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Identification of suitable intercrops performance under aerobic rice (*Oryza sativa* L) cultivation

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Abstract
A Field experiment was conducted during *Kharif* season of 2004 and 2005 at UAS, Hebbal Bangalore, to investigate the suitable intercrops performance under aerobic rice (*Oryza sativa*) cultivation. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replication having two factors, factor A (2) row patterns, and factor B: Intercrops (7) and thus experiment was comprised of 14 treatments. Normal row spacing: (45 x 20 cm) and in paired row spacing**:** (30/60 cm x 20. The Intercrop combinations were as follows, I_1 –Rice + Bhendi, I_2-Rice + Cluster bean,I_3-Rice + French bean, I_4-Ric+Ragi, I^5-Rice +Radish, I_6-Rice + Soybean,I_7-Rice + Sunhemph.Significantly higher grain yield (23.7q ha^{-1}) was obtained in paired row intercrops than in normal row (19.7q ha^{-1}) intercropping. Among various inter cropping systems, significantly higher grain yield (27.7 q ha^{-1}) was recorded with Rice + bhendi intercropping system and it was statistically on par with Rice+ cluster bean (26.0 q ha^{-1}) intercropping systems. Significantly lower grain yield (6.8 q ha^{-1}) was obtained in rice+ Ragi intercropping system.

Keywords: Suitable intercrops performance, aerobic rice, *Oryza sativa* L, cultivation

Introduction
Aerobic method is a new concept of growing rice. It is a production system which concentrates on direct seeding and irrigating intermittently, in contrast to the practices, such as, raising nursery, puddling, transplanting and submergence. Traditional rice cultivation requires field to remain flooded for four to five months for every crop and creates water losses through percolation into the soil, besides substantial evaporation and seepage losses. Traditional puddling system demands about 3,000 to 5,000 liters of freshwater to produce 1 kg of rice. In aerobic paddy, irrigation is applied as and when the soil becomes dry. Aerobic rice is one of the options to minimize water requirement of rice crop Aerobic rice production is one such alternate method which is known to use less water than lowland rice (Tabbal *et al*., 2002) [9]. Intercropping literally means growing two or more crops in a unit land area with a definite row pattern. Intercropping rice with various vegetables and green manuring crops is the new school of thought. The main objective of intercropping in rice is to achieve a substantial increase in rice yield with additional yield of vegetables and green manure for building up of the soil fertility. It is an age old practice of sustainable land use systems without degrading the soil fertility. Many a times, intercropping is one the most profitable ventures than the sole crop or monocropping. With this background, efforts were made to investigate suitable intercropping under aerobic method of rice cultivation trials entitled "Identification of suitable intercrops performance under aerobic rice (*Oryza sitva* L) cultivation" which were carried to know the performance of different intercrops in aerobic rice cultivation. Hence, shifting gradually from traditional rice production system to aerobically growing rice especially in water scarce irrigated low lands can mitigate occurrence of water-related problems (Castaneda *et al*., 2002) [3].

Material and Methods
The field experiments were conducted, in the Agronomy Field Unit, Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore, situated in the Eastern Dry Zone of Karnataka at 12° 58' N latitude 77° 35' E longitude with an altitude of 930 meters above mean sea level. The soil of the experimental site was red sandy loam in texture. The soil of the experimental site was slightly acidic in reaction (pH 6.7), low in available nitrogen (180.4 kg ha-1), medium in available phosphorus (29.4-30.1 kg ha-1) and available potassium (220.42 to 231.2 kg ha-1). The organic carbon content was low to medium (0.39 to 0.4%). Field capacity was 13.52 -13.54 per cent, permanent wilting point was 7.83-7.90 per cent, available water 1.64 -1.65 cm and Bulk density was 1.56 g/ccs.

The experiment was laid out on a randomized block design in three replications. The treatment comprised of combinations of two factors viz. – Row pattern (2) and intercrops (7) Row pattern, Normal and Paired row, Normal row spacing: (45 x 20 cm) with 10 rows and 16 plants /plot in gross plot of 4.5 x 3.2 m. and 6 rows with 12 plants in a net plot of 2.7 x 2.4 m. Paired row spacing: (30/60 cm x 20 cm) Gross plot: 4.5x 3.2 m (a spacing of 30 cm between rows of aerobic rice and 60 cm between pairs of rows.

