Similarly ALR 2 x JL 24, Girnar 1 x GG 2 and ICGS 44 x JL 24 registered positive heterosis.

Kernel weight

Three-way crosses significantly outyielded single crosses and parents whereas single crosses were on par with parents. Four three-way combinations *viz.*, (Girnar 1 x JL 24) x GG 2, (Girnar 1 x JL 24) x GG 2, (JL 24 x GG 2) x Co 2 and (ICGS 44 x ALR 2) x GG 2 recorded heterosis. In single crosses, Girnar 1 x ALR 2 and Girnar 1 x GG 2 registered positive heterosis.

Pod yield

Single crosses ranked first followed by three-way crosses and both of them were superior to the parents. Seven single crosses comprising all the five combinations involving ICGS 44 as pistillate parent besides ALR 2 x JL 24 and ALR 2 x GG 2 exhibited heterotic effects. None of the three-way crosses registered significant positive heterosis.

Shelling out turn

Three-way crosses were superior to both single crosses and parents. However, single crosses failed to outyield the parents. None of the single crosses recorded significant positive heterosis. Sixteen out of 20 three-way crosses exhibited positive heterosis for this trait.

The range of the mean values revealed that the three-way crosses recorded narrow range for four out of six traits studied *viz.*, number of branches, number of mature pods, pod yield and shelling out turn. This suggests that three-way crosses have more buffering capacity compared to single crosses. Similar results were obtained in several crops.

Arunachalam *et al.* (1984) pointed out that the heterotic hybrids can also produce desirable transgressive segregants in advanced generations. In the present study high level of heterotic effects were recorded by three-way crosses for the traits *viz.*, shelling out turn, pod weight and kernel weight. Hence, for the improvement of these traits three-way crosses may yield fruitful results than single crosses.

REFERENCES

ARUNACHALAM, V., BANDHYOPADHYAY, A., NIGAM, S.N. and GIBBONS, R.W. (1984). Heterosis in relation to genetic divergence and combining ability in groundnut (*Arachis hypogaea* L.) **Euphytica 33**: 33-39.

WEATHERSPOON, J.H. (1970). Comparative yields of single, three-way and double crosses of maize. **Crop Sci., 10** : 157-159.

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RESIDUAL EFFECT OF ORGANIC MANURES AND INORGANIC FERTILIZERS ON SUCCEEDING RATOON RICE

Y.V.SINGH and B.K.MANDAL
Krishi Vigyan Kendra
Central Rice Research Institute
Cuttack 753 006

ABSTRACT

A two year field experiment was conducted to determine the residual effects of different organic and inorganic sources of nitrogen on the succeeding ratoon crop of rice (cv.IR 36). Eighteen treatments consisting of five green manure crops *viz.*, Azolla (*Azolla pinnata* R.Brown); Ipomoea (*Ipomoea carnea*) water hyacinth (*Eichhornia crassipes* Mart Solms) *Pistia* sp. and blue green algae (BGA) and one farm yard manure (FYM) combination with various rates of inorganic N fertilizer were evaluated. Only 42.0 to 58.0 per cent culms regenerated in ratoon crop from the 50 hills/m^2 of plant crop. Variation in the grain yields (1.32 to 2.42 t/ha) of ratoon crop was a consequence of the residual fertility left by the different sources of N applied to the preceding plant crop. Incorporation of *Azolla* and BGA to the preceeding plant crop resulted in higher grain and straw yield of ratoon crop. Concentration of N,P and K in grain and straw of ratoon rice was higher in the treatments having higher fertility. Residual status of N,P and K in the soil after ratooning declined compared with initial values.

KEY WORDS : Plant crop, ratoon crop, residual fertility

Grain production from a ratoon crop with the help of nutrients applied to the preceding crop might be one approach to increase food grain production, land use efficiency, and farmers' income, especially in the case of deep water rice (Kulakanchankul *et al.*, 1990). Attention has been given to the use of *Azolla* and BGA as a potential biofertilizer in rice production. Incorporation of one crop of *Azolla* is equivalent to a split application of 30 kg fertilizer N (Watanabe, 1987). Positive impact on grain yield of rice due to *Ipomoea* sp. (Jha *et al.*, 1980), and water hyacinth (Mukhopadhyay and Hossain, 1991) has also been reported. Hence, the study was undertakne to find out the effects of different sources of nitrogen applied to the preceding rice crop on the performance of a succeeding ratoon rice.

