

Effect of levels of nitrogen, phosphorus and potassium on productivity, nutrient uptake and soil fertility in rice (*Oryza sativa*) in an Alfisols of Tambiraparani tract

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2011–12 and 2012–2013 at Agricultural College and Research Institute, Killikulam, Tamil Nadu, to study the effect of different levels of NPK on productivity, nutrient uptake, economics and soil fertility of rice (*Oryza sativa* L.). The experiment was carried out in randomized block design and replicated thrice with 7 treatments involving of 3 levels of N and 2 levels of P and K each. Application of 200 : 75 : 75 kg N : P : K/ha resulted in the maximum plant height (95.7 cm), productive tillers/plant (18.3), panicle length (27.2), grains/panicle (25.3), seed weight (24.1 g), grain yield (7.04 t/ha), straw yield (8.58 t/ha), net returns (₹52.6 × 10³/ha) and benefit: cost ratio (1.65), N, P and K (171.9, 28.6 and 185.2 kg/ha respectively) uptake compared to the control. Significant built up of organic carbon (1.24%), available N (326.7 kg/ha), available P (21.4 kg/ha) and available K (362.7 kg/ha) was registered with 200 : 75 : 75 kg N : P : K/ha. The maximum balance of N, P and K (50.7, 5.6 and 74.0 kg/ha respectively) were also recorded under the same treatment.

Key words : Alfisols, Available nutrients, Grain and straw yields, N : P : K levels, Nutrient content and uptake

Rice is the most important staple food crop in the world and is grown under a broad range of environmental conditions. The global production of rice has been estimated to be at the level of 680 million tonnes and the area of production is estimated as 150 million ha (Fageria *et al.*, 2014). India is the second largest producer of rice after China. In India, it is cultivated in an area of 43.97 million ha with the production of 106.29 million tonnes with productivity of 2.37 t/ha (DAC, GoI, 2014). In Tamil Nadu, the production is 7.46 million tonnes from the area of 2.01 million ha with the productivity of 3.9 t/ha (DES, 2014).

The productivity of rice has been stagnant in Tambiraparani river basin during the last decade, mostly because of inadequate and imbalanced supply of plant nutrients. The erratic rainfall and poor economic status of the rice farmers of this river basin are major causes of low dose of fertilizers. Under certain situation, cost of cultivation exceeds the net realization, making it unprofitable. Yield enhancement has been the major challenge which has to come through increased productivity in the back-

drop of imbalanced nutrition. Apart from many improved production technologies, imbalanced use of chemical fertilizers leading to the emergence of multiple nutrient deficiencies are major constraints in achieving higher yield. To achieve sustainable yield increases to meet the growing demand of the state population, it is essential to enhance the productivity of rice in this basin. To augment the rice production, the rescheduling of NPK fertilizers have been conceptualized wherein lowland rice-growing soils. The rescheduling NPK is an effective nutrient management technology for increasing the productivity of rice and nutrient-use efficiency. It is not only for obtaining higher yield but also a cost-effective nutrient-management technique of lowland rice farmers. Nutrient management should be aimed at achieving the main goal of sustainable productivity. Since the location-specific nutrient management in this river basin is lacking, the study was undertaken to evaluate the right scheduling of NPK on growth and yield of rice.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 2011–12 and 2012–13 at Agricultural

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College and Research Institute, Killikulam, Thoothukudi, Tamil Nadu. The climate of the experimental site is semi arid with mean annual rainfall of 750 mm. The soil was clay loam, nearly neutral in reaction (pH 6.85), low in organic carbon (0.42%), low in available N (276 kg/ha), medium in available phosphorus (15.8 kg/ha) and high in available potassium (288 kg/ha). The cation-exchange capacity of the soil was 27.4 c mol (p^+)/kg. The bulk density of the soil was 1.33 Mg/m³. The soil was taxonomically grouped as Rhodustalfs.

