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Influence of Precision Management Practices on Growth and Yield of Drip Irrigated Aerobic Rice

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Abstract

Field experiment was conducted at ZARS, GKVK, UAS, Bengaluru to assess the precision management practices on growth and yield of aerobic rice during summer 2016. The results revealed that, among interactions between nutrient management, planting geometry and water management, application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×15 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity produced significant grain (8.68 t ha^{-1}) and straw (10.80 t ha^{-1}) yield than other interactions and recommended practices in aerobic rice.

Keywords: Precision management practices, aerobic rice, planting geometry, drip irrigation

Rice (*Oryza sativa* L.) is among the most widely used cereals across the globe, grown under diverse range of climatic conditions to feed the mankind. About 75 per cent of the world's rice is produced from 79 m. ha. of irrigated lowland fields that together receive an estimated 24-30 per cent of the world's developed freshwater resources (Bouman *et al.,* 2007). The high productivity of irrigated lowland rice, however, is threatened by increasing water scarcity. In the next 25 years, 15-20 m. ha. of lowland rice in Asia are projected to suffer from water scarcity. A new technology to respond to more severe water shortages is the aerobic rice system, in which specially developed, input – response rice varieties with "aerobic adaptation" are grown in well-drained, non-puddled, and unsaturated soils without ponded water just like wheat or maize. Water requirement in aerobic rice systems (with aerobic rice cultivars) were 30-50 per cent less than in flooded systems and the yields were almost 15-20 per cent higher than puddled rice (Nagaraju *et al.,* 2014).

Macronutrients like N, P and K are the most important yield limiting nutrients affecting growth and quality in rice. Nitrogen use efficiency (NUE) of rice is usually low due to volatilization, runoff, denitrification and leaching losses. Moreover, direct seeded rice soils are often exposed to dry and wet conditions and difference in N dynamics and losses pathways often results in different fertilizer recoveries in aerobic soils. Even high and non-synchronous applied nutrients and irrigation water may limit grain yield due to limited grain filling rate by decrease in post-anthesis assimilates translocation (Zhang *et al.,* 2009). Split application is one of strategies for efficient use of N fertilizers throughout the growing season by synchronizing with plant demand and improved N uptake for maximum straw and grain yield. The more precise way of supplying nutrients in split is through fertigation, which is the judicious application of fertilizers through irrigation water, which will maximize the nutrient uptake, while using minimum amount of water and fertilizer. Plant geometry in rice has a direct role on the grain yield, since it is an important yield parameter maintaining inadequate or excess plant population often leads to reduction in yield. So, finding out the optimum split doses of nutrients, plant population and irrigation scheduling is of major importance. Keeping the above facts in mind, the present study was conducted to standardize the precision management practices and to know their effects on growth and yield of aerobic rice

Material and Methods

A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru during summer 2016. The site is located at 13^0 05' 2" N latitude and 77^0 34'

02" E longitude with an altitude of 930 m above mean sea level. The soil of the experimental site was sandy loam. The initial soil pH was 5.93 and electrical conductivity was 0.34 dSm^{-1}. Available nitrogen, phosphorus and potassium were 319.3, 28.4 and 293.0 kg ha^{-1}, respectively. The experiment was laid out in Randomized Complete Block Design with factorial concept (FRCBD) and replicated thrice. Two nutrient management practices (N_1: 50% N&K from sowing to 30 DAS + 25% N&K from 31 to 50 DAS + 25% N&K from 51 to 80 DAS and N_2:25% N&K from sowing to 30 DAS + 25% N&K from 31 to 50 DAS + 25% N&K from 51 to 80 DAS + 25% N&K from 81 to 105 DAS), three planting geometry (P_1: 25×25 cm, P_2: 25×20 cm andP_3: 25×15 cm) and two water management practices (I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity and I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity) with one control (Recommended plant population and fertilizer dose with drip irrigation)and one absolute control (no RDF) were included in this study.

