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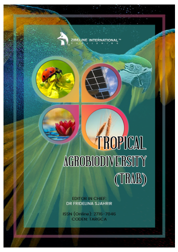

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RESEARCH ARTICLE

INFLUENCE OF SEED SOURCE ON PLANT GROWTH, YIELD AND YIELD GAP OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Seed source is influenced on plant growth and yield of a crop. The objective of this research was to investigate the plant growth and yield including gap of rice collected seed from different sources in Bangladesh. The seed of rice variety BRRI dhan28 of *Oryza sativa* L. was used as study material. The treatments were consisted of four sources of seed *viz*. Bangladesh Agricultural Development Corporation (BADC), private seed company, farmers' own seed and seed from local market. The seed was also obtained from Bangladesh Rice Research Institute (BRRI) that was used for control. Data regarding plant growth parameters (plant height, leaf area, absolute growth rate, AGR and relative growth rate, RGR); yield attributes (number of spikelet/panicles, 1000-grain weight and yield/ton); and percentage of yield gap were investigated. Minimum plant growth parameters except RGR and all yield attributes of rice were observed in the seed of BRRI followed by BADC; while the highest RGR was observed in the seed of BRRI and BADC simultaneously. The yield gap of rice was the highest in the seed of the market. The plant growth and grain yield of rice were comparatively higher in the seed of BRRI followed by BADC and company due to higher knowledge of seed production and processing technology; while higher yield gap were observed in the seed of farmer and market due to poor seed production and processing facilities as well as their poor knowledge.

KEYWORDS

Seed source, Rice, *Oryza sativa*, Plant growth, Yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is a primary source of food for approximately 3.5 billion people around the world (Karki et al., 2018). This crop supplies 50% of the dietary calories as well as is a substantial part of the protein intake for about 520 million people living in poverty in Asia (Muthayya et al., 2014). In Asia, where 90% of rice is consumed, ensuring there is enough affordable rice for everyone. In Africa and Latin America, rice is becoming a more important staple food too (IRRI, 2015). In the 2018-19 financial year, about 11.8 million ha of land in Bangladesh was used for rice cultivation with annual production of 34.91 million tons (BBS, 2018). In Bangladesh, more rice will be required in future because of increasing population. Decreasing resources (e.g. land, labor, soil health and water), and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as the great challenges to keep the pace of rice production in the background of increasing population. Sufficient rice production is the key to ensure food security in Bangladesh. But now-a-days, the yield of rice in Bangladesh is comparatively lower than other rice growing countries of the world due to insufficient quality seed.

Seed is the most valuable, basic and vital living input for increasing crop production. The effectiveness of the other inputs like fertilizers, irrigation, pesticides and crop management can only be virtualized to the productivity of agriculture if seeds of high quality are used. If the seed is not quality one, the use of other inputs become less fruitful and sometimes wasteful. All other inputs and crop management practices create favorable environment for this living input, so that, a plant can grow perfectly and give the potential yield. But it has to go a long way to establish the importance of quality seed. Several steps are taken for its development at different stages. Varietal development, multiplication, processing, preservation, quality control these are various processes which ultimately contribute to the good seed for production of good crop. Seed source influenced growth and yield during the growing season but the response depended on seed size and variety. The source of seed can also be important since location influences seed nutrient content. The seed source has significant effect on seedling dry weight. The number of tillers was significantly affected by main effect of variety, seed source and seed rate (Alemayehu, 2015; Gadisa, 2019). The influence of seed source on seed quality attributes, such as germination percentage, rate of germination, seedling root length and seedling fresh weight, was significant under laboratory conditions (Alemayehu, 2015; Gadisa, 2019).

Quality seed of high yielding variety is the key for better crop establishment and yield. Unless the seeds are good quality the use of other inputs and technologies of crop production would become meaningless. Bangladesh annually requires about 235970 metric tons of rice seeds to

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grow in about 9650000 acres of land (BADC, 2015). About 36% of rice seeds are produced under the supervision of the Bangladesh Agricultural Development Corporation (BADC) and the rest of the seeds are produced and managed by the farmers' themselves, private company and NGO's (BADC, 2015). The quality of farmers' seed is not maintained during production, processing and storage. In many cases, farmers' collect their seeds from their friends or neighbors; and thus, there is no specific system to control the quality of seeds. Hence, it is conceived that the quality of seeds produced by majority of the farmers' is low standard. Also, there is very little information regarding the level of farmers' knowledge on the production of rice seed and method of quality testing before sowing. Farmers' sometimes get good germination and good crop, but in the most cases they get poor germination, and occasionally seeds do not germinate which results in total crop production failure (Hossain et al., 1994a; Islam, 2009).

