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Effect of green organic mulching and nitrogen management on productivity, N use efficiency and profitability of Basmati aerobic rice (*Oryza sativa*)

R K MEENA[1] and Y V SINGH[2]

ICAR- Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

A field experiment was conducted in *kharif* seasons of 2013 and 2014 at ICAR-IARI, New Delhi to study the effect of green organic mulching and nitrogen (N) management on crop productivity, N-use efficiency and economics of aerobic rice (*Oryza sativa* L.). The experiment was laid out in split plot design with residue management practices assigned to main plots, and N management treatments allocated in sub plots and replicated thrice. Results revealed that with green mulching all yield attributes, viz. effective tillers, panicle length, panicle weight and 1000-grain weight were significantly higher in transplanted rice (TPR) than other treatments. N management at 100% recommended dose of N (RDN) + *Azotobacter* recorded the highest values of all the yield attributes and those were *at par* with 100% RDN. Highest grain (3.95 and 3.73 t/ha), straw and biological yield were obtained with TPR treatment. Similarly, N management with mineral fertilizer and *Azotobacter* biofertilizer significantly enhanced the grain, straw and biological yields and highest the grain (4.29 and 3.44 t/ha), straw and biological yield was recorded with 100% RDN + Liquid *Azotobacter*. The uptake of N in grain, straw and its total were highest with TPR during both the years. Among the N management treatments, maximum N-uptake were recorded with 100% RDN + *Azotobacter* in grain (58.0 and 47.4 kg/ha) and straw (47.9 and 41.9 kg/ha). Data pertaining to nitrogen use efficiencies (agronomic and crop recovery efficiency) were positively influenced with residue application and N management. The highest value of agronomic (15.2 and 11.7 kg grain increased/kg N applied) efficiency and crop recovery (43.9 and 37.9 %) efficiency were observed with 100% RDN + *Azotobacter* during both the year of experiment. The cost of cultivation was highest under TPR (₹ 48.79×10^3 and 56.04×10^3) which was followed by *Leucaena* and *Sesbania* treatments. In case of N management, cost of cultivation was highest in 100% RDN +*Azotobacte*r (₹ 42.14×10^3 and 49.07×10^3) which was closely followed by 100% RDN during both the years. The maximum gross return (₹ 122.2×10^3 and 116.0×10^3) and net return (₹ 73.4×10^3 and 59.9×10^3) were recorded in TPR. However, in N management 100% RDN + *Azotobacter* gave highest gross (₹ 132.7×10^3 and 107.1×10^3) and net return (₹ 90.5×10^3 and 58.0×10^3) and it was followed by 100% RDN.

Key words: Aerobic rice, *Azotobacter,* N use efficiency, N uptake, Yield attributes

Indiscriminate and unbalance use of the natural resource base with high chemical inputs and changing climate in recent have led to the negative yield trend and plateauing productivity of major cropping systems. In the world, about 75 per cent of the rice (*Oryza sativa* L.) production comes from irrigated lowland rice fields. The decline of water table in some regions has reached an alarming situation. For example, in the IGP of India it is declining by 0.5–0.7 m each year (Carriger and Vallee 2007). Irrigated transplanted rice having labour, energy and water shortages problems with poor soil fertility which adversely affect the productivity of the rice-wheat (R-W) cropping system. In Asia, 17 mha of irrigated rice areas may experience 'physical water scarcity' and 22 mha may have 'economic water scarcity' by 2025 (Tuong and Bouman 2003, Singh 2013). Yet more rice needs to be produced with less and less water to feed the ever-growing population, which may need judicious water management practices with suitable water saving technologies in rice cultivation. Therefore, the need of hour is to develop alternative production systems that require less water and energy. Aerobic rice (AR) system is such a new production system in which rice is grown under non-puddled, non-flooded and unsaturated soil conditions (Tuong and Bouman 2003, Singh 2013).

