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Effect of Continuous Application of Nutrient Management Options on Crop Yields in Rice- Rice Cropping System

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ABSTRACT

The Permanent manurial trial (PMT) in rice was established at RARS Pattambi in 1972 and is being conducted continuously in the same field with eight treatments of varying nutrient management options. The objective of the experiment was to study the effect of long term application of fertilizers and manures on growth and yield of the plant and monitoring of soil quality. The PMT experiment with 44 years of cropping history revealed the superiority of integrated nutrient management with 50 Per cent NPK along with 50% FYM over the sole use of fertilizers. The use of fertilizers alone or ammonium sulphate alone did not produce sustainable yields in the long run indicating the need for balanced application of nutrients and integration of organic and inorganic sources of plant nutrients for sustainable yields.

Key Words: Fertilizer, Integrated, Laterite soil, Long term, Management, Manure, Nutrient.

INTRODUCTION

The Permanent Manurial Trials (PMT) serve as an important tool to understand the effect of intensive cropping and continuous fertilizer/ manure application on crop yields and soil health. The PMT has been laid out at Regional Agricultural Research Station, Pattambi with the main objective of studying the effect of continuous application of plant nutrients (NPK) in organic and inorganic forms and in combinations on sustainable production in the rice-rice cropping sequence.

There are many reports on the effect of long term application of fertilizers and organic manures on growth and yield. Thulasi *et al* (2020) indicated that integrated application of both chemical fertilizers and organic manures has arisen as a promising choice not only for sustaining higher productivity but also for providing maximum stability to crop production. Application of 10t farm yard manure (FYM)/ ha significantly increases the grain and straw yields of rice and wheat (Singh *et al*, 1996). Singh *et al* (2002) observed a significant increase in grain yield with the application of FYM or incorporation of rice straw or green manure in rice along with recommended NPK fertilizers over different levels of NPK supplied through inorganic fertilizers. FYM was found to produce highest grain yield of rice when compared to other organics such as rice straw, green manure and succeeding wheat crop. The present paper discusses the effect of long term application of fertilizers and organic manures on rice yield and growth related parameters after 44 years of continuous cropping.

MATERIALS AND METHODS

The Permanent Manurial Trial was initiated in 1972 with 8 treatments. The field experiment was being conducted continuously in the same field with the same treatments and the results of the experiment after 44 years of cropping cycle are presented in this paper. The PMT consisted of 8 treatments laid out in RBD with four replications. The treatments include: T_1: 90 kg N /ha as cattle manure, T_2: 90 kg N /ha as green leaf manure, T_3: 45 kg N /ha as cattle manure

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+ 45 kg N/ha as green leaf manure, T_4: 90 kg N / ha as ammonium sulphate, T_5: 45 kg N /ha as cattle manure + N:P_2O_5:K_2O 45:45:45 kg /ha, T_6: 45 kg N /ha as green leaf manure + N:P_2O_5:K_2O 45:45:45 kg /ha, T_7: 22.5 kg N /ha as green leaf manure + 22.5 kg N /ha as cattle manure + N:P_2O_5:K_2O 45:45:45 kg /ha and T_8: N:P_2O_5:K_2O 90:45:45 kg /ha. Grain yield, straw yield and growth parameters reported in the paper were measured in the rabi crop of 2017.

Stomatal conductance, Photosynthetic rate and internal CO_2 concentration were measured using the instrument Infrared Gas Analyser (Model: LC pro-SD Advanced photosynthetic system) and readings were taken between 9 am and 10 am during the active tillering stage of the crop. Photosynthetic rate of the youngest fully expanded leaves of rice plants was measured The analysis was conducted in the sample chamber, with a light intensity of 500 µmol photons /(m^{-2}s), a leaf temperature of 28 ℃, and CO2 concentration of 390±5 µmol mol^{-1}.

RESULTS AND DISCUSSION

Crop growth parameters

The average plant height of the crop ranged from 78.98 to 87.10 cm in all the treatments under PMT (Table 1). However, there was no significant difference in plant height among various nutrient management practices. Average number of tillers per plant ranged from 7.95 to 9.11. Average number of panicles per hill ranged from 7.22 to 9.00. The treatment T5 had the maximum no of panicles per hill (9.00) and it was statistically at par with all organic treatments (T1, T2 and T3) and also the treatments with integrated nutrient management (T6 and T7). The lowest value for number of panicles per hill was 7.22, noticed in T4 (90 kg N /ha) as ammonium sulphate).

