

## Effect of Different Levels of Nitrogen on Macronutrient Availability of Paddy in Vertisols of TBP Command

Sankalpa C.P., Vishwanath J.

Received 24 November 2016; Accepted 26 December 2016; Published online 13 January 2017

**Abstract** A field experiment was conducted during *kharif* 2012 to study the effect of graded levels of nitrogen on macro and micronutrient availability at different physiological stages of rice crop and residual macro and micronutrient content in soil. The experiment was laid out in factorial randomized block design with five levels of nitrogen (RDN, 20% extra RDN, 40% extra RDN, 60% extra RDN and 80% extra RDN) and two different rice varieties (GGV-05-01 and BPT-5204) was taken and replicated thrice. Application of different levels of nitrogen decreased the availability of NPK across growth stages whereas at any given rice stage (at tillering/panicle initiation/flowering

stage) the availability N increased with increased levels of nitrogen applied. Effect of varieties and their interaction with nitrogen levels was non-significant on the availability of macro nutrients. After harvest of the crop, except N, residual macro and micronutrients contents in soil decreased with increasing levels of N.

**Keywords** Paddy, Nitrogen levels, Macronutrient uptake, Residual macronutrient.

### Introduction

Rice (*Oryza sativa* L.) is a staple food for 65% of the total population in India and is consumed by more than one half of the world's population [1]. It constitutes about 41.5% of the total grain food production and 55% of total cereal population [2]. India has largest area under rice cultivation with an area of 44.40 million hectare and production of 104.32 million tonnes next to China. In Karnataka rice is cultivated in an area of 1.54 million hectare with an annual production of 3.9 million tonnes and production of 2974 kg ha<sup>-1</sup> [3]. The current global population of 6.4 billion is expected to reach 7.5 billion by 2020 and 9.0 billion by 2050 AD. It will be necessary for rice yields in Asia to be increased by 25% per annum between 2010 and 2020 [4].

Gangavati in Thunga Bhadra Project (TBP) command area is called as Rice Bowl of Karnataka. Nearly

---

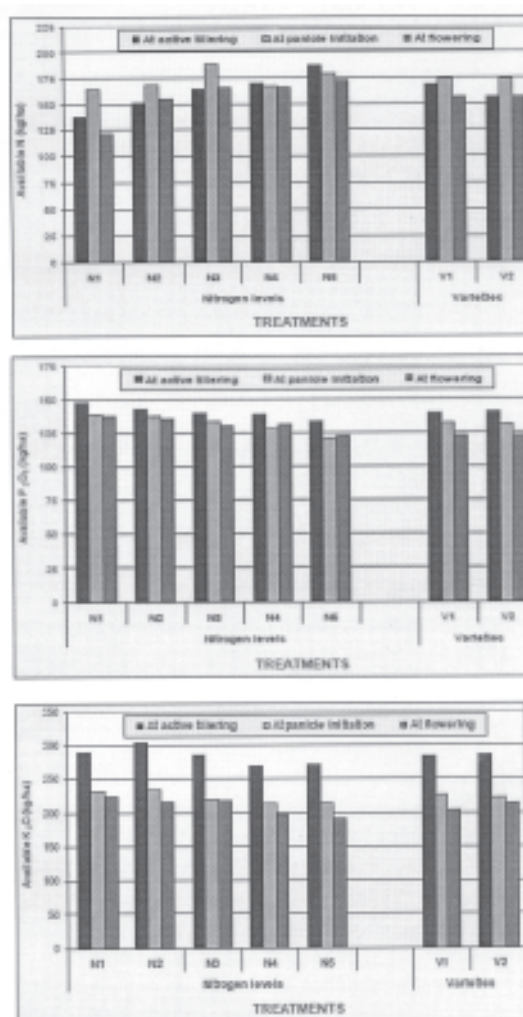
Sankalpa C.P.<sup>1\*</sup>, Vishwanath J.<sup>2</sup>  
<sup>1</sup>PhD Scholar,  
Department of Soil Science and Agricultural Chemistry,  
UAS Dharwad, India  
<sup>2</sup>Senior Scientist,  
Saline and Water Scheme,  
Gangavathi, India  
e-mail : sankalpacp@gmail.com  
\*Correspondence