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. Seeds of MAS 946-1 rice variety were dibbled at 2 per hill by following spacing of 25cm × 25cm, 25cm × 20cm and 25cm × 15cm as per the treatment with seed rate of 5 kg ha^{-1}. FYM at 8 tonnes ha^{-1} was applied two weeks before sowing. The required fertilizer nutrients were calculated and was applied as per treatments whereas phosphorous was applied in two equal splits (50 per cent as basal and remaining 50 per cent at 30 DAS) uniform to all the treatments. The recommended dose of fertilizer was 100:50:50 kg N, P_2O_5 and K_2O ha^{-1}. Pre-sowing irrigation was uniformly given to all treatments. According to treatments drip irrigation was scheduled every day based on pan evaporation (Epan). As per treatment requirement fertigation was provided and the fertigation was scheduled at once in four days. Nitrogen and potassium were supplied through urea (46% N) and sulphate of potash (50% K_2O). However for control, muriate of potash used as potassium source and SSP as phosphorus source (for all the treatments). Londax power (Bensulfuron methyl 0.6% + Pretilachlor 6% GR) at 10 kg ha^{-1} was applied at 2 DAS as pre-emergence herbicide. Plant population was maintained according to the treatment by thinning excess seedlings at 21 DAS leaving one seedling per hill. Healthy crop stand was ensured by adopting need based plant protection and recommended package of practices. Five plants were selected at random and tagged. These plants were used for recording plant height, tillers, leaf area and leaf area index. Leaf area was measured using leaf area meter and LAI was calculated as ratio of leaf area per plant to area occupied by the plant. Yield attributes like number of productive tillers $hill^{-1}$, panicle length, panicle weight, grains $panicle^{-1}$, 1000 grain weight, grain yield, straw yield were recorded.The data was statistically analysed following standard procedures.

RESULTS AND DISCUSSION

Growth parameters of aerobic rice

Growth parameters of rice were significantly influenced by precision management practices (Table I). Significantly higher plant height (93.4 cm), numbers of tillers (28.86 $hill^{-1}$), total dry matter accumulation (127.51 g $hill^{-1}$) at harvest and leaf area (3324.99 cm^2 $hill^{-1}$) and LAI (6.87) at 90 DAS were recorded in the treatment receiving 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS (N_2) as compared to treatment receiving 50 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS (N_1). 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 also reported by Vanitha and Mohandass (2014) in aerobic rice.

Planting geometry of 25×15 cm *i.e.* 26 hills m^{-2} recorded significantly higher plant height (91.0 cm) at harvest and LAI (7.49) at 90 DAS. Higher plant height

TABLE I

Growth parameters of aerobic rice as influenced by precision management practices under drip irrigation

Treatments	Plant height (cm)	No. of tillers hill^{-1}	Leaf area (cm^2 hill^{-1})	LAI	Total dry matter accumulation (g hill^{-1})
Nutrient management (N)					
N_1	84.1	23.64	2723.99	5.61	87.68
N_2	93.4	28.86	3324.99	6.87	127.51
S. Em±	0.75	0.34	38.85	0.08	1.27
C. D.@5%	2.17	0.98	112.94	0.23	3.69
Planting geometry (P)					
P_1	85.8	28.38	3269.94	5.23	121.20
P_2	89.5	25.98	2993.45	5.99	107.47
P_3	91.0	24.39	2810.08	7.49	94.12
S. Em±	0.91	0.41	47.58	0.10	1.55
C. D.@5%	2.66	1.20	138.33	0.29	4.52
Water management (I)					
I_1	90.2	26.81	3088.17	6.38	111.18
I_2	87.4	25.70	2960.81	6.10	104.01
S. Em±	0.75	0.34	38.85	0.08	1.27
C. D.@5%	2.17	0.98	112.94	0.23	3.69
Nutrient management x Planting geometry x Water management (N x P x I)					
$N_1P_1I_1$	82.4	26.13	3010.73	4.82	103.36
$N_1P_1I_2$	81.3	25.80	2972.33	4.76	97.47
$N_1P_2I_1$	85.9	23.30	2684.31	5.37	92.04
$N_1P_2I_2$	83.7	22.90	2638.23	5.28	83.58
$N_1P_3I_1$	86.4	22.87	2634.39	7.03	77.77
$N_1P_3I_2$	84.8	20.87	2403.97	6.41	71.84
$N_2P_1I_1$	91.2	31.57	3636.68	5.82	145.98
$N_2P_1I_2$	88.2	30.03	3460.03	5.54	137.99
$N_2P_2I_1$	95.6	29.57	3406.27	6.81	130.23
$N_2P_2I_2$	92.9	28.17	3244.98	6.49	124.01
$N_2P_3I_1$	99.4	27.40	3156.66	8.42	117.71
$N_2P_3I_2$	93.2	26.43	3045.29	8.12	109.14
Control	75.3	18.21	2097.91	4.20	66.76
Absolute control	60.7	15.55	1792.23	3.58	44.83
S. Em±	1.83	0.83	95.17	0.20	3.11
C. D.@5%	3.76	2.40	276.6	0.57	9.03