Crop sequence with R-W, that yields around 10 t/ha removes more than 300 kg N, 30 kg P and 300 kg K/ha from the soil (Naresh 2013). In conventional agriculture production system we are following clean cultivation and all the produced crop residues went out from field. If these residues are not returned this may cause mining of soil for major and minor nutrients which leading to net negative balance and multi-nutrient deficiencies in crops. This is one of the major reasons for the yield decline or stagnation in the R-W system. There has been increased and serious

[1]Scientist, (e mail: rajeshkumar2793@ gmail.com), ICAR-NDRI-Karnal, [2]Principal Scientist (e mail: yvsingh63@ yahoo.co.in), CCUBGA, ICAR-IARI, New Delhi.

realization that crop residues are a resource constituting a readily available source of nutrients and organic material for rice farmers. In addition to N, P and K, residue incorporation may help to overcome deficiencies of other nutrients, viz. S, Zn and B deficiencies, which are widespread in the R-W cropping system belt (Prasad 2005). Crop residue in green organic form like *Sesbania* and *Leucaena* could be better option in rice based cropping system. *Sesbania* generally used for *in-situ* incorporation before rice transplanting. Besides it can be used as green leaf manuring after rice crop establishment and thus it will act as organic mulch and add nutrient to the soil. *Leucaena* also can be grown over the wasteland/bund area and its soft twigs can be used as organic mulch in aerobic rice. Use of organic mulch is a proven source of crop nutrition over a period in crop growth and also suppresses weeds and reduces evaporation loss in aerobic system. Biological N fixation (BNF) technology can play an important role in partially substituting the commercially available N fertilizer use in rice culture, thus reducing these soil health problems to some extent (Meena *et al*. 2014). *Azotobacter* supply additional N in an eco-friendly manner and plays a vital role in wheat production. Seed inoculation with *Azotobacter* increased the yield of crops by 10-15%. However, the information on effect of green organic mulching and N management in aerobic rice crop are generally lacking. Therefore, field investigation was conducted to evaluate the effect of green organic mulching and N management on productivity, N use efficiency and economics of aerobic rice.

MATERIALS AND METHODS

An experiment was conducted during two wet (*kharif*) seasons of 2013 and 2014 at ICAR-Indian Agricultural Research Institute, New Delhi. The climate of Delhi is sub-tropical and semi-arid type with 680 mm average rainfall. There was a lot of variation in total rainfall received during first (2013) and second (2014) season of rice crops and it was 1203 mm and 472.6 mm, respectively. The mean maximum temperature also during the second year or rice cultivation was higher (40.1°C) than the first year (37.3°C). The soils of experimental field had 166.0 kg/ha alkaline permanganate oxidizable N, 16.54 kg/ha available P, 254.2 kg/ha 1 N ammonium acetate exchangeable K, 0.54% soil organic carbon, electrical conductivity (EC) 0.203 dS/m and 8.32 pH. The experiment was laid out in split-plot design with 20 treatments combinations replicated thrice. The treatments included, Bare soil; *Sesbania* mulching 10 t/ha (fresh weight, FW); *Leucaena* mulching 10 t/ha FW and transplanted rice (TPR) in main plots. In sub-plot treatments were: N_0; 75% RDN (90 kg/ha); 100% RDN (120 kg/ha); 75% RDN + Liquid *Azotobacter* and 100% RDN + Liquid *Azotobacter*.Urea was taken as the mineral source of N. In this study, liquid formulation of bacterial biofertilizer (*Azotobacter chroococcum*) was applied through seed treatment @100 ml per acre area. Liquid formulation of *Azotobacter* biofertilizer were obtained from the Division of Microbiology, ICAR-IARI, New Delhi and seeds were inoculated before sowing as per the treatments. In case of aerobic rice (AR) pre-soaked (for 24 hr) and incubated seeds (cv. Pusa Basmati 1509) in moist gunny cloth for another 24 hr were used for seed inoculation with liquid *Azotobacter.* Treated seeds were dried under shade and after one hour used for sowing (25 June 2013 and 28 June 2014, respectively). Under AR system, the fields were dry ploughed and harrowed. Seed were sown manually (row spacing 22.5 cm) as per treatment and later light irrigation was applied. Thinning and gap filling was done at 15 days after sowing (DAS). In transplanted rice (TPR) land preparation consisted of harrowing followed by puddling in standing water. In TPR, after puddling 21 days old seedlings of same rice variety were transplanted on 12 July and 15 July at 20 cm × 10 cm spacing keeping 2 seedlings/hill in 2013 and 2014, respectively. In TPR standing water was maintained until about 10 days before physiological maturity. Nitrogen was applied in 3 equal splits, i.e. basal, active tillering and panicle initiation stage. A common dose of P and K was applied in all the treatments. In control (N_0) treatment P_2O_5 applied through SSP fertilizer. *Sesbania aculeata* was sown in separate field by broadcasting method 40 days before the sowing of rice crop. It was manually cut and then applied @10 t/ha on fresh weight basis (FW) between the rows of rice after germination. The green loops of *Leucaena leucocephala* were manually collected by pruning of shrubs planted available near the experimental field. The collected material was applied @ 10.0 t/ha FW between the rows of rice after its germination.