The mean panicle length ranged from 20.80 to 24.23 cm. The treatment T5, where 50 per cent of mineral N was supplied through cattle manure had higher panicle length than all other treatments (24.23 cm). Treatment T4 (90 kg N /ha as ammonium sulphate) registered the least value (20.80 cm). Long term application of different nutrient management practices significantly influenced the number of filled grains (Table 1) per panicle of the crop. The mean values of number of filled grains per panicle ranged from 94 to 123. The treatment T5 (45 kg N /ha as cattle manure + NPK 45:45:45 kg /ha) recorded the highest number of filled grains (123). The lowest value was recorded by T4 (90 kg N /ha as ammonium sulphate).The data (Table 1) revealed that numbers of chaffy grains were significantly influenced by different nutrient management practices in PMT field. The mean value ranged from 7.48 to 17. The highest number of chaffy grains was recorded in T4 (90 kg N/ ha as ammonium sulphate) with mean value of 17. The 100 per cent NPK treated plots produced the crop with lowest number of chaffy grains (7.48). In short, the treatments differed significantly with respect to growth parameters except number of tillers and plant height. The completely organic (T1) and integrated treatments (T5) had comparable growth parameters as evidenced by their yields. However, the quantity of organic manures to substitute 100 per cent N is very huge and not a feasible practice. Larijani and Hoseini (2012) reported that the integrated application of organic and inorganic fertilizers could improve growth parameters and grain yield in comparison to the sole application of inorganic fertilizers. Hemalatha *et al* (2000) also observed that in situ incorporation of Sesbania registered the highest plant height, number of tillers and dry matter production. The immediate release of nitrogen from fertilizers, and improved soil physical, chemical and biological properties due to the application of organic manures enhanced the growth and number of effective tillers. This fact explained the better yield and growth related parameters under treatments which include integrated use of fertilizers and manures.

Crop productivity

The PMT provide ample information on the effect of organic manures and inorganic fertilizers on sustaining productivity. In PMT with dwarf indica

Table 1. Effect of long term application of different nutrient managementpractices on biometric parameters in rice under PMT.

Treatment	Biometric parameter					
	Plant height (cm)	No. oftillers /plant	No. of panicles/plant	Panicle length (cm)	No. offilled grainsper panicle	No. ofchaffy grainsper Panicle
T1	87.1	9.04	8.70^{a}	23.87^{ab}	114^{ab}	12.00^{b}
T2	83.65	8.50	8.22^{ab}	22.15^{cde}	105^{bc}	9.00^{cd}
T3	84.78	9.11	8.29^{a}	22.78^{bcd}	105^{bc}	11.00^{bc}
T4	78.98	7.95	7.22^{c}	20.80^{e}	94^{c}	17.00^{a}
T5	87.10	9.04	9.00^{a}	24.23^{a}	123^{a}	12.00^{b}
T6	84.00	8.72	8.22^{ab}	22.54^{bcd}	104^{bc}	11.40^{bc}
T7	84.75	8.69	8.38^{a}	22.89^{abc}	104^{bc}	10.45^{bc}
T8	82.95	8.68	7.49^{bc}	21.48^{de}	101^{bc}	7.48^{d}
CD(0.05)	NS	NS	0.79	1.35	13.73	2.87

rice variety Jaya; the organic nutrient management practice (T1) and the INM practice (T5) were equally superior in growth and productivity over other treatments (Table 2). The per hectare grain yield ranged from 3487 to 5505 kg. The highest mean grain yield of 5505 kg /ha was recorded by the treatment T5 (45 kg N /ha as cattle manure + NPK 45:45:45 kg /ha), which was on par with that in T1.

These results were also in conformity with the findings of Kumar *et al* (2014) in rice. Sumayya Sulaiman (2017) has referred the works of Kurumthottical based on PMT with rice at ORARS Kayamkulam revealed that the highest grain yield was observed from the plots where N was applied as cattle manure alone or in combination with chemical fertilizers. FYM when applied along with inorganic fertilizers might have solubilized native P and K in soil by the production of organic acids and enhanced their availability and enhanced the plant uptake and hence the yield and growth related parameters.

Straw yield

Straw yield obtained in the experiments followed the same trend as their grain yieldwith respect to the treatment effects, the highest value being recorded by the treatment involving combination of cattle manure, green manure and chemical fertilizers in PMT. The highest mean straw yield of 5968 kg / ha was recorded by the organic treatment T1 (90 kg N /ha as cattle manure), which was at par with integrated treatment T5. The treatment T4 recorded the lowest mean value of 3792 kg /ha for the straw yield which was at par with treatment T8 (3931 kg / ha). The results were in agreement with Kavimani *et al* (2000) who reported that the application of FYM along with chemical fertilizers contributed N to rice besides leaving a substantial effect on succeeding crop. A combined use of organic manures and inorganic fertilizers is known to reduce N losses by forming organic mineral complexes and thus ensure continuous N availability to rice plants resulting in greater yield. Higher nutrient status obtained through chemical fertilizers and the sustained release of plant nutrients by the mineralization

Table 2. Effect of long term application of different nutrient managementpractices on yield in rice under PMT.

