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Influence of Planting Geometry and Growth Regulators on Productivity of Rice under Aerobic Condition

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Abstract

A field experiment was conducted during *kharif* 2015 at ZARS, GKVK, Bengaluru in red sandy loam soil (pH 7.1; OC 0.67 %) with medium available nitrogen (333.7 kg ha^{-1}), phosphorus (43.6 kg ha^{-1}) and potassium (258.0 kg ha^{-1}). Experiment was laid out in RCBD with factorial analysis, consisting of planting geometry (25 cm × 10 cm, 25 cm × 15 cm and 25 cm × 25 cm) and application of growth regulators (NAA at 50 ppm and 100 ppm, Deconal at 4 and 8 per cent and no application of growth regulators) at maximum tillering stage. Planting geometry of 25 cm × 25 cm and application of NAA at 100 ppm recorded significantly higher number of leaves (91.90 and 104.87 plant^{-1}), leaf area (2015 and 2196 cm^2 plant^{-1}), number of tillers (29.15 and 32.81 plant^{-1}), total dry matter production (94.51 and 91.49 g plant^{-1}), test weight (23.99 and 23.81 g) and filled grains (69.85 and 74.01 panicle^{-1}). Planting geometry of 25 cm×15 cm and application of NAA at 100 ppm recorded significantly higher productive tillers (18.85 and 22.77 plant^{-1}), grain yield (5111 and 5618 kg ha^{-1}), straw yield (7185 and 7651 kg ha^{-1}), gross returns (89,305 and 99,136 Rs. ha^{-1}), net returns (53,230 and 61,621 Rs. ha^{-1}) and B:C (2.47 and 2.54).

Keywords : Aerobic rice, Geometry, Growth regulators, Yield

Rice (*Oryza sativa* L.) is the most important cereal food crop of the world and grown on an area of 150 million hectares with annual production of 525 million tonnes, constituting nearly 11 per cent of the world's cultivated land. More than 90 per cent of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition.

Rice occupies a pivotal place in Indian agriculture and it contributes to 15 per cent of annual GDP. It accounts for about 42 per cent of total food grain production and 55 per cent of cereal production in the country. In India, it is grown in an area of 46.19 m ha hectare with a production of 106.29 m t and productivity of 2462 kg ha^{-1}. In Karnataka, rice is grown in an area of 1.34 m ha with an annual production of 3.95 million tonnes with productivity of 3098 kg ha^{-1} (Anon., 2015).

Rice consumes around 4000-5000 litres of water to produce one kg grain, which is three times higher than other cereals (Anon., 2015). Irrigated lowland rice is consequently the most important agricultural ecosystem in Asia. However, there are signs that declining water availability is threatening the sustainability of this system. In view of these demands and constraints, the question is - does rice need standing water for optimum production? Flooding in rice is used as management tool, not a specific requirement. Rice is unique in the sense that transplanted paddy requires lot of water for land preparation. Can we go for an alternative that reduces this component? As a result, the concept of aerobic rice was first developed in China (Bouman and Tuong, 2001). The term "Aerobic rice" was coined by International Rice Research Institute (Bouman *et al*., 2002).

The number of unproductive tillers per plant are more in aerobic rice than transplanted rice, to maximise the productive tillers use of growth regulators found to be an option. Few research works reported the use of growth regulators in rice to maximize the productivity.

Keeping these points in view, the present investigation on 'Influence of planting geometry and growth regulators on productivity of rice (*Oryza sativa* L.) under aerobic condition' was under taken during *kharif* 2015 at Agronomy field unit, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru.