60–65% of 3.63 lakh ha of the command in Karnataka (comprising Bellary, Kppal and Raichur districts) is under paddy. Paddy is the maximum consumer of nitrogenous fertilizer constituting 1/3<sup>rd</sup> of the total nitrogen (N) consumption of the world. Thus, N is the most critical input that most frequently limits rice production and is the key input in nutrient management [5]. In TBP command, intensive rice-rice cropping system involving twice or thrice the recommended dose of major nutrients, especially N with little or no organic resources is being practiced [6] which has resulted in the decreased yields or attaining plateau in parts of the command. Application of excess doses of nitrogenous fertilizer leads to deficiencies of other macronutrients like phosphorus and potassium and it is also considered as one of the major causes of the declining productivity trends observed in rice growing countries. As reported by Rashid et al. [7] phosphorus and potassium are also required in relatively for plant growth, seed development and they are as important as macronutrient in rice production to obtain optimum yield and balanced nutrition. N application to the soil accelerates vegetative growth of plants and this may lead to phosphorus and potassium deficiency in soil [8].

Although the effect of N fertilization on phosphorus and potassium deficiency has seldom been studied, several publications suggest that management of N fertilizer could affect the soil availability and grain micronutrient status. However, such information is not available for TBP command where rice is the staple food and nitrogenous fertilizers are being applied excessively. Hence, the present study was conducted to study the effect of graded levels of N on macronutrient availability at different physiological stages of rice crop and residual macronutrient content in soil after the harvest of the rice crop Vertisols of TBP command.

### Materials and Methods

A field experiment was conducted during *kharif* 2012 at Agricultural Research Station, Gangavathi and is located in North Eastern Dry Zone (Zone 3) of Karnataka. The soils of the experimental site were medium Vertisols. The experiment was laid out in a



**Fig. 1.** Macronutrient ( N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ) availability ( kg ha<sup>-1</sup> ) in surface soil (0–15 cm) at different physiological stages of rice.

factorial randomized completely block design with five treatments (RDN, 20% extra RDN, 40% extra RDN, 60% extra RDN and 80% extra RDN) and replicated thrice and two varieties (GGV-05-01 and BPT-5204). Prior to the initiation of the experiment soil samples and after harvest of crop were collected to a depth of 30 cm with an increment of 15 cm and analyzed for basic properties viz., pH, EC, OrgC, available NPK, Ca, Mg and S by following standard procedures. At different physiological stages and after the harvest

**Table 1.** Macronutrient availability (kg ha<sup>-1</sup>) in surface soil (0–15 cm) at different physiological stages of rice.

Treatments	Nitrogen			Phosphorus			Potassium		
	Active tillering	Panicle initiation	Flowering	Active tillering	Panicle initiation	Flowering	Active tillering	Panicle initiation	Flowering
Nitrogen levels									
N <sub>1</sub> : Control	137.2	164.3	121.6	148.2	138.4	137.3	289.7	232.7	223.9
N <sub>2</sub> : RDF+20% additional N	150.3	168.0	154.9	142.9	136.8	135.1	303.9	235.1	216.5
N <sub>3</sub> : RDF+40% additional N	164.3	188.7	165.7	139.1	133.0	130.5	284.3	221.2	217.4
N <sub>4</sub> : RDF+60% additional N	168.9	166.8	165.5	138.1	128.6	130.7	269.3	215.2	196.9
N <sub>5</sub> : RDF+80% additional N	186.8	179.2	172.7	132.7	121.0	122.4	271.3	214.1	188.9
SEm±	3.20	3.31	5.08	0.52	1.6	1.76	5.55	4.03	7.85
CD @ 5%	9.52	9.82	9.15	1.54	4.74	5.23	16.48	11.98	23.33
Variety									
V <sub>1</sub> : GGV-05-01	167.9	173.4	155.9	140.1	132.3	122.9	283.0	224.9	204.4
V <sub>2</sub> : BPT-5204	156.1	173.4	156.2	140.3	130.8	122.9	284.4	222.5	213.0
SEm±	2.03	2.09	1.95	0.33	1.01	1.11	3.51	2.55	4.97
CD @ 5%	6.02	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
N <sub>1</sub> V <sub>1</sub>	145.6	173.6	120.7	148.1	139.2	135.6	292.8	229.8	220.1
N <sub>1</sub> V <sub>2</sub>	128.8	154.9	122.5	148.3	137.6	139.0	286.6	235.6	227.8
N <sub>2</sub> V <sub>1</sub>	151.2	168.0	151.2	143.9	138.6	134.7	303.0	231.7	212.5
N <sub>2</sub> V <sub>2</sub>	149.3	168.0	158.7	141.9	135.0	135.4	304.8	238.6	220.4
N <sub>3</sub> V <sub>1</sub>	168.0	175.5	165.4	139.4	133.8	128.5	280.1	219.8	221.9
N <sub>3</sub> V <sub>2</sub>	160.5	202.0	166.0	138.8	132.3	132.5	288.6	222.6	212.9
N <sub>4</sub> V <sub>1</sub>	169.9	165.2	170.5	137.3	128.9	128.8	268.1	228.0	188.9
N <sub>4</sub> V <sub>2</sub>	168.0	168.3	160.5	138.9	128.3	132.6	270.6	202.4	204.8
N <sub>5</sub> V <sub>1</sub>	200.0	184.8	171.7	131.7	121.2	123.4	271.2	215.0	178.7
N <sub>5</sub> V <sub>2</sub>	173.6	173.6	173.6	133.7	120.7	121.4	271.4	213.2	199.2
SEm±	4.53	4.67	4.36	0.73	2.26	2.49	7.84	5.70	11.10
CD @ 5%	NS	13.89	NS	NS	NS	NS	NS	NS	NS