Treatment	Yield (kg /ha)	
	Grain yield	Straw yield
T1	5436^{ab}	5968^{a}
T2	4741^{c}	5170^{b}
T3	4940^{c}	5418^{ab}
T4	3487^{d}	3792^{c}
T5	5505^{a}	5859^{a}
T6	4857^{c}	5231^{b}
T7	4994^{bc}	5513^{ab}
T8	3668^{d}	3931^{c}
CD(0.05)	452.68	561.58

of the applied organics account for the highest straw yield recorded. Further the enhancement of microbial activity and their associated enzyme activity leading to improvement of soil environment might have also contributed to the increased straw yields (Nikhil, 2014).

Grain yield

Grain yield was lowest in plots treated with ammonium sulphate (3487 kg /ha) and at par with that in NPK treated plots *i.e.,* T8 (3668 kg /ha). The reduced yield in the plots which received ammonium sulphate alone throughout the 44 years of cropping in PMT plots indicate the negative effects of imbalanced fertilizer application. In the LTFE plot maintained at RARS Pattambi, compared to NPK treatments, the mean yield of rice was reduced to 86 and 69 per cent respectively in plots receiving 100 per cent NP and 100 per cent N alone treatments (Thulasi *et al*, 2020). This indicates the importance of balanced application of the nutrients. Study for a single season indicated that the application of 100% recommended dose of nitrogen fertilizer is the most effective treatment in respect of growth, yield attributes, bulb yield along with highest net return and B:C ratio in onion (Dhillon and Singh, 2019) while The integrated treatments involving both organic and inorganic fertilizer influenced favourably the fertility status of the soil as compared to the control (Esther Longkumer, 2021).

The results of PMT experiment over the 44 years indicated that the use of fertilizers alone (without organic manures) did not produce sustainable yields in the long run. Though comparable yields were obtained during the initial years, the grain and straw yields showed a declining trend after 10 years of continuous cropping.

Physiological parameters

Application of various treatments significantly influenced the stomatal conductance and photosynthetic rate as shown in the Table 3. The parameters were recorded on first fully expanded leaf from top between 9:00-10:00 A.M at active tillering stage. The absolute values of stomatal conductance ranged from 0.15 to 0.25 mol H_2O m^{-2} s^{-1}. Treatment T5 and T1 recorded the highest stomatal conductance with mean value 0.25 mol H2O m^{-2} s^{-1}. The lowest value was registered for T8 and was on par with that of T4. The treatment T1

Table 3. Effect of long term application of different nutrient managementpractices on physiological parameters in rice under PMT.

Treatment	Physiological parameter		
	Photosynthetic rate (µ mol CO_2 m^{-2} s^{-1})	Stomatal conductance (mol H_2O m^{-2} s^{-1})	Internal CO_2 rate (µ mol CO_2 m^{-2} s^{-1})
T1	25.05^{a}	0.25^{a}	289.4^{a}
T2	21.65^{cd}	0.19^{c}	289.2^{a}
T3	23.89^{abc}	0.22^{ab}	288.2^{a}
T4	16.09^{e}	0.15^{d}	259.6^{b}
T5	24.35^{ab}	0.25^{a}	288.7^{a}
T6	20.75^{d}	0.21^{bc}	287.1^{a}
T7	22.17^{bcd}	0.23^{ab}	283.5^{a}
T8	15.23^{e}	0.15^{d}	261.2^{b}
CD(0.05)	2.52	0.03	8.48

recorded higher photosynthetic rate than all other treatments (25.05 µmol CO2 m^{-2} s^{-1}), which was on par with thatin T3 and T5. Treatment T8 recorded the lowest photosynthetic rate (15.23 µmol CO2 m^{-2} s^{-1}) which was at par with T4 with mean value 16.09 µmol CO2 m^{-2} s^{-1}.

