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Precision nutrient management through drip irrigation in aerobic rice

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Abstract

A field experiment was conducted during *kharif* 2015 to asses the spatial variability and precision nutrient management through drip irrigation in aerobic rice at ZARS, GKVK, Bangalore. The experimental field has been delineated into 48 grids of 4.5 m x 4.5 m using geospatial technology. Soil samples from 0-15 cm depth were collected and analysed. There was spatial variability for available nitrogen (154 to 277 kg ha^{-1}), phosphorous (45 to 152 kg ha^{-1}) and potassium (200 to 346 kg ha^{-1}). The variability was addressed through precision nutrient management approach with target yield. Application of 25 % N & K from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS + 25 % from 81 to 105 DAS through drip irrigation recorded significantly higher grain yield (11.0 Mg ha^{-1}) over application of N & K as per package of practice (9.2 Mg ha^{-1}) which was 20.2 per cent higher over application of N & K as per UAS (B) recommendations through drip irrigation and 70.1 per cent over soil application. Targeted yield of 12 Mg ha^{-1} recorded significantly higher grain yield (12.8 Mg ha^{-1}) over rest of the targets. The actual yields were 22.0, 11.3, 8.2 and 7.3 per cent higher than the targeted yields of 6, 8, 10 and 12 Mg ha^{-1}, respectively.

Keywords:Spatial variability, precision nutrient management, drip irrigation, aerobic rice

Introduction

Rice is the staple food for most people in Asia, home to 60 percent of the world's population, providing about half of their daily calories. Effective management of rice systems is essential to increase the productivity of paddy fields. Among yield limiting factors for rice, nutrients are the most important (Samonte *et al.,* 2006). Nitrogen fertilization is the major agronomic practice that affects the yield of rice, which requires as much as possible at early and mid tillering stages to maximize panicle number and during reproductive stage to produce optimum spikelets per panicle and percentage filled spikelets (Sathiya and Ramesh, 2009). Similarly Potassium performs important role in enzyme activation, photosynthesis, photosynthate translocation, protein synthesis and plant water relations and known to play an important role in the plant's ability to resist disease. So, proper nitrogen and potassium management is key factor in narrowing the yield gap of rice. Application of nitrogen and potassium at right time and at right place, as per crop demand increases paddy yield by improving use efficiencies by crop (Shakouri *et al.,* 2012).

Successful management strategies, however, will depend on the assessment and understanding of spatial variability of soil and crop yield and their relationships. Moreover, knowledge about spatial and temporal behaviour in the variability of nutrient status is the key for precision management. Site specific nutrient management can help to minimize fertilizer inputs without prejudicing yields, which would contribute to bridge economic with environmental advantages (Koch *et al.,* 2004).

The more precise way to supply nutrients in split is the fertigation, the judicious application of fertilizers through irrigation water, which will maximize the nutrient uptake, while using minimum amount of water and fertilizer. Fertigation gives advantages such as higher use efficiency of water and fertilizer, minimum leaching losses of N, direct supply of nutrients to the root zone, control of nutrient concentration in soil solution and saving in application cost.

With the above background, the present investigation was carried out to asses soil spatial variability and to develop a guideline for judicious application of fertilizer for maximum production of aerobic rice through precision management practices.

Materials and Methods

A field experiment was conducted at Zonal Agricultural Research Station, UAS, Bangalore during *Kharif* 2015. The site was located at 13^{0} 05' 21" N latitude, 77^{0} 34' 02" E longitudes with an altitude of 947 m above mean sea level. Forty eight grids of 4.5 m X 4.5 m were formed. Soil sampling was done in each grid and analysed for physical and chemical properties by following standard procedures. Soils varied spatially for pH, EC and available NPK. The initial soil varied spatially for pH (5.4 to 6.6), electrical conductivity (0.10 to 0.43 dSm^{-1}), available nitrogen, phosphorus and potassium (154 to 277, 45 to 152 and 200 to 346 kg N, P_2O_5 and K_2O ha^{-1}, respectively).