MATERIALS AND METHODS

The study was carried out at the Research Farm of Bidhan Chandra Krisi Vishwavidyalaya at Mohanpur, West Bengal during *Kharif* season. The farm is located at 30° N, 89° E at at an elevation of 9.75 m amsl in the humid sub-tropical climatic zone. Long term average annual rainfall is 1396 mm. The soil type was sandy loam alluvial classified as Entisol.

Details of the treatments used in the preceding crop of rice are given in Table of results. All the organic manures except BGA were applied in t/ha and urea and BGA in kg/ha. In T_2, T_3 and T_4 *Azolla* was incorporated in main crop before transplanting while in T_5, first does of *Azolla* was incorporated as basal and second dose 21 days after transplanting (DAT). In T_6, 30 kg N/ha was applied at panicle initiation stage in addition to T_5. T_7 included N application through urea in 3 splits. T_8, T_9, T_{14}, T_{15}, T_{16} and T_{17} included basal application of organic manures as pertreatment followed by 2 splits of fertilizer N. In T_{12} and T_{13} in addition to T_8 and T_9, basal dose of N was applied. In T_{10} and T_{11} dual culture means that *Azolla* @ 1 or 2 t/ha was applied 7 DAT on standing water so it multiplied there. T_{18} included inoculation of BGA (precultured inoculam of *Aulsoira fertilissima* and *Nostoc muscorum*) at 7 DAT. The design adopted was randomised block design with there replications.

The dry season rice was harvested in May at a cutting height of 15 cm above the ground. The field was maintained with a shallow (2 to 3 cm) flood. A basal dose of 26 kg P and 50 kg K ha^{-1} was applied to the plant crop and no fertilizer was applied to the ratoon crop. The ratoon crops were harvested on 12 and 15 September respectively. Soil samples were taken after the harvest of ratoon crop during both years of experimentation and analysed for total N. available P and K. Grain and straw samples were analysed to determine the concentration of N,P and K.

Chemical analysis of different organic manure indicated that their nitrogen contribution to rice crop when added @ 10 t/ha was as follows: *Azolla* 31 kg/ha; BGA 24 kg/ha; water hyacinth 11.5 kg/ha; *Pistia* 14.5 kg/ha; *Ipomoea* 21.0 kg/ha and FYM 22 kg/ha.

RESULTS AND DISCUSSION

Plant growth attributes

The extent of regeneration was between 42.0 to 50.0 per cent of the hills from a plant crop having 50 hills m^{-2} (Table 1). Plant height at maturity of the ratoon crop ranged between 30.5 and 38.8 in contrast to a 90 cm height of the plant crop. Application of Azolla and other materials to the preceding crop resulted in a significant increase in plant hight of the ratoon crop compared with the control. The ratoon crop produced 120 to 182 tillers m^{-2} as compared to 400 tillers m^{-2} recorded in the plant crop. There were differences in tiller number among the treatments with the highest number of tillers produced with T_{13}. These findings seem logical in view of previous studies that initial nutrition and growth of ratoon crop depended on the carbohydrate left in the stubbles of plant crop, the nutrient status of the soil and concentration in straw of plant crop (Mandal and Panda, 1985).

Yield components and yield

The number of effective tillers m^{-2} in the ratoon crop increased due to the application of organic and inorganic materials to the plant crop.

able 1. Influence of organic manures and urea on growth attributes, yield components and yield of ratoon rice (2 year pooled data)