The experiment was carried out in randomized block design (RBD) in 40/m² for each plot size with 7 treatments replicated 3 times. The treatments were: T_1 , recommended dose of fertilizer (RDF) alone (150 : 50 : 50 kg of N : P : K/ha); T_2 , 175 : 50 : 50 kg of N : P : K/ha; T_3 , 200 : 50 : 50 kg of N : P : K/ha; T_4 , 150 : 75 : 75 kg of N : P : K/ha; T_5 , 175 : 75 : 75 kg of N : P : K/ha; T_6 , 200 : 75 : 75 kg of N : P : K/ha; and T_7 , absolute control. The rice variety 'ASD 16' was taken as test crop for the 2 years during the season of 2011–2012 and 2012–2013. Transplanting of rice was done during December of every season, with the spacing of 25 cm × 25 cm and harvested in March in all the years of experimentation.

The cultivation practices were followed as per the guidance of crop production guide of Tamil Nadu Agricultural University (TNAU, 2010). The fertilizer sources were urea for N (46% N), single superphosphate for P (16% water-soluble P₂O₅) and muriate of potash for K (60% of K₂O). Nitrogen was applied in 3 equal splits, i.e. one-third each at transplanting, active tillering and panicle-initiation stage. Potash was applied in 2 splits with 60% at transplanting and 40% at panicle-initiation stage. Five representative plants from each plot were collected and observations of biometric and yield attributes such as plant height, productive tillers/plant, panicles/m², length of panicle, grains/panicle and seed weight were recorded as per the standard procedures. Soil samples were collected from the surface layer (0–30 cm) from all the plots before application of treatments and after rice harvesting. The nutrient content and uptake by plant were analysed through prescribed laboratory procedures. Soil samples were analysed for organic carbon (Walkley and Black, 1934), alkaline permanganate-oxidizable N (Subbiah and Asija, 1956), 0.5 M NaHCO₃-extractable P (Olsen *et al.*, 1954) and available potassium by flame photometry after extracting 1 N NH₄OAC (Schollenberger and Simon, 1965). Two-way analysis of variance (ANOVA) was performed for each trait for all seasons and the combined (pooled) over seasons after testing error variance homogeneity was carried out according to the procedure outlined by Gomez and Gomez (1984) statistical package. Significance difference between the treatments were compared

with the critical difference at (\pm 5%) probability by LSD. Economics of the rice cultivation as influenced by chemical fertilizer and management practices were calculated by considering the prevailing market price of rice grain and straw and different inputs.

RESULTS AND DISCUSSION

Growth attributes

The growth and yield attributes of rice, viz. plant height, number of productive tillers, panicle length, number of grains and seed weight, were significantly influenced by different NPK levels (Table 1). The height of plant significantly differed for various treatments. The ranges of the plant height was 88.5 to 95.7 cm at final harvesting. At harvesting, the tallest plant (95.7 cm) was recorded in the treatment with 200 : 75 : 75 kg of N : P : K/ha, followed by treatment with 200 : 50 : 50 kg of N : P : K/ha had recorded next tallest plant (94.4 cm). The increase in plant height owing to the enhanced level of NPK application might have attributed to the better rooting and absorption of nutrients by plants (Mahajan *et al.* 2011). The shortest plant (88.5 cm) were recorded in the absolute control.

Yield attributes

Yield attributes of rice, viz. productive tillers/plant, panicles/m², grains/panicle and seed weight, were significantly affected due to application of different levels of nitrogen with phosphorus and potassium (Table 1). In general, N : P : K at higher level (200:75:75 kg/ha) resulted in significantly higher values of yield attributes than that of lower levels of NPK as 150:50:50 kg/ha. The maximum values of yield attributes, viz. maximum productive tillers/plant (18.3), longest panicle (27.2 cm), maximum grains/panicle (211.7) and the maximum seed weight (25.98 g) were obtained from the treatment 200 : 75 : 75 kg of N : P : K/ha. The treatment with 200 : 50 : 50 kg of N : P : K/ha recorded the next best values of productive tillers/plant (16.9), longest panicle (26.1 cm), maximum grains/panicle (202.3) and the maximum seed weight (25.9 g). Both the treatments were at par with each other. The results are support the findings of Upadhyay and Vishwakarma (2009).