of the crop soil samples to a depth of 15 cm was collected and analyzed for nitrogen, phosphorus and potassium content in soil. Initial soil nutrient status was near neutral pH 7.95, soluble salt contents in soils as indicated by ECe were less than 4 dSm<sup>-1</sup>, organic carbon content was 9.23 g kg<sup>-1</sup>, available N 160 kg ha<sup>-1</sup> which was low in available N both in surface and subsurface soil as per soil fertility ratings (<280 kg ha<sup>-1</sup>) [9], available phosphorus (P<sub>2</sub>O<sub>5</sub>) content was 121 kg ha<sup>-1</sup> which was high in P<sub>2</sub>O<sub>5</sub> content as per soil test rating (>55 kg ha<sup>-1</sup>), available potassium (K<sub>2</sub>O) content was 266 kg ha<sup>-1</sup> which was medium in K<sub>2</sub>O content as per soil test rating (141–336 kg ha<sup>-1</sup>) and available S content was 18 ppm which was medium (10–50 ppm) in sulfur content. Initial average of exchangeable Ca and Mg in soil were in high category as per soil test rating (>1000 and > 500 ppm, respectively).

## Results and Discussion

Soil macronutrient availability at different physiological stages of rice as influenced by different treatments

Nitrogen is considered to be the major limiting nutrient for sustainable paddy production. Realizing its importance and response to its application in crop production, farmers of the TBP command are in the practice of applying N fertilizers over and above the recommendation for paddy. It has been reported that 2–3 times greater than the recommended N is being applied in a single season in the command for paddy. As N is generally help in enhancing overall crop vigor is also expected to induce higher requirement of other nutrients by the crop including micronutrients for completion of its life cycle. Over the period, it is ob-

**Table 2.** Residual available nitrogen, phosphorus and potassium (kg ha<sup>-1</sup>) after harvest of rice crop at different depths. NS : Non Significant.

Treatments	Nitrogen		Phosphorus		Potassium	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
<b>Nitrogen levels</b>						
N <sub>1</sub> : Control	159.4	145.9	140.0	116.9	215.3	159.5
N <sub>2</sub> : RDF + 20% additional N	158.5	144.6	136.9	115.2	220.1	165.1
N <sub>3</sub> : RDF + 40% additional N	171.7	160.5	129.4	107.3	209.3	166.0
N <sub>4</sub> : RDF + 60% additional N	182.2	160.7	127.4	104.4	195.5	156.4
N <sub>5</sub> : RDF + 80% additional N	181.7	163.2	123.5	92.7	182.6	158.1
SEm±	2.86	3.81	1.18	0.80	5.41	4.56
CD @ 5%	8.50	11.3	3.50	2.4	16.09	NS
<b>Variety</b>						
V <sub>1</sub> : GGV-05-01	172	156.0	131.2	109.3	188.1	162.6
V <sub>2</sub> : BPT-5204	170	153.9	131.7	105.3	190.4	159.4
SEm±	1.81	2.41	0.74	0.51	3.42	2.89
CD @ 5%	NS	NS	NS	1.5	NS	NS
<b>Interaction</b>						
N <sub>1</sub> V <sub>1</sub>	160.5	141.9	139.8	115.1	213.4	157.7
N <sub>1</sub> V <sub>2</sub>	158.2	149.9	140.2	118.7	217.2	161.2
N <sub>2</sub> V <sub>1</sub>	163.6	151.2	137.6	113.7	215.8	172.0
N <sub>2</sub> V <sub>2</sub>	153.4	138.0	136.3	116.7	224.2	158.3
N <sub>3</sub> V <sub>1</sub>	173.6	166.1	128.8	109.1	215.2	173.6
N <sub>3</sub> V <sub>2</sub>	169.9	154.9	130.0	105.5	203.4	158.4
N <sub>4</sub> V <sub>1</sub>	181.7	154.9	127.1	107.8	193.2	153.2
N <sub>4</sub> V <sub>2</sub>	182.6	166.4	127.8	101.0	197.8	159.6
N <sub>5</sub> V <sub>1</sub>	179.2	166.1	122.6	100.9	179.6	156.7
N <sub>5</sub> V <sub>2</sub>	184.2	160.3	124.4	84.5	185.6	159.6
SEm±	4.05	5.39	1.66	1.13	7.66	6.45
CD @ 5%	NS	NS	NS	3.4	NS	NS

