Mysore J. Agric. Sci., 52 (4) : 755-760 (2018)

Evaluation of Graded Levels of Nutrients and Different Irrigation Methods on Growth and Yield of Aerobic Rice

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ABSTRACT

A field experiment was conducted at Zonal Agricultural Research Station, V. C. Farm, Mandya, University of Agricultural Sciences, GKVK, Bengaluru during *kharif*-2017 to evaluate the graded levels of nutrients and different irrigation methods on growth and yield of aerobic rice. Among the different treatments, 125 per cent NPK through water soluble fertilizers recorded significantly higher grain yield (7881 kg ha^{-1}), straw yield (9300 kg ha^{-1}) and yield attributes *viz.,* total number of grains per panicle (328.0), panicle length (25.10 cm), panicle weight (5.20 g), productive tillers (30.40) and test weight (21.10 g) compared to recommended package of practice with surface irrigation (4098 kg ha^{-1}, 4869 kg ha^{-1}, 211.30, 16.17 cm, 3.35 g, 19.58 % 18.21, respectively). However, (T_6) 100 per cent NPK through water soluble fertilizers (7166 kg ha^{-1}, 8622 kg ha^{-1}, 295.50, 22.61 cm, 4.68 g, 27.39 and 20.01 g, respectively) was on par with the superior treatment (T_7). 125 per cent NPK treated through water soluble fertilizers also recorded significantly higher values for uptake of nitrogen, phosphorus and potassium by both straw and grain (128.41 and 90.64, 43.13 and 26.98, 51.35 and 157.29 kg ha^{-1}, respectively) and it was at par with treatment T_6.

Keywords: Nutrients, Water soluble fertilizers, Irrigation, Yield, Aerobic rice

RICE (*Oryza sativa* L.) is one of the most important staple food crops in Asia and it occupies the enviable prime place among the food crops after wheat. Human consumption accounts 85 per cent of total production of rice and it deserves a special status among cereals as world's most important wetland crop. But recent developments demonstrated that rice can also be grown under non flooded conditions also and generally called as "aerobic rice". Aerobic rice is a production system where in rice is grown in well-drained, non- puddled and unsaturated soils (Anonymous, 2007).

The estimated water availability for agriculture is 83.3 per cent of total water used today; it is anticipated to shrink upto 71.6 per cent in 2025 and upto 64.6 per cent in 2050 (Anonymous, 2012). The shrinking water resources and competition from other sectors leads to 10 to 15 per cent decrease in the share of water allocated to irrigation in the next two decades. Limited supply of water necessitates a shift in the production from attainment of potential yield per unit of land to potential yield per unit of water.

Drip irrigation, also known as trickle irrigation is an irrigation method that applies water slowly to the root zone of plants. The goal is to optimize water and input usage. Drip irrigation reduces deep percolation, evaporation and controls soil water status more precisely within the crop root zone (Vanitha and Mohandass, 2014).

Fertilizer application in wetland rice farming is currently done manually through soil application in split doses. The technique employed is not precise and cause problems of fluctuating nutrient supply and uneven fertilizer spread. This leads to various losses of nutrients under submerged cultivation including loss of water and fertilizers through seepage and percolation and also contributing to global warming through considerable emission of methane (Bouman *et al*., 2008).

Addressing these issues, require an integrated approach in soil-water-plant nutrient management at the plant rooting zone. Drip irrigation is the novel technique where in water is applied to the root zone in required quantity at right time matching with the demand of crop. In addition, simultaneous application of fertilizers (fertigation) opens new possibilities for controlling water and nutrient supply to crops besides maintaining the desired concentration and distribution of nutrients and water in the soil. In drip-fertigation system, uptake of N, P and K are substantially improved.

The research pertaining to drip irrigation and fertigation related research in aerobic rice is very limited particularly on optimal scheduling of drip irrigation, fertigation and source of fertilizer to be applied. Keeping these things in the view, the present investigation was undertaken to evaluate the graded levels of nutrients and different irrigation methods on growth and yield of aerobic rice.

