Madras Agric. J., 103 (1-3): 31-34, March 2016

Effect of Nutrient Levels on Productivity, Profitability and Soil Fertility in Rice (*Oryza sativa*) in Alfisols of Tambiraparani Tract

M. Paramasivan*, V. Arunkumar and N. Senthilkumar
Department of Soil Science and Agricultural Chemistry,
Agricultural College and Research Institute, Tamil Nadu Agricultural University,
Killikulam, Vallanad – 628 252, Thoothukudi.

A field experiment was conducted during 2012-13 and 2013-2014 at Agricultural College and Research Institute, Killikulam to study the effect of different levels of nutrient on productivity, nutrients uptake, economics and soil fertility of rice. The experiment was carried out in a randomized block design replicated thrice with 7 treatments involving three levels of N and two levels of P and K. Application of 200:75:75 kg NPK ha^{-1} produced the maximum plant height (95.7 cm), number of productive tillers / plant (18.3), panicle length (27.2), number of grains /panicle (212), 1000 grain weight (26.0 g), grain yield (7.04 t ha^{-1}), straw yield (8.58 t ha^{-1}), net return (52,576/ ha), B:C ratio (1.65), N, P and K (171.9, 28.6 and 185.2 kg/ha, respectively) and uptake compared to control. Significant built up of organic carbon (1.24 %), available N (326.7 kg ha^{-1}), P (21.4 kg ha^{-1}) and K (362.7 kg ha^{-1}) was registered with the application of 200:75:75 kg of NPK ha^{-1}. The maximum balance of N, P and K (50.7, 5.6 and 74.0 kg ha^{-1}, respectively) were also recorded under this treatment.

Key words: Alfisol, Rice, NPK level, Available nutrients, Grain and straw yield

Rice *(Oryza sativa)* is the most important stable 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 tones and the area of production is estimated as 150 million ha (FAOSTAT, 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 and the average productivity is 2.37 t ha^{-1} (DAC, GoI, 2014). In Tamil Nadu, the production is 7.46 million tonnes from an area of 2.01 million ha with the average productivity of 3.9 t ha^{-1} (DES, 2014).

The productivity of rice has been stagnated in recent years in Tambiraparani river basin, Tamil Nadu and it is relatively poor with narrow profit margin compared to the national average. Under certain situation, cost of cultivation exceeds the net realisation, making it non profitable. Yield enhancement has been the major challenge, which has to come through increased productivity in the back drop of imbalanced nutrition. Inspite of improved production technologies, imbalanced use of chemical fertilizers lead to the emergence of multiple nutrient deficiencies. To achieve sustainable yield increase it is essential to reschedule NPK fertilizers increase the nutrient use efficiency and higher yield will be a cost effective measure to help low land rice farmers. Since location specific nutrient management in the study area is lacking, current investigation was undertaken to evaluate the right scheduling of NPK on growth and yield of low land rice.

*Corresponding author's e-mail: paramusoil@gmail.com

Materials and Methods

A field experiment was conducted during 2012–13 and 2013–14 at Agricultural College and Research Institute, Killikulam, Thoothukudi, Tamil Nadu. The climate of the experimental site is semi arid with a mean annual rainfall of 750 mm. The soil in experimental field was clay loam grouped as Typic Haplustalfs, nearly neutral (pH 6.85), low in organic carbon (0.42 %) and available N (276 kg ha^{-1}), medium in available phosphorus (15.8 kg ha^{-1}) and high in available potassium (288 kg ha^{-1}). The cation exchange capacity of the soil was 27.4 c mol (p+) / kg with the bulk density of 1.33 mg m^{-3}.

The experiment was carried out in randomized block design (RBD) in a plot size of 40 m^2 with seven treatments which were replicated thrice. The treatments were, T1- 100 % recommended dose of fertilizer (RDF) alone (150-50-50 kg of N-P-K ha^{-1}); T2- 175-50-50 kg of N-P-K ha^{-1}; T3- 200-50-50 kg of N-P-K ha^{-1}; T4- 150-75-75 kg of N-P-K ha^{-1}; T5- 175-75-75 kg of N-P-K ha^{-1}; T6- 200-75-75 kg of N-P-K ha^{-1}; T7- Absolute control. The rice variety ASD 16 was taken as the test crop. Transplanting was done during rabi season (Oct- March) and harvested during March in the subsequent year.