Data on yield attributes and yield were recorded as per standard procedures at the maturity stage of crop. N concentration in rice grain and straw samples were determined by modified Kjeldahl method. The N uptake by the crop (straw and grain) was worked out by multiplying N content in crop part with the respective part and expressed in kg/ha. Total N uptake was computed by adding the grain and straw uptake. Agronomic efficiency (AE) and recovery efficiency (RE) of applied N were computed using the standard formula. The economic parameter (cost of cultivation, gross return, net return and B: C ratio) were recorded on the basis of prevailing market prices of inputs and outputs. All the data obtained from experiment was statistically analysed using the *F*-test as per the standard procedure.

RESULTS AND DISCUSSION

Yield attributes and yield

Application of green organic mulch significantly influenced all the yield attributes of rice except 1000-grain weight as compared to bare soil (Table 1). The highest effective tillers, panicle length, grains/panicle, panicle weight and 1000 grain weight were observed with transplanted rice (TPR). 1000-grain weight was statistically *at par* among the residue application treatments during both the years. All the yield attributes of TPR were statistically *at par* with *Leucaena* during first year of experimentation,

Table 1 Effect of residue and N management on yield attributes of rice

Treatment	Effective tillers/m^2		Panicle length (cm)		Grains/panicle		Panicle weight (g)		1000 grain wt. (g)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Residue application										
Bare soil	244.3	174.5	26.4	23.4	111.0	75.0	2.04	1.52	22.9	22.5
Sesbania @10 t/ha	251.1	181.5	26.9	24.5	112.8	77.2	2.09	1.56	22.9	22.5
Leuceaena @10 t/ha	256.7	186.5	27.3	24.3	114.9	78.8	2.16	1.59	23.0	22.6
TPR	279.2	248.6	28.0	26.3	139.7	132.2	2.44	2.21	23.2	23.0
SEm±	6.65	4.85	0.31	0.27	3.35	2.78	0.06	0.05	0.14	0.15
LSD (P = 0.05)	23.0	16.8	1.06	0.95	11.59	9.62	0.22	0.17	NS	NS
Nitrogen management										
Control (N_0)	161.7	121.3	25.0	23.3	101.2	75.6	1.92	1.57	21.8	21.3
75% RDN	254.6	190.1	26.9	24.4	118.7	88.9	2.09	1.67	22.9	22.5
100% RDN	292.9	226.5	28.0	25.1	126.3	95.4	2.31	1.78	23.5	23.1
75% RDN + *Azo	274.6	209.4	27.5	24.8	124.0	97.5	2.18	1.72	23.4	23.0
100% RDN + *Azo	305.4	241.5	28.3	25.5	127.8	96.6	2.42	1.85	23.5	23.2
SEm±	5.40	4.04	0.35	0.19	1.88	1.65	0.04	0.05	0.21	0.22
LSD (P = 0.05)	15.57	11.63	1.00	0.55	5.41	4.75	0.12	0.15	0.62	0.63

TPR=Transplanted rice; RDN=Recommended dose of N; *=Liquid *Azotobacter.*

however, in second year TPR revealed significantly higher yield attributes than other treatments. *Leucaena* and *Sesbania* applied treatment were *at par* with each other during both the years. Lowest values of the entire yield attributing character were recorded with bare soil during both the year of studies. The values of all the yield attributes were lower during second season compared to the first season. This might be due to the fact that the crop faced drought like situation and high temperature during the second year and weed problem especially in aerobic rice also aggravated. These conditions create unfavorable environment for crop growth and resulted it adversely affecting all the growth and development of rice crop. 1000 grain weight was slightly higher under TPR compared to residue applied aerobic rice (AR). Better values of yield attributes under TPR compared to AR were due to the more favourable environment under TPR compared to AR conditions and there was less chance of physical, chemical and biological stress. Pooniya and Shivay (2012) also reported similar findings.