The intercrop combinations were as follows I_1: Bhendi, I_2: Cluster bean, I_3: French beanI_4: Finger millet, I5: Radishn I_6: Soybean and I_7: Sunhemp After land preparation, well decomposed farm yard manure (FYM) was applied and equal quantity of farm yard manure at the rate of 10 t ha-1 was applied to each plot three weeks prior to sowing the recommended package of practices were followed for growing the crop. A common fertilizer dose of 100:50:50 kg N, P_2O_5 and K_2O ha^{-1} was adopted. Half of the fertilizer was applied as basal and the remaining quantity was applied in two equal splits at maximum tillering and panicle initiation stage. Overnight soaked seeds were manually dibbled at the rate of one seed per hill. Weeds were controlled by spraying Pretilochlor as pre emergent herbicide spray @ 0.75 kg per hectare. The late emerged weeds were controlled by hand weeding at regular intervals. Crop was irrigated as and when the soil developed cracks by following alternate wetting and drying cycles. Monocrotophos was sprayed @ 2 ml lit^{-1} in order to control the same. However from flowering to grain filling stage, soil was kept moist by giving irrigation at three to five days interval. The collected data on yield, plant characters and yield related attributes were analysed statistically by using "Analysis of Variance Technique" and the means were compared with the help of a statistical package programme MSTAT-C.

Results and Discussion

Significantly higher grain yield (23.7q ha^{-1}) was obtained in paired row intercrops than in normal row (19.7q ha^{-1}) intercropping table-2. The grain yield varied significantly in paired row (2:1) pattern on comparison to normal row (1:1) in aerobic rice grown with different intercrops. Higher leaf area (2544 cm^2), LAI (4.09) and LAD (70 days) were recorded with paired row intercropping compared to normal with leaf area 2236 cm^2, LAI 2.48 and LAD 43.6 days (table 1). Yield attributes (table-2) like more number of productive tillers (27.17 hill^{-1}), panicle length (23.8cm), number of grains (129) panicle^{-1}, panicle weight (3.39 g) and test weight (24.5 g) increased the grain yield of aerobic rice substantially as compared to normal row pattern. This was in conformity with the findings of Willey and Rao (1980). Significantly higher grain yield in paired row intercrops than in normal row intercropping is mainly due to higher leaf area (2544 cm2), LAI (4.02) and LAD (54 days) was recorded with paired row intercropping compared to normal with leaf area 2236.4 cm2, LAI 2.48 and LAD 43 days. Yield attributes like more number of productive tillers (27.17 hill^{-1}), panicle length (23.8cm), number of grains (153 panicle^{-1}), panicle weight (3.3 g) and test weight (24.15 g) increased the grain yield of aerobic rice substantially as compared to normal row pattern. These results are in corroboration with the findings of Sarkar et al. (2003). Higher straw yield (43.7q ha-^{1}) was recorded in paired rows which was significantly superior over the normal row (36.4q ha-^{1}) intercropping systems. These results are in conformity with Laskar *et al*. (2005) [6]

Among various inter cropping systems, significantly higher grain yield (27.7 q ha^{-1}) was recorded with Rice + bendi intercropping system and it was statistically on par with Rice+ cluster bean (26.0 q ha^{-1}) intercropping systems (Table-2). Significantly lower grain yield (6.8 q ha^{-1}) was obtained in rice+ Ragi intercropping system. Higher straw yield (46 q ha^{-1}) was recorded in paired rows which was significantly superior over the normal row (36.4q ha^{-1}) intercropping systems. The lower straw yield leads to a quantitative reduction in grain yield. The grain yield was found to be more adversely affected than the straw yield (Behera *et al*., 2002) [2]. Among various inter cropping systems, significantly higher grain yield (27.7 q ha^{-1}) was recorded with Rice + bhendi intercropping system and it was statistically on par with Rice+ cluster bean (26 q ha^{-1}) intercropping systems. Significantly lower grain yield (6.8 q ha^{-1}) was obtained in rice+ Ragi intercropping system. These results are in conformity with Singh *et al*. (2007) [8], who reported highest rice equivalent yield with rice + groundnut intercropping and higher B:C ratio in rice + groundnut intercropping system.