Several factors affect the quality of seeds at different developmental stage of the crops. Therefore, seed quality assessments in rice major growing areas are very important to determine the planting value of seed produced in the study area. The use of quality seed has significantly increased crop productivity by 15- 25% (Tanner and Sahle, 1993). The low yield might be due to the use of farm saved poor quality seeds of local cultivars. Because, farmer saved seeds (FSS) are known to be rich in inert matters, weed seeds, higher moisture contents and are stored in poor facilities (David, 2006; Mbega, 2007). The poor storage facilities of FSS reduced seed quality, leading to low yield and incomes for small-scale growers (Syed et al., 2012). In recent years, it has been proposed in scientific forums that in spite of the need for more investigation, unfortunately there are not enough sources in this case (Khan et al., 2015). Usually the farmers or other seed producers don't provide appropriate measure to attain a good standard of seed quality (Khan et al., 2015). Considering the above fact, the study was conducted to judge the effect of seed source on plant growth and yield of rice collected seed from different sources in Bangladesh. The yield gap of rice was also investigated in this study.

2. Materials and Methods

2.1 Seed source

The study was conducted in Agricultural Laboratory of School of Agriculture & Rural Development (SARD), Bangladesh Open University (BOU), Gazipur- 1705, Bangladesh. The field study was conducted in the farmers' rice field at Kamarjuri village of Gazipur in Bangladesh during *Boro* season from December 2019 to May 2020. The seeds of rice variety BRRI dhan28 of *Oryza sativa* L. (Family: Gramineae) were used as study material. The seed samples were obtained from 23 districts in Bangladesh. The treatments were consisted of four sources of seed *viz*. BADC, private seed company, farmers' own seed and seed from local market. At least 1 kg of seed sample was collected from each spot. The seed was purchased of 2 kg packet from ACI, Siddiks, Supreme, BRAC and McDonals private seed company in Bangladesh. The seed was also obtained from Bangladesh Rice Research Institute (BRRI) that was used for control. In case of the seed source of BRRI, BADC and private seed company, the certified seed were collected. The seed category of the rest of two sources was unknown. The seed was processed as existing facilities of different seed sources and stored in a gunny bag for a year before being used.

2.2 Seed sampling

After the collection of seed samples, the primary seed samples from all sources *viz*. BADC, private seed company, farmers' and local market were mixed thoroughly according to each seed source to make a composite sample separately. About 500 gm of each composite sample was taken as submitted samples. All the seed samples collected from different seed sources were labeled properly and were preserved in the laboratory of SARD at 20 °C until the samples were used for conducting experiments. Working seed samples were taken time to time from the preserved seed samples as per requirement. Total procedure was maintained following the ISTA rules (ISTA, 1999).

2.3 Experimental design and rice cultivation

The experimental design was randomized complete block (RCBD) with four replicates. Two rice seedlings (40-day-old) were transplanted at 20 × 15 cm spacing under irrigated condition (BRRI, 2020). The field was fertilized with 120 kg urea, 30 kg TSP, 50 kg MP, 30 kg Gypsum and 4 kg Zn per ha. Urea was applied as top dressing into two times. Urea of 50% was top dressed after 15-20 days of transplant; and the rest of urea was top dressed after 35 days of transplant and mixed well with soil (BRRI, 2020). The intercultural operations especially irrigation management, insect and weed control were done properly.

2.4 Determination of plant growth parameter of rice

Plants were harvested at day 45 and again at 70 days after transplanting and data were recorded. In each treatment, plants were separated into leaves and stems. Data on plant height (cm) was measured by a meter scale. Data on leaf area, LA (cm^2) was measured by a LI-COR portable area meter. Each time, after measurement of leaf area and plant fresh weight, plants were placed in an oven (Model DGG- 9140 B) at 60 °C for 48 h, and dry weight (g) was then measured. Data on leaf weight (fresh and dry) (g) was measured by a digital weighing machine. Then the dry matter (% DM) per hill was calculated by fresh and dry weight of the hill as shown in Equation (1). Absolute growth rate (AGR) and relative growth (RGR) were calculated according to the formulae as follows (Radford, 1967; Watson, 1952):

