Ratoon Rice Response to Different Fertilizer Doses in Irrigated Condition

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Summary

The response of different fertilizer doses was studied on the ratoon crop as well as main crop. The different fertilizer doses under the study were F1 (N=90, P2O5 = 45, K2O=50, S=13, Zn = 4: in kg ha⁻¹), F2 (N=105, P2O5 = 55, K2O=60, S=13, Zn = 4: in kg ha⁻¹), F3 (N=120, P2O5 = 65, K2O=70, S=13, Zn = 4: in kg ha⁻¹), F4 (N=135, P2O5 =75, K2O=80, S=13, Zn=4: in kg ha⁻¹) and F5 (N=150, P2O5 = 85, K2O = 90, S=13, Zn = 4: in kg ha⁻¹). In the main crop, the highest grain and biological yields were produced by F3 dose. The highest straw yield was produced by F4 dose. The lowest grain yield and the lowest biological yield were produced by F1 dose and the lowest straw yield was produced by F2 dose. The highest crop duration was found using F1 dose and the shortest crop duration was found using F3 doses. In the ratoon crop, the highest grain yield, straw yield and biological yield was produced by F5 dose whereas the lowest grain yield, straw yield and biological yield was achieved with F1 dose. The longest crop duration was observed using F2 dose and the shortest crop duration was recorded using F5 dose.

Key words

rice, ratoon, fertilizer dose, yield, crop duration

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Introduction

Increasing rice grain yields per unit of area is one approach to improving total rice production (Santos et al., 2003). Ratooning is the practice of harvesting grain from tillers originating from the stubble of a previously harvested crop (main crop). It enhances rice grain yields without increasing land area (Mengel and Wilson, 1981) because it provides higher resource-use efficiency per unit of land area and per unit of time (Santos et al., 2003). Therefore, the benefit in ratooning lies in the facts of avoiding elaborate land preparation, saving of seed planting costs (Zandstra and Samson, 1979), economic use of machineries, high water use efficiency (Prashar, 1970) and considerable saving in cropping time as it has the advantages of reduced growth duration (Haque and Coffman, 1980).

On an average, ratoon rice can give a yield of roughly equivalent to 40% of that of the main crop, with 40% reduction in crop duration (Chauhan et al., 1983). Ratoon yield is generally less than the main crop but cases of higher yield have also been reported in paddy (Santhi et al., 1993). If grain yield of the ratoon crop alone is considered, it may be seen discouraging. However, if consideration is given to the time factor to express yield, ratoon cultures are found to be very encouraging (Quddus and Pendleton, 1990).

In Bangladesh, crop intensification through rice ratooning constitutes one of the important options for the farmers in achieving food security. In this context, ratooning can play a very significant role with its very short growth duration usually taking only 35% to 60% of the time required for the main crop (Jones and Snyder, 1987). In Bangladesh context, there is potential for rice ratooning form the stubble of boro rice with residual soil moisture and monsoon rainwater.

Satisfactory yield of ratoon rice depends on varieties, seasonal requirements, optimum fertilizer dose, time of fertilization, cutting height, planting dates, spacing, growth duration, date of harvest, water and pest management and so on. Among them fertilizer has an important role on the performance of ratoon rice. The ratoon crop responded to N fertilizers given in the main crop (Szokolay, 1956; Ishikawa, 1964; Balasubramanian et al., 1970). It was observed that yield of ratoon crop increased with the increasing rate of nitrogen up to 125 kg ha⁻¹ (Balasubramanian and Krishnasamy, 1997). Results indicated that the application of nitrogen by 140 kg ha⁻¹ had better yields (increase 12.8-16.1%) and rice quality than nitrogen application at the level of 100 kg ha⁻¹ (Chuang and Ding, 1992). Performance of ratoon rice is also affected by phosphorus doses (Bahr et al., 1977). Kavoosi et al. (2004) found that the highest grain yield have obtained from ratoon rice when K₂O was applied as 100 kg ha⁻¹.

Therefore, the present study was undertaken to determine the optimum fertilizer dose for ratoon of rice in Boro (winter) season under Bangladesh condition.