Note: CD-Critical difference, NS-Non-significant

N_1: 50% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS

N_2:25% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS +25% N&K from 81 to 105 DAS

P_1: 16 hills m^{-2} (25×25 cm),P_2: 20 hills m^{-2} (25×20 cm), P_3: 26 hills m^{-2} (25×15 cm)

I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity

I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity

Control: Recommended plant population with soil application of fertilizer dose and drip irrigation

Absolute Control: (No RDF and drip irrigation) under higher plant density might be due to competition between individual plants for space and nutrients there by instead of horizontal spread, plant has shown more vertical growth under high population level. Similar results were also observed by Shashidhar (2011). Whereas, 25×25 cm *i.e.* 16 hills m^{-2} recorded significantly more numbers of tillers (28.38 $hill^{-1}$), total dry matter accumulation (121.20 g $hill^{-1}$) at harvest and leaf area (3269.94 cm^2 $hill^{-1}$) at 90 DAS.Wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw nutrients and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants (Shashidhar, 2011).

Among water management practices, drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity (I_1) recorded significantly higher growth parameters *viz.,* higher plant height (90.2 cm), numbers of tillers (26.81 $hill^{-1}$), total dry matter accumulation (111.18 g $hill^{-1}$) at harvest and leaf area (3088.17 cm^2 $hill^{-1}$) and LAI (6.38) at 90 DAS as compared to drip irrigation scheduling at 100 per cent PE up to tillering+125 per cent PE from tillering to PI+150 per cent PE from PI to physiological maturity (I_2). This might be due to availability of adequate moisture at different growth stages and continuous optimum soil moisture status in soil layer throughout the growth stages resulted in higher growth of the plant. Similar results were also reported by Balamani *et al.* (2012).

The interaction effect of nutrient management, planting geometry and water management with control and absolute control found to be significant. Application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×25 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity recorded more growth parameters than other interactions, control and absolute control. In control, soil application of nutrients only in two splits resulted in inadequate availability to the growing plants leading to reduced growth parameters.

Yield and yield parameters of aerobic rice

Yield attributes like number of productive tillers $hill^{-1}$, panicle length, panicle weight, test weight, total number of grains $panicle^{-1}$, grain yield and straw yield were favourably influenced by different precision management practices (Table II). Among nutrient management practices, N_2 *i.e.* 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS recorded significantly higher number of productive tillers (23.05 $hill^{-1}$), panicle length (23.80 cm), panicle weight (4.02 g), thousand grain weight (25.92 g), total number of grains (198.71 $panicle^{-1}$), grain yield (7.57 t ha^{-1}) and straw yield (9.43 t ha^{-1}) as compared to N_1 *i.e.* 50 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS. Availability of nutrients to crop at all critical growth stages and better translocation of assimilates to panicles during anthesis resulted in high yield parameters and grain yield (Patel *et al.,* 2010).