$$DM\% = \frac{\text{Final dry wt.(g)} \times 100}{\text{Initial wet wt.(g)}} \quad (1)$$

$$AGR = \frac{W2 - W1}{T2 - T1} \quad (2)$$

$$RGR = \frac{(\log_e W2 - \log_e W1)}{T2 - T1} \quad (3)$$

Where, W1 = Dry matter at time T1 and W2 = Dry matter at time T2

2.5 Measurement of yield attributes and yield gap of rice

2.5.1 *Number of spikelet/panicle*

Total number of spikelet per panicle was counted manually from the panicles which were selected randomly from 10 hills of each plot. The mean of ten randomly selected panicles from plot was used to determine the number of grains per panicle.

2.5.2 *Test weight*

Thousand grains were selected randomly from the grain yield of each plot and weighed with the help of portable automatic electronic balance at about 14% moisture content. The thousand grains weight was expressed in gm.

2.5.3 *Grain yield*

The crops were harvested at maturity from 2.5 × 2 m area at 15 cm above ground level for grain yield calculation. Grain yields were recorded at 14% moisture content and calculated as follows:

$$\text{Grain yield (ton/ha)} = \frac{GW \times 10 \times (100 - M)}{A \times 86} \quad (4)$$

Where, GW = Grain weight in kg
M = % Moisture of grain
A = Area of sample in m^2

2.5.4 *Yield gap*

The yield gaps were estimated according to as follows (Singh et al., 2013):

$$\text{Yield gap} = \frac{YR - YD}{YR} \times 100 \quad (5)$$

Where, YR is the research station yield, YD is the demonstration plot yield at farmer's level. The research station (BRRI) yield of BRRI dhan28 is 5.5 to 6.0 tons per hectare (BRRI, 2020). Here, the yield gap of BRRI dhan28 was calculated considering the yield of BRRI dhan28 is 5.5 tons.

2.6 Statistical analysis

Data concerning plant height and leaf area were analyzed with two-way ANOVA between seed source and the observation period. Data on absolute growth rate (AGR), relative growth rate (RGR), number of spikelet/panicle, 1000-grain weight, yield/hectare and yield gap were analyzed with a one-way ANOVA. The statistical analyses were performed using SAS software (SAS Institute, 2001). Means were separated using Least Significant Difference (LSD) test at 5% level of significance.

3. Results and Discussion

The plant growth parameters of rice *viz*. plant height, leaf area, AGR and RGR were observed. The interaction of the factors i.e. seed source and observation period was significantly different on plant height (F = 60.96; df = 9, 39; P < 0.0001; Figure 1) and leaf area (F = 107.08; df = 9, 39; P < 0.0001; Figure 2) as compared with their respective controls. One-way ANOVA results also showed the significant differences among the seed source on AGR (F = 3.10; df = 4, 19; P = 0.048) and RGR (F = 3.82; df = 4, 19; P = 0.025) as compared with their respective controls (Figure 3). The growth parameter of AGR was the highest in the seed source of BRRI; while the highest RGR was observed in the seed source of BRRI and BADC simultaneously with average mean values of 0.023 and 0.0004, respectively (Figure 3). However, the seed quality is very important for optimum plant growth in farm which is influenced by many factors such as genetic characteristics, viability, germination percent, vigor, moisture content, storage conditions, survival ability and seed health (Akbar et al., 2004).

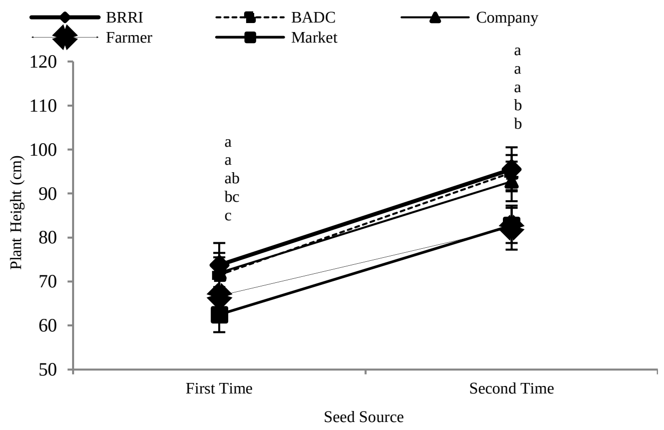

Figure 1: Mean (± Standard Error, SE) of Plant Height of different sources of rice seed in Bangladesh. Means with the same letter are not significantly different (LSD-test, following two-way ANOVA: P < 0.05).

