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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT AND SPACING ON GROWTH AND YIELD OF RICE (BIRRI dhan69)

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A B S T R A C T

With the development of high yielding rice varieties, use of chemical fertilizers increased rapidly in Bangladesh. Depending on chemical fertilizer solely is not wise and maintaining soil health becomes a great concern worldwide. The purpose of the study is to know about the effect of organic and inorganic fertilizer on growth and yield of rice. The experiment was laid out in a split-plot design with four nutrient managements (N_1= BRRI recommended fertilizer dose (N-P-K-S-Z = 117-19-58-15-4 kg ha^{-1}), N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + Decomposed poultry litter (DPL) (2.5 t ha^{-1}) and N_4= No fertilizer) in the main plots and three spacing(S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm and S_3= 25 cm × 15 cm) in the sub-plots with three replications. In growth and yield characteristics, insignificant difference was found for different spacing but significant difference was found for different nutrient managements. N_1 and N_3 performed better than N_2 and N_4 in all observed characteristics. N_1 and N_3 gave statistically similar result in yield. The result revealed that, with the application of 2.5 t ha^{-1} DPL we can reduce 25% chemical fertilizer without yield reduction in rice.

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INTRODUCTION

More than 759.6 Mt of rice was produced globally in 2017 (FAO, 2018). Rice is the most important cereal crop in Asia and approximately 90% of annual production is grown and consumed. But the mean yields in Asia are low compared to global mean yields (Haider, 2018). Bangladesh was the fourth largest rice producer in the world, but its productivity was low compared with other Asian countries. To increase rice yield proper fertilizers management is very important (Stellacci *et al.,* 2013). The excess use of fertilizers with chemically unbalanced NPK ratios and in intensive rice production has resulted in soil-related problems, such as acidification (Chen, 2016), loss of organic matter, deterioration of the structure, and reductions in biological activities and fertility (Zhong and Cai, 2007). Balanced use of fertilizer nutrients in adequate quantities is necessary to increase yield and to sustain soil health and productivity level (Mahato et al*.,* 2007). Organic fertilizer can improve soil physical and chemical properties, enhance soil conservation of nutrients and promote the crop growth (Mi *et al.,* 2018). There has been increased interest in using poultry litter as organic fertilizer. In Grey Terrace soils (AEZ 28), BRRI dhan69 were able to produce 5.08-5.60 t ha^{-1} grain yield with 20% less of recommended fertilizer dose (BRRI, 2014-2015). In addition rice transplanted at a closer spacing recorded significantly higher yield as compared to wider spacing (Pandey and Tiwari, 1996). So, this experiment was conducted with integrated nutrient management by using poultry litter with different spacing in rice.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in Boro 2016-17 at Bangladesh Rice Research Institute (BRRI) farm, Gazipur. The soil of BRRI farm was clay loam under Madhupur tract (AEZ 28).

Plant materials and planting method

Planting crop was BRRI dhan69. Thirty-nine-day-old seedling was transplanted using one seedling per hill on 17th January, 2017.

Experimental design and application of manures and fertilizers

The experiment was laid out in split plot design with three replications, the main plot treatments were nutrient management, N_1= BRRI recommended fertilizer dose (N-P-K-S-Z = 117-19-58-15-4 kg ha^{-}1), N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + Decomposed poultry litter (DPL) (2.5 t ha^{-1}) and N_4= No fertilizer. The sub plot treatments were spacing, S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm and S_3= 25 cm × 15 cm. Full doses of PKSZ and poultry litter were applied during final land preparation and N was top dressed at 15, 30 and 45 DAT.

Data collection procedure

For tillering pattern, tiller number was counted at twelve hills for each plot which started from 35 DAT and continued up to maturity at 15 days interval. Leaf area index (LAI) was taken at heading stage from one representative hill (selected from average of twelve hills). Plant height was measured from the base of the plant to tip of the panicle. At maturity, 5 m^2 areas was harvested for grain yield and adjusted to 14% moisture content.

