Effect of mulch and organic amendment on yield performance of dry direct seeded BORO rice

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Received: 05 April 2019/ Accepted: 24 April 2019/ Published: 30 April 2019

Abstract: An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from February to June 2018 with a view to study the effect of mulch and organic amendments on growth and yield performance of BRRI dhan58 under dry direct seeded boro rice production system. The experiment included two set of treatments. A. Mulch (M1=rice straw mulch @ 7 t ha−1 and M2=No mulch) and B. Organic amendments (T1=Tricho-compost (TC) @ 5 t ha−1, T2=Farm Yard Manure (FYM) @ 5 t ha−1, T3=Mustard Oil Cake (MOC) @ 0.5 t ha−1, T4=Tricho-compost (TC) @ 5 t ha−1 + Mustard Oil Cake (MOC) @ 0.5 t ha−1, T5=Farm Yard Manure (FYM) @ 5 t ha−1 + Mustard Oil Cake (MOC) @ 0.5 t ha−1, T6=Control). The experiment was laid out in a split-plot design with mulch in the main plot and organic amendments in the sub-plot. The treatments were replicated three times. The higher plant height (95.90 cm), no. of effective tillers hill−1 (11.48), 1000-grains weight (24.75 g), grain yield (5.34 t ha−1), and straw yield (7.38 t ha−1) were found from rice straw mulch plots. The highest plant height (103.40 cm), panicle length (23.24 cm), no. of grain panicle−1 (118.79), 1000-grain weight (25.23 g), grain yield (5.67 t ha−1), straw yield (7.80 t ha−1), biological yield (13.47 t ha−1) and harvest index (42.06%) were found from treatment T4 (Tricho compost+Mustard Oil Cake). The crop grown with recommended rate of fertilizers (T6) gave the worst performance. The interaction between mulch and organic amendments were not significant for grain yield. Thus the study concludes that rice straw mulching gives better yield than no mulch plots and the organic amendment is better than recommended inorganic fertilizer application.

Keywords: rice straw mulch; organic amendment; yield performance; biological yield
1. Introduction

Rice (*Oryza sativa* L.) is the major food crop of Bangladesh. Rice also contributes 95% of food production in Bangladesh. About 74.85% of cropped area of Bangladesh is used for rice production (BBS, 2017). In Bangladesh *boro* rice is mainly cultivated in puddled transplanted system and requires full irrigation and it is about 1500 to 2000 mm. The scarcity of irrigation water due to decline of water table as well as lack of surface water causes *boro* rice crop failure. This conventional methods of rice production require large amounts of energy, water and labour, which were becoming increasingly scarce and expensive. Hence, it is important to find efficient and comprehensive strategies that support global food security. In this regard dry direct seeded *boro* rice cultivation system can be used as an alternative approach, which is an environment friendly technology that helps saving of 50-60% irrigation water. Dry direct seeded *boro* rice production system, a water saving *boro* rice production technology, has been developed through continuous research at Department of Agronomy, Bangladesh Agricultural University, Mymensingh which could be successfully used in the country to produce *boro* rice with less water in a sustainable way.

Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. There were three principal methods of direct seeding of rice (DSR): dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils) and water seeding (seeds sown into standing water). Dry seeding has been the principal method of rice establishment since the 1950s in developing countries (Pandey and Velasco, 2005). In the traditional transplanting system (TPR), puddling creates a hard pan below the plough-zone and reduces soil permeability. It leads to high losses of water through puddling, surface evaporation and percolation. Water resources, both surface and underground were shrinking and water has become a limiting factor in rice production (Farooq et al., 2009). In recent years, there has been a shift from TPR to DSR cultivation in several countries of Southeast Asia. This shift was principally brought about by the expensive labor component for transplanting due to an acute farm labor shortage, which also delayed rice sowing (Chan and Nor, 1993). Among the rice growing countries, Bangladesh stands 4th in position following China, India, and Indonesia (FAO, 2008). The production of rice in the country was 9.77 million tons from 9.2 million hectares of land in 1971-72 which became 33.914 million tons from 11.53 million hectares in 2011-12 (BBS, 2012). The adoption of a direct-seeded method for lowland rice culture would significantly decrease costs of rice production. The labor requirement for transplanted rice (nursery and transplanting) is approximately 50 person day’s ha⁻¹ in comparison to 37 person day’s ha⁻¹ for drill or wet seeded rice (FAO, 2010). In comparison to transplanted rice direct seeded rice also minimizes the emissions of methane gas. With the development of resource conserving technologies, direct seeding is being emerged as a viable alternative to transplanted rice (Tripathi et al., 2004). However, mulching practice along with organic amendment in dry direct seeded rice production system, can provide several benefits to crop production through improving soil moisture, heat energy and nutrient status in soil, preventing soil and water loss, soil salinity from flowing back to surface, and controlling weeds, thus incorporation of organic materials such as crop residues offers a sustainable and ecologically sound alternative for meeting the nutrient requirements of crops (Boyle et al., 1989). Thus, there is an enormous potential of recycling these residues in the crop production systems (Mandal et al., 2004). As indicated by Mendoza and Samson (1999) the use of rice straw mulching for conserving soil moisture in different crops is possible. Hence, conservation of soil moisture coupled with yield enhancements by rice straw mulching and organic amendment would be beneficial in integrated plant management systems, while minimizing the impact of agrochemicals; which is an important concern in current agricultural activities. Since not much works have been done in this field, this research was designed to address the problem of making DSR popular among farmers with the objective of evaluating the effect of mulch and organic amendment on yield performance dry direct seeded *boro* rice. This study was undertaken to evaluate the effect of mulch on growth and yield performance of dry direct seeded *boro* rice; to find out the effect of organic amendments of *BRRI* dhan58 under dry direct seeded system of cultivation; and to observe the interaction effect of mulch and organic amendments, if any, on yield and yield attributes of *BRRI* dhan58 under dry direct seeded system of cultivation.