The cultivation practices were followed as per the guidance of crop production guide for Tamil Nadu (CPG, TNAU, 2012). The fertilizer sources used were urea for N (46 % N), single super phosphate for P (16 % water soluble P2O5) and muriate of potash for K (60 % of K2O). Nitrogen was applied in 3 equal splits, one–third each at transplanting, active tillering and panicle-initiation stages. Five representative plant samples in each plot were collected and observations on biometric and yield attributes *viz.,* plant height, number of productive tillers/ plant, number of panicles/ m^2, length of panicle, grains/panicle and test weight were recorded. Soil samples were collected from the surface layer (0-15 cm) from all the plots before treatment and after rice harvesting. The nutrient content and uptake by plants were analysed through prescribed laboratory procedures. Soil samples were analysed for organic carbon following Walkley and Black (1934), alkaline permanganate oxidizable N as described by Subbiah and Asija (1956), 0.5 M $NaHCO_3$-extractable P (Olsen *et al.,* 1954) and available potassium by flame photometry with extracting 1 N NH_4OAC (Schollenberger and Simon, 1945). Two-way analysis of variance (ANOVA) was performed for each trait for both the seasons, the testing error variance ascertaining homogeneity following Gomez and Gomez (1984). Economics of rice cultivation as influenced by chemical fertilizer and management practices were calculated by considering the prevailing market price of grain, straw and inputs used.

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 test weight were significantly influenced by different NPK levels (Table 1). The height of the plant significantly differed for various treatments and varied from 88.5 to 95.7 cm.

Table 1. Effect of NPK levels on growth parameters and yield attributes of rice

Treatments	Plant height (cm)	No. of productive tillers/ plant	Panicle length (cm)	No. of grains / panicle	Test weight (g) (1000 grains)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (ha^{-1})	Cost of cultivation (ha^{-1})	Net return (ha^{-1})	BC ratio
T1 – 150:50:50 (CPG)	92.9	13.8	22.7	194	24.5	5345	6973	64140	27235	36905	1.35
T2 – 175:50:50	93.1	13.3	24.9	198	24.9	5553	7340	64236	28340	35896	1.26
T3 – 200:50:50	94.4	16.9	26.1	202	25.9	6700	8002	80400	30800	49600	1.61
T4 – 150:75:75	92.7	15.2	25.6	200	25.6	5813	7526	69756	30530	39226	1.28
T5 – 175:75:75	93.4	16.2	25.7	202	25.8	6492	7491	77904	31700	46204	1.46
T6 – 200:75:75	95.7	18.3	27.2	212	26.0	7043	8581	84516	31940	52576	1.65
T7 – 0:0:0 (control)	88.5	12.9	20.5	174	24.1	4073	5569	48876	23750	25126	1.06
SEd	1.38	1.43	0.81	6.24	0.09	124.3	376.5	-	-	-	-
CD (P=0.05)	3.01	3.13	1.75	13.6	0.20	270.8	820.4	-	-	-	-

*Pooled mean of 2012-13 and 2013-14

The tallest plant (95.7 cm) was recorded in the treatment (T6) with 200-75-75 kg of N-P-K ha^{-1}), followed by treatment (T3) with 200-50-50 kg of N-P-K ha^{-1} (94.4 cm). The increase in plant height due to the enhanced level of NPK application might have attributed to the better rooting and absorption of nutrients by plants as reported earlier by Mahajan *et al.,* (2011).

Yield attributes

Yield attributes of rice, *viz.,* number of productive tillers/plant, panicle /m^2, grains/panicle and test weight were significantly affected due to the application of different levels of nitrogen and phosphorus (Table 1). In general, NPK at higher level (200:75:75 kg ha^{-1}) gave significantly higher values of yield attributes than those with lower levels (150 kg ha^{-1}). The maximum productive tillers $plant^{-1}$ (18.3), longest panicle (27.2 cm), maximum grains $panicle^{-1}$ (212) and the test weight (26.0 g) were obtained with the application of 200-75-75 kg of N-P-K ha^{-1}. Addition of 200-50-50 kg of N-P-K/ha recorded the next best values of yield attributes *viz.,* productive tillers $plant^{-1}$ (16.9), panicle length (26.1 cm), number of grains $panicle^{-1}$ (202) and the test weight (25.9 g). However, both the treatments were on par to each other. Adequate supply of nutrients in balanced quantity throughout the growth stages enables the plants to assimilate sufficient photosynthetic product and thus increased the dry matter accumulation. These results support the findings of Yadav *et al.* (2009). The minimum productive tillers (12.9), shortest panicle length (20.5 cm), minimum number of grains $panicle^{-1}$ (174.3) and the least test weight (24.08 g) were noted in absolute control without fertilizer application.