Yield

The grain and straw yields of rice varied significantly among the treatments. The maximum grain and straw yields (7.0 and 8.6 t/ha) were recorded in the treatment applied with 200 : 75 : 75 kg of N : P : K/ha, being 72% higher over the control followed by the application of 200 : 50 : 50 kg of N : P : K/ha registered the next best grain and straw yield (6.7 and 8.0 t/ha) and these treatments were at par with each other. The increase in grain and

straw yield with the increase in NPK levels might attributed to increase growth parameters and yield attributes. The results confirm the findings of Sandhu and Mahal (2014). The low yield of grain and straw might be due to the fact low levels of NPK might not favourable for proper growth and formation of yield attributes. This result corroborates the findings of Gill *et al.* (2014).

Economics

The application of 200 : 75 : 75 kg of N : P : K/ha fetched significantly highest net returns (52.6×10^3) and benefit: cost ratio (1.65) over the rest of the treatments (Table 1), followed by treatment was 200 : 50 : 50 kg of N : P : K/ha. This might be owing to higher productivity as well as efficient use of fertilizers owing to increased economic returns in rice. The variation in the cost of cultivation under different treatments were recorded due to variable cost of fertilizers. Grain and straw yields were the major factors which caused differences in net return. These results are in close conformity with the findings of Reddy *et al.* (2009).

Nutrient uptake and balance

The total uptake of N, P and K in rice was significantly influenced by the application of N, P and K (Table 2). The significantly highest amount of N, P and K uptake by rice was recorded with an application of 200 : 75 : 75 kg of N : P : K/ha and on par with 200 : 50 : 50 kg of N : P : K/ha. The percentage increase in N, P and K uptake with 200 : 75 : 75 kg of N : P : K/ha to the tune of 91.4, 72.4 and 81.9, respectively over the control. However, the application of 175 : 75 : 75 kg of N : P : K/ha recorded significantly higher uptake of P and K to the magnitude of 23.6 and 170.1 kg/ha, respectively, over the control. This increase was mainly owing to increased grain and straw yields and higher concentration of respective applied nutrients, i.e. N, P and K. These results confirm the findings of Singh *et al.* (2012) and Chaudhary *et al.* (2014).

A positive N, P and K balance was observed under the treatment applied with enhanced levels of N with P and K. The treatment applied with 200 : 75 : 75 kg of N : P : K/ha registered the maximum balance of N, P and K (50.7, 5.6 and 74.0 kg/ha respectively), followed by 200 : 50 : 50

Table 1. Effect of NPK levels on growth, yield attributes, yield and economics of rice (pooled data of 2 years)

Treatment (N : P : K kg/ha)	Plant height (cm)	Productive tillers/plant	Panicle length (cm)	Grains/ panicle	1,000- grain weight (s)	Grain yield (t/ha)	Straw yield (t/ha)	Gross returns (₹×10 ³ /ha)	Cost of cultivation (₹×10 ³ /ha)	Net returns (₹×10 ³ /ha)	Benefit: cost ratio
T ₁ , 150 : 50 : 50	92.9	13.8	22.7	193.7	24.5	5.3	7.0	64.1	27.2	36.9	2.36
T ₂ , 175 : 50 : 50	93.1	13.3	24.9	198.3	24.9	5.6	7.3	64.2	28.3	35.9	2.27
T ₃ , 200 : 50 : 50	94.4	16.9	26.1	202.3	25.9	6.7	8.0	80.4	30.8	49.6	2.61
T ₄ , 150 : 75 : 75	92.7	15.2	25.6	200.0	25.6	5.8	7.5	69.8	30.5	39.2	2.29
T ₅ , 175 : 75 : 75	93.4	16.2	25.7	201.7	25.9	6.5	7.5	77.9	31.7	46.2	2.46
T ₆ , 200 : 75 : 75	95.7	18.3	27.2	211.7	20.0	7.0	8.6	84.5	31.9	52.6	2.65
T ₇ , 0 : 0 : 0 (control)	88.5	12.9	20.5	174.3	24.1	4.1	5.6	48.9	23.8	25.1	2.05
SEM±	1.38	1.43	0.81	6.24	0.09	0.124	37.6	—	—	—	—
CD (P=0.05)	3.01	3.13	1.75	13.60	0.20	0.271	82.0	—	—	—	—