2. Materials and Methods

2.1. Description of experimental site

2.1.1. Location

This experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, located at 24°75’ N latitude and 90°50’ E longitude having an altitude of 18 m. The experimental site belongs to the Sonatala series of Old Brahmaputra Floodplain Agro ecological Zone (AEZ9) having non-calcareous dark grey floodplain soils.
2.1.2. Soil
The land was medium high with moderate drainage facilities and the soil was silt loam. The pH value was 6.40. Soil contained 2.27% organic matter, 0.123% total N, 5.60 ppm available P, 0.22 meq 100 g\(^{-1}\) exchangeable K and 15.007 ppm available S.

2.1.3. Climate
The experimental area is under the sub-tropical climate which is characterized by its heavy rainfall during Kharif season (April to September) and scanty rainfall occurred during Rabi season (October to March).

2.2. Experimental treatments
The treatment and treatment contents are shown in Table 1.

Table 1. Treatments and contents.

<table>
<thead>
<tr>
<th>Name of treatment</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_1)</td>
<td>Trico-compost (TC) @ 5 ton ha(^{-1})</td>
</tr>
<tr>
<td>T(_2)</td>
<td>Farm yard manure (FYM) @ 5 ton ha(^{-1})</td>
</tr>
<tr>
<td>T(_3)</td>
<td>Mustard oil cake (MOC) @ 0.5 ton ha(^{-1})</td>
</tr>
<tr>
<td>T(_4)</td>
<td>Trico-compost (TC) @ 5 ton ha(^{-1}) + Mustard oil cake (MOC) @ 0.5 ton ha(^{-1})</td>
</tr>
<tr>
<td>T(_5)</td>
<td>Farm yard manure (FYM) @ 5 ton ha(^{-1}) + Mustard oil cake (MOC) @ 0.5 ton ha(^{-1})</td>
</tr>
<tr>
<td>T(_6)</td>
<td>Control</td>
</tr>
<tr>
<td>M(_1)</td>
<td>Rice straw @ 7 ton ha(^{-1})</td>
</tr>
<tr>
<td>M(_2)</td>
<td>No mulch</td>
</tr>
</tbody>
</table>

2.3. Experimental design and layout
The experiment was laid out in a split-plot design as mulch in the main plot and organic amendments in the sub-plot with three replications. The total numbers of unit plots were 36. The size of each unit plot was 10 m\(^2\) (4.0 m \(\times\) 2.5 m). The spaces between blocks and plots were 1 m and 0.75 m respectively.

2.4. Description of the rice cultivar
2.4.1. BRRI dhan58
BRRI dhan58 was developed by the scientist of BRRI (Bangladesh Rice Research Institute from BRRI dhan29-SC3-28-16-4-HR2 and it was officially released by National Seed Board of Bangladesh in 2012. It is a boro rice variety with photoperiod insensitivity, 7-10 days earliness than BRRI dhan29 with similar grain type. BRRI dhan58 requires 150-155 days to mature and average yield is 7-7.5 t ha\(^{-1}\).

2.5. Crop husbandry
2.5.1. Collection of seed
Healthy seeds of BRRI dhan58 were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh.

2.5.2. Priming of seed
Healthy and vigorous seeds were selected for priming. Before sowing the seeds were primed following hydro priming technique by soaking in water for 24 hours at room temperature and then incubated for 30 hours at 35°C. The primed seeds were then sown directly in the field.

2.5.3. Land preparation
The land was first opened with a power tiller and subsequently leveled by laddering. Weeds and stubbles of the previous crop were collected and removed from the field. Before sowing, fields were prepared by ploughing and harrowing to obtain a smooth seedbed. The land was finally prepared on 18\(^{\text{th}}\) February 2018.

2.5.4. Application of fertilizer and manures
The land was fertilized as per treatment specification. The experimental plots were fertilized with triple super phosphate (TSP), muriate of potash (MoP) and gypsum at the rate of 120, 120 and 80 kg ha\(^{-1}\) respectively, along with Trico-compost and Farm Yard Manure (FYM) at the rate of 5 t ha\(^{-1}\) respectively in different unit of plots at the time of final land preparation. The manures were thoroughly mixed with the soil. Urea was applied in three
equal splits at 15, 30 and 45 days after sowing (DAS). Mustard oil cake (MOC) was applied 15 days after sowing (DAS).

2.5.5. Sowing of seed
Seed was sown in furrows with 4 seeds hill$^{-1}$ on 19 February 2018 under dry direct seeded system.