Yield

The maximum grain and straw yields (7043 and 8581 kg ha^{-1}) were recorded in with the addition of 200-75-75 kg of N-P-K ha^{-1}, which was 72% higher over the control followed by the application of 200-50-50 kg of N-P-K ha^{-1}, which registered the grain and straw yield of 6700 and 8002 kg ha^{-1}, respectively. However, both these treatments were found to be on par. The increase in NPK levels might have regulated adequate supply of nutrients over prolonged period that ultimately resulted in increased grain and straw yield. The results are confirm the findings of Sandhu and Mahal (2014). The low yield of grain and straw, which might be due to insufficient nutrient supply to the plants by the application of low levels of NPK. This results corroborate the findings of Gill et al., (2013).

Economics

The application of 200-75-75 kg of N-P-K ha^{-1} fetched significantly the highest net returns (Rs. 52,576) and benefit: cost ratio (1.65) over the rest of the treatments (Table 1). The better treatment was 200-50-50 kg of N-P-K ha^{-1}, which fetched a net return of Rs. 49, 600 and benefit : cost ratio of 1.61. This might be due to increased higher productivity and lower cost of cultivation. The variation in the cost of cultivation under different treatments were recorded due to variable costs of fertilizers. Grain and straw yield 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 various levels of fertilizers (Table 2). The highest and significantly higher amount of N, P and K uptake by rice was recorded with the application of 200-75-75 kg of N-P-K ha^{-1}, which was on par with the application of 200-50-50 kg of N-P-K ha^{-1}.

Table 2. Nutrient availability (kg/ha) and nutrient uptake (kg/ha) of rice as influenced by levels of application of NPK

Treatments	Organic carbon (%)	Available nutrients (kg/ha)			Nutrient uptake (kg/ha)		
		N	P	K	N	P	K
T1 – 150:50:50 (CPG)	0.74	251.7	14.9	295.0	128.8	16.9	132.2
T2 – 175:50:50	0.95	273.0	15.8	298.3	136.9	19.3	139.6
T3 – 200:50:50	1.13	309.3	16.5	300.7	164.2	21.9	149.4
T4 – 150:75:75	0.95	285.3	18.4	314.0	144.3	22.8	161.3
T5 – 175:75:75	1.02	269.3	19.3	328.3	145.1	23.6	170.1
T6 – 200:75:75	1.24	326.7	21.4	362.7	171.9	28.6	185.2
T7 – 0:0:0 (control)	0.57	218.0	11.9	263.3	89.8	10.5	101.8
SEd	0.098	23.17	1.01	15.96	5.73	2.00	6.02
CD (P=0.05)	0.215	50.50	2.20	34.79	12.48	4.36	13.13

The per cent increase in N, P and K uptake under 200-75-75 kg of N-P-K ha^{-1} was up to the tune of 91.4, 72.4 and 81.9 %, respectively over control. However, the application of 175-75-75 kg of N-P-K ha^{-1} also recorded significantly higher uptake of P and K to the magnitude of 23.6 and 170.1 kg ha^{-1}, respectively over control. This could be ascribed to the increase in the available N, P and K contents in soil resulting from the increasing availability of nutrients which ultimately increased nutrient content in the plant tissue and greater biomass production. Since the uptake of nutrient is a function of dry matter and nutrient content, the increased straw and grain yields together with higher NPK content resulted in greater uptake of these elements. The results confirm the findings of Singh *et al.,* (2012) and Chaudhary *et al.,* (2014).

A positive N, P and K balance were observed under the treatment applied with enhanced levels of nitrogen with phosphorus and potassium. The treatment applied with 200-75-75 kg of N-P-K ha^{-1} registered highest status of N, P and K (50.7, 5.6 and 74.0 kg ha^{-1}, respectively) followed by the next higher values of balance N, P and K (33.3, 0.7 and 12.7 kg ha^{-1}, respectively) were recorded under the treatment with application of 200-50-50 kg of N-P-K ha^{-1} (Table.3). This could be due to the addition of large amount of NPK fertilizers. A negative balance of N, P and K were noticed under all the treatment applied with low level of N. The negative balance values for N, P and K were too high in control (-58.0, -3.9 and -25.0 kg ha^{-1}, respectively). This was probably owing to greater availability of nutrients for growth and development of rice (sink) in enhanced levels of N, P and K application (source), which led to more removal of N, P and K by rice and corroborate with the findings of Srivastava, *et al.,* (2014).

Soil fertility

The post harvest soil analysis showed that, organic carbon and available N content of the soil varied from 0.57 to 1.24 % and 218.0 - 326.7 kg ha^{-1}, respectively in various treatments. The highest organic carbon (1.24 %) and available N (326.7 kg ha^{-1}) was noted with the application of 200:75:75 kg of NPK ha^{-1}. The next superior value (309.3 kg ha^{-1}) of available N was recorded for the treatment, which received 200:50:50 kg of NPK ha^{-1}. 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 Singh and Walia (2010).