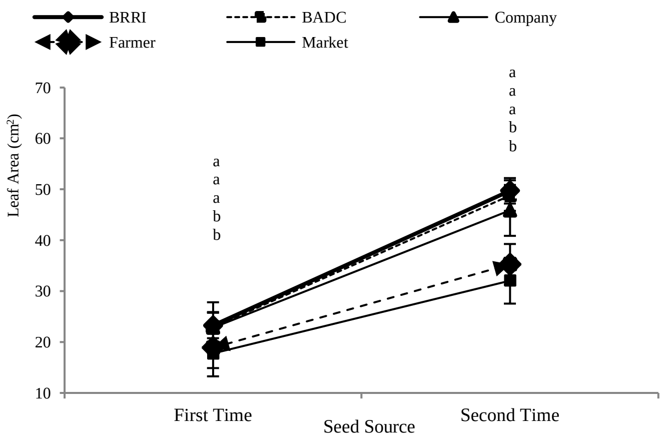

Figure 2: Mean (± Standard Error, SE) of Leaf Area of different sources of rice seed in Bangladesh. Means with the same letter are not significantly different (LSD-test, following two-way ANOVA: P < 0.05).

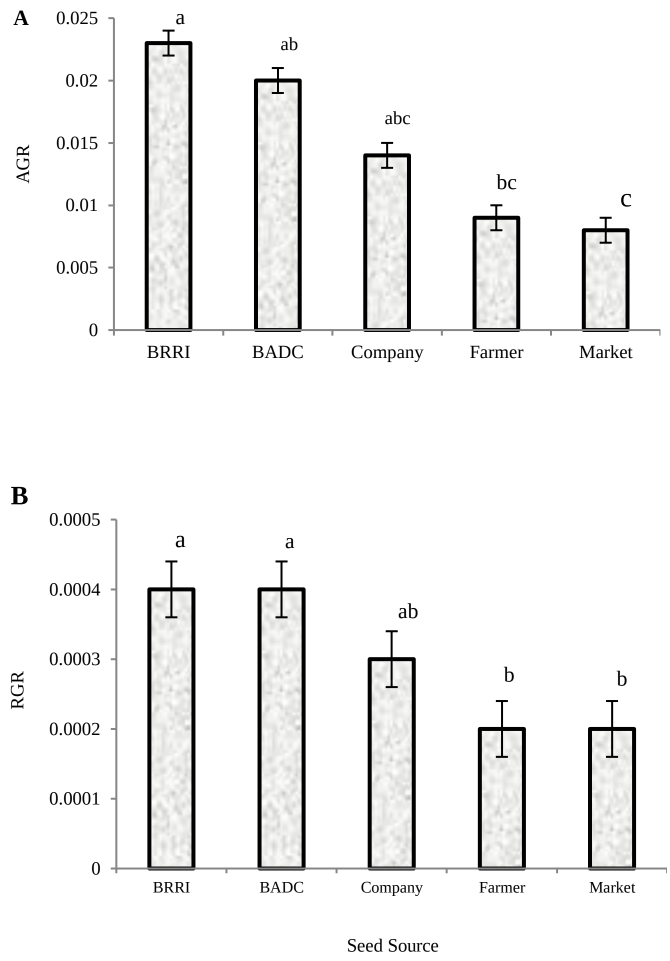

Figure 3: Mean (± Standard Error, SE) of growth rate (Absolute Growth Rate, AGR & Relative Growth Rate, RGR) of different sources of rice seed in Bangladesh. Means with the same letter are not significantly different (LSD-test, following one-way ANOVA: P < 0.05).

For achieving optimum plant growth, the basic requirement of farming is to obtain quality seed. The tested plant growth parameters *viz*. plant height, number of tiller and dry weight of wheat showed a significant variation among different seed sources at different days after sowing; and the tallest plant was found from the seed source of BARI (Bangladesh Agricultural Research Institute) which was statistically identical with BADC; while shortest from Farmer seed source (Khan et al., 2015). Maximum number of tillers of wheat was found from BARI; whereas minimum number of tiller of wheat was found from Farmer seed source (Khan et al., 2015). There was different information found by that seed source had no effect on plant growth of wheat (Hussein and McDonald, 2012). However, the number of stems per hill was significantly affected by seed source in potato (Ibrahim, 1987; Van der Zaag, et al., 1990).