The N management treatment through urea and biofertilizer significantly influenced all the yield attributing characters of rice as compared to N control. The maximum values of all the yield attributes were found with 100% RDN + *Azotobacter* which was statistically *at par* with 100% RDN during both the years. Continuous supply of N by *Azotobacter* during whole growth period resulted in increase the availability of N for plants. The lowest values of the entire yield attributing character were recorded with N control. This could be attributed to the proper and balanced supply of N and increased accumulation of photosynthates from source to sink with increased levels of fertilizer N. Similar results were reported earlier by Singh *et al.* (2013).

The highest grain (3.95 and 3.73 t/ha), straw (7.81 and 7.80 t/ha) and biological yield were recorded in TPR which was *at par* with *Leucaena* while, lowest yields recorded with bare soil (Table 2). Yield recorded under *Sesbania* treatment was higher but statistically *at par* with TPR. Yield recorded in second year was lower compared to first year. Higher N availability under *Leucaena* applied treatment compared to rest of treatment resulted in higher yield compared to *Sesbania* and bare soil. Higher panicle sterility under AR due to different stresses during cropping season resulted in lower yield compared to TPR. This difference might be explained by the lower grain HI, which indicates for the lower proportion of dry matter allocated to the grain (vs. straw plus grain), and the lower Fe HI, which indicates the lower proportion of Fe allocated to the grain (vs. straw plus grain), under aerobic conditions (Fan *et al.* 2012). Fe is an essential nutrient for plants and Fe is required for respiration and photosynthesis. Insufficient Fe uptake leads to interveinal chlorosis in leaves and reduced yield with the shift from flooded to aerobic cultivation, the soil pH gradually increases, which is one of the factors leading to yield decline of continuous aerobic rice (Xiang *et al.* 2009). Among the N management treatment highest grain, straw and biological yield was reported with 100% RDN + *Azotobacter* which was followed by 100% RDN and 75% RDN + *Azotobacter.* The balanced and optimum supply of nutrient through INM resulted plant free from nutrient stress which induced for higher yield. These findings are accordance with the findings of Meena *et al.*(2014).

There was no significant effect of residue application on HI but highest HI was recorded in TPR (33.5 and 32.3 %) and lowest in bare soil treatment. Among N management treatments, higher and lowest values of HI were recorded in 100% RDN + *Azotobacter* and control

Table 2 Effect of residue and N management on grain, straw, biological yields and harvest index of rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Biological yield (t/ha)		Harvest index (%)	
	2013	2014	2013	2014	2013	2014	2013	2014
Residue application								
Bare soil	3.30	2.52	6.96	5.37	10.25	7.89	32.1	31.9
Sesbania @10 t/ha	3.51	2.68	7.33	5.70	10.84	8.38	32.3	32.0
Leuceaena @10 t/ha	3.64	2.80	7.54	5.93	11.19	8.73	32.5	32.1
TPR	3.95	3.73	7.81	7.80	11.76	11.52	33.5	32.3
SEm±	0.095	0.069	0.146	0.178	0.231	0.177	0.311	0.857
LSD (P = 0.05)	0.33	0.24	0.507	0.616	0.800	0.614	NS	NS
Nitrogen management								
Control (N_0)	2.47	2.03	5.23	4.48	7.70	6.52	32.0	31.3
75% RDN	3.51	2.82	7.41	6.03	10.92	8.85	32.1	31.9
100% RDN	3.98	3.29	8.20	6.88	12.18	10.16	32.6	32.3
75% RDN + *Azo	3.76	3.07	7.79	6.46	11.54	9.54	32.5	32.2
100% RDN + *Azo	4.29	3.44	8.43	7.15	12.71	10.60	33.7	32.5
SEm±	0.064	0.054	0.105	0.117	0.133	0.141	0.451	0.527
LSD (P = 0.05)	0.18	0.16	0.303	0.336	0.383	0.405	NS	NS

plot, respectively during both the years. The HI is mainly controlled by partition of photosynthates between harvesting and non-harvesting organs during the crop growth cycle. It is evident that the economic yield is closely related to crop growth process. Hence, the variation in partitioning of photosynthates in grain and vegetative organs of different treatments possibly caused a significant variation in HI. The similar results have been reported by Jat *et al.* (2014).

