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

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ARTICLE INFO

ABSTRACT

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 (N1= BRRI recommended fertilizer dose (N-P-K-S-Z = 117-19-58-15-4 kg ha-1), N2= 75% of BRRI recommended dose, N3= 75% of BRRI recommended dose + Decomposed poultry litter (DPL) (2.5 t ha-1) and N4= No fertilizer) in the main plots and three spacing(S1= 20 cm × 20 cm, S2= 20 cm × 15 cm and S3= 25 cm × 15 cm) in the subplots with three replications. In growth and yield characteristics, insignificant difference was found for different spacing but significant difference was found for different nutrient managements. N1 and N3 performed better than N2 and N4 in all observed characteristics. N1 and N3 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.

To cite this article: Akter R, MA Badshah, A Sultana, MJ Turon and MJ Islam, 2020. Influence of integrated nutrient management and spacing on growth and yield of rice (BIRRI dhan69). Res. Agric. Livest. Fish. 7 (1): 25-32.
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, N₁= BRRI recommended fertilizer dose (N-P-K-S-Z = 117-19-58-15-4 kg ha⁻¹), N₂= 75% of BRRI recommended dose, N₃= 75% of BRRI recommended dose + Decomposed poultry litter (DPL) (2.5 t ha⁻¹) and N₄= No fertilizer. The sub plot treatments were spacing, S₁= 20 cm × 20 cm, S₂= 20 cm × 15 cm and S₃= 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 m² 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 (S2) gave 16.7% and 9.7% higher LAI than 20 cm × 20 cm (S1) and 25 cm × 15 cm (S3) 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) (N3) gave highest plant height (93 cm) which is 5.3% higher than 75% BRD (N2). 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 (N1) and 75% of BRD + 2.5 t ha⁻¹ of DPL (N3) gave similar result. N2 gave 31% lower leaf area index than N1 and N3. 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.

![Graph of plant height and leaf area index](image)

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

**Figure 2.** Effect of spacing 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 N₃S₁ and N₃S₃. The highest LAI was observed with N₁S₂ which is statistically similar with N₃S₂.
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 (S2) gave comparatively more tiller per unit area than S1 and S3. 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 N3 (75 % of BRD + 2.5 t ha-1 of DPL) which is 34.4% and 40.7% higher than N1 (BRD) and N2 (75 % BRD), respectively but from 50 DAT to maturity N1 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 (m²) at different DAT |
|---------------|-------------------------------------|
|               | 35 DAT | 50 DAT | 65 DAT | 80 DAT | 95 DAT | At maturity |
| Spacing       |        |        |        |        |        |            |
| S1            | 86     | 173    | 223    | 202    | 189    | 181        |
| S2            | 106    | 186    | 235    | 224    | 206    | 190        |
| S3            | 90     | 179    | 230    | 220    | 198    | 186        |
| LSD0.05       | 2.09   | 3.91   | 3.64   | 1.92   | 5.84   | ns         |
| Integrated nutrient |    |        |        |        |        |            |
| N1            | 90     | 211    | 273    | 252    | 233    | 213        |
| N2            | 86     | 182    | 236    | 219    | 200    | 197        |
| N3            | 121    | 192    | 265    | 249    | 224    | 199        |
| N4            | 79     | 131    | 144    | 138    | 133    | 128        |
| LSD0.05       | 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       |

N1 = BRRI recommended dose, N2 = 75% of BRRI recommended dose, N3 = 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N4 = No fertilizer, S1 = 20 cm × 20 cm, S2 = 20 cm × 15 cm, S3 = 25 cm × 15 cm.