Materials and methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2003 to August 2004. Geographically, the experimental area is located at 24° 75’ N and 90° 50’ E longitude at the elevation of above 18 m the sea level. The soil of the experimental pot was silty-loam having noncalcarious properties. The soil was little less then neutral (pH 6.8) in nature.

The rice variety BRRI dhan 28 was used in this experiment. The treatments comprising five different fertilizer doses viz. fertilizer doses F₁ (N=90, P₂O₅ = 45, K₂O=50, S=13, Zn = 4: in kg ha⁻¹), F₂ (N=105, P₂O₅ = 55, K₂O=60, S=13, Zn = 4: in kg ha⁻¹), F₃ (N=120, P₂O₅ = 65, K₂O=70, S=13, Zn = 4: in kg ha⁻¹), F₄ (N=135, P₂O₅ =75, K₂O=80, S=13, Zn=4: in kg ha⁻¹) and F₅ (N=150, P₂O₅ = 85, K₂O = 90, S=13, Zn = 4: in kg ha⁻¹). The experiments were laid out in a randomized complete block design with three replications for both: the main and the ratoon crops.

The experiments individual plot size was 10 m² (4 m × 2.5 m). Land was prepared by deep plowing followed by laddering. Forty three day old seedlings were transplant ed in the main field at the rate of two seedlings hill⁻¹. The main crop was fertilized according to the experimental treatments. Except urea, fertilizers were applied at the time of final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). Intercultural operations such as weeding, water management and plant protection measures were done as and when required for ensuring and maintaining the normal growth of crop.

The main crop was harvested leaving a culm height 25 cm above the ground level. Ten hills (excluding border hills) were randomly selected from each unit plot prior to harvest for recording of necessary data on different crop characters. Entire plot was harvested for taking grain and straw yield data. Grain and straw yield of 10 sample plants of each plot were added to those of entire plot to calculate the yields (grain and straw) per unit plot. The data on crop characters like plant height, total number of tillers hill⁻¹, number of effective tillers hill⁻¹, number of panicles hill⁻¹, number of fertile grain panicle⁻¹, 1000-grain weight, grain yield, straw yield and crop duration were recorded from sample plants at maturity. Biological yield and harvest index were calculated from the grain and straw yields of each entire plot. Collected data were analyzed following ANOVA techniques by using MSTAT-C computer package.
The mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

**Results and discussion**

**Plant height**

The plant height was significantly influenced by the fertilizer dose. Both of the main crop and ratoon crop were affected by fertilizer doses (Table 1). It was observed that the highest plant height of main crop as well as ratoon crop was produced by F3 dose (N=120, P2O5 = 65, K2O = 70, S=13, Zn = 4: in kg ha-1) whereas the lowest plant height was produced by F2 dose (N=150, P2O5 = 85, K2O = 90, S=13, Zn = 4: in kg ha-1). The increase in plant height due to application of increased level of nitrogen might be associated with stimulating effect of nitrogen of various physiological processes including cell division and cell elongation of the plant. Zandstra and Samson (1979) stated that plant height increased significantly due to nitrogen application. The excess doses of N after F4 did not show increases in plant height. Mengel and Wilson (1981) reported that an N fertilizer application rate of 125 kg ha-1 followed by immediate flooding produced highest ratoon rice yields. In every case the plant height of the ratoon crop was lower than the main crop and it ranged from 70-73% of the main crop. It was due to less ability to use the resources in plant body which is confirmed by Jones (1993).

**Total number of tillers hill-1**

Fertilizer dose had a significant effect on the total number of tillers hill-1 in this study. Only the main crop showed a significant response to N in terms of tiller production. The highest total number of tillers hill-1 was produced by F3 dose. On the contrary, the lowest total number of tillers hill-1 was produced by F1, which was statistically similar to that produced in the case of F2 dose (Table 1). Total number of tillers hill-1 produced by F4 was 23.43 and 21.79, respectively, which was statistically different from each other. This result corroborated with the result of Maqsood et al. (1999). The variation of fertilizer dose did not show significant changes in plant height in ratoon crop. However, numerically the highest total number of tillers hill-1 was found in F2 dose whereas the lowest total number of tillers hill-1 was found in F1 dose (Table 2). It was due to less potentiality of the ratoon rice to tiller production (Bollich and Turner, 1988).