served that the yields are either attaining plateau or declining to some extent in the command. Further, as compared to average paddy yields of other regions, there is scope for increasing the yields in the TBP command. Hence, a field experiment was conducted at ARS Gangavathi during *khari* 2012 in order to assess the effect of higher levels of N and how popularly grown paddy varieties (BPT-5204 and GGV-05-01) interact to the applied N on availability of macronutrients (nitrogen, phosphorus and potassium) in soil at different physiological stages of rice crop and at after the harvest of the crop.

#### Available nitrogen

Though no consistent temporal trend was observed across crop growth stages in soil N availability irrespective of levels of N and varieties, soil available N

status in general except N<sub>3</sub> and N<sub>4</sub> was slightly low at flowering stage (Table 1 and Fig. 1) compared to other stages of the crop which may be attributed to the continuous absorption of N by crop with increasing biomass as the crop growth stage advances. Lack of consistent trend may also be explained due to the split application of N at crop stage coinciding with AT and PI. At AT, PI and FL stage, N<sub>5</sub>, N<sub>3</sub>, and N<sub>5</sub> had significantly higher soil available N contents respectively. However, N<sub>5</sub> was on par with N<sub>3</sub> at PI and FL stage of the crop. This could be due to the application of highest level of N (80% more than RDN) in N<sub>5</sub> which might have resulted in higher levels of residual available N after meeting the crop nutrient requirement at different crop growth stages. Between the varieties except at AT stage, available N status due to levels of N was non-significant at other stages reflecting that both the varieties might have used avail-

able N to the same extent. Further, except at PI, no significant differences were observed due to interaction of levels of N and varieties.

#### Available phosphorus ( $P_2O_5$ )

Decreasing temporal trend was observed across crop growth stages in soil  $P_2O_5$  availability irrespective of N levels and varieties (Table 1 and Fig. 1) which may be attributed to the continuous absorption of P by crop with increasing biomass as the crop growth stage advances. The magnitude of decrease was comparatively more from AT to PI stage and with increasing levels of N. Further, significant differences among N levels were observed at three stages of crop growth. At AT stage,  $N_1$  (148.2 kg ha<sup>-1</sup>) had significantly higher available  $P_2O_5$  compared to rest of the treatments with the lowest in  $N_5$  (132.7 kg ha<sup>-1</sup>). At PI and FL stages as well  $N_1$  had significantly higher soil available  $P_2O_5$  content compared to  $N_3$ ,  $N_4$  and  $N_5$  with the lowest at  $N_5$  in all the stages. This could be due to the reason that increased levels of N could have increased the nutrient requirement of crop for P and thus reducing its content in soil. Similar to soil available N, no significant differences were observed between the varieties at three stages of crop may be attributed to higher initial soil available  $P_2O_5$  content (121 kg ha<sup>-1</sup>) which might have masked the effect of varieties on residual soil available  $P_2O_5$  content any given stage of crop. There were no significant differences observed due to the interaction of levels of N and varieties on soil available  $P_2O_5$ .

#### Available potassium ( $K_2O$ )

Decreasing temporal trend was observed across crop growth stages in soil  $K_2O$  availability among the N levels and varieties and the magnitude of decrease from AT to FL stage was more than N and  $P_2O_5$  (Table 1 and Fig. 1). The decline in soil  $K_2O$  content may be attributed to the continuous absorption of K by crop with increasing biomass as the crop growth stage advances. The magnitude of decrease was comparatively more from AT to PI stage and with increasing levels of N. Greater reduction in soil  $K_2O$  content with increasing levels of N could be again related to increased nutrient requirement of crop with enhanced biomass production at higher levels of N. Similar to

available  $P_2O_5$  content, no significant differences were observed either between the varieties and or due to interaction effects between levels of N and variety.