Statistical analysis

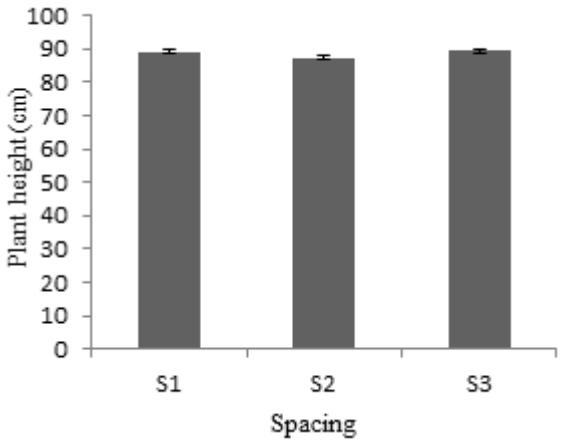
The data were statistically analyzed using Statistics 10 analytical software. The least significant difference (LSD) at 5% probability was used to compare means of the treatments.

RESULTS AND DISCUSSION

Plant height and leaf area index (LAI)

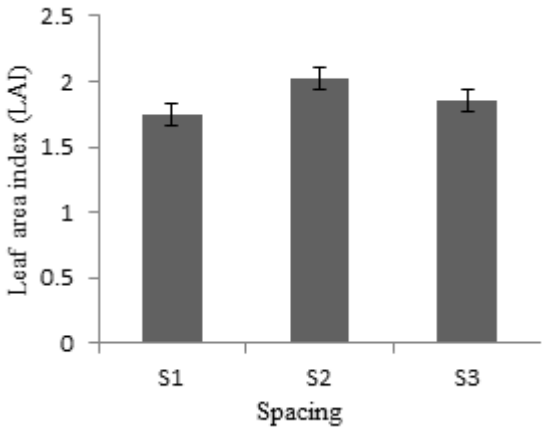
Plant height was not significantly influenced by spacing in this study and similar result was found by Bhowmik *et al.* (2012). But leaf area index (LAI) differed significantly. 20 cm × 15 cm (S_2) gave 16.7% and 9.7% higher LAI than 20 cm × 20 cm (S_1) and 25 cm × 15 cm (S_3) respectively due to higher plant population in closer spacing. Hasanuzzaman *et al.* (2009) reported that, when number of seedling decreased than LAI also decreased.

For integrated nutrient there was significant difference in plant height and leaf area index. 75% of BRRI recommended dose (BRD) + 2.5 t $ha^{-1}$of decomposed poultry litter (DPL)(N_3) gave highest plant height (93 cm) which is 5.3% higher than 75% BRD (N_2). Kohayashi *et al.* (1989) also observed that inorganic fertilizer with combination of organic fertilizer gave highest plant height. In leaf area index BRRI recommended dose (N_1) and 75 % of BRD + 2.5 t ha^{-1} of DPL (N_3) gave similar result. N_2 gave 31% lower leaf area index than N_1 and N_3. Same result was found by Ndaeyo *et al.* (2003) who reported that higher NPK fertilizer significantly increased the number of leaves in rice and consequently higher LAI.



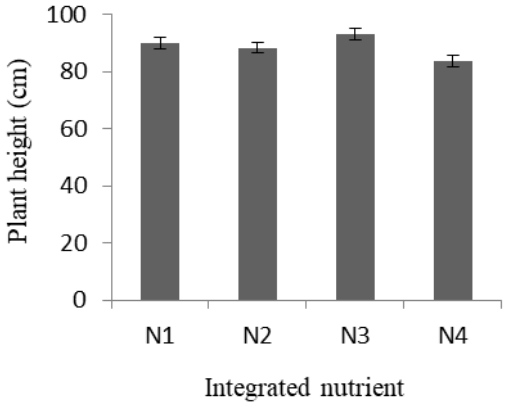
S_1 = 20 cm × 20 cm, S_2 = 20 cm × 15 cm, S_3 = 25 cm × 15 cm