The higher values were observed in organic manure treated plots. This result was in concurrence with the work conducted by Efthimiadou *et al (*2010). A decrease in photosynthetic rate with deficiency of nitrogen was also reported by Gyuga *et al* (2002). The different treatments differed significantly with respect to stomatal conductance and internal CO_2 concentration (*Ci*). The highest values were obtained for the treatment where combined application of mineral and organic sources of nutrients was followed. The proper balanced nutrition enhances the stomatal conductance which is the primary physiological process responsible for plant dry matter production. This result was in agreement with the results of Efthimiadou and coworkers (2010). Stomata apparently do not respond directly to the CO_2 concentration around the leaf. The CO_2 sensor for stomatal action is located in the epidermis and is presumably in the guard cells. Therefore, most workers have assumed that the CO_2 concentration in the guard cells is dependent on the concentration in the intercellular spaces and not on the external CO2 concentration. The *Ci* depends on the flux of CO_2 through thestomatal pore and is determined by the net assimilation rate and stomatal conductance.

CONCLUSION

The present paper discussed the effect of permanent application of fertilizers and manures on growth and productivity of the rice in central laterites of Kerala. It is essential to sustain and enhance productivity of rice-rice cropping system to feed ever growing population with decreasing availability of natural resources like land and water foragriculture. Plant nutrients play an eminent role in sustaining productivity. In PMT with dwarf indica rice variety Jaya; the organic nutrient management practice and the INM practice were equally superior in growth and productivity over other treatments. The plots which received nitrogen alone and

chemical fertilizers alone registered lowest grain yields. In general, the effect of long term application of different nutrient management practices on rice growth parameters corroborated the trends in grain and straw yields. Hence Integrated Nutrient Management is proved to be a sustainable strategy for better yields in long term studies.

REFERENCES

Efthimiadou A, Bilalis D, Karkanis A and Froud Williams B (2010). Combined organic/inorganic fertilization enhance soil quality and increased yield, photosynthesis and sustainability of sweet maize crop. *Australian J Crop Sci* **4**: 722-729.

Esther Longkumer T (2021). Integrated nutrient management in Rajmash (*Phaseolus vulgaris* L.) affects soil chemical properties *J Krishi Vigyan* **9** (2) : 104-107

Gyuga P, Demagante A L and Paulsen G M (2002). Photosynthesis and grain growth of wheat under extreme nitrogen nutrition regimes during maturation. *J Plant Nutr* **25**(6): 1281-1290.

Hemalatha M, Thirumugan V, and Balasubramanian R (2000). Effect of organic sources of nitrogen on productivity and quality of rice (Oryza sativa) and soil fertility. *Indian J Agron* **45** (3): 564-567.

Dhillon Iqbal Singh and Singh Didar (2019). Effect of integrated nutrient management on productivity and economics of rabi onion (*Allium cepa* L) *J Krishi Vigyan* **8** (1) : 87-91

Kavimani R, Annadurai K, Vijayabaskaran S and Rangaraju G (2000). Effect of farm yard manure and nitrogen on growth and yield of pearlmillet under rainfed alfisol. *Madras Agric J* **87**(10/12): 713-714.

Kumar V, Parihar A K S, Kumar S, and Chourasiya A (2014). Performance of hybrid rice (*Oryza sativa* L.) to integrated nutrient management (INM) in partially reclaimed sodic soil. *The Bioscan* **9**(2): 835-7

Larijani B A and Hoseini S J (2012). Comparison of Integrated Chemical and Organic Fertilizer Management on Rice Growth and Yield under System of Rice Intensification (SRI). *Int J Agron Plant Prod* 3 (S): 726-731.

Nikhil K (2014). *Biological profile of ferralitic alluvial paddy soils under long term differential fertilizer application*. M.Sc.(Ag) Thesis, Kerala Agricultural University, Thrissur, 112p.

Singh A, Singh R D and Awasthi R P (1996). Organic and inorganic sources of fertilizers for sustained productivity in rice - wheat sequence on humid hilly soils of Sikkim. *Indian J Agron* **41**(2): 191-194.

Singh G, Kumar T, Kumar V, Kumar R G and Sharma, R. (2002). Effect of integrated nutrient management on transplanted rice (Oryza sativa) and its xxvi residual effect on succeeding wheat (Triticum aestivum) cross in rainfed low lands. *Indian J Agron* **47** (3): 311-317

Sumayya Sulaiman (2017). *Sequestration of carbon as influenced by nutrient management practices under Long Term Fertilizer Experiments*. M.Sc.(Ag) Thesis, Kerala Agricultural University, Thrissur.

Thulasi V, Moossa P P and Muneshwar Singh (2020). Rice growth and yield under twenty years of cropping in a long term fertilizer in central laterites of Kerala. *An Asian J Soil Sci* **15** (1):41-45

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