Material and Methods

Field experiment was conducted during *kharif* 2017 at Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, V.C. Farm, Mandya, Southern Dry Zone (Zone 6), Karnataka. The experimental site is located between 12º 51' and latitude and 77º 35' E longitude at an altitude of 930 m above mean sea level (MSL). The soil was sandy loam in texture with organic carbon of 0.47 per cent. The initial nitrogen, phosphorus and potassium contents of the soil were 167.3, 19.8 and 172.2 kg ha^{-1}, respectively. The soil pH was 7.3 with an EC of 0.09 ds m^{-1}. Paddy (KRH-4) was taken up as a test crop. Recommended dose of fertilizer is 125: 62.5: 62.5 kg of N, P_2O_5 and K_2O per ha. In this investigation, 12 different treatment combinations were tried in RCBD with 3 replications.

The treatments were :

T_1 - Absolute control with surface irrigation

T_2 - Absolute control with drip irrigation

T_3 - Package of practice with surface irrigation

T_4 - 50 % N, P and K – Water soluble fertilizer (WSF)

T_5 - 75 % N, P and K – WSF

T_6 - 100 % N, P and K – WSF

T_7 - 125 % N, P and K - WSF

T_8 - 50 % N, P and K - Conventional fertilizer (CF)

T_9 - 75 % N, P and K - CF

T_{10} - 100 % N, P and K - CF

T_{11} - 125 % N, P and K - CF

T_{12} - 100 % N & K- WSF and P - CF

The plot size was 10 m × 6 m (60 m^2) and a pre germinated paddy seed was dibbled at a spacing of 30 x 30 cm. FYM was applied 15 days before sowing to all the treatments at the rate of 10 t ha^{-1}. The drip line was passed in between two consecutive rows by skipping one row alternatively, which includes18 emitters in each row at a distance of 30 cm with a total of 180 emitters per plot. This system included pump, filter units, fertigation tank, ventury, main line and sub line for each replication and a lateral for each plot.

The quantity of water to be irrigated was calculated based on daily pan evaporation (Epan). The experimental plot was irrigated once in two days. Fertigation was done through ventury system at 4 days interval. Fertilizer solution was filled in plastic bucket and connected to suction device of ventury. Fertigation of nitrogen, phosphorus and potassium in case of water soluble fertilizers was through water soluble urea, mono ammonium phosphate (MAP) and KCl, respectively. Conventional fertilizers (urea and muriate of potash) were applied through drip irrigation and phosphorus (single super phosphate) was applied directly to soil.

Observations were made on growth and yield attributes like plant height, number of tillers, leaf area, number of productive tillers, panicle length, panicle weight, total number of grains per panicle, thousand grain weight, grain and straw yield. Uptake of nitrogen, phosphorus and potassium were calculated using the below mentioned formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%)}}{100} \text{ X Biomass (kg ha}^{-1})$$

Results and Discussion

Growth parameters of aerobic rice at harvest as influenced by graded levels of nutrients and different irrigation methods

Plant height varied significantly at harvest due to graded levels of nutrients and different irrigation methods (Table 1). Highest plant height of 94.20 cm was recorded in 125 per cent N, P and K through water soluble fertilizer treatment (T_7) which was on par with 100 per cent N, P and K through water soluble fertilizer treatment (T_6) that recorded plant height of 84.87 cm. The lowest plant height of 52.58 cm was recorded in absolute control with surface irrigation method. Apart from absolute control, the plot that received fertilizers as per package of practice and surface irrigation showed lower plant height of 60.67 cm.

Table 1

Growth parameters of aerobic rice as influenced by graded levels of nutrients and irrigation methods

Treatments	Plant height (cm)	No of tillers	Leaf area (cm^2)	Total dry matter (g $hill^{-1}$)
T_1	52.98	19.94	603.1	76.63
T_2	55.58	20.92	632.7	80.40
T_3	60.67	22.84	690.6	87.76
T_4	68.90	25.93	784.2	99.66
T_5	72.02	27.11	819.8	104.1
T_6	84.87	31.95	966.0	122.7
T_7	94.20	35.46	1072	136.2
T_8	68.39	25.74	778.4	98.92
T_9	70.72	26.62	805.0	102.3
T_{10}	77.19	29.06	878.6	111.6
T_{11}	77.32	29.10	880.1	111.8
T_{12}	77.55	29.19	882.7	112.1
S.Em ±	5.22	1.97	59.44	07.55
CD @ 5 %	15.32	5.77	174.3	22.15

Number of tillers in the aerobic rice varied significantly at harvest varied significantly. 125 per cent N, P and K through water soluble fertilizer treatment (T_7) showed highest number of tillers (35.46) which was on par (31.95) with 100 per cent N, P and K through water soluble fertilizers (T_6). The lowest numbers of tillers (19.94) was recorded under surface irrigation with no fertilizer.