Figure 1. Effect of spacing on plant height of BRRI dhan69 (Small bar represents SE)



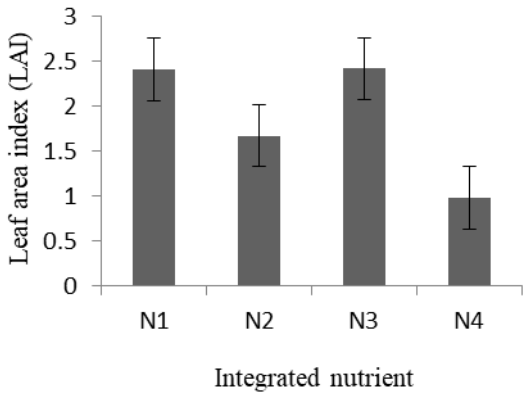
S_1 = 20 cm × 20 cm, S_2 = 20 cm × 15 cm, S_3 = 25 cm × 15 cm

Figure 2. Effect of spacing on leaf area index of BRRI dhan69 (Small bar represents SE)



N_1 = BRD, N_2 = 75% of BRD, N_3 = 75% of BRD+ 2.5 t ha^{-1} DPL, N_4 = No fertilizer

Figure 3. Effect of integrated nutrient on plant height of BRRI dhan69 (Small bar represents SE)



N_1 = BRD, N_2 = 75% of BRD, N_3 = 75% of BRD + 2.5 t ha^{-1} DPL, N_4 = No fertilizer

Figure 4. Effect of integrated nutrient on leaf area index of BRRI dhan69 (Small bar represents SE)

Significant difference was found in plant height and leaf area index for interaction effect. Maximum plant height (94 cm) was observed with N_3S_1 and N_3S_3.The highest LAI was observed with N_1S_2 which is statistically similar with N_3S_2.

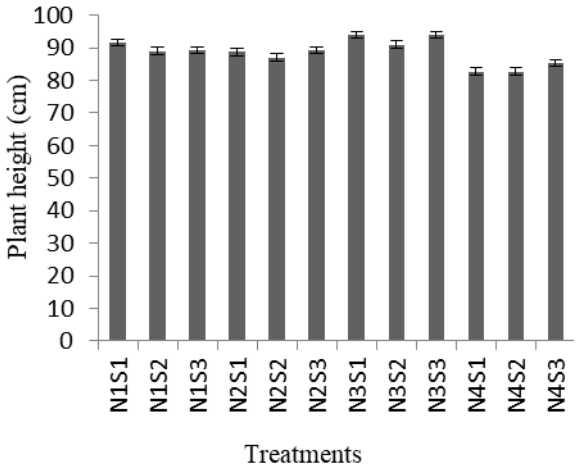


Figure 5. Interaction effect of integrated nutrient and spacing on plant height of BRRI dhan69 (Small bar represents SE)

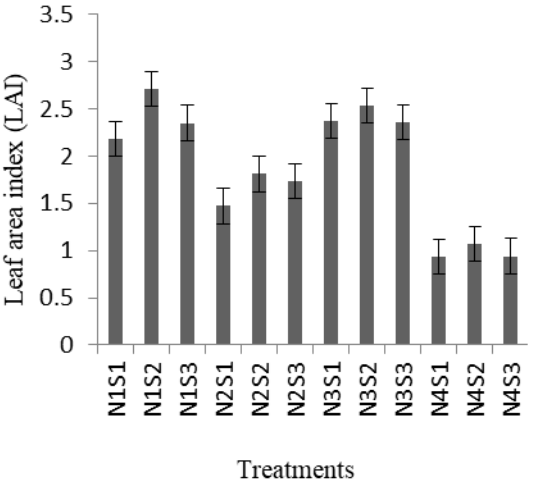


Figure 6. Interaction effect of integrated nutrient and spacing on leaf area index of BRRI dhan69 (Small bar represents SE)