**Number of effective tillers hill-1**

Fertilizer dose had significant effect on the number of effective tillers hill-1. In the main crop, the highest number of effective tillers hill-1 was produced by F3 dose and it was similar to that produced in F4 dose. The lowest number of effective tillers hill-1 was produced by F1 dose which was statistically similar to that of F2 dose. The number of effective tiller hill-1 produced by F2 dose was statistically dissimilar to that produced at rest of the fertilizer doses. In ratoon crop, the number of effective tillers hill-1 was not significantly influenced by fertilizer dose. Numerically, the highest number of effective tillers hill-1 was produced by F5 dose. The lowest number of effective tillers hill-1 was produced by F1 dose. It was due to the less capacity of ratoon crop to produce effective tiller with increased N, P and K. Ratoon crop also possesses less tiller producing potentiality than the main crop (Bollich and Turner, 1988).

**Number of panicles hill-1**

Number of panicles hill-1 was significantly affected by different fertilizer doses both in main crop and ratoon crop in this study (Table 2). In case of main crop the highest number of panicle (42.11) was observed from F5 which was statistically similar with F4. In case of ratoon crop, maximum numbers of panicle was observed from F3 which was statistically different from other doses. Although the response of fertilizer doses in rice was significant, the panicle producing capacity in ratoon crops was almost half

<table>
<thead>
<tr>
<th>Fertilizer dose</th>
<th>Plant height (cm)</th>
<th>Total number of tillers hill-1</th>
<th>Number of effective tillers hill-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main crop</td>
<td>Ratoon crop</td>
<td>% of main crop</td>
</tr>
<tr>
<td>F1</td>
<td>113.72 c</td>
<td>82.81 c</td>
<td>72.82 (-27.18)</td>
</tr>
<tr>
<td>F2</td>
<td>120.22 b</td>
<td>87.85 b</td>
<td>73.07 (-26.93)</td>
</tr>
<tr>
<td>F3</td>
<td>133.18 a</td>
<td>97.36 a</td>
<td>73.11 (-26.89)</td>
</tr>
<tr>
<td>F4</td>
<td>127.90 d</td>
<td>78.84 d</td>
<td>73.07 (-26.93)</td>
</tr>
<tr>
<td>F5</td>
<td>98.02 e</td>
<td>69.03 e</td>
<td>70.42 (-29.58)</td>
</tr>
<tr>
<td>S</td>
<td>1.54</td>
<td>0.66</td>
<td>-</td>
</tr>
</tbody>
</table>

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with different letters differ significantly (as per DMRT) at P≤0.05. * Figures in the parentheses indicate % increase (+) or decrease (-) in the ratoon crop as compared to the respective value in the main crop; F1 (N=90, P2O5 = 45, K2O=50, S=13, Zn = 4: in kg ha-1); F2 (N=105, P2O5 = 55, K2O=60, S=13, Zn = 4: in kg ha-1); F3 (N=120, P2O5 = 65, K2O=70, S=13, Zn = 4: in kg ha-1); F4 (N=135, P2O5 = 75, K2O=80, S=13, Zn = 4: in kg ha-1); F5 (N=150, P2O5 = 85, K2O = 90, S=13, Zn = 4: in kg ha-1).
the main crop. It was due to less number of effective tillers as well as less nutrient use efficiency. This result was supported by Bollich et al. (1994). In both of the cases F₁ produced lowest number of panicles hill⁻¹.

**Number of fertile grain panicle⁻¹**

Number of fertile grains panicle⁻¹ was significantly influenced by fertilizer dose in main crop as well as in ratoon crop. In the main crop, highest number of fertile grains panicle⁻¹ was found in F₁ dose, which was statistically different than other doses (Table 2). The lowest number of fertile grains panicle⁻¹ was found in F₅ dose, which was statistically similar to that produced in F₂ dose. In ratoon crop the fertile grain production was 46-60% lower than in main crop. It was due to less number of effective tillers as well as less nutrient supply to the ratoon crop. Kasturi and Purushothaman (1992) observed that grain yield and 1000-grain weight were highest with 100 kg N + 50 kg K₂O ha⁻¹. Fageria et al. (1997) also found similar results.