Among 3 different planting geometries, significantly higher number of productive tillers (23.05 $hill^{-1}$), panicle length (23.79 cm), panicle weight (4.02 g), thousand grain weight (25.92 g), and total number of grains (198.71 $panicle^{-1}$) were recorded in planting geometry of 25×25 cm but the higher grain yield of 7.17 t ha^{-1} and straw yield of 8.96 t ha^{-1} was recorded in case of planting geometry of 25×15 cm. Planting geometry of 25 cm x 15 cm accommodated more number of plants per unit area than 25 cm x 25 cm and provided optimum space for light interception, nutrient absorption and weed suppression. Hence the higher yield was observed in case of planting geometry of 25 cm x 15 cm. These results are in accordance with the findings of Sultana *et al.* (2012).

Significantly higher number of productive tillers (21.57 $hill^{-1}$), panicle length (22.15 cm), panicle weight (3.74 g), thousand grain weight (24.12 g), total number of grains (172.30 $panicle^{-1}$), grain yield (6.56 t ha^{-1}) and straw yield (8.22 t ha^{-1}) were recorded when drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per

TABLE II

Yield parameters and yield of aerobic rice as influenced by precision management practices under drip irrigation

Treatments	No. of productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (cm)	Thousand grain weight (g)	Total No. of grains panicle^{-1}	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Nutrient management (N)							
N_1	19.49	19.67	3.36	21.43	134.88	5.14	6.48
N_2	23.05	23.79	4.02	25.92	198.71	7.57	9.43
S.Em±	0.25	0.16	0.03	0.19	1.97	0.08	0.09
C.D. (P=0.05)	0.74	0.48	0.09	0.57	5.74	0.22	0.27
Planting geometry (P)							
P_1	22.85	23.16	3.91	25.23	188.17	5.54	6.96
P_2	21.15	21.78	3.68	23.73	166.78	6.35	7.95
P_3	19.82	20.26	3.48	22.07	145.45	7.17	8.96
S.Em±	0.31	0.20	0.04	0.24	2.42	0.09	0.11
C.D. (P=0.05)	0.91	0.58	0.11	0.69	7.03	0.27	0.33
Water management (I)							
P_1	22.85	23.16	3.91	25.23	188.17	5.54	6.96
P_2	21.15	21.78	3.68	23.73	166.78	6.35	7.95
P_3	19.82	20.26	3.48	22.07	145.45	7.17	8.96
S.Em±	0.31	0.20	0.04	0.24	2.42	0.09	0.11
C.D. (P=0.05)	0.91	0.58	0.11	0.69	7.03	0.27	0.33
Nutrient management x Planting geometry x Water management (N x P x I)							
$N_1P_1I_1$	20.74	21.48	3.63	23.40	159.25	4.57	5.75
$N_1P_1I_2$	20.68	21.13	3.57	23.02	150.24	4.20	5.31
$N_1P_2I_1$	19.45	20.33	3.43	22.15	141.23	5.38	6.81
$N_1P_2I_2$	19.23	19.11	3.23	20.82	128.28	4.89	6.18
$N_1P_3I_1$	18.72	18.90	3.19	20.58	120.05	6.07	7.64
$N_1P_3I_2$	18.13	17.10	3.10	18.63	110.25	5.72	7.21
$N_2P_1I_1$	25.39	25.22	4.26	27.48	227.77	6.92	8.71
$N_2P_1I_2$	24.57	24.82	4.19	27.04	215.43	6.47	8.07
$N_2P_2I_1$	23.54	24.06	4.06	26.21	203.96	7.77	9.63
$N_2P_2I_2$	22.38	23.63	3.99	25.74	193.64	7.38	9.17
$N_2P_3I_1$	21.59	22.89	3.87	24.93	181.56	8.68	10.80
$N_2P_3I_2$	20.83	22.15	3.74	24.13	169.93	8.21	10.21
Control	16.10	16.34	3.04	18.28	102.90	3.92	4.94
Absolute control	10.28	12.82	2.25	17.30	69.04	2.63	3.32
S. Em±	0.62	0.40	0.08	0.48	4.84	0.18	0.23
C. D.@5%	1.81	1.16	0.22	1.38	14.05	0.53	0.66

Note: CD-Critical difference, NS-Non-significant

N_1: 50% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS

N_2:25% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS +25% N&K from 81 to 105 DAS