Tillering pattern

Among all the treatments maximum tiller number was found at 65 DAT. For spacing there was significant difference in tiller number from 35 DAT to 95 DAT but at maturity there was no significant difference. Closer spacing (S_2) gave comparatively more tiller per unit area than S_1 and S_3. Wider space allows the individual plants to produce more tillers but it provides the smaller number of hills per unit area (Vijayakumar *et al.,* 2005 and Bhowmik *et al*., 2012) For integrated nutrient at 35 DAT highest tiller number (121) was found in N_3 (75 % of BRD + 2.5 t $ha^{-1}$of DPL)) which is 34.4% and 40.7% higher than N_1 (BRD) and N_2 (75 % BRD), respectively but from 50 DAT to maturity N_1 gave highest tiller number (Table 1). Lack of nutrient affected the formation of new cells so that plant growth was obstructed and tiller formation was decreased (Sution *et al.* 2017).

Table 1. Effect of spacing and integrated nutrient on tillering pattern of BRRI dhan69 in Boro 2016-17, BRRI, Gazipur

Treatment	Tiller number (m^2) at different DAT					
	35 DAT	**50 DAT**	**65 DAT**	**80 DAT**	**95 DAT**	**At maturity**
Spacing						
S_1	86	173	223	202	189	181
S_2	106	186	235	224	206	190
S_3	90	179	230	220	198	186
$LSD_{0.05}$	2.09	3.91	3.64	1.92	5.84	ns
Integrated nutrient						
N_1	90	211	273	252	233	213
N_2	86	182	236	219	200	197
N_3	121	192	265	249	224	199
N_4	79	131	144	138	133	128
$LSD_{0.05}$	3.89	3.73	4.10	4.61	7.95	6.93
CV	3.59	1.81	1.56	1.87	3.56	3.37

N_1= BRRI recommended dose, N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N_4= No fertilizer, S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm, S_3= 25 cm × 15 cm.

At 35 DAT N_3S_2 showed highest tiller number but at 50 DAT higher tiller number was found at N_1S_2 and continued till maturity. From 65 DAT to maturity between the treatments N_1S_2 and N_3S_2 there was no significant difference for tiller number.

Yield and yield components

In this study variation of plant spacing showed non-significant differences in panicle number, grains $panicle^{-1}$, 1000 grains weight, sterility percentage and respectively in grain yield. In harvest index also there was no significant difference. Panicle number, grains $panicle^{-1}$, grain yield and sterility (%) affected significantly by integrated nutrient. BRD (N_1) gave highest panicle number but 75% of BRD + 2.5 t $ha^{-1}$of DPL (N_3) gave highest grains $panicle^{-1}$. In grain yield no significant difference was found between N_1 and N_3. N_3 gave 3% and 39.4% lower sterility (%) than N_1 and N_2 (75% of BRD) respectively. Organic fertilizers provide a more balanced mix of nutrients to plants, particularly micronutrients, which improve rice yields (Miller, 2007). Moe *et al.* (2017) reported that the combined application of inorganic and organic manures improving N uptake in rice and thus increase rice yield. In 1000 grains weight and harvest index there was no significant difference for the variation of integrated nutrient.

Table 2. Interaction effect of integrated nutrient and spacing on tillering pattern of BRRI dhan69 in Boro 2016-17, BRRI, Gazipur

Treatment	Tiller number (m^2) at different DAT					
	35 DAT	50 DAT	65 DAT	80 DAT	95 DAT	At maturity
N_1S_1	81	213	271	241	218	210
N_1S_2	102	216	284	273	250	215
N_1S_3	88	205	263	251	230	214
N_2S_1	76	171	232	209	192	190
N_2S_2	104	185	231	216	200	196
N_2S_3	77	191	245	231	208	206
N_3S_1	120	188	251	224	214	194
N_3S_2	130	203	281	271	242	208
N_3S_3	112	184	262	252	216	196
N_4S_1	65	119	136	132	130	128
N_4S_2	87	138	145	137	133	126
N_4S_3	84	135	150	144	136	129
$LSD_{0.05}$	4.18	7.82	7.28	3.89	11.69	7.06
CV%	2.57	2.52	1.84	1.04	3.48	2.28

N_1= BRRI recommended dose, N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N_4= No fertilizer, S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm, S_3= 25 cm × 15 cm.