**1000-grain weight**

In this study 1000-grain weight was significantly affected by fertilizer dose both in main crop and ratoon crop. The highest 1000-grain weight was found in F₃ dose (N=120, P₂O₅ = 65, K₂O=70, S=13, Zn = 4: in kg ha⁻¹) both in main and ratoon crop (Table 2). On the contrary, the lowest 1000-grain weight was found in F₅ dose in case of main crop. But in ratoon crop it was lowest with F₁ treatments. It was revealed that the response of using fertilizers was higher in ratoon crop than in main crop in Boro rice. Probable reason for lower grain weight might be due to insufficient nutrient supply to the ratoon crop. Kasturi and Purushothaman (1992) observed that grain yield and 1000-grain weight were highest with 100 kg N + 50 kg K₂O ha⁻¹. Fageria et al. (1997) also found similar results.

**Grain yield**

In the main crop, grain yield was significantly influenced by fertilizer dose. The highest grain yield was found in F₃ dose which was statistically similar to that produced at F₄ dose (Table 3). The lowest grain yield was found in F₁ dose which was statistically similar to that produced in

### Table 2. Effect of fertilizer dose on the number of panicles, fertile grain and 1000-grain weight of main and ratoon crop of Boro rice

<table>
<thead>
<tr>
<th>Fertilizer dose</th>
<th>Number of panicles hill⁻¹</th>
<th>Number of fertile grain panicle⁻¹</th>
<th>1000-grain yield (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main crop</td>
<td>Ratoon crop</td>
<td>% of main crop</td>
</tr>
<tr>
<td>F₁</td>
<td>27.88 d</td>
<td>14.32 d</td>
<td>51.36 (±48.64)</td>
</tr>
<tr>
<td>F₂</td>
<td>34.55 c</td>
<td>16.22 c</td>
<td>46.95 (±53.05)</td>
</tr>
<tr>
<td>F₃</td>
<td>38.99 b</td>
<td>19.78 b</td>
<td>50.73 (±49.27)</td>
</tr>
<tr>
<td>F₄</td>
<td>40.11 a</td>
<td>20.44 a</td>
<td>50.96 (±49.04)</td>
</tr>
<tr>
<td>F₅</td>
<td>42.11 a</td>
<td>22.76 a</td>
<td>54.05 (±45.95)</td>
</tr>
<tr>
<td>Sₓ</td>
<td>0.89</td>
<td>0.76</td>
<td>-</td>
</tr>
</tbody>
</table>

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with different letters differ significantly (as per DMRT) at P≤0.05.* Figures in the parentheses indicate % increase (+) or decrease (-) in the ratoon crop as compared to the respective value in the main crop. F₁ (N=90, P₂O₅ = 45, K₂O=50, S=13, Zn = 4: in kg ha⁻¹); F₂ (N=105, P₂O₅ = 55, K₂O=60, S=13, Zn = 4: in kg ha⁻¹); F₃ (N=120, P₂O₅ = 65, K₂O=70, S=13, Zn = 4: in kg ha⁻¹); F₄ (N =135, P₂O₅ =75, K₂O=80, S=13, Zn=4: in kg ha⁻¹); F₅ (N=150, P₂O₅ = 85, K₂O = 90, S=13, Zn = 4: in kg ha⁻¹)

### Table 3. Effect of fertilizer dose on the yields and harvest index of main and ratoon crop of Boro rice

<table>
<thead>
<tr>
<th>Fertilizer dose</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main crop</td>
<td>Ratoon crop</td>
<td>% of main crop</td>
</tr>
<tr>
<td>F₁</td>
<td>4.92 d</td>
<td>1.22 b</td>
<td>24.75 (±75.25)</td>
</tr>
<tr>
<td>F₂</td>
<td>5.20 cd</td>
<td>1.24 b</td>
<td>23.81 (±76.19)</td>
</tr>
<tr>
<td>F₃</td>
<td>6.18 a</td>
<td>1.28 b</td>
<td>20.77 (±79.23)</td>
</tr>
<tr>
<td>F₄</td>
<td>5.85 ab</td>
<td>1.42 a</td>
<td>24.32 (±75.68)</td>
</tr>
<tr>
<td>F₅</td>
<td>5.54 bc</td>
<td>1.42 a</td>
<td>25.58 (±74.42)</td>
</tr>
<tr>
<td>Sₓ</td>
<td>0.13</td>
<td>0.04</td>
<td>-</td>
</tr>
</tbody>
</table>