	Treatments	Number of regenerated stubbles m^{-2}	Plant height at harvest (cm)	Number of tillers m^{-2} (at harvest)	Number of effective tillers m^{-2}	Number of grains pancile^{-1}	Sterility percentage	Test weight of grains(g)	Grain yield (t/ha)	Straw yield (t/ha)
1	Control (No N)	21.0	30.5	124.2	77.0	51.5	33.4	20.0	1.32	1.69
2	A_5	22.4	33.7	120.4	89.9	55.9	28.6	19.6	1.78	2.71
3	A_{10}	25.0	34.0	145.5	123.6	55.0	29.7	20.3	2.17	2.96
4	A_{15}	25.4	36.1	164.1	126.1	60.7	26.1	20.7	2.22	2.92
5	$A_5 + A_5$	24.3	36.5	160.0	117.2	61.7	25.5	19.3	2.02	2.64
6	$A_5 + A_5 + N_{30}$	26.9	35.7	149.8	113.7	63.9	29.5	21.4	2.24	3.01
7	$N_{60} + N_{30} + N_{30}$	27.3	38.1	163.4	118.1	62.9	24.1	19.1	2.32	3.02
8	$A_5 + N_{30} + N_{30}$	21.5	36.7	153.2	113.4	67.1	22.1	20.6	1.80	2.49
9	$A_{10} + N_{30} + N_{30}$	26.8	37.3	155.0	115.9	68.0	23.1	20.6	1.94	3.07
10	A_1 (dual)	27.3	34.4	149.2	106.3	55.4	27.1	20.1	2.42	2.88
11	A_2 (dual)	26.8	34.9	168.0	131.6	57.5	30.3	19.3	2.35	2.87
12	$A_5N_{30} + N_{30} + N_{30}$	24.0	37.9	154.5	121.2	64.1	27.1	19.8	2.08	2.84
13	$A_{10} N_{30}$+ N_{30}+ $N_{30} + N_{30}$	29.0	38.5	181.6	134.1	63.5	27.4	19.8	2.19	2.94
14	$I_{10} + N_{30} + N_{30}$	24.8	37.1	174.5	113.8	62.3	28.2	20.1	1.83	2.75
15	$F_{10} + N_{30} + N_{30}$	24.5	38.8	151.8	110.8	65.6	29.0	19.6	1.88	2.59
16	$W_{10} + N_{30} + N_{30}$	28.5	38.4	165.9	124.5	65.6	24.7	29.9	2.25	2.71
17	$P_{10} + N_{30} + N_{30}$	27.3	37.7	164.6	112.3	65.6	19.0	20.9	2.15	3.09
18	B 0.03	26.0	38.1	172.5	127.3	66.3	25.0	21.1	2.31	2.99
	SD (0.05)	4.3	4.6	14.6	15.3	3.8	1.8	NS	0.21	0.36

= *Azolla* sp.; B = BGA, F = FYM; I = *Ipomoea* sp.; P = *Pistia* sp.; W = Water hyacinth in tonne ha^{-1} and N = Nitrogen through urea Kg ha^{-1}
S = Not significant.

he number of effective tillers ranged between 77 nd 134. The number of filled grains panicle^{-1} was ncreased as a result of different treatments over ontrol (Table 1). Spikelet sterility was quite high n ratoon crop and it ranged between 19 and 33 mong different treatments (Table 1). However, educed sterility was observed due to higher soil ertility created by some treatments. Thousand rian weight was not influenced by the treatments. Mean grain yield in the ratoon crop was much ower (2.09 t/ha) than the plant crop (5.01 t/ha) Table 1). Similar trend was observed for straw ield. Grain yield increased significantly due to the esidual effects of organic manures ranging etween 1.32 (control) and 2.42 t/ha (T_{10}). However, on application of urea to plant crop, grain ield of ratoon rice was 2.32 t/ha. Our findings on ield components and yield were in agreement with he findings of several workers (Zandstra and Samson, 1979). Substantial amounts of residual ertility resulted from the application of different rganic and inorganic materials. This enhanced stubble regeneration which, in turn, increased the number of tillers and yield.

Concentration of N, P and K in grain and straw

Nitrogen concentration ranged between 1, 10 and 1.22 per cent in the grain and 0.43 ad 0.50 per cent in the straw and the values of different treatments were significantly higher over control in grain as well as straw (Table 2). The lowest N concentrations were recorded in the control treatment. Phosphorous concentration in the grain as well as straw was not significantly influenced due to the different treatments. Lower concentrations of N, P and K in grain and straw of the ratoon crop as compared to the plant crop were probably due to the shorter crop duration, depletion of nutrients by plant crop and less efficient root system in ratoon crop.