2.5.6. Application of mulch
Mulch were applied in different unit of plots as per layout of the experiment at the rate of 7 t ha$^{-1}$ respectively.

2.5.7. Intercultural operations
2.5.7.1. Weed management
Pendimethalin (Trade name: Panida 33EC) was applied for weed control @ 50 ml 10 L$^{-1}$ of water as pre-emergence herbicide on 20 February, 2018. Crops were infested with different weeds. Weeding was done twice by hand pulling on 14 March and 2 April.

2.5.7.2. Irrigation
Irrigation was provided only to maintain the field at moist soil condition for successful crop growth and development. Irrigation was done twice on 15 March and 23 April, 2018.

2.6. Sampling, harvesting and processing
The crop was harvested at full maturity; when about 80% of the grains became golden yellow in color. Five hills (excluding border hills) were randomly selected for each plot and uprooted before harvesting for recording the necessary data on various plant characters. Crop was harvested from central 1.5 m × 3 m area of each plot to record the yields of grain, and straw. The crop was threshed by pedal thresher. Grains were sun dried and cleaned. Straw was also sun dried properly. Finally, grain yields was adjusted to 14% moisture and converted to ton per hectare.

2.7. Collection of data
Plant height, Number of total tiller hill$^{-1}$, Number of effective tiller hill$^{-1}$, Number of non-effective tiller hill$^{-1}$, Panicle length, Number of grains panicle$^{-1}$, Number of sterile grains panicle$^{-1}$, 1000-grain weight, Grain yield, Straw yield, Biological yield, and Harvest index yield and yield components were taken during study period

2.8. Procedure of recording data
2.8.1. Plant height
The plant height at maturity stage was measured from ground level to tip of the uppermost panicle. The average height of five hills considered as the height to the plant for each plot.

2.8.2. Number of total tillers, effective tillers and non-effective tillers hill$^{-1}$
Tillers, which had at least one visible leaf, were counted including both effective and non-effective tillers.

2.8.3. Panicle length
Length of panicles was measured from the first node to the tip of the panicle from each panicle and then average was expressed in cm. Each observation was an average of five hills.

2.8.4. Number of sterile grains panicle$^{-1}$
Presence of material in the spikelet was considered as grain and total number of filled and unfilled grains present on each panicle was counted.

2.8.5. 1000-grain weight
One thousand clean and dried grains were counted from the seed stock obtained from five sample hills of each plot and weighed using an electric balance. The weight was adjusted at a seed moisture content of 14%.

2.8.6. Grain yield
Grains obtained from central 4.5 m$^2$ area of each plot were sun dried and weighed carefully. The dry weight of grains was adjusted to 14% moisture content and finally converted to t per hectare.
2.8.7. Straw yield
Straws obtained from central 4.5 m² area of each plot were sun dried and weighed separately and finally converted to t per hectare.

2.8.8. Biological yield (%)
Grain yield and straw yield were altogether regarded as biological yield. Biological yield was calculated with the following formula:

\[ \text{Biological yield (t ha}^{-1}) = \text{Grain yield (t ha}^{-1}) + \text{Straw yield (t ha}^{-1}) \].

2.8.9. Harvest index
Harvest index is the ratio of economic yield to biological yield expressed as percentage and was calculated with the following formula:

\[ \text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100 \]

2.9. Statistical analysis
The collected data were compiled and tabulated in proper form and were subjected to statistical analysis. Data were analyzed using the analysis of variance (ANOVA) technique with the help of a computer package program STATISTIX10 and mean differences were adjudged by Least Significance Difference (LSD) test.

3. Results and Discussion
3.1. Plant height
3.1.1. Effect of mulching
Plant height was not significantly affected by mulching. However, the higher plant height (95.90cm) was obtained from M₁ and the lower plant height (91.91cm) was obtained from M₂.

3.1.2. Effect of organic amendments
Plant height was significantly influenced by organic amendments. The maximum plant height (103.80cm) was obtained from T₄ (5 ton trico-compost ha⁻¹ and 0.5 t mustard oil cake ha⁻¹) while the lowest plant height (85.55cm) was obtained from T₆ (Table 2). According to Muhammad et al. (2012), application of organic amendments have significant effect on plant height. They have reported that plant height increased with the application of organic amendments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>No. of total tillers hill⁻¹</th>
<th>No. of effective tillers hill⁻¹</th>
<th>No. of non effective tillers hill⁻¹</th>
<th>Panicle length (cm)</th>
<th>No. of grains panicle⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>90.23cd</td>
<td>13.89d</td>
<td>10.56d</td>
<td>3.32c</td>
<td>22.51c</td>
<td>112.78bc</td>
</tr>
<tr>
<td>T₂</td>
<td>95.81b</td>
<td>15.02c</td>
<td>11.14c</td>
<td>3.88ab</td>
<td>22.81bc</td>
<td>113.86b</td>
</tr>
<tr>
<td>T₃</td>
<td>94.58bc</td>
<td>15.38bc</td>
<td>11.38bc</td>
<td>4.00a</td>
<td>22.91ab</td>
<td>110.04cd</td>
</tr>
<tr>
<td>T₄</td>
<td>103.80a</td>
<td>16.16a</td>
<td>12.31a</td>
<td>3.85ab</td>
<td>23.24a</td>
<td>118.79a</td>
</tr>
<tr>
<td>T₅</td>
<td>93.49bc</td>
<td>15.56b</td>
<td>11.63b</td>
<td>3.95ab</td>
<td>22.80bc</td>
<td>115.82ab</td>
</tr>
<tr>
<td>T₆</td>
<td>85.55d</td>
<td>13.48e</td>
<td>9.94e</td>
<td>3.53bc</td>
<td>21.74d</td>
<td>108.91d</td>
</tr>
<tr>
<td>Level of significant</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>CV%</td>
<td>4.90</td>
<td>2.06</td>
<td>3.35</td>
<td>10.30</td>
<td>1.25</td>
<td>2.29</td>
</tr>
</tbody>
</table>