At 35 DAT N3S2 showed highest tiller number but at 50 DAT higher tiller number was found at N1S2 and continued till maturity. From 65 DAT to maturity between the treatments N1S2 and N3S2 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 (N1) gave highest panicle number but 75% of BRD + 2.5 t ha-1 of DPL (N3) gave highest grains panicle-1. In grain yield no significant difference was found between N1 and N3. N2 gave 3% and 39.4% lower sterility (%) than N1 and N2 (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 (m²) at different DAT | 35 DAT | 50 DAT | 65 DAT | 80 DAT | 95 DAT | At maturity |
|-----------|-------------------------------------|--------|--------|--------|--------|--------|------------|
| N₁S₁      | 81                                  | 213    | 271    | 241    | 218    | 210    |
| N₁S₂      | 102                                 | 216    | 284    | 273    | 250    | 215    |
| N₁S₃      | 88                                  | 205    | 263    | 251    | 230    | 214    |
| N₂S₁      | 76                                  | 171    | 232    | 209    | 192    | 190    |
| N₂S₂      | 104                                 | 185    | 231    | 216    | 200    | 196    |
| N₂S₃      | 77                                  | 191    | 245    | 231    | 208    | 206    |
| N₃S₁      | 120                                 | 188    | 251    | 224    | 214    | 194    |
| N₃S₂      | 130                                 | 203    | 281    | 271    | 242    | 208    |
| N₃S₃      | 112                                 | 184    | 262    | 252    | 216    | 196    |
| N₄S₁      | 65                                  | 119    | 136    | 132    | 130    | 128    |
| N₄S₂      | 87                                  | 138    | 145    | 137    | 133    | 126    |
| N₄S₃      | 84                                  | 135    | 150    | 144    | 136    | 129    |
| LSD₀.₀₅   | 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   |

N₁= BRRI recommended dose, N₂= 75% of BRRI recommended dose, N₃= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N₄= No fertilizer, S₁= 20 cm × 20 cm, S₂= 20 cm × 15 cm, S₃= 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 m²) | Grains panicle⁻¹ | 1000 GW | Yield (t/ha) | Sterility (%) | HI |
|-----------|---------------|------------------|---------|--------------|---------------|----|
| Spacing   |               |                  |         |              |               |    |
| S₁        | 174           | 130              | 23.6    | 4.99         | 13.2          | 0.53|
| S₂        | 177           | 127              | 23.7    | 5.10         | 9.2           | 0.53|
| S₃        | 181           | 128              | 23.5    | 5.13         | 13.9          | 0.54|
| LSD₀.₀₅   | ns            | ns               | ns      | ns           | ns            | ns |

Integrated nutrient

| Treatment | Panicle (1 m²) | Grains panicle⁻¹ | 1000 GW | Yield (t/ha) | Sterility (%) | HI |
|-----------|---------------|------------------|---------|--------------|---------------|----|
| N₁        | 208           | 133              | 23.5    | 5.84         | 16.3          | 0.53|
| N₂        | 196           | 112              | 23.4    | 5.49         | 17.5          | 0.54|
| N₃        | 199           | 141              | 23.7    | 5.79         | 10.6          | 0.52|
| N₄        | 118           | 128              | 23.7    | 3.16         | 4.1           | 0.54|
| LSD₀.₀₅   | 8.08          | 14.08            | ns      | 0.18         | 4.22          | ns |
| CV        | 3.99          | 9.60             | 1.07    | 3.13         | 30.19         | 5.41|

N₁= BRRI recommended dose, N₂= 75% of BRRI recommended dose, N₃= 75% of BRRI recommended dose + 2.5 t/ha decomposed poultry litter, N₄= No fertilizer, S₁= 20 cm × 20 cm, S₂= 20 cm × 15 cm, S₃= 25 cm × 15 cm.
N$_1$S$_2$ gave higher grain yield (6.21 t ha$^{-1}$) of BRRI dhan69 due to higher number of panicles and grains per panicle. N$_3$S$_2$ gave 5.5% lower yield from N$_1$S$_2$ due to less number of panicles. N$_3$S$_3$ gave statistically similar yield (6.08 t ha$^{-1}$) with N$_1$S$_2$ because it gave second highest panicle m$^{-2}$ and grains panicle$^{-1}$. Highest thousand grains weight (23.8) was found both in N$_3$S$_2$ and N$_4$S$_2$. In sterility (%) N$_1$S$_1$ and N$_2$S$_1$ gave similar result. Lowest sterility (%) was observed with N$_4$S$_1$ and highest with N$_2$S$_1$. Highest harvest index was observed with N$_4$S$_3$ where the lowest harvest index was observed with N$_3$S$_3$.

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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