Residual N, P and K contents in soil

After harvest of the ratoon crop, residual soil fertility was found to decline from the initial levels

Table 2. Residual influence of organic manures and urea on concentration of N, P and K in grain and straw of ratoon rice and residual total N, available P and K in soil after ratooning (2 year pooled data)

	Treatments	Nitrogen (Percent)		Phosphorus (per cent)		Potassium (per cent)		Total Nitrogen (% N)	Available phosphorus (kg P ha^{-1})	Availabl Potassiur (kg K ha
		Grain	Straw	Grain	Straw	Grain	Straw			
T_1	Control (No N)	1.10	0.43	0.42	0.09	0.55	1.37	0.056	10.7	129.2
T_2	A_5	1.17	0.53	0.47	0.10	0.64	1.42	0.059	11.6	133.3
T_3	A_{10}	1.18	0.53	0.46	0.12	0.65	1.44	0.059	12.3	133.6
T_4	A_{15}	1.19	0.56	0.47	0.12	0.67	1.49	0.058	12.4	133.2
T_5	$A_5 + A_5$	1.19	0.54	0.46	0.12	0.64	1.43	0.057	12.2	135.0
T_6	$A_5 + A_5 + N_{30}$	1.17	0.55	0.49	0.14	0.64	1.47	0.058	12.7	133.3
T_7	$N_{60} + N_{30} + N_{30}$	1.17	0.53	0.48	0.12	0.66	1.45	0.057	12.6	133.8
T_8	$A_5 + N_{30} + N_{30}$	1.19	0.51	0.49	0.12	0.67	1.49	0.058	13.2	133.3
T_9	$A_{10} + N_{30} + N_{30}$	1.20	0.57	0.51	0.13	0.64	1.45	0.059	14.0	134.9
T_{10}	A_1 (dual)	1.18	0.54	0.43	0.12	0.61	1.52	0.057	12.5	132.0
T_{11}	A_2 (dual)	1.16	0.55	0.49	0.11	0.62	1.50	0.058	12.1	132.1
T_{12}	$A_5N_{30} + N_{30} + N_{30}$	1.21	0.56	0.51	0.12	0.61	1.60	0.057	12.5	134.3
T_{13}	$A_{10}N_{30} + N_{30} + N_{30}$	1.18	0.58	0.49	0.12	0.64	1.58	0.058	12.2	133.6
T_{14}	$I_{10} + N_{30} + N_{30}$	1.22	0.57	0.51	0.12	0.63	1.61	0.059	13.3	134.0
T_{15}	$F_{10} + N_{30} + N_{30}$	1.22	0.54	0.51	0.11	0.67	1.53	0.057	13.4	133.7
T_{16}	$W_{10} + N_{30} + N_{30}$	1.19	0.57	0.52	0.13	0.66	1.51	0.058	12.8	134.8
T_{17}	$P_{10} + N_{30} + N_{30}$	1.19	0.58	0.52	0.13	0.64	1.54	0.058	13.2	137.4
T_{18}	B 0.03	1.20	0.55	0.52	0.12	0.65	1.51	0.058	12.1	131.5
LSD (0.05)		0.05	0.07	NS	NS	0.06	0.06	0.002	2.4	4.2

NS = Not Significant

(Table 2). Total N content after the ratoon crop ranged between 0.056 and 0.059 per cent (Table 2). However, mean total N content before ratoon crop was 0.064% In most of the treatments, mean residual available P status of the soil declined from 10.7 to 14 kg P/ha. Mean available K content after ratooning was found to range from 129.2 to 137.4 kg K/ha in different treatments which declined from the mean value of 146.2 kg K/ha available before ratooning.

Ratooning though giving poor yield as compared to the plant crop, may be a good practice where single cropping is presently in vogue. The addition of organic materials to the plant crop was advantageous by sustaining soil fertility levles, which, in turn, favourably influenced the succeeding crop.

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REFERENCES

KUPAKANCHANAKUL, I., VARGARE, B.B. and KUPAKANCHANAKUL, K.(1990) Ratooning ability and potential herbage production from ratoon crops from the rice cultivers. **Int.Rice Res. Newsl., 15(5)**:10

MANDAL, B.K. and PANDA, T.K.(1985). Studies on ratooning of rice. **Oryza 22**: 219-225.

WATANABE, I. (1987). Summary report of the Azolla programme of the International Network on soil fertility and fertilizer evaluation for rice. In : *Azolla Utilization.* Proceedings of the Workshop on *Azolla* Use. Fuzhou, Fujian, China, 31 March-5 April, 1985. IRRI, Manila. Philippines, pp.101-108.

ZANDSTRA, H.G. and SAMSON, B.T.(1979) Rice ratoon management. **Paper presented at the International Rice Research Conference** April 17- 22, 1979 IRRI, Manila, Philippines.

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