Leaf area and total dry matter of aerobic rice also showed significant difference for graded levels of nutrient application and different methods of irrigation. The leaf area and dry matter of 1072 cm^2 and 136.2 g $hill^{-1}$ were highest in the treatment that received 125 per cent N, P and K through water soluble fertilizer treatment (T_7) which was on par with T_6 treatment that received 100 per cent N, P and K through water soluble fertilizer (966.0 cm^2 and 122.7 g/hill, respectively). The improvement in growth parameters could be attributed to continuous supply of water there by maintaining optimum water and nutrient availability throughout crop growth in drip irrigations.

This variation in growth parameters under surface and drip irrigation system was mainly due to the differences in wetting patterns, water distributions in soil and relative water use by crop. Similar findings were reported by Sharma *et al*. (2013). Govindan and Grace (2012) have also mentioned that the beneficial effect of drip fertigation might have been vested with the more number of functional leaves, leaf area, increased tiller number and rate of photosynthesis that in turn increased productivity in different rice varieties.

Yield and yield parameters of aerobic rice at harvest as influenced by graded levels of nutrients and different irrigation methods.

There was significant difference among the treatments due to graded levels of nutrients and irrigation methods on yield parameters (Table 2).

Significantly higher yield parameters like total number of grain per panicle, panicle length (cm), panicle weight (g) and productive tillers of 94.20, 35.46, 1072 and 136.2, respectively were recorded in the treatment that

TABLE 2

Yield parameters of aerobic rice as influenced by graded levels of nutrients and irrigation methods

Treatments	Plant height (cm)	No of tillers	Leaf area (cm^2)	Total dry matter (g $hill^{-1}$)
T_1	184.5	14.12	2.92	17.10
T_2	193.5	14.81	3.07	17.94
T_3	211.3	16.17	3.35	19.58
T_4	239.9	18.36	3.80	22.23
T_5	250.8	19.19	3.98	23.24
T_6	295.5	22.61	4.68	27.39
T_7	328.0	25.10	5.20	30.40
T_8	238.1	18.22	3.77	22.07
T_9	246.3	18.84	3.90	22.82
T_{10}	268.8	20.57	4.26	24.91
T_{11}	269.2	20.60	4.27	24.95
T_{12}	270.0	20.66	4.28	25.03
S.Em ±	18.18	01.39	0.29	1.69
CD @ 5 %	53.30	04.08	0.85	4.94

TABLE 3

Yield, test weight and harvest index of aerobic rice as influenced by graded levels of nutrients and irrigation methods

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Test weight (g)	Harvest index
T_1	2711	3299	17.87	0.45
T_2	3087	3643	18.01	0.46
T_3	4098	4869	18.21	0.46
T_4	5817	6864	18.43	0.46
T_5	6081	7142	19.13	0.46
T_6	7166	8622	20.01	0.45
T_7	7881	9300	21.10	0.46
T_8	5774	6813	18.32	0.46
T_9	5971	6973	18.84	0.46
T_{10}	6517	7623	19.29	0.46
T_{11}	6528	7670	19.32	0.46
T_{12}	6747	7816	19.37	0.46
S.Em ±	423.9	486.02	1.17	
CD @ 5 %	1243	1426	3.43	NS

received 125 per cent N, P and K through water soluble fertilizer (T_7) and was on par with 100 per cent N, P and K through water soluble fertilizer (T_6) recorded 295.5, 22.61cm, 4.68g and 27.39, respectively for the former yield parameters. The lowest values of 184.5, 14.12, 2.92 and 17.10 for total number of grain per panicle, panicle length (cm), panicle weight (g) and productive tillers, respectively were recorded in absolute control treatment with surface irrigation.

There was significant difference in yield parameters among the treatments due to graded levels of nutrients and irrigation methods (Table 3). Significantly higher grain and straw yield of 7881 and 9300 kg ha^{-1}, were obtained in the treatment that received 125 per cent N, P and K through water soluble fertilizer treatment (T_7). This was on par with 100 per cent N, P and K through water soluble fertilizer (T_6) (7166 & 8622 kg/ha respectively). Both these treatments were among the set of nutrient supplied through water soluble fertilizers and drip irrigation. Among the treatments that received conventional fertilizers, the treatment that received 125 per cent N, P and K and with surface method of irrigation (T_{12}) recorded higher grain and straw yield of 6747 and 7816 kg/ha, respectively.