#### Residual soil nutrient status after harvest

##### *Macronutrients (N, $P_2O_5$ and $K_2O$ )*

Soil available N,  $P_2O_5$  and  $K_2O$  contents were highest at surface compared to subsurface (Table 2). In surface soil, available N,  $P_2O_5$  and  $K_2O$  contents were almost in the range observed at flowering stage. Among the treatments after harvest of crop, significant differences were observed with respect to NPK. With respect to N, at surface and subsurface either  $N_4$  or  $N_5$  had significantly higher residual soil N than  $N_1$ ,  $N_2$  and  $N_3$  but was on par each other and was slightly around initial values. Higher rate of application of N in  $N_4$  and  $N_5$  compared to rest of the treatments could have resulted in significantly higher residual N at harvest at both depths after meeting the crop requirement for its enhanced uptake and yield. However, either varieties or the interaction effects showed differences in residual soil available N at both depths. Unlike N, the  $P_2O_5$  and  $K_2O$  content in soil after harvest at both depths decreased with increased levels of N applied except for  $K_2O$  content at 15–30 cm where no significant differences were observed. This decreasing trend could be related to increase in uptake of these nutrients by crop with increase in levels of N applied (Table 2). Greater uptake might have resulted in greater depletion and thus leaving lower nutrient contents at harvest. The varieties and the interaction effects did not differ significantly. In general, N content or protein content in grain increased with increase in the level of N applied and was more than straw at all the levels of N applied. Higher content of N in grain was attributed to the reason that the absorbed nitrogen used for rice straw and leaf growth at the tillering stage is transported to the panicles at advanced developmental stages. Therefore, the total amount of N in the straw decreases, while both the panicles and plants increase with progressive development. Consequently, the N content in the grains is higher than that in the straw before harvest.

## Conclusion

Across the physiological stages, availability of macro nutrient like phosphorus and potassium content in soil showed decreasing temporal trend except available nitrogen where not much variation was observed between the stages. At a given crop growth stage available N increased with increasing levels of N applied whereas available  $P_2O_5$  and  $K_2O$  contents decreased. Generally, varieties and their interaction with levels of N showed no significant difference for majority of nutrients. After harvest, except nitrogen, phosphorus and potassium observe to decline with the increase in the levels of N. Compared to their initial values except N, all the soil nutrient content maintained same level or slightly decreased at harvest of crop. In general, variety and interaction with N levels had no effect on residual nutrient contents after the harvest of crop.

## References

1. Ma H, Chong K, Deng XW (2007) Rice research: past, present and future. *J Integr Pl Biol* 49 : 729—730.
2. Yadav AS, Jaidev, Ram H, Upadhyay MK (2010) Effect of nitrogen levels and plant geometry on growth, yield and root characteristics of hybrid rice (*Oryza sativa*). *Crop Res* 40 : 16—19.
3. Anonymous (2010) Production of food grains. *Surv Ind Agric, the Hindu year book*, pp 43—46.
4. Dobermann, Witt (2003) Increasing productivity of intensive rice systems through site-specific nutrient management. *International Rice Research Institute Handbook Series*. International Rice Research Institute (IRRI), Los Banos, Philippines.
5. Devi MG, Sumathi V, Reddy ST, Aruna P (2012) Influence of levels and time of nitrogen application on yield, nutrient uptake and post-harvest nitrogen status of soil in aerobic rice. *Curr Biota* 6 : 98—102.
6. Reddy BGM (2004) Response of irrigated transplanting rice to level of major nutrient and time of application. PhD thesis. Univ of Agric Sci Dharwad, pp 210.
7. Rashid A, Yasin M, Ashraf M, Mann RA (2004) Boron deficiency in calcareous reduces on rice yield and impairs grain quality. *Int Rice Res Notes* 29 : 58—60.
8. Loneragan J, Webb MJ (2003) Interaction between zinc and other nutrients affecting the growth of plants. In: Robson AD (ed). *Zinc in soils and plants*, Soil Sci and Pl Nutri, pp 119—132.
9. Tandon HLS (2005) *Methods of analysis of soils, plants, waters, fertilizers and organic manures*. Fertilizer development and consultation organisation, New Delhi, India, pp 140.