Material and Methods

A field experiment was conducted during *kharif* 2015 at ZARS, GKVK, Bengaluru in red sandy loam soil (pH 7.1; OC 0.67 %) with medium available nitrogen (333.7 kg ha^{-1}), phosphorus (43.6 kg ha^{-1}) and potassium (258.0 kg ha^{-1}). Experiment was laid out in RCBD with factorial analysis, consisting of planting geometry (25 cm × 10 cm, 25 cm × 15 cm and 25 cm × 25 cm) and application of growth regulators (NAA at 50 ppm and 100 ppm, Deconal at 4 and 8 per cent and no application of growth regulators) at maximum tillering stage. The aerobic rice variety MAS-946 developed by the University of Agricultural Sciences, Bangalore was used for the experiment. The land was prepared by using a tractor drawn disc plough once followed by cultivator twice. The sowing was taken up on 8th July, 2015 by maintaining spacing as per the treatments using seed rate of five kg ha^{-1}. Immediately after sowing the seeds were covered with soil with the help of wooden plank. FYM was applied before 15 days of sowing to all the treatment plots at the rate of 10 tonnes ha^{-1}. Fertilizers were applied as per the recommendation. Out of 100:50:50 N, P_2O_5 and K_2O kg ha^{-1}nutrients, 50 per cent N and the entire dose of P and K were applied as basal and remaining 50 per cent N in two equal splits at 30 and 60 DAS, respectively. All plots were irrigated with a depth of 5 cm immediately after sowing and subsequent irrigation were given at a depth of 4 cm at 5 days interval throughout the crop growth period of the crop. Depending upon rainfall the irrigation was given.

Table 1

Leaf area of rice at different growth stages as influenced by planting geometry and growth regulators under aerobic condition

(Leaf area - cm^2 plant^{-1})

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	Harvest
Factor A: Planting geometry					
A_1	31	774	1880	1892	1733
A_2	33	882	2078	1940	1792
A_3	38	972	2299	2131	2015
S.Em±	1.03	27.11	53.35	38.46	62.03
CD (p=0.05)	NS	78.21	153.87	110.94	178.91
Factor B : Growth regulators					
B_1	35	886	2319	2147	2009
B_2	37	970	2766	2419	2196
B_3	33	852	1922	1853	1835
B_4	33	839	1787	1775	1643
B_5	32	833	1625	1602	1551
S.Em±	1.33	35.00	68.87	49.66	80.08
CD(p=0.05)	NS	NS	198.15	143.23	230.96
Interaction					
S.Em±	6.63	60.63	119.29	86.01	138.70
CD(p=0.05)	NS	NS	NS	NS	NS

Note: **NS:** Non-significant. DAS: Days after sowing.

Planting geometry **(A):**
A1: 25 cm x 10 cm
A2: 25 cm x 15 cm
A3: 25 cm x 25 cm

Growth regulators (B):
B1: Application of NAA @ 50 ppm
B2: Application of NAA @ 100 ppm
B3: Application of Deconal @ 4%
B4: Application of of Deconal @ 8%
B5: No Application of growth regulators

Irrigation was stopped a week prior to harvest of the crop. The weeds are the major problem in aerobic rice. To control weeds pre emergent herbicide pyrazosulfuron ethyl (10% WP) was applied at 20 g a.i ha^{-1} on moist soil at three days after sowing and three hand weeding were done manually at 25, 45 and 75 DAS in order to keep the plots weed free. During the experimental period, the crop was slightly affected by blast and stem borer. To avoid the crop damage due to these incidents pesticides *viz.,* Chlorpyriphos and Tricyclazole were sprayed (at the rate of 2 ml L^{-1} and 1 g L^{-1}, respectively) to overcome minor incidence of stem borer and blast. The crop was harvested on 24th November, 2015 at 134 days after sowing as the ear heads turned brownish colour coupled with straw turned to yellowish colour in more than 90 per cent plants.The cost of cultivation was computed by considering the present prices of inputs prevailed during their use for different treatments. Similarly, the prevailing market price for rice and straw value was considered for calculating gross return. The per hectare cost of cultivation was deducted from per hectare gross returns to get per hectare net returns. Data recorded on various observations was subjected to analysis of variance given by Rangaswamy (2010). The level of significance used in 'F' and 't' tests were at $p \leq 0.05$, critical difference values were calculated wherever the 'F' test was found to be significant.

Results and Discussion

Significantly higher leaf area (972, 2299, 2131 and 2015 cm^2 $plant^{-1}$ at 60, 90, 120 DAS and at harvest,

Table 2

Total dry matter production of rice at different growth stages as influenced by planting geometry and growth regulators under aerobic condition (dry matter production - g $plant^{-1}$)

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	Harvest
Factor A: Planting geometry					
A_1	0.97	23.99	44.20	86.01	89.06
A_2	1.33	26.35	46.13	88.96	91.63
A_3	1.65	28.85	49.12	92.04	94.51
S.Em±	0.05	0.64	1.19	1.66	1.79
CD (p=0.05)	0.14	1.84	3.42	4.78	5.15
Factor B : Growth regulators					
B_1	1.36	27.80	48.41	90.96	93.66
B_2	1.45	28.08	49.80	93.84	97.78
B_3	1.27	26.31	47.00	88.69	91.49
B_4	1.25	25.79	44.15	86.39	89.33
B_5	1.24	24.76	43.07	85.14	88.07
S.Em±	0.06	0.82	1.53	2.14	2.13
CD (p=0.05)	NS	NS	4.42	6.17	6.65
Interaction					
S.Em±	0.11	1.43	2.65	3.70	3.99
CD (p=0.05)	NS	NS	NS	NS	NS

Note: **NS:** Non-significant. DAS: Days after sowing.