Table 3. Effect of spacing and integrated nutrient on yield and ancillary characters of BRRI dhan69 in Boro 2016-17, BRRI, Gazipur

Treatment	Panicle (1 m^2)	Grains $panicle^{-1}$	1000 GW	Yield (t/ha)	Sterility (%)	HI
Spacing						
S_1	174	130	23.6	4.99	13.2	0.53
S_2	177	127	23.7	5.10	9.2	0.53
S_3	181	128	23.5	5.13	13.9	0.54
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns
Integrated nutrient						
N_1	208	133	23.5	5.84	16.3	0.53
N_2	196	112	23.4	5.49	17.5	0.54
N_3	199	141	23.7	5.79	10.6	0.52
N_4	118	128	23.7	3.16	4.1	0.54
$LSD_{0.05}$	8.08	14.08	ns	0.18	4.22	ns
CV	3.99	9.60	1.07	3.13	30.19	5.41

N_1= BRRI recommended dose, N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N_4= No fertilizer, S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm, S_3= 25 cm × 15 cm.

N_1S_2 gave higher grain yield (6.21 t ha^{-1}) of BRRI dhan69 due to higher number of panicles and grains per panicle. N_3S_2 gave 5.5% lower yield from N_1S_2 due to less number of panicles. N_3S_3 gave statistically similar yield (6.08 t ha^{-1}) with N_1S_2 because it gave second highest panicle m^{-2} and grains $panicle^{-1}$. Highest thousand grains weight (23.8) was found both in N_3S_2 and N_4S_2. In sterility (%) N_1S_1 and N_2S_1 gave similar result. Lowest sterility (%) was observed with N_4S_1 and highest with N_2S_1. Highest harvest index was observed with N_4S_3 where the lowest harvest index was observed with N_3S_3.

Table 4. Interaction effect of integrated nutrient and spacing on yield and ancillary characters of BRRI dhan69 in Boro 2016-17, BRRI, Gazipur

Treatment	Panicle ($1m^2$)	Grains $panicle^{-1}$	1000 GW	Yield (t/ha)	Sterility (%)	HI
N1S1	208	117	23.7	5.52	24.8	0.53
N1S2	212	147	23.5	6.21	9.0	0.55
N1S3	203	135	23.3	5.80	15.1	0.53
N2S1	188	128	23.2	5.68	25.6	0.53
N2S2	195	104	23.5	5.34	11.4	0.53
N2S3	205	105	23.5	5.46	15.5	0.55
N3S1	183	138	23.7	5.41	9.8	0.55
N3S2	187	140	23.8	5.87	12.4	0.52
N3S3	196	144	23.7	6.08	9.5	0.50
N4S1	118	138	23.7	3.34	2.5	0.53
N4S2	115	117	23.8	2.96	4.1	0.52
N4S3	121	128	23.5	3.18	5.6	0.56
$LSD_{0.05}$	9.24	10.96	0.44	0.18	5.60	0.29
CV	3.04	4.98	1.10	2.01	26.71	3.15

N_1= BRRI recommended dose, N_2= 75% of BRRI recommended dose, N_3= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N_4= No fertilizer, S_1= 20 cm × 20 cm, S_2= 20 cm × 15 cm, S_3= 25 cm × 15 cm.

CONCLUSION

Yield sacrifice will not consider by farmers, so integrated nutrient management should be taken as to remain the yield satisfactory. We should concern about soil health for future demand and in this purpose organic fertilizer should be included for rice cultivation. Seventy five percent of BRRI recommended dose of chemical fertilizer + Decomposed poultry litter (2.5 t ha^{-1}) with 25 cm × 15 cm spacing may be a good option for cultivation of BRRI dhan69. However, multi-location field trials would be required for the verification of the results.

CONFLICT OF INTEREST

There is no conflict of interest.

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