The lowest grain and straw yield of 2711 and 3299 kg ha^{-1}, respectively was recorded in the absolute control treatment with surface irrigation method (T_1). Apart from the absolute control treatments, the plot that received fertilizers as per package of practice and surface irrigation (T_3) showed lower grain and straw yield of 4098 and 4869 kg ha^{-1}, respectively. Harvest index showed non significant difference among the treatments. However 125 per cent N, P and K through water soluble fertilizer treatment (T_7) recorded higher HI.

Test weight of rice grain after the harvest also showed significant difference among the treatments. Significantly higher test weight (21.10 g) was obtained in the treatment that received 125 per cent N, P and K through water soluble fertilizer treatment (T_7) and this was on par 100 per cent N, P and K through water soluble fertilizer (T_6) that recorded 20.01 g. Lowest test weight of 17.87 g was recorded in the absolute control treatment with surface irrigation method (T_1).

Higher grain yield recorded in 125 per cent N, P and K treatment might be due to its superiority in producing higher productive tillers hill^{-1}, panicle length, thousand seed weight and total number of grains panicle^{-1} and these observations are in line with the findings of Gururaj, (2013).

The increase in yield attributes under drip fertigation might be due to enhanced availability and uptake of nutrients leading to enhanced photosynthesis, expansion of leaves and translocation of nutrients to reproductive parts compared to conventional method of nutrient application to soil and the findings are also in line with Parthasarathi *et al.,* (2012).

The increase in yield attributes and yield under drip irrigation might be due to efficient water utilization, higher absorption and accumulation of nutrients by crop Sharma *et al.,* (2013). Surface irrigation in contrast resulted in considerable wastage of water and plant nutrients and imbalanced soil water-nutrient environment leading to the declined grain and straw yield and similar results reported by Balamani *et al.,* (2012).

Uptake of major nutrients as influenced by graded levels of nutrients and different irrigation methods

Application of 125 per cent of recommended dose of fertilizers (T_7) recorded significantly higher uptake of nitrogen, phosphorus and potassium in grain and straw (128.41and 90.64, 43.13 and 26.98, 51.35 and 157.29, respectively) (Fig. 1). This treatment was on par with 100 per cent N, P and K through water soluble fertilizer (T_6). Lower uptake of N, P and K in both straw and grain was observed in the in the absolute control treatment with surface irrigation method (T_1). Higher fertilizer dose have marked influence on N, P and K uptake due to increased dry matter production and also higher nutrient content in the aerobic rice. Use of higher dose of nitrogen might have helped in inducing good vegetative growth and root system, which increased the higher N uptake. The higher NPK uptake by drip irrigation observed might be due to proper soil moisture which facilitated higher absorption of nutrients by aerobic rice than surface irrigation. In general surface irrigation, leads to uneven distribution of water in the aerobic rice plots. Fanish *et al*., (2011) found that maintaining high soil moisture content favoured high nutrient uptake under aerobic crops. Decrease in total N, P and K uptake was observed in aerobic rice with surface irrigation was due to reduced soil moisture which might have reduced nitrate reductase activity, nitrification and P diffusion through the soil to root surface.

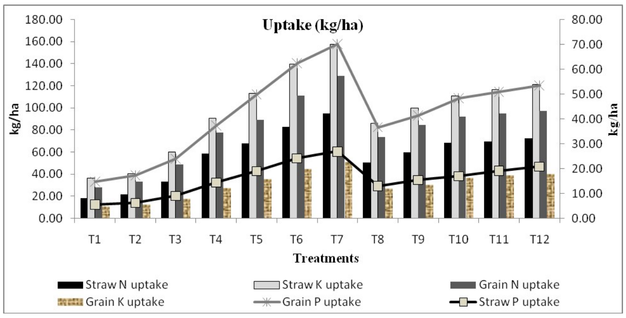

Fig. 1: Straw and grain uptake of N, P and K (kg ha^{-1}) by aerobic rice as influenced by graded levels of nutrients and irrigation methods

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(*Received :* May, 2018 *Accepted :* October, 2018)