Significant differences between the seed sources at age 27 months for height, collar diameter, number of branches, leaf area and field survival of *Jatropha curcas* Linn. were also reported (Ginwal et al., 2004). The yield attributes of rice *viz*. number of spikelet/panicle, 1000-grain weight, grain yield and yield gap were also observed in this research. The first three parameters were highest in the source of BRRI followed by BADC; whereas, the last one was maximum in the seed of market followed by farmer. One-way ANOVA results showed the significant differences among the seed source on all variables of yield attributes- number of spikelet/panicle (F = 11.72; df = 4, 19; P = 0.0002), 1000-grain weight (F = 61.43; df = 4, 19; P < 0.0001), grain yield (F = 147.20; df = 4, 19; P < 0.0001), and yield gap (F = 147.04; df = 4, 19; P < 0.0001) as compared with their respective controls (Table 1).

Table 1: Mean (± Standard Error, SE) of number of spikelet per panicle, 1000-grain weight (g), yield (ton) per hectare and percentage of yield gap of different sources of rice seed in Bangladesh				
Seed Source	Spikelet/Panicle	1000-Grain wt. (g)	Yield (Ton)/Ha	% Yield Gap
BRRI	127.75 ± 5.40 a	23.25 ± 1.27 a	4.90 ± 0.90 a	10.86 ± 1.58 d
BADC	124.50 ± 4.13 a	22.75 ± 1.93 a	4.88 ± 0.03 a	11.23 ± 0.50 d
Company	122.25 ± 4.92 a	21.75 ± 2.38 a	4.65 ± 0.05 b	15.41 ± 0.90 c
Farmer	112.75 ± 4.97 b	16.75 ± 1.16 b	3.50 ± 0.08 c	36.37 ± 1.51 b
Market	104.75 ± 5.42 b	14.25 ± 1.11 b	3.07 ± 0.08 d	44.14 ± 1.54 a

Means with the same letter within a column are not significantly different (LSD-test, following one-way ANOVA: $P < 0.05$).

The number of spikelet/panicle, 1000-grain weight and yield of rice were highest in the seed of BRRI with average mean values of 127.75, 23.25 g and 4.9 tons, respectively (Table 1); while the yield gap of rice was the highest in the seed of the market with average mean value of 44.14% (Table 1). For achieving optimum yield production, the basic requirement of farming is to obtain quality seed. High quality seed is important to ensure in achieving maximum yield. Seed source is a major factor that reduces the grain yield of cereals (Gadisa, 2019). Number of grains and filled grains of wheat was varied significantly due to the variation of seed sources; and significant variation was also observed on 1000-grain weight of wheat among the different seed sources (Khan et al., 2015).

They also reported that maximum grain yield of wheat found from BARI which was statistically identical with BADC whereas minimum from Farmer. Plants grown from different seed sources yielded differently (Sikka et al., 1997; Alacho, 2000; Asamenew and Bahru, 2000; Demo, 2000; Getachew and Mela, 2000; Khaurana, 2000; Mayona, 2000; Nugaliyadde and Baba, 2000). The reason for the superiority of the seeds of BADC seed source could be due to the conditions in the growth of the parent plant during the production that formed the seedlings obtained from the cultivation of these seeds which have better compatibility (Khan et al., 2015). They also reported the seed source of BADC and research institution like BARI showed better plant growth and yield of wheat than farmer's seed that is similar with our findings.

4. Conclusion

The seed source of BRRI is the parent stock while BADC is the seed producing authority in Bangladesh and private company produces seed for commercial purpose. The seed sources of BRRI, BADC and company have all modern facilities for seed production and processing those are very important factors for long term storage. Therefore, the seed quality of these three sources is comparatively higher than other two sources. Due to higher quality seed sources, the plant growth and grain yield of rice were comparatively higher in the seed of BRRI followed by BADC and company. The higher yield gap was observed in the seed of farmer and market due to poor seed production and processing facilities as well as their poor knowledge. This result indicates that the seed sources of farmer and market are not suitable for rice cultivation; therefore, the growers should avoid the seed from these two sources for rice cultivation in Bangladesh.

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