*= Significant at 5% level of probability  
** = Significant at 1% level of probability  
***= Significant at 0.01% level of probability  
NS= Not significant

3.1.3. Effect of interaction
Plant height was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum plant height (104.71cm) was found from M₁T₄ while the lowest plant height (83.63cm) was found from M₂T₆ (Table 3).
Table 3. Effect of interaction between rice straw mulching and organic amendments on yield and yield attributes of BRRI dhan58 under dry direct seeded system of cultivation.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Plant height (cm)</th>
<th>No. of total tillers hill(^1)</th>
<th>No. effective tillers hill(^1)</th>
<th>No. non effective tillers hill(^1)</th>
<th>Panicle length (cm)</th>
<th>No. of grains panicle(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1)T(_1)</td>
<td>92.50de</td>
<td>14.13e</td>
<td>10.81cd</td>
<td>3.32</td>
<td>22.65cd</td>
<td>114.39bc</td>
</tr>
<tr>
<td>M(_1)T(_2)</td>
<td>96.70bcd</td>
<td>15.28cd</td>
<td>11.40bc</td>
<td>3.88</td>
<td>23.03bc</td>
<td>116.84ab</td>
</tr>
<tr>
<td>M(_1)T(_3)</td>
<td>100.52abc</td>
<td>15.83b</td>
<td>11.82b</td>
<td>4.00</td>
<td>23.20ab</td>
<td>111.98cd</td>
</tr>
<tr>
<td>M(_1)T(_4)</td>
<td>104.71a</td>
<td>16.73a</td>
<td>12.74a</td>
<td>3.99</td>
<td>23.57a</td>
<td>120.10a</td>
</tr>
<tr>
<td>M(_1)T(_5)</td>
<td>93.56cde</td>
<td>16.05b</td>
<td>11.98b</td>
<td>4.07</td>
<td>23.17ab</td>
<td>117.77ab</td>
</tr>
<tr>
<td>M(_1)T(_6)</td>
<td>87.47ef</td>
<td>13.60f</td>
<td>10.18de</td>
<td>3.42</td>
<td>21.75e</td>
<td>110.12cd</td>
</tr>
<tr>
<td>M(_1)T(_7)</td>
<td>87.97def</td>
<td>13.65ef</td>
<td>10.34de</td>
<td>3.32</td>
<td>22.37d</td>
<td>111.17cd</td>
</tr>
<tr>
<td>M(_1)T(_8)</td>
<td>94.92cde</td>
<td>14.76d</td>
<td>10.85cd</td>
<td>3.88</td>
<td>22.56cd</td>
<td>110.87cd</td>
</tr>
<tr>
<td>M(_1)T(_9)</td>
<td>88.56def</td>
<td>14.94d</td>
<td>10.94cd</td>
<td>4.00</td>
<td>22.62cd</td>
<td>108.11d</td>
</tr>
<tr>
<td>M(_2)T(_1)</td>
<td>102.90ab</td>
<td>15.59bc</td>
<td>11.88b</td>
<td>3.71</td>
<td>22.92bc</td>
<td>117.49ab</td>
</tr>
<tr>
<td>M(_2)T(_2)</td>
<td>93.42cde</td>
<td>15.10cd</td>
<td>11.28bc</td>
<td>3.82</td>
<td>22.43d</td>
<td>113.87bc</td>
</tr>
<tr>
<td>M(_2)T(_3)</td>
<td>83.63f</td>
<td>13.35f</td>
<td>9.71e</td>
<td>3.64</td>
<td>21.73e</td>
<td>107.69d</td>
</tr>
</tbody>
</table>

Level of significant: ** = Significant at 1% level of probability; *** = Significant at 0.01% level of probability; NS = Not significant.

CV% = 4.90

3.2.2. Effect of organic amendments

Number of total tillers hill\(^1\) was significantly influenced by mulching. The highest number of total tillers hill\(^1\) (15.27) was obtained from M\(_1\) and the lowest number of total tillers hill\(^1\) (14.56) was obtained from M\(_2\) (Table 4). Similar results on number of total tillers hill\(^1\) due to application of rice straw mulch have been reported by Devasinghe et al. (2013). They found that number of total tillers hill\(^1\) were increased with the application of rice straw mulch.

Table 4. Effect of rice straw mulching on yield and yield attributes of BRRI dhan58 under dry direct seeded system of cultivation.