Increased grain yield (27.7 q ha^{-1}) in rice+ Bhendi intercropping system might be due to better yield components. More number of productive tillers hill^{-1} (28.5), more number of filled grains panicle^{-1} (148.5), higher panicle length (22.8 cm) and more test weight (24.4 g) was found in this type of cropping systems compared to other intercropping systems. Increased yield in paired row intercropping systems might be attributed to higher growth and yield components like plant height, number of tillers, leaf area, LAI and LAD. Paired row pattern has produced significantly higher plant height (62 cm), number of tillers (35.92), leaf area (2660 cm^2 hill^{-1}) and leaf area index (4.67) and more leaf area duration (80.7 days). Better root development helped better utilization of nutrient and moisture from soil as studied by Aravind Kumar and Prasad (2002) [1].

Radiation interception by the crop canopy has influenced the aerobic rice crop yield. Among the various intercropping systems, significantly more light transmission (56%) was observed in rice+ bendi intercropping system. It was found to be on par with the with rice + cluster bean (56) and rice + French bean (54). Significantly lower percent light transmission (43) was recorded in rice+ ragi intercropping system. Further, because of the aerobic condition, Ragi will dominate for resource utilization. The results are in line with the findings of Sarkar and Pal (2004) [7].

Increased grain yield (27.7 q ha^{-1}) in rice+ Bhendi intercropping system might be due to better yield components, number of productive tillers hill^{-1} (28.5), more number of filled grains panicle^{-1} (147), higher panicle length (22.75 cm) and more test weight (24.4 g) was found in this type of cropping systems compared to other intercropping systems. Radiation interception on the crop canopy has influenced the aerobic rice crop yield. Among various intercropping systems, significantly more light interception (56%**)** was observed in rice+ bhendi intercropping system. It was found to on par with the with rice + cluster bean (55$^)$ and rice + French bean (54) Significantly lower percent light absorption (43) was recorded in rice+ ragi intercropping system. More yields in paired rows might also be due to less competition for moisture and light by the component crops Jana and Ghosh (1996) [5], Jadhav *et.al*. (2003) [4]

Table 1: Growth parameters, leaf area duration and per cent light interception (PLI) of aerobic rice as influenced by different row patterns and intercrops

Treatment	Plant height (cm)	No. of tillers hill^{-1}	Leaf area (cm^2)	Leaf Area Index	Leaf area duration	Dry matter (g hill^{-1})	PLI
Row Pattern (R)							
R_1: Rice in intercrop 45 cm × 20 cm	61	30.31	2236	2.48	32.8	149	50
R_2: Rice in intercrop 30/60 cm × 20 cm	66	33.26	2544	4.09	43.6	153	54
S.Em±	1.01	0.8	29.8	0.04	0.5	0.71	0.51
C.D @ 5%	2.90	2.4	84.3	0.12	1.45	2.00	1.52
Intercrop (I)							
I_1- Rice + Bhendi	66.5	35.92	2660	4.39	83.2	104.83	56
I_2- Rice + Cluster bean	64.5	30.08	2500	3.54	83.3	101.5	55
I_3- Rice + French bean	64.3	25.67	2490	1.84	85.2	54.5	54
I_4- Ric + Ragi	42.8	34.92	1325	3.66	83.3	54.5	43
I_5- Rice + Radish	65.2	31.25	2632	3.24	83.2	97.83	49
I_6-Rice + Soybean	63.0	33.25	2283	3.4	0.41	87.67	55
I_7-Rice + Sunhemp	64.7	30.5	2400	0.08	1.2	98.5	55
S.Em±	1.90	0.34	55.8	0.22	1	1.72	1.02
C.D @ 5%	5.50	0.96	157.7	4.39	2.71	4.87	2.86
Interaction (R x I)							
$R_1 \times I_1$	64.7	35.5	2167	3.11	82.7	166	61
$R_1 \times I_2$	65.7	33.83	2438	2.71	84	166	55
$R_1 \times I_3$	64.2	34.5	2250	2.5	84	153	51
$R_1 \times I_4$	43.0	13.67	1317	1.46	84	98	49
$R_1 \times I_5$	66.4	34.5	2630	2.92	83.7	158	50
$R_1 \times I_6$	64.5	31.33	2050	2.28	85.7	156	50
$R_1 \times I_7$	64.5	33.17	2633	2.41	83.7	166	49
$R_2 \times I_1$	64.5	36.83	2800	4.67	83.3	166	61
$R_2 \times I_2$	64.7	35	2520	4.23	83.7	163	50
$R_2 \times I_3$	66.3	33.67	2750	4.2	82.7	152	55
$R_2 \times I_4$	42.8	24.17	1333	2.22	85.7	107	49
$R_2 \times I_5$	64.1	35.33	2633	4.39	84.7	163	50
$R_2 \times I_6$	61.0	31.17	2517	4.19	83.7	155	54
$R_2 \times I_7$	64.7	33.33	2800	4.39	84.3	163	58
S.Em±	0.60	0.48	78.9	0.11	0.6	1.90	1.2
C.D @ 5%	2.10	1.3	2.89	0.31	1.73	5.40	4.5
Sole crop in 45 cm × 20 cm	60	33	2800	5.5	90	160	50
Sole crop in Paired rows 30/60 cm × 20 cm	62	34.4	2321	6.2	88	166	55