Planting geometry **(A):**
A1: 25 cm x 10 cm
A2: 25 cm x 15 cm
A3: 25 cm x 25 cm

Growth regulators (B):
B1: Application of NAA @ 50 ppm
B2: Application of NAA @ 100 ppm
B3: Application of Deconal @ 4%
B4: Application of of Deconal @ 8%
B5: No Application of growth regulators

respectively) was noticed in 25 cm x 25 cm followed by 25 cm x 15 cm. However, significantly lower leaf area recorded in 25 cm x 10 cm (Table 1). This is mainly due to effective utilisation of moisture, nutrients and solar radiation due to less competition among the plants. Similar observations are also noticed by Shashidhar (2011) who found that 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 the nutrition and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants.

Application of NAA at 100 ppm has recorded significantly higher leaf area (2766, 2419 and 2196 cm^2 $plant^{-1}$ at 90, 120 DAS and at harvest, respectively) followed by application of NAA at 50 ppm and deconal at 4 per cent. However, Significantly lower leaf area was recorded with no application of growth regulators followed by application of deconal at 8 per cent (Table 1). Application of NAA as promotes taller plants, more number of leaves and more number of tillers resulting in higher leaf area (Tiwari *et al*., 2011).

Planting geometry of 25 cm x 25 cm recorded significantly higher total dry matter production from

TABLE 3

Number of productive and unproductive tillers $plant^{-1}$ in rice as influenced by planting geometry and growth regulators under aerobic condition

Treatments	Productive tillers	Unproductive tillers	Total tillers
Factor A: Planting geometry			
A_1	17.21	8.44	25.65
A_2	18.85	8.40	27.25
A_3	16.85	12.29	29.15
S.Em±	0.51	0.34	0.73
CD (p=0.05)	1.47	0.99	2.10
Factor B : Growth regulators			
B_1	19.54	9.46	29.78
B_2	22.77	8.58	32.76
B_3	16.98	9.80	26.98
B_4	15.35	10.15	25.19
B_5	13.54	10.56	22.03
S.Em±	0.66	0.44	0.94
CD (p=0.05)	1.90	1.28	2.71
Interaction			
S.Em±	1.14	0.77	1.63
CD (p=0.05)	NS	NS	NS

Note:
NS: Non-significant. DAS: Days after sowing.
Planting geometry **(A):** Growth regulators (B):
A1: 25 cm x 10 cm **B1**: Application of NAA @ 50 ppm
A2: 25 cm x 15 cm **B2**: Application of NAA @ 100 ppm
A3: 25 cm x 25 cm **B3**: Application of Deconal @ 4%
B4: Application of of Deconal @ 8%
B5: No Application of growth regulators

TABLE 4

Grain yield, straw yield and harvest index of rice as influenced by planting geometry and growth regulators under aerobic condition

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
Factor A: Planting geometry			
A^1	4862	6974	0.410
A_2	5111	7185	0.415
A_3	4636	6728	0.407
S.Em±	129.18	123.19	0.008
CD (p=0.05)	372.6	355.22	0.022
Factor B: Growth regulators			
B_1	5428	7541	0.0418
B_2	5618	7651	0.424
B_3	4896	6969	0.413
B_4	4448	6552	0.404
B_5	4060	6098	0.394
S.Em±	166.77	159.04	0.01
CD (p=0.05)	481.03	458.71	0.029
Interaction			
S.Em±	288.86	275.46	0.017
CD (p=0.05)	NS	NS	NS

Note:
NS: Non-significant. DAS: Days after sowing.
Planting geometry **(A):** Growth regulators (B):
A1: 25 cm x 10 cm **B1**: Application of NAA @ 50 ppm
A2: 25 cm x 15 cm **B2**: Application of NAA @ 100 ppm
A3: 25 cm x 25 cm **B3**: Application of Deconal @ 4%
B4: Application of of Deconal @ 8%
B5: No Application of growth regulators