P_1: 16 hills m^{-2} (25×25 cm), P_2: 20 hills m^{-2} (25×20 cm), P_3: 26 hills m^{-2} (25×15 cm)

I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity

I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity

Control: Recommended plant population with soil application of fertilizer dose and drip irrigation

Absolute Control: (No RDF and drip irrigation) cent PE from PI to physiological maturity (I_1) compared to those with 100 per cent PE up to tillering+125 per cent PE from tillering to PI+150 per cent PE from PI to physiological maturity (I_2). Higher yield and yield component in I_1 might be due to adequate moisture regime and more frequent wettings at later stages of crop growth which might have facilitated to survive more number of productive tillers and to improve other yield attributes resulting in higher grain and straw yield (Shekara *et al.,* 2010).

The interaction effect of nutrient management, planting geometry and water management with control and absolute control found to be significant. Application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×15 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity recorded higher grain (8.68 t ha^{-1}) and straw (10.80 t ha^{-1}) yield than other interactions, control and absolute control. This might be due to adequate supply of required plant nutrients and water at later stages of crop growth. These results are in accordance with the findings of Sundrapandiyan (2012).

From the study, it can be concluded that application of N&K in 4 equal splits upto 105 DAS with plant density of 26 hills m^{-2} and drip irrigation at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity are the best precision management practices in rice for realising higher grain yield (8.68 t ha^{-1}).

References

Balamani, K., Ramulu, M., Reddy, D. M. and Umadevi, M., 2012, Effect of irrigation methods and irrigation schedules on aerobic rice *(Oryza sativa* L.*). J. Res. ANGRAU.,* **40** (4) : 84 - 86.

Bouman, B. A. M., Humphreys, E., Tuong, T. P. and Barker, R., 2007, Rice and water. *Adv. Agron.,* **92** : 187 - 234.

Nagaraju, Anusha, S., Gururaj Kombali, Rekha, B., Sheshadri, T. and Shankar, M. A., 2014, Drip irrigation and fertigation in direct seeded aerobic rice in Karnataka, India- research status. In: *Proc. 4th international rice congress* 27th Oct. - 1st Nov., Bangkok, Thailand, p. 1042 - 1043.

Patel, D. P., Das, A., Munda, G. C., Ghosh, P. K., Borodoloi, J. S. and Kumar, M., 2010. Evaluation of yield and physiological attributes of high-yielding rice cultivars under aerobic and flood-irrigated management practices in mid-hills ecosystem. *Agric. Water Manage.,* **97** : 1269 - 1276.

Shashidhar, B. N., 2011, Influence of plant density and method of establishment on the performance of hybrid rice under aerobic methods of cultivation. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

Shekara, B. G., Sharanappa and Krishnamurthy, N., 2010, Effect of irrigation schedules on growth and yield of aerobic rice (*Oryza sativa* L.) under varied levels of farm yard manure in Cauvery command area. *Indian J. Agron*., **55** : 35 - 39.

Sultana, M. R., Rahman, M. M. and Rahman, M. H., 2012, Effect of row and hill spacing on the yield performance of boro rice (cv. BRRI dhan45) under aerobic system of cultivation. *J. Bangladesh Agril. Univ.,* **10** (1) : 39 - 42.

Sundrapandiyan, R., 2012, Study on the effect of drip biogation on the productivity of aerobic rice, *M. Sc. (Agri.) Thesis*, Tamil Nadu Agril. Univ., Coimbatore.

Vanitha, K. and Mohandass, S., 2014, Effect of humic acid on plant growth characters and grain yield of drip fertigated aerobic rice (*Oryza sativa* L.). *The Bioscan,* **9** (1) : 45 - 50.

Zhang, L. S., Lin, B. A. M., Bouman, C., Xue, F., Wei, H., Tao, X., Yang, H., Wang, D., Zhao and Dittert, K., 2009, Response of aerobic rice growth and grain yield to N fertilizer at two contrasting sites near Beijing, China. *Field Crops Res.,* **114** : 45 - 53.

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