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with different letters differ significantly (as per DMRT) at P≤0.05.* Figures in the parentheses indicate % increase (+) or decrease (-) in the ratoon crop as compared to the respective value in the main crop. F₁ (N=90, P₂O₅ = 45, K₂O=50, S=13, Zn = 4: in kg ha⁻¹); F₂ (N=105, P₂O₅ = 55, K₂O=60, S=13, Zn = 4: in kg ha⁻¹); F₃ (N=120, P₂O₅ = 65, K₂O=70, S=13, Zn = 4: in kg ha⁻¹); F₄ (N =135, P₂O₅ =75, K₂O=80, S=13, Zn=4: in kg ha⁻¹); F₅ (N=150, P₂O₅ = 85, K₂O = 90, S=13, Zn = 4: in kg ha⁻¹)
However, in main crop numerically the highest yield was found in F4 dose, which was statistically similar to that produced in F5 dose, which indicated that response of fertilizer doses to grain production was influenced by fertilizer dose. In main crop, the highest straw yield was found in F5 dose, which was statistically similar to that in rest of the fertilizer doses except F4 dose. In case of ratoon crop, the response was little more than in main crop. In this case the highest straw yield was found in F4 dose, which was statistically similar to that produced in F2 dose. The lowest straw yield was found in F2 dose. Fertilizer dose also showed a significant effect on the grain yield of ratoon crop. But in this case, the highest grain yield was obtained from F4 dose which was statistically identical with F5 dose, which indicated that response of ratoon rice to fertilizer was stronger than that of main crop. "Kasturi and Purushothaman (1992) also observed that grain yield varied with different fertilizer dose. The higher response of fertilizer doses to grain production might be due to more number of tillers, more panicles and grain weight. This result was in agreement with Choi and Kwon (1985), Hsieh and Young (1959) and Szokolay (1956).

**Straw yield**

Results showed that the straw yield was significantly influenced by fertilizer dose. In main crop, the highest straw yield was found in F4 dose, which was identical to that produced in F1 doses. The lowest straw yield was found in F2 dose, which was statistically similar to that in rest of the fertilizer doses except F4 dose. In case of ratoon crop, the response was little more than in main crop. In this case the highest straw yield was found in F2 dose, which was statistically similar to that produced in F4 dose. The lowest straw yield was found in F1 dose. It was due to lower plant height and tiller production with these treatments. These results were supported by Setty et al. (1993), Kasturi and Purushothaman (1992) and Yuan et al. (1996).

**Harvest index**

There were no significant differences in harvest index due to fertilizer doses in both main crop and ratoon crop (Table 3). However, in main crop numerically the highest harvest index was found in F3 dose. On the other hand, the lowest harvest index was found in F1 dose. But in case of ratoon crop, the opposite result was observed.

**Crop duration**

Crop duration was significantly affected by fertilizer dose. In main crop, the effect was statistically significant whereas there were no significant effect of fertilizer doses on ratoon crops. In main crop, the highest crop duration was observed in F1 dose. On the other hand, the lowest crop duration was observed in F3 dose, which was statistically similar to that of F4 and F5 doses (Figure 1). In case of ratoon crop, the highest crop duration was recorded in F2 dose and the lowest crop duration was observed in F5 dose. In every case the duration of ratoon crop was much shorter than main crop. 43-55% lower crop duration was observed in case of ratoon cropping in Boro rice. This result is supported by Santos et al. (2003) and Haque and Coffman (1980). Jones and Snyder (1987) reported that ratoon rice needs very short growth duration usually taking only 35% to 60% of the time required for the main crop.

**Conclusions**

From the study it may be concluded that performance of ratoon rice as well as main crop of rice have a tremendous response to different fertilizer doses. In both of the cases yield and yield components were significantly influenced by fertilizer doses. Maximum grain yield of main crop as well as ratoon crop was produced by N=150, P2O5 = 85, K2O = 90, S=13, Zn = 4: in kg ha⁻¹. Grain yield from ratoon crop was found to be lower than main crop but the crop duration was much shorter than main crop that may be a good alternative to increase total rice production.

**References**