Nitrogen uptake and use efficiency

All combinations of residue and N-management had significant effect on N-uptake by grain, straw and its total over the control during both the years of study. The uptake of N in grain was recorded highest with TPR (51.1 and 48.2 kg/ha) during both the years. During the first year N uptake with TPR was at par with *Leucaena* applied treatment, whereas in second year it was significantly higher N uptake than rest of the treatments. The value of N uptake by straw was maximum with TPR (42.7 and 43.1 kg/ha) during both the years. During first year TPR showed *at par* N uptake in *Leucaena* and *Sesbania* applied treatments while in second year TPR had significantly higher N uptake than rest of the treatments. Total N uptake also followed the similar trend. Among the N management treatments, maximum N-uptake was recorded with 100% RDN + *Azotobacter* in grain (58.0 and 47.4 kg/ha), straw (47.9 and 41.9 kg/ha) and as well as total during both the years. 100% RDN + *Azotobacter* had significantly higher N-uptake from rest of combination except rice straw where it was at par with 100% RDN and on par on rest of combination. However the lowest was recorded with bare soil. This might be due to high N concentration in *Leucaena* (around 4%) which was very high compared to *Sesbania*. So, N uptake was also highest in grain and straw. The highest yield (grain, straw and biological) was recorded with TPR during both the years it resulted in highest uptake under TPR. These results are in close conformity with Pooniya and Shivay (2011). N availability to plants responsible for increased N in grain and straw with respective treatments. Among the N management treatments, maximum N-uptake was recorded with 100% RDN + *Azotobacter* in grain and straw during both the years. This might be due to the sufficient and continued availability of N from inorganic and organic source that eventually led to higher N uptake (Dixit and Gupta 2000). Higher N uptake under different integrated nutrient sources over organic and chemical fertilizer used alone in different cropping systems have been reported (Singh *et al.* 2013, Saha *et al.* 2015).

Residue management and N management had non-significant influence on N use efficiencies. In case of N management highest value of agronomic (15.2 and 11.7 kg grain increased/kg N applied) efficiency and crop recovery (43.9 and 37.9%) efficiency were recorded with 100% RDN + *Azotobacter* during both the years of experiment (Table 3). However, the lowest of all these efficiencies were recorded with 75% RDN during both the years of study. During first year of experiment the values of all the efficiencies were higher as compared to second year. It might be due to more and longer time availability of N with *Azotobacter* which resulted in more yield with respective to applied inputs. During first year of experiment the value of all the efficiencies were higher as compared to second year. This might be due to drought and weed problem in second year which caused reduction in crop yield. Nitrogen use efficiency might be affected by crop species, soil type, temperature, application rate of N fertilizer, soil moisture condition and crop rotation (Halvorson *et al.* 2004). Physiological efficiency and crop recovery efficiency of aromatic rice was significantly influenced due to preceding summer green manuring crop (Pooniya and Shivay 2011). Prasad

Table 3 Effect of residue and N management on N uptake and N use efficiency of aerobic rice

Treatment	N uptake by grain (kg/ha)		N uptake by straw (kg/ha)		Total N uptake (kg/ha)		Agronomic efficiency (kg grain increased/kg N applied)		Crop recovery efficiency (%)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Residue application										
Bare soil	42.2	32.2	37.3	29.1	79.5	61.3	11.1	7.70	32.5	23.6
Sesbania @ 10 t/ha	45.7	35.1	40.3	31.9	86.0	67.1	10.9	7.74	32.7	25.1
Leuceaena @ 10 t/ha	48.0	38.2	41.9	33.7	89.9	72.0	9.9	7.54	31.1	26.6
TPR	51.1	48.2	42.7	43.1	93.8	91.2	10.9	11.0	33.1	34.4
SEm±	1.39	0.87	0.76	1.03	2.00	1.20	1.22	0.85	1.74	1.29
LSD (P = 0.05)	4.81	3.01	2.63	3.56	6.93	4.14	NS	NS	NS	NS
N management										
Control (N_0)	27.5	22.3	25.7	21.6	53.3	43.9				
75% RDN	45.3	36.7	40.1	32.8	85.4	69.6	11.6	8.8	35.8	28.5
100% RDN	53.3	44.8	46.2	39.7	99.5	84.5	12.6	10.5	38.5	33.8
75% RDN + *Azo	49.5	41.0	42.9	36.2	92.4	77.1	14.3	11.5	43.5	36.9
100% RDN + *Azo	58.0	47.4	47.9	41.9	105.9	89.4	15.2	11.7	43.9	37.9
SEm±	0.90	0.77	0.60	0.75	1.17	1.21	0.642	0.55	1.15	1.12
LSD (P = 0.05)	2.60	2.23	1.73	2.16	3.36	3.48	NS	NS	NS	NS