<table>
<thead>
<tr>
<th>Mulching</th>
<th>Plant height (cm)</th>
<th>No. of total tillers hill(^1)</th>
<th>No. effective tillers hill(^1)</th>
<th>No. non effective tillers hill(^1)</th>
<th>Panicle length (cm)</th>
<th>No. of grains panicle(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1)</td>
<td>95.90</td>
<td>15.27a</td>
<td>11.48a</td>
<td>3.78</td>
<td>22.89a</td>
<td>115.20a</td>
</tr>
<tr>
<td>M(_2)</td>
<td>91.91</td>
<td>14.56b</td>
<td>10.83b</td>
<td>3.72</td>
<td>22.44b</td>
<td>111.53b</td>
</tr>
</tbody>
</table>

Level of significant: ** = Significant at 1% level of probability; *** = Significant at 0.01% level of probability; NS = Not significant.

CV% = 4.36

3.2.3. Effect of interaction

Number of total tillers hill\(^1\) was significantly influenced by the interaction of mulching and different level of organic amendments. The maximum number of total tillers hill\(^1\) (16.73) was found from M\(_1\)T\(_4\) while the lowest number of total tillers hill\(^1\) (13.35) was found from M\(_2\)T\(_6\) (Table 3).
3.3. Number of effective tillers hill$^{-1}$

3.3.1. Effect of mulching

Number of effective tillers hill$^{-1}$ was significantly influenced by mulching. The highest number of effective tillers hill$^{-1}$ (11.48) was obtained from M$_1$ and the lowest number of effective tillers hill$^{-1}$ (10.83) was obtained from M$_2$ (Table 4).

3.3.2. Effect of organic amendments

Number of effective tillers hill$^{-1}$ was significantly influenced by organic amendments. The highest number of effective tillers hill$^{-1}$ (12.31) was obtained from T$_4$ while the lowest number of effective tillers hill$^{-1}$ (9.94) was obtained from T$_6$ (Table 2). According to Hafiz et al. (2011), application of different organic amendments were significant effect on number of effective tillers hill$^{-1}$ of wheat. They had reported that number of effective tillers hill$^{-1}$ were increased with the application of different organic manures.

3.3.3. Effect of interaction

Number of effective tillers hill$^{-1}$ was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum number of effective tillers hill$^{-1}$ (12.78) was found from M$_1$T$_4$ while the lowest number of effective tillers hill$^{-1}$ (9.71) was found from M$_2$T$_6$ (Table 3).

3.4. Number of non-effective tillers hill$^{-1}$

3.4.1. Effect of mulching

Number of non-effective tillers hill$^{-1}$ was not significantly influenced by mulching. However, he highest number of non-effective tillers hill$^{-1}$ (3.78) was obtained from M$_1$ and the lowest number of non-effective tillers hill$^{-1}$ (3.72) was obtained from M$_2$ (Table 4).

3.4.2. Effect of organic amendments

Number of non-effective tillers hill$^{-1}$ was significantly influenced by organic amendments. The highest number of non-effective tillers hill$^{-1}$ (4.00) was obtained from T$_3$ which was statistically similar with T$_2$, T$_4$ and T$_5$. The lowest number of non-effective tillers hill$^{-1}$ (3.32) was obtained from T$_1$ (Table 2).

3.4.3. Effect of interaction

Number of non-effective tillers hill$^{-1}$ was not significantly influenced by the interaction of mulching and different level of organic amendments. The maximum number of non-effective tillers hill$^{-1}$ (4.07) was found from M$_1$T$_5$ while the lowest number of non-effective tillers hill$^{-1}$ (3.32) was found from M$_2$T$_1$ (Table 3).

3.5. Panicle length

3.5.1. Effect of mulching

Panicle length was significantly influenced by mulching. The highest panicle length (22.89cm) was obtained from M$_1$ and the lowest panicle length (22.44cm) was obtained from M$_2$ (Table 4). Similar results on panicle length due to application of rice straw mulch have been reported by Devasinghe et al. (2013). They found that panicle length was increased with the application of rice straw mulch.

3.5.2. Effect of organic amendments

Panicle length was significantly influenced by organic amendments. The highest number of panicle length (23.24cm) was obtained from T$_4$ while the lowest panicle length (21.74cm) was obtained from T$_6$ (Table 2). According to Muhammad et al. (2012), application of organic amendments have significant effect on panicle length, they have reported that panicle length was increased with the application of organic amendments.

3.5.3. Effect of interaction

Panicle length was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum panicle length (223.57cm) was found from M$_1$T$_4$ while the lowest panicle length (21.73cm) was found from M$_2$T$_6$ (Table 3).

3.6. Number of grains panicle$^{-1}$

3.6.1. Effect of mulching

Number of grains panicle$^{-1}$ was significantly influenced by mulching. The highest number of grains panicle$^{-1}$ (115.20) was obtained from M$_1$ and the lowest number of grains panicle$^{-1}$ (111.53) was obtained from M$_2$ (Table
4). Similar results were reported by Devi et al. (1991), application of rice straw mulching have significant effect on soil moisture content and growth parameter of rice. They had found, number of grains panicle\(^{-1}\) were increased with the application of rice straw mulch.