The treatment with the application of 200:75:75 kg of NPK ha^{-1} had achieved the highest value of available P (21.4 kg ha^{-1}). The next best value (19.3 kg ha^{-1}) was observed for the application of 175:75:75 kg of NPK ha^{-1}.

The higher available P might be due to the enhanced level of P fertilizers, which enhanced the solubility and increased available P content in the soil. Gupta *et al.,* (2006) and Urkurkar *et al.,* (2010) also reported that higher phosphorus concentration in soil applied with higher levels of phosphorus.

The highest available K value (362.7 kg ha^{-1}) was registered for the treatment applied with 200:75:75

Table 3. Nutrients balance as influenced by different levels of application of NPK

Treatment	Nutrients added (A) (kg/ha)			Nutrients removed (B) (kg/ha)			Soil available nutrients (C) (kg/ha)			Actual gain/loss (C-A*)		
	N	P	K	N	P	K	N	P	K	N	P	K
T1 – 150:50:50 (CPG)	150	50	50	128	16.9	132	251	14.9	295	-24.3	-0.9	7
T2 – 175:50:50	175	50	50	136	19.3	139	273	15.8	298	-3	0	10
T3 – 200:50:50	200	50	50	164	21.9	149	309	16.5	300	33.3	0.7	12.7
T4 – 150:75:75	150	75	75	144	22.8	161	285	18.4	314	9.3	2.6	26
T5 – 175:75:75	175	75	75	145	23.6	170	269	19.3	328	-6.7	3.5	40
T6 – 200:75:75	200	75	75	171	28.6	185	326	21.4	362	50.7	5.6	74
T7 – 0:0:0 (control)	0	0	0	89	10.5	101	218	11.9	263	-58	-3.9	-25
SEm±	-	-	-	5.73	2.00	6.02	23.2	1.01	15.9			
CD (P=0.05)	-	-	-	12.5	4.36	13.1	50.5	2.20	34.8			

kg of NPK ha^{-1}. The treatment with 175:75:75 kg of NPK ha^{-1} which recorded the next highest level of available K (328.3 kg ha^{-1}). This increase in available K content in the soil due to increased level of fertilizer might be attributed to the direct addition of potassium in the available K pool in soil and release of K. Similar results were reported by Ravichandran *et al.,* (2011).

Conclusion

It is concluded that application of 200:75:75 of NPK ha^{-1} could be recommended for increasing the yield of rice to obtain better net return and sustaining soil fertility in Tambiraparani river basin in Tamil Nadu.

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.

CPG, TNAU. 2012. Crop Production Guide, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

DAC, GoI. 2014. *Agricultural Statistics at a Glance*. Directorate of Economics and Statistics, Department of Agriculture and Cooperation. Ministry of Agriculture, Government of India, New Delhi. p 2.

DES. 2014. Department of Economics and Statistics. *Tamil Nadu at a Glance.,* Statistical Hand Book of Tamil Nadu. p 205.

FAOSTAT. 2014. http://faostat.fao.org/default.aspx, Food and Agriculture Organization, Rome.

Gill, Jagjot Singh and Walia, Sohan Songh. 2013. Quality and grain yield of basmati rice as influenced by different establishment methods and nitrogen *levels. Asian J. Soil Sci.* **8**(2): 311-318.

Gomez K M and Gomez A A. 1984. *Statistical Procedure for Agricultural Research*. Edition **2**, John Wiley, New York. p: 574.

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**: 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. *Agron. J.* **103**: 1676-1682.

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), U.S.D.A Circular, **939**, 1-19.

Ravichandran, M. and Sriramachandrasekharan. 2011. Optimizing timing of potassium application in productivity enhancement of crops. *Karnataka J. Agric. Sci.,* **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. *Asian J. Soil Sci.,* **4**(2): 248-53.

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, G. and Walia, S.S. 2010. Influence of FYM, brown manuring and levels of nitrogen and soil properties of direct seeded and transplanted rice. *GeoBios*, **37**:210-216.

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. *Curr. Sci.* **25**, 259-260.

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**: 208-212.

Walkley, A. and Black, I.A. 1934. An examination of soil organic carbon by chromic acid titration method. Soil Science **37**, 29.

Yadav, V., Singh, L.R., Singh, R. and Mishra. D.N. 2009. Effect of age planting, level and time of nitrogen applicationon yield and quality rice under mid western plain zone of UP. *Environment and Ecology* **27**:233-34.

Received after revision: March 10, 2016; Accepted: March 28, 2016