Table 2. Nutrients balance sheet as influenced by different levels of nitrogen, phosphorus and potassium (pooled data of 2 years)

Treatment (N : P : K kg/ha)	Nutrients added (kg/ha)			Nutrients removed (B)/ uptake (kg/ha)			Soil available nutrients (C) (kg/ha)				Actual gain/loss (C-A*) (kg/ha)		
	N	P	K	N	P	K	Organic carbon (%)	N	P	K	N	P	K
	T ₁ , 150 : 50 : 50	150	50	50	128.8	16.9	132.2	0.74	251.7	14.9	295.0	-24.3	-0.9
T ₂ , 175 : 50 : 50	175	50	50	136.9	19.3	139.6	0.95	273.0	15.8	298.3	-3	0	10
T ₃ , 200 : 50 : 50	200	50	50	164.2	21.9	149.4	1.13	309.3	16.5	300.7	33.3	0.7	12.7
T ₄ , 150 : 75 : 75	150	75	75	144.3	22.8	161.3	0.95	285.3	18.4	314.0	9.3	2.6	26
T ₅ , 175 : 75 : 75	175	75	75	145.1	23.6	170.1	1.02	269.3	19.3	328.3	-6.7	3.5	40
T ₆ , 200 : 75 : 75	200	75	75	171.9	28.6	185.2	1.24	326.7	21.4	362.7	50.7	5.6	74
T ₇ , 0 : 0 : 0 (control)	0	0	0	89.8	10.5	101.8	0.57	218.0	11.9	263.3	-58	-3.9	-25
SEM±	—	—	—	5.73	2.00	6.02	0.098	23.17	1.01	15.96	—	—	—
CD (P=0.05)	—	—	—	12.48	4.36	13.13	0.215	50.50	2.20	34.79	—	—	—

Initial status 276.0 : 15.8 : 288.0 kg N : P : K/ha (A)

kg of N : P : K/ha (33.3, 0.7 and 12.7 kg/ha, respectively) (Table. 2). A negative balance of N, P and K were noticed under all the treatment applied with low level of N as 150 kg/ha. The negative balance values for N, P and K were too high in control (-58.0, -3.9 and -25.0 kg/ha respectively) due more mining of soil NPK coupled with absence of fertilization. Srivastava, *et al.* (2014) also reported the similar results.

Soil fertility

At the end of the experiment, the organic carbon and available N content of the soil varied from 0.57 to 1.24% and from 218.0 to 326.7 kg/ha, respectively, in various treatments. The highest organic carbon (1.24%) obtained by the application of 200 : 75 : 75 kg N : P : K/ha. The application of 200 : 75 : 75 kg of N : P : K/ha had proved superior by registering significantly highest available N (326.7 kg/ha). The next superior value (309.3 kg/ha) of available N was recorded for the treatment which received 200 : 50 : 50 kg of N : P : K/ha. The decline in the available N status of the soil might be attributed to the utilization of N for growth of rice. These results are in agreement with the findings of Patra *et al.* (2017).

The treatment 200 : 75 : 75 kg of N : P : K/ha had achieved the highest value of available P (21.4 kg/ha) followed by 19.3 kg/ha with 175 : 75 : 75 kg of N : P : K/ha. The higher available P might be owing to the enhanced level of P fertilizers with higher doses and the higher availability in the soil-available pool due to water solubility, as reported earlier by Gupta *et al.* (2006) and Urkurkar *et al.* (2010).

The highest available K value (362.7 kg/ha) was registered for the treatment applied with 200 : 75 : 75 kg of N : P : K/ha. The treatment with 175 : 75 : 75 kg of N : P : K/ha which recorded the next highest level of available K (328.3 kg/ha). Available K content in the soil increased owing to an increased level of K fertilizers added in the soil. Similar results were reported by Ravichandran *et al.* (2011).

Based on 2 year study, it can be concluded that the application of 200 : 75 : 75kg of N : P : K/ha is advisable for obtaining higher yield of rice, net returns and sustaining the soil fertility.