3.6.2. Effect of organic amendments
Number of grains panicle\(^{-1}\) was significantly influenced by organic amendments. The highest number of grains panicle\(^{-1}\) (118.79) was obtained from \(T_4\) while the lowest number of grains panicle\(^{-1}\) (108.91) was obtained from \(T_6\) as shown in (Table 2). According to Hafiz et al. (2011), application of different organic amendments were significant effect on number of grains panicle\(^{-1}\). They had reported that number of grains panicle\(^{-1}\) were increased with the application of different organic manures.

3.6.3. Effect of interaction
Number of grains panicle\(^{-1}\) was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum number of grains panicle\(^{-1}\) (120.10) was found from \(M_1T_4\) while the lowest number of grains panicle\(^{-1}\) (107.69) was found from \(M_2T_6\) (Table 3).

3.7. Number of sterile spikelets panicle\(^{-1}\)

3.7.1. Effect of mulching
Number of sterile spikelets panicle\(^{-1}\) was significantly influenced by mulching. The highest number of sterile spikelets panicle\(^{-1}\) (23.62) was obtained from \(M_1\) and the lowest number of grains panicle\(^{-1}\) (20.39) was obtained from \(M_2\) (Table 5).

Table 5. Effect of rice straw mulching on yield and yield attributes of BRRI dhan58 under dry direct seeded system of cultivation.

<table>
<thead>
<tr>
<th>Mulching</th>
<th>No. of sterile spikelets panicle(^{-1})</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (t ha(^{-1}))</th>
<th>Percent increase yield over no mulching (%)</th>
<th>Straw yield (t ha(^{-1}))</th>
<th>Percent increase yield over no mulching (%)</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(M_1)</td>
<td>23.62a</td>
<td>24.75</td>
<td>5.34a</td>
<td>9.93</td>
<td>7.38a</td>
<td>8.13</td>
<td>12.73a</td>
<td>41.95</td>
</tr>
<tr>
<td>(M_2)</td>
<td>20.39b</td>
<td>24.72</td>
<td>4.81b</td>
<td>0.00</td>
<td>6.78b</td>
<td>0.00</td>
<td>11.60b</td>
<td>41.53</td>
</tr>
<tr>
<td>Level of significant</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>**</td>
<td>NS</td>
</tr>
<tr>
<td>CV%</td>
<td>1.08</td>
<td>1.55</td>
<td>5.35</td>
<td>-</td>
<td>3.60</td>
<td>-</td>
<td>4.30</td>
<td>1.21</td>
</tr>
</tbody>
</table>

* = Significant at 5% level of probability
** = Significant at 1% level of probability
*** = Significant at 0.01% level of probability
NS = Not significant

3.7.2. Effect of organic amendments
Number of sterile spikelets panicle\(^{-1}\) was significantly influenced by organic amendments. The highest number of sterile spikelets panicle\(^{-1}\) (23.77) was obtained from \(T_6\) while the lowest number of sterile spikelets panicle\(^{-1}\) (20.81) was obtained from \(T_4\) (Table 6).
Table 6. Effect of organic amendments on yield and yield attributes of BRRI dhan58 under dry direct seeded system of cultivation.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of sterile spikelets panicle</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (t ha(^{-1}))</th>
<th>Percent increase yield over control (%)</th>
<th>Straw yield (t ha(^{-1}))</th>
<th>Percent increase yield over control (%)</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_1)</td>
<td>21.52bc 25.07a</td>
<td>5.16b</td>
<td>14.53</td>
<td>7.16bc</td>
<td>13.55</td>
<td>12.32bc</td>
<td>41.88ab</td>
<td></td>
</tr>
<tr>
<td>T(_2)</td>
<td>21.52bc 24.42b</td>
<td>4.91c</td>
<td>10.18</td>
<td>6.87c</td>
<td>9.90</td>
<td>11.78c</td>
<td>41.70ab</td>
<td></td>
</tr>
<tr>
<td>T(_3)</td>
<td>22.64ab 24.38bc</td>
<td>5.09bc</td>
<td>13.36</td>
<td>7.16bc</td>
<td>13.55</td>
<td>12.25bc</td>
<td>41.55b</td>
<td></td>
</tr>
<tr>
<td>T(_4)</td>
<td>20.81c 25.23a</td>
<td>5.67a</td>
<td>22.22</td>
<td>7.80a</td>
<td>20.64</td>
<td>13.47a</td>
<td>42.06a</td>
<td></td>
</tr>
<tr>
<td>T(_5)</td>
<td>21.79bc 25.15a</td>
<td>5.24b</td>
<td>15.84</td>
<td>7.33b</td>
<td>15.55</td>
<td>12.57b</td>
<td>41.69b</td>
<td></td>
</tr>
<tr>
<td>T(_6)</td>
<td>23.77a 24.17c</td>
<td>4.41d</td>
<td>0.00</td>
<td>6.19d</td>
<td>0.00</td>
<td>10.61d</td>
<td>41.60b</td>
<td></td>
</tr>
<tr>
<td>Level of significant</td>
<td>**</td>
<td>**</td>
<td>*</td>
<td>**</td>
<td>-</td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td>4.51</td>
<td>0.74</td>
<td>4.05</td>
<td>-</td>
<td>4.34</td>
<td>-</td>
<td>4.17</td>
<td>0.73</td>
</tr>
</tbody>
</table>

*= Significant at 5% level of probability
**= Significant at 1% level of probability
***= Significant at 0.01% level of probability
NS = Not significant

3.7.3. Effect of interaction

Number of sterile spikelets panicle\(^{-1}\) was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum number of sterile spikelets panicle\(^{-1}\) (24.97) was found from M\(_1\)T\(_6\) while the lowest number of sterile spikelets panicle\(^{-1}\) (18.90) was found from M\(_3\)T\(_4\) (Table 7).