Table 2: Yield and yield components of aerobic rice as influenced by different row patterns and intercrops

Treatment	No. of productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (g)	No. of filled grains pancle^{-1}	No. of unfilled grains pancle^{-1}	Straw yield (qha^{-1})	Test weight (g)	Yield (qha^{-1})
Row Pattern (R)								
R_1: Rice in intercrop 45 cm × 20 cm	23.8	21.3	2.99	126	24.7	36.4	22	19.7
R_2: Rice in intercrop 30/60 cm × 20 cm	27.17	22.1	3.39	129	22.9	43.7	24.5	23.7
S.Em±	0.3	0.1	0.06	0.6	0.4	0.31	0.2	1.45
C.D @ 5%	0.81	0.41	0.18	1.8	1.1	1	0.7	4.03
Intercrop (I)								
I_1- Rice + Bhendi	28.5	22.8	4.3	147	16	46	24.4	27.7
I_2- Rice + Cluster bean	26.2	22.6	3.4	146	20.8	45.8	23.6	26
I_3- Rice + French bean	25.7	21.8	3.3	129	21.7	42.4	22.8	22.5
I_4- Ric + Ragi	19.5	19.5	1.8	59	32.5	12.7	21.1	6.8
I_5- Rice + Radish	27.7	22.3	3.6	143	21.2	45.4	21.7	24.1
I_6-Rice + Soybean	25	21.8	3.2	132	24.2	41.9	22.5	22.6
I_7-Rice + Sunhemp	26.5	21.2	2.9	130	26.5	50	22.6	22.4
S.Em±	0.7	0.3	0.1	1.7	1.2	0.6	0.4	3
C.D @ 5%	2.2	0.8	0.4	5.1	3.4	1.8	1.2	11.6
Interaction (R x I)								
$R_1 \times I_1$	26.7	22.75	3.7	144	17.7	53.9	23.8	23.8
$R_1 \times I_2$	25	22.2	3.2	146	22.7	46.5	23.5	25.7
$R_1 \times I_3$	24.3	21	3.2	131	19.3	40.1	23.3	21.8
$R_1 \times I_4$	12	18.8	1.3	56	35.7	11	18.7	5.9
$R_1 \times I_5$	26.7	22.2	3.5	139	19	43.5	21	23.6
$R_1 \times I_6$	25	22.2	3.4	134	24	34.9	23	17.7
$R_1 \times I_7$	26.3	23.6	3.8	149	14.3	46.1	23.3	24.6

$R_2 \times I_1$	29.3	23.2	4.8	149	14.3	53.3	24.8	28.8
$R_2 \times I_2$	26.3	23	3.5	145	19	44.4	22.3	28.7
$R_2 \times I_3$	27	22.7	3.5	127	24	44.7	22.3	23.8
$R_2 \times I_4$	27	20.2	2.2	62	29.3	14.3	23.5	7.9
$R_2 \times I_5$	28.7	22.3	3.7	139	23.3	45.4	22.3	23.2
$R_2 \times I_6$	25	21.5	3	130	24.3	45.9	22	26.3
$R_2 \times I_7$	26.7	21.8	3	132	28.3	46.1	23.3	22
S.Em±	1.1	0.4	0.2	2.5	1.7	0.91	0.6	3.7
C.D @ 5%	3.1	1.1	0.5	7.1	4.8	2.64	1.83	10.5
Sole crop in 45 cm × 20 cm	28	20.7	3.5	134	28	60.7	25.2	43.1
Sole crop in Paired rows 30/60 cm × 20 cm	27	22.5	3.9	152	20	68.3	24.6	49.5

Conclusion: Growing Rice + Bhendi in paired (2:1) row intercropping systems performed better than the normal row (1:1) intercropping system. Therefore, growing rice with intercrops in 2:1 row proportion proved to give better yield and yield parameters than in 1:1 row proportion.

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