REFERENCES

- Chaudhary, S.K., Shiveshwar Pratap Singh, Singh, Y. and Dharmendar. 2014. Influence of integrated use of fertilizers on SRI grown rice (*Oryza sativa*) and their residual effect on succeeding wheat (*Triticum aestivum*) in calcareous soil properties. *Indian Journal of Agronomy* **59**(4): 527–533.
- DAC, GoI. 2014. *Agricultural Statistics at a Glance*. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi (www.dacnet.nic.in).
- DES. 2014. Season and Crop Report, Directorate of Economics and Statistics. Government of Tamil Nadu.
- Fageria, N.K., Wander, A.E., and Siva, S.C. 2014. Rice (*Oryza sativa*) cultivation in Brazil. *Indian Journal of Agronomy* **59**(3): 350–358.
- Gill, Jagjot Singh and Walia, Sohan Songh. 2014. Quality and grain yield of basmati rice as influenced by different establishment methods and nitrogen levels. *An Asian Journal of Soil Science* **8**(2): 311–318.
- Gomez, K.M. and Gomez, A.A. 1984. *Statistical Procedure for Agricultural Research*. edn 2 574 pp. John Wiley, New York.
- Gupta, V., Sharma, R.S. and Vishvakarma, S.K. 2006. Long-term effect of integrated nutrient management on yield sustainability and soil fertility of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **51**(3): 160–164.
- Mahajan, G., Chauhan, B.S. and Gill, M.S. 2011. Optimal nitrogen fertilization timing and rate in dry-seeded rice in northwest India. *Agronomy Journal* **103**: 1,676–1,682.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (NaHCO₃). *United States Department of Agricultural Circular* **939**: 1–19.
- Patra, A.K., Mishra, K.N., Garnayak, L.M., Halder, J. and Swain, S.K. 2017. Influence of long-term integrated nutrient management on productivity soil properties in rice (*Oryza sativa*)–rice cropping system in an acidic soil. *Indian Journal of Agronomy* **62**(2): 111–117.
- Ravichandran, M. and Sriramachandrasekharan 2011. Optimizing timing of potassium application in productivity enhancement of crops. *Karnataka Journal of Agricultural Science* **24**(1): 75–80.
- Reddy, M.G.B., Hebbena, M., Patil, V.C. and Patil, S.G. 2009. Response of transplanted rice to level and timing of NPK application; effect of growth, grain yield and economics. *An Asian Journal of Soil Science* **49**(2): 248–253.
- Sandhu, S.S. and Mahal, S.S. 2014. Performance of rice (*Oryza sativa*) under different planting methods, nitrogen levels and irrigation schedules. *Indian Journal of Agronomy* **59**(3): 392–397.
- Schollenberger, C.J. and Simon, R.H. 1945. Determination of exchange capacity and exchangeable bases in soils: ammonium acetate method. *Soil Science* **59**: 13–24.
- Singh, S.P., Suppaiah, S.V. and Kumar, R.M. 2012. Response of rice varieties to nitrogen application time under direct seeded puddle condition. *Oryza* **43**: 157–158.
- Srivastava, V.K., Singh, J.K., Bohra, J.S. and Singh, S.P. 2014. Effect fertilizer levels and organic sources of nitrogen on production potential of hybrid rice (*Oryza sativa*) and soil properties under system of rice intensification. *Indian Journal of Agronomy* **59**(4): 607–612.
- Subbiah, B.U. and Asija, C.L. 1956. A rapid procedure for estimation of available nitrogen in soil. *Current Science* **25**(1): 259–260.
- TNAU. 2010. *Crop Production Guide*. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.
- Upadhyay, V.B. and Vishwakarma, S.K. 2014. Long-term effect of integrated nutrient management in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **59**(2): 209–214.

Urkurkar, J.S., Tiwari, A., Shrikant Chitale and Bajpai, R.K. 2010. Influence of long term use of inorganic and organic manures on soil fertility and sustainable productivity of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) in Inceptisols. *Indian*

Journal of Agricultural Sciences **80**(2): 208–212.

Walkley, A. and Black, I.A. 1934. An examination of soil organic carbon by chromic acid titration method. *Soil Science* **37**(1–6): 29–38.