Table 4 Effect of residue and N management on economics of rice cultivation

Treatment	Cost of cultivation (₹×10³/ha)		Gross return (₹ ×10³/ha)		Net return (₹ ×10³/ha)		B:C ratio	
	2013	2014	2013	2014	2013	2014	2013	2014
Residue application								
Bare soil	36.86	43.60	102.77	78.59	65.91	34.99	1.78	0.80
Sesbania @10 t/ha	40.36	47.20	109.29	83.54	68.93	36.34	1.70	0.77
Leuceaena @10 t/ha	40.76	47.64	113.31	87.41	72.56	39.78	1.78	0.83
TPR	48.90	56.15	122.22	116.00	73.31	59.85	1.50	1.06
SEm±			2.85	1.89	2.85	1.89	0.068	0.037
LSD (*P*= 0.05)			9.86	6.54	9.86	6.54	NS	0.13
Nitrogen management								
Control (N_0)	40.86	47.78	76.93	63.66	36.08	15.87	0.89	0.32
75% RDN	41.69	48.62	109.43	88.12	67.73	39.49	1.64	0.80
100% RDN	42.07	49.00	123.61	102.33	81.54	53.33	1.95	1.08
75% RDN + *Azo	41.79	48.72	116.84	95.72	75.04	47.00	1.81	0.95
100% RDN + *Azo	42.17	49.10	132.68	107.10	90.51	58.00	2.16	1.17
SEm±			1.82	1.57	1.82	1.57	0.042	0.032
LSD (*P*= 0.05)			5.24	4.52	5.24	4.52	0.12	0.09

(2005) reported that all N use efficiencies increased when followed the holistic approach of nutrient management like, judicious combined use of fertilizers, biofertilizers and organic manures (FYM, compost, vermicomposting, biogas slurry, green manures, crop residues etc).

Economics

Economic analysis of rice production showed that residue application and N management had significant influence on economics of rice cultivation. The highest cost of cultivation (COC) was recorded under TPR (₹ 48.90 × 10^3 and 56.15×10^3) which was followed by *Leucaena* and *Sesbania* treatment. This might be due to higher cost involved in raising of nursery, labour charge and irrigation cost. During the second season low rainfall was (473 mm) received during cropping season resulted higher number of irrigation and man days required which adversely affected the COC compared to first year. In case of N management highest COC was observed in 100% RDN + *Azotobacter* (₹ 42.17 × 10^3 and 49.10 × 10^3) which was very closely followed by 100% RDN during both the years.

The maximum gross (₹ 122.2 × 10^3 and 116.0 × 10^3) and net return (₹ 73.3 × 10^3 and 59.9 × 10^3) was recorded in TPR which was at par with *Leucaena* applied treatment during first year, however it was significantly higher than rest of the treatment during second year. This might be due to higher grain and straw yield recorded under TPR compared to rest of treatments. Among the N management treatment 100% RDN + *Azotobacter*, recorded highest gross return and net return during both the years of experiment which was followed by 100% RDN. The value of B: C ratio was highest with *Leucaena* treatment (₹ 1.78) during first year which was *at par* with bare soil (₹ 1.78) during the second year. It might be due to good performance of *Leucaena* treatment during first year while, drought and weed problem in second year had caused reduction in crop yield and finally affected the B: C ratio of aerobic rice. Among the N management treatment 100% RDN + *Azotobacter* gave highest B: C ratio (₹ 2.16 and 1.17) which was followed by 100% RDN during both the years of experimentation. Pooniya and Shivay (2011) also reported highest values of gross, net returns and B: C ratio of rice with *Sesbania aculeata* summer green manured crop. The sustainable yield advantages by integrated nutrient management over chemical fertilization alone have been emphasized by Singh *et al*. (2011).

It was concluded that the performance of rice cultivar Pusa Basmati 1509 was better under transplanted cultivation and produced higher yield than aerobic rice. But higher cost of cultivation under TPR negatively affected its economics. Green organic mulching with *Leucaena* in AR cultivation recorded the higher B: C ratio compared to TPR. Integrated N management with 120 kg N + *Azotobacter* gave highest rice productivity, N use efficiency, net return and B: C ratio.

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