Spatial variability was managed through precision nutrient management practices. There were thirteen treatment combinations comprised of three variable application levels of N and K through drip irrigation (**L_1**: N & K application as per UAS (B) package of practice - 50 % from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS; **L_2**: N & K 25 % from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS + 25 % from 81 to 105 DAS; **L_3**: N & K 25 % from sowing to 30 DAS + 50 % from 31 to 50 DAS + 25 % from 51 to 80 DAS) and four targeted yield levels (**Y_1**: 6 Mg ha^{-1}, **Y_2**: 8 Mg ha^{-1}, **Y_3**: 10 Mg ha^{-1} and **Y_4**: 12 Mg ha^{-1}) with one control wherein recommended dose of fertilizer (RDF-100:50:50 kg NPK ha^{-1}) was applied directly to soil. The experiment was laid out in Factorial Randomized Complete Block Design (FRCBD) with four replications.

The land was brought to fine tilth before sowing by ploughing twice with tractor drawn disc plough and passing cultivator and two harrowing. Drip fertigation system included pump, filter units, fertigation tank, ventury, main line and sub line. Irrigation was provided through laterals separated at 50 cm apart in alternative rows. Inline emitters were at 40 cm apart with discharge rate of 3 lph. The hybrid used was KRH-4 at seed rate of 5 kg ha^{-1} with a spacing of 25 cm × 20 cm.

Farm yard manure was applied two weeks before sowing @ 8 Mg ha^{-1}. The chemical fertilizer nutrients required for targeted yield levels were calculated using Soil Test Crop Response (STCR) equations developed by UAS, Bangalore. Fertilizer N required (F.N) = 5.166 T - 0.799 S.N ($KMnO_4$) – 0.967 OM., $F.P_2O_5$ = 1.636 T - 0.256 $S.P_2O_5$ (Olsen's) –

0.077 OM. and F.K_2O = 2.31 T – 0.493 S.K_2O (Am. Ac.) – 0.114 OM. The quantity of NPK applied for the targeted yield levels of 6, 8, 10 and 12 Mg ha^{-1} were 73.0:48.1:9.7, 175.3:86.3:55.3, 266.7:119.4:92.7 and 380.9:150.6:135.1 kg N, P_2O_5 and K_2O ha^{-1}, respectively. N&K were applied as per treatments wherein phosphorous was applied in two equal splits (50 per cent as basal and remaining 50 per cent at 30 DAS).

Pre sowing irrigation was given uniformly to all treatments. Drip irrigation was scheduled based on pan evaporation (E_{pan}) *i.e.* 125 per cent E_{pan} from sowing to tillering + 150 per cent E_{pan} from tillering to panicle emergence + 200 per cent E_{pan} from panicle emergence to physiological maturity. Fertigation was done through ventury as per treatment requirement. Nitrogen and potassium were supplied through urea (46 % N) and sulphate of potash (0-0-50), respectively. However, muriate of potash was the source for potassium for control and SSP as phosphorus source for all the treatments. Weeds were managed by pre emergent application of Londax power (Bensulfuron methyl 0.6% + Pretilachlor 6% GR) @10 kg ha^{-1}, at 2 DAS. Optimum plant population was maintained by thinning excess seedlings at 10 DAS leaving one seedling per hill. Healthy crop stand was ensured by adopting need based crop management practices. Five plants were selected, tagged randomly and were used for recording plant height, total dry matter (TDM) and leaf area index (LAI), which was calculated as ratio of leaf area per plant to area occupied by the plant. Yield attributes like productive tillers $hill^{-1}$, panicle length, filled grains $panicle^{-1}$, 1000 grain weight were recorded and finally grain and straw yield per ha were worked out. The data recorded were analysed statistically by following standard procedures.

Results and Discussion

Initial soil variability for available nitrogen, phosphorus and potassium during June 2015 are depicted in Fig. 1. The data revealed that, soil available nitrogen, phosphorous and potassium varied from 154 to 277, 45 to 152 and 200 to 346 kg for N, P_2O_5 and K_2O ha^{-1}, respectively. The quantity of nitrogen, phosphorous and potassium applied based on variability for targeted yield levels of aerobic rice clearly revealed there was saving in nitrogenous and potassic fertilizers to an extent of 36.98 per cent and 415 per cent respectively over blanket application of N&K as per recommendation.

