogeshwar Kumar, M.K. Yadav and Singh Kalyan. 2013. Effect of organic nitrogen sources on yield quality and nutrient uptake of rice (*Oryza sativa*) under different cropping system. *An Int. J. Plant Res.,* **26(1):** 58-66.
17. Yosef Tabar, S. 2013. Effect of nitrogen and phosphorus fertilizer management on growth and yield of rice. *Int. J. Agri. Crop Sci.,* **5(15):** 1659-1662.