TABLE 5

Economics of rice as influenced by planting geometry and Growth regulators under aerobic condition

Treatments	Cost of cultivaton (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Planting geometry				
A_1	36255	84481	48226	2.33
A_2	36075	89305	53230	2.47
A_3	35895	80058	44163	2.23
S.Em±	-	2077.60	2127.60	0.07
CD (p=0.05)	-	6557.73	6647.73	0.20
Growth regulators				
B_1	36315	95022	58707	2.51
B_2	37515	99136	61621	2.54
B_3	35515	85106	49591	2.39
B_4	35915	76393	40478	2.12
B_5	35115	66916	31801	1.90
S.Em±	-	2869.47	2429.47	0.09
CD (p=0.05)	-	7953.29	7213.29	0.25
Interaction				
S.Em±	-	5205.48	5002.41	0.15
CD (p=0.05)	-	NS	NS	NS

Note: **NS:** Non-significant. DAS: Days after sowing.
Planting geometry **(A):**
A1: 25 cm x 10 cm
A2: 25 cm x 15 cm
A3: 25 cm x 25 cm
Growth regulators (B):
B1: Application of NAA @ 50 ppm
B2: Application of NAA @ 100 ppm
B3: Application of Deconal @ 4%
B4: Application of of Deconal @ 8%
B5: No Application of growth regulators

60 DAS to harvest. However, significantly lower total dry matter production was noticed in planting geometry of 25 cm x 10 cm from 60 DAS to harvest (Table 2). Higher dry matter accumulation was a consequence of increased plant height, number of tillers plant^{-1} and more number of leaves. In most of the periodical observations these growth attributing parameters were significantly superior at planting geometry of 25 cm x 25 cm and resulting in higher dry matter (94.51 g plant^{-1}) at harvest as compared to rest of the treatments. These results are in conformity with the findings of Sultana (2012) and Faisul *et al*. (2013).

Application of NAA at 100 ppm recorded significantly higher total dry matter production followed by NAA at 50 ppm, deconal at 4 per cent and deconal at 8 per cent from 90 DAS to harvest. While, significantly lower total dry matter was recorded with no application of growth regulators from 90 DAS to harvest (Table 2). This is because of increased number of tillers and more number of leaves coupled with some biochemical and physiological aspects including total chlorophyll, soluble protein and delayed senescence of leaves, which increased the photosynthesis. This photosynthates production resulted in enhanced dry matter accumulation (Golam Adam and Jahan Nagis, 2011).

The number of productive tillers per plant were recorded significantly higher in 25 cm × 25 cm plant spacing (Table 3). Productive tillers increased linearly with increase in plant geometry but the increase may not maintain the number of productive tillers. This might be due to rectangular planting geometry provide optimum space for light interception, nutrient absorption and effective synchronization in translocation of assimilates. Findings are confirmed by the results of Nayak *et al*. (2003) and other studies.

Planting geometry significantly influenced the grain yield (Table 4). Significantly higher grain and straw yield was noticed in 25 cm x 15 cm (5111 and 7185 kg ha^{-1}, respectively), which is on par with planting geometry of 25 cm x 10 cm (4862 and 6974 kg ha^{-1}, respectively). This might be due to cumulative influence of higher plant population, more leaf area index, more of light interception and higher number of productive tillers resulting in increased grain and straw yield. The results are in accordance with Sultana *et al.* (2012) and Parashiva *et al*. (2011).

Planting geometry 25 cm x 15 cm recorded significantly higher gross income (89,305 Rs. ha^{-1}), net income (53,230 Rs. ha^{-1}) and benefit cost ratio (2.47) (Table 5). This might be due to effective utilization of growth factors providing optimum space for light interception, nutrient absorption and weed suppression resulted in higher grain yield which lead to higher gross returns, net returns and B:C ratio. These findings are in align with those of Sridhara *et al.* (2011).

Application of NAA at 100 ppm at maximum tillering stage recorded significantly higher gross income (99,136 Rs. ha^{-1}), net income (61,621 Rs. ha^{-1}) and benefit cost ratio (2.54). This might be due to better growth and yield attributes, which resulted in higher grain yield as compared to other treatments. This is agreement with the findings of Bokhsh *et al*., 2012.

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