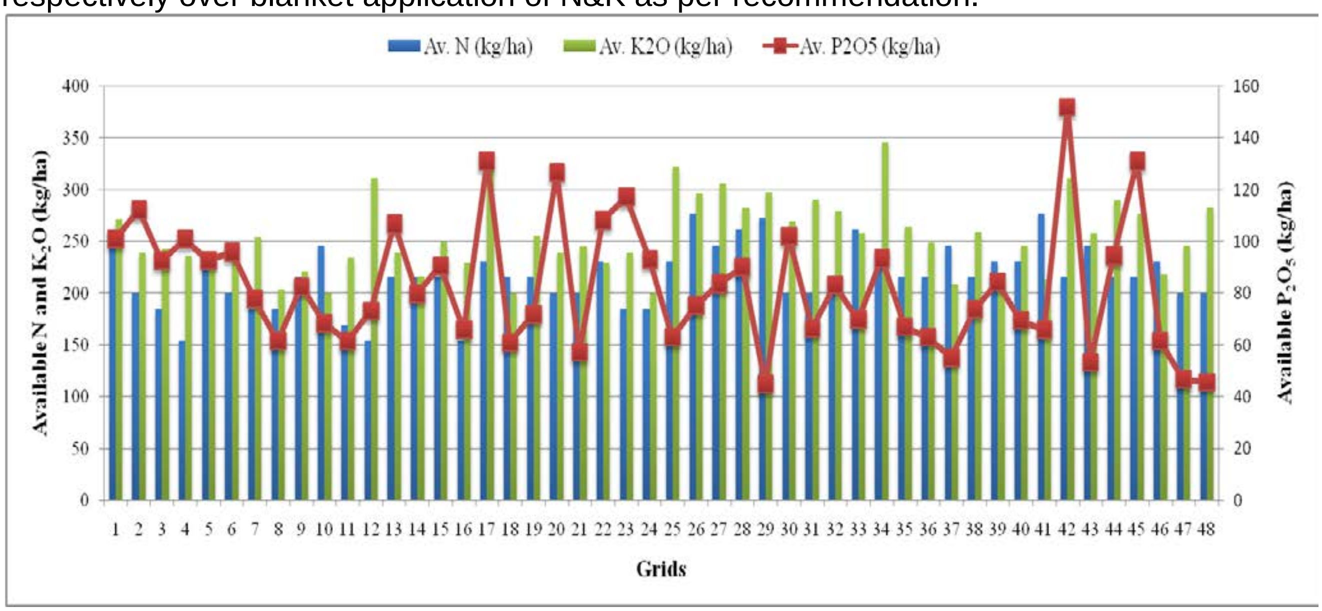

Fig. 1: Spatial variability of soil available nitrogen, phosphorus and potassium in the experimental site (June 2015).

Growth parameters

Growth parameters were significantly varied due to precision nutrient management practices (Table 1). Application of 25 % N & K from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS + 25 % from 81 to 105 DAS recorded significantly higher plant height (89.7 cm), LAI (5.8) and TDM (109.3 g plant^{-1}) over application of N&K as per package of practice (86.5 cm, 5.5 and 95.9 g plant^{-1}, respectively). Least plant height, LAI and TDM were observed under surface irrigation with soil application of fertilizers (72.9 cm, 4.1 and 61.9 g plant^{-1}, respectively). This increase in growth parameters was attributed to timely supply of nutrients as per crop needs which increases photosynthetic area of crop and thereby higher assimilation of photosynthates. Similar findings were reported by Sampathkumar and Pandian (2010) in maize; Vanitha and Mohandass (2014) in aerobic rice. Among targeted yield levels, targeted yield level of 12 Mg ha^{-1} recorded significantly higher plant height (95.0 cm), LAI (6.2) and TDM (132.1 g plant^{-1}) over rest of the targets. The better growth in higher targeted yield level is mainly due to the application of higher level of nutrients which lead to lesser dilution of nutrients per unit soil volume thereby higher uptake by crop. Similar results were observed by Murthy *et al.* (2012).

Table 1: Influence of precision nutrient management on growth parameters and yield of aerobic rice

Treatments	Plant height (cm)	LAI	TDM (g plant^{-1})	Grain yield (Mg ha^{-1})	Straw yield (Mg ha^{-1})
Precision nutrient management levels (L)					
L_1	86.5	5.5	95.9	9.2	10.6
L_2	89.7	5.8	109.3	11.0	12.7
L_3	87.0	5.7	107.5	9.6	11.1
S.Em±	0.39	0.05	1.71	0.20	0.23
CD @ 5%	1.11	0.16	4.91	0.58	0.67
Targeted yield levels (Y)					
*Y_1	79.6	5.0	78.5	7.3	8.5
Y_2	85.2	5.6	93.2	8.9	10.3
Y_3	91.2	5.9	113.0	10.8	12.4
Y_4	95.0	6.2	132.1	12.8	14.6
S.Em.±	0.45	0.06	1.98	0.24	0.27
CD @ 5%	1.28	0.18	5.67	0.68	0.78
Interaction (L×Y)					
S.Em.±	0.77	0.11	3.43	0.41	0.47
CD @ 5%	NS	NS	NS	NS	NS
Control	72.9	4.1	61.9	6.5	7.3