Table 7. Effect of interaction between rice straw mulching and organic amendments on yield and yield attributes of BRRI dhan58 under dry direct seeded system of cultivation.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>No. of sterile spikelets panicle(^{-1})</th>
<th>1000-grain weight (g)</th>
<th>Grain yield (t ha(^{-1}))</th>
<th>Percent increase yield over no mulching + control (%)</th>
<th>Straw yield (t ha(^{-1}))</th>
<th>Percent increase yield over no mulching + control (%)</th>
<th>Biological yield (t ha(^{-1}))</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M(_1)T(_1)</td>
<td>19.70de 25.07</td>
<td>5.44</td>
<td>21.51</td>
<td>7.50b</td>
<td>19.07</td>
<td>12.94b</td>
<td>42.07b</td>
<td></td>
</tr>
<tr>
<td>M(_1)T(_2)</td>
<td>19.84de 24.50</td>
<td>5.09</td>
<td>16.11</td>
<td>7.13bc</td>
<td>14.87</td>
<td>12.22bc</td>
<td>41.76b</td>
<td></td>
</tr>
<tr>
<td>M(_1)T(_3)</td>
<td>20.88d 24.37</td>
<td>5.45</td>
<td>21.65</td>
<td>7.59b</td>
<td>20.03</td>
<td>13.04b</td>
<td>41.77b</td>
<td></td>
</tr>
<tr>
<td>M(_1)T(_4)</td>
<td>18.907e 25.33</td>
<td>6.08</td>
<td>29.77</td>
<td>8.16a</td>
<td>25.61</td>
<td>14.24a</td>
<td>42.68a</td>
<td></td>
</tr>
<tr>
<td>M(_1)T(_5)</td>
<td>20.46de 25.20</td>
<td>5.45</td>
<td>21.65</td>
<td>7.62b</td>
<td>20.34</td>
<td>13.06b</td>
<td>41.69b</td>
<td></td>
</tr>
<tr>
<td>M(_1)T(_6)</td>
<td>22.57c 24.03</td>
<td>4.55</td>
<td>6.15</td>
<td>6.32de</td>
<td>3.96</td>
<td>10.87de</td>
<td>41.87b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_1)</td>
<td>23.35abc 25.07</td>
<td>4.88</td>
<td>12.50</td>
<td>6.82cd</td>
<td>11.00</td>
<td>11.70cd</td>
<td>41.70b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_2)</td>
<td>23.21bc 24.33</td>
<td>4.73</td>
<td>9.73</td>
<td>6.61cd</td>
<td>8.17</td>
<td>11.35cd</td>
<td>41.72b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_3)</td>
<td>24.40ab 24.40</td>
<td>4.73</td>
<td>9.73</td>
<td>6.72cd</td>
<td>9.67</td>
<td>11.45cd</td>
<td>41.33b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_4)</td>
<td>22.71bc 25.13</td>
<td>5.27</td>
<td>18.98</td>
<td>7.44b</td>
<td>18.41</td>
<td>12.71b</td>
<td>41.44b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_5)</td>
<td>23.12bc 25.10</td>
<td>5.03</td>
<td>15.11</td>
<td>7.05bc</td>
<td>13.90</td>
<td>12.08bc</td>
<td>41.68b</td>
<td></td>
</tr>
<tr>
<td>M(_2)T(_6)</td>
<td>24.97a 24.30</td>
<td>4.27</td>
<td>0.00</td>
<td>6.07e</td>
<td>0.00</td>
<td>10.34e</td>
<td>41.33b</td>
<td></td>
</tr>
<tr>
<td>Level of significant</td>
<td>**</td>
<td>NS</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>CV%</td>
<td>4.51</td>
<td>0.74</td>
<td>4.05</td>
<td>-</td>
<td>4.34</td>
<td>-</td>
<td>4.17</td>
<td>0.73</td>
</tr>
</tbody>
</table>

*= Significant at 5% level of probability
**= Significant at 1% level of probability
***= Significant at 0.01% level of probability

3.8. Weight of 1000-grains

3.8.1. Effect of mulching

Weight of 1000-grains was not significantly influenced by mulching. The maximum weight of 1000-grains (24.75 g) was obtained from M\(_1\) and the lowest weight of 1000-grains (24.72 g) was obtained from M\(_2\) (Table 5). Similar results due to application of rice straw mulch have been reported by Devasinghe et al. (2013). They found that weight of 1000-grains were increased with the application of rice straw mulch.
3.8.2. Effect of organic amendments
Weight of 1000-grains was significantly influenced by organic amendments. The highest weight of 1000-grains (25.23 g) was obtained from T_4 which is statistically similar with T_5 and T_1. The lowest weight of 1000-grains (24.17 g) was obtained from T_6 (Table 6).