*Y_1-6 Mg ha^{-1}, Y_2-8 Mg ha^{-1},Y_3-10 Mg ha^{-1},Y_4-12 Mg ha^{-1}, NS- non significant

Yield and yield parameters

The yield and yield parameters *viz.,* number of productive tillers, panicle length, filled grains and thousand seed weight were significantly influenced by precision nutrient management levels and targeted yield levels (Table 1&2). Among precision nutrient management levels, application of 25 % N & K from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS + 25 % from 81 to 105 DAS recorded significantly higher yield and yield parameters like number of productive tillers (24.4 hill^{-1}), panicle length (24.6

cm), filled grains panicle^{-1} (429), thousand grain weight (18.2 g), higher grain yield (11.0 Mg ha^{-1}) and straw yield (12.7 Mg ha^{-1}) over application of N & K as per package of practice (9.2 and 10.6 Mg ha^{-1} of grain and straw yield, respectively). The higher yield and yield components were mainly due to higher dry matter production per unit area under split application of adequate quantity of nutrients at right time through drip fertigation which might have improved soil-water relationships. Sampathkumar and Pandian (2010) also observed the similar results in maize.

Table 2: Influence of precision nutrient management onyield parameters of aerobic rice

Treatments	No. of productive tillers hill^{-1}	Panicle length (cm)	Number of filled grains panicle^{-1}	Thousand grain weight (g)
Precision nutrient management levels (L)				
L_1	21.3	23.6	389	17.7
L_2	24.4	24.6	429	18.2
L_3	23.8	24.1	405	17.9
S.Em.±	0.37	0.15	6.04	0.05
CD @ 5%	1.06	0.44	17.32	0.16
Targeted yield levels (Y)				
*Y_1	19.7	23.5	349	16.9
Y_2	22.2	24.0	383	17.6
Y_3	24.5	24.5	417	18.2
Y_4	26.3	25.1	481	18.9
S.Em.±	0.43	0.18	6.97	0.06
CD @ 5%	1.22	0.51	20.00	0.18
Interaction (L×Y)				
S.Em±	0.74	0.31	12.08	0.11
CD @ 5%	NS	NS	NS	NS
Control	14.8	21.2	241	16.0

*Y_1-6 Mg ha^{-1}, Y_2-8 Mg ha^{-1},Y_3-10 Mg ha^{-1},Y_4-12 Mg ha^{-1}, NS- non significant

Among targeted yield levels, targeted yield of 12 Mg ha^{-1} recorded significantly higher number of productive tillers (26.3 hill^{-1}), panicle length (25.1 cm), filled grains panicle^{-1} (481), thousand grain weight (18.9 g), grain yield (12.8 Mg ha^{-1}) and straw yield (14.6 Mg ha^{-1}) over rest of the targets. This was mainly due to availability of adequate quantity of nutrients during critical stages of plant growth might have resulted in better growth characters and yield components at various phenological stages and finally on the yield. However, surface irrigation with soil application of nutrients recorded least grain (6.5 Mg ha^{-1}) and straw yield (7.3 Mg ha^{-1}). This was mainly due to inadequate supply of required plant nutrients and irrigation water. These results are in accordance with the findings of Bouman *et al.* (2002).

Conclusion

Overall results indicated that, application of 25 % N & K from sowing to 30 DAS + 25 % from 31 to 50 DAS + 25 % from 51 to 80 DAS + 25 % from 81 to 105 DAS through drip irrigation could achieved 20.2 per cent higher grain yield over application of N & K as per UAS (B) recommendations through drip irrigation and 70.1 per cent over soil application.

Similarly, the actual yields were 22.0, 11.3, 8.2 and 7.3 per cent higher than the targeted yields of 6, 8, 10 and 12 Mg ha^{-1}, respectively.

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