3.8.3. Effect of interaction
Weight of 1000-grains was not significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum weight of 1000-grains (25.33 g) was found from M_1T_4 while the lowest weight of 1000-grains (24.30 g) was found from M_2T_6 (Table 7).

3.9. Grain yield
3.9.1. Effect of mulching
Grain yield was significantly influenced by mulching. The higher grain yield (5.34 t ha\(^{-1}\)) was obtained from M_1 and the lowest grain yield (4.81 t ha\(^{-1}\)) was obtained from M_2 (Table 5). From the table 5 it is also clear that about 9.93% grain yield was increased over no mulching. Similar results on grain yield due to application of rice straw mulch have been reported by Devasinghe et al. (2013). They found that grain yield was increased with the application of rice straw mulch.

3.9.2. Effect of organic amendments
Grain yield was significantly influenced by organic amendments. The maximum grain yield (5.68 t ha\(^{-1}\)) was obtained from T_4 while the lowest amount of grain yield (4.41 t ha\(^{-1}\)) was obtained from T_6 (Table 6). It is also noted that 22.22% grain yield was increased over control treatment (Table 6). According to Muhammad et al. (2012), organic amendments have significant effect on grain yield, they reported that grain yield was increased with the organic amendments.

3.9.3. Effect of interaction
Grain yield was not significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum grain yield (6.08 t ha\(^{-1}\)) was found from M_1T_4 while the lowest grain yield (4.27 t ha\(^{-1}\)) was found from M_2T_6. The maximum grain yield percent (29.77%) over no mulching + control were found from M_1T_4 (Table 7).

3.10. Straw yield
3.10.1. Effect of mulching
Straw yield was significantly influenced by mulching. The highest straw yield (7.38 t ha\(^{-1}\)) was obtained from M_1 and the lowest straw yield (6.78 t ha\(^{-1}\)) was obtained from M_2 (Table 5). From the table 5 it was found that straw yield were increased 8.13% due to rice straw mulching over no mulching. Similar results were reported by Devi et al. (1991), application of rice straw mulching have significant effect on soil moisture content and growth parameter of rice. They found that number of straw yield of rice were increased with the application of rice straw mulch.

3.10.2. Effect of organic amendments
Straw yield was significantly influenced by organic amendments. The highest straw yield (7.80 t ha\(^{-1}\)) was obtained from T_4 while the lowest straw yield (6.19 t ha\(^{-1}\)) was obtained from T_6 (Table 6). It was also noted that 20.64% straw yield was increased over control treatment (Table 6). According to Hafiz et al. (2011), application of different organic amendments were significant effect on straw yield. They have reported that straw yield were increased with the application of different organic manures.

3.10.3. Effect of interaction
Straw yield was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum straw yield (8.16 t ha\(^{-1}\)) was found from M_1T_4 while the lowest straw yield (6.07) was found from M_2T_6 (Table 7). From the Table 7 it was also found that the highest increasing percent of yield 25.61% was obtained from M_1T_4.
3.11. Biological yield

3.11.1. Effect of mulching
Biological yield was significantly influenced by mulching. The highest biological yield (12.73 t ha\(^{-1}\)) was obtained from M\(_1\) and the lowest biological yield (11.60 t ha\(^{-1}\)) was obtained from M\(_2\) (Table 5).

3.11.2. Effect of organic amendments
Biological yield was significantly influenced by organic amendments. The highest biological yield (13.47 t ha\(^{-1}\)) was obtained from T\(_4\) while the lowest biological yield (10.61 t ha\(^{-1}\)) was obtained from T\(_6\) (Table 6).

3.11.3. Effect of interaction
Biological yield was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum biological yield (14.24 t ha\(^{-1}\)) was found from M\(_1\)T\(_4\) while the minimum biological yield (10.34 t ha\(^{-1}\)) was found from M\(_2\)T\(_6\) (Table 7).

3.12. Harvest index

3.12.1. Effect of mulching
Harvest index was not significantly influenced by mulching. The maximum harvest index (41.95\%) was obtained from M\(_1\) and the minimum harvest index (41.53\%) was obtained from M\(_2\) (Table 5).

3.12.2. Effect of organic amendments
Harvest index was significantly influenced by organic amendments. The maximum harvest index (42.06\%) was obtained from T\(_4\) while the minimum harvest index (41.60\%) was obtained from T\(_6\) (Table 6).

3.12.3. Effect of interaction
Harvest index was significantly influenced by the interaction effect of mulching and different level of organic amendments. The maximum harvest index (42.68\%) was found from M\(_1\)T\(_4\) while the minimum harvest index (41.33\%) was found from M\(_2\)T\(_6\) (Table 7).

4. Conclusions
Based on the result of the present study it may be concluded that in combination with 7 ton rice straw mulch ha\(^{-1}\) along with 5 ton trico-compost ha\(^{-1}\) and 0.5 ton mustard oil cake (MOC) ha\(^{-1}\) with recommended dose of other fertilizers was the best to obtain the highest grain yield of BRRI dhan58 in boro season under dry direct seeded system.

Conflict of interest
None to declare.

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