STATUS OF **DHAINCHA** INCORPORATED SOIL AFTER RICE HARVEST IN (BORO) RICE–**DHAINCHA**–RICE (T. AMAN) CROPPING PATTERN

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ABSTRACT. An experiment was conducted at Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, to find out the effect of **dhaincha** incorporation on subsequent rice crop yield and post-harvest soil nutrient status. The experiment was laid out in a randomized complete block design having three replications. Nine **dhaincha** accessions were used as experimental materials along with a control (without **dhaincha** plant). Seeds of **dhaincha** accessions were sown in experimental plot @ 60 kg ha⁻¹. Sixty days old **dhaincha** plants were mixed up with soil. Soil samples were collected twice, before sowing of **dhaincha** seeds and after rice crop harvest. Forty five days old healthy rice seedlings were transplanted in the well prepared **dhaincha** incorporated plots at the spacing of 15 cm x 25 cm (plant-plant x row-row). The pH and nutrient status were improved in **dhaincha** incorporated soil over the control. The highest grain yield (5.81 t ha⁻¹) was obtained from **dhaincha** Acc. 33 incorporated plot followed by Acc. 25 (5.73 t ha⁻¹) and the lowest in control (4.35 t ha⁻¹). Due to the incorporation of **dhaincha** biomass in soil, the rice grain yield increased 7.82% to 33.56% over the control. Among the **dhaincha** accessions, number 33 showed the best performance in terms of influencing grain yield. A precise conclusion to be built up through collection of large number of germplasms from Bangladesh is needed.

**Keywords:** **Dhaincha** incorporation; grain yield; rice; residual nutrient status.

INTRODUCTION

Bangladesh, one of the most densely populated countries of the world, faces great challenges of food and nutritional security as a result of socioeconomic and climate change (Osmani et al., 2016). To meet the ever increasing food demand, farmers are compelled to go for intensive
cereal crop cultivation (Dhaka et al., 2015), following rice-rice and/or rice-
rice-rice based cropping pattern. Therefore, soil fertility and organic
matter reduction have emerged as major threats to crop production
(Rahman et al., 2013), and cultivable land loses its productivity day by day
(Alam & Salahin, 2013). Due to intensive land use without
green/organic manure, soil fertility has caused exhaustion in Bangladesh.
In this situation, physical and nutritional characteristics of cultivable
lands in Bangladesh become worse and crop production is moving downward (Anonymous, 2012). Green
manure crops like dhaincha (Sesbania spp.) cultivation may be one of the
best options to overcome this situation. Green manure is the ideal
source of organic matter, which influences on the crop production
quality and soil fertility (Hemalatha et al., 2000; Sarwar et al., 2017).

Dhaincha is the cheapest green
manure crop and available source of
organic matter (Sarwar et al., 2017). It
is sometimes cultivated in some
places of Bangladesh during monsoon
season, following (Boro) rice-fallow
(Dhaincha)-rice (T. Aman) or (Boro)
rice-fallow (Dhaincha)-winter
vegetables cropping pattern. Dhaincha is an ideal green manure
crop, quick growing, succulent, easily
decomposable and produce maximum
amount of organic matter, as well as
nitrogen in soils (Palaniappan & Siddeswaran, 2001). It enhances soil
physical properties and water holding
capacity, reduces the leaching of
nutrients from the soil, and increases
the crop yield (Heering, 1995; Abro &
Abbasi, 2002). Sixty days old
dhaincha [S. bispinosa (Jaqc.) W.F.
Wight] crop may produce up to
80 t ha⁻¹ total dry mass in the
monsoon season of Bangladesh
(Chanda et al., 2017). Sarwar et al.
(2017) also reported that the
increment of rice grain yield was 7%
to 39% in dhaincha incorporated soil
with the recommended doses of PKS
fertilizers over the control (no green
manure). Moreover, rice grain yield
increased 32% to 77% over the
control due to (dhaincha) green
manure incorporation with different
doses of NPK fertilizers application
(Ehsan et al., 2014; Noor-A-Jannat
et al., 2015). Most of the published
research reports are based on effect of
dhaincha incorporation on soil
nutritional status and succeeding crop
yield (Abro and Abbasi, 2002;
Rahman et al., 2012; Sarwar et al.,
2017). However, information on the
residual effect of dhaincha
incorporation in soil after the
succeeding crop harvest is scanty
(Rahman et al., 2013; Ganapathi
et al., 2014). Based on the aforesaid
situation, the objectives of the present
study were, therefore, to find out the
effect of green manure from different
dhaincha accessions on subsequent
rice crop, and nutritional status of
soils after the rice crop harvest.

MATERIALS AND METHODS

An experiment was conducted at
Field Laboratory of the Department of
Crop Botany, Bangladesh Agricultural
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University, Mymensingh, during the period of May to December 2016. Nine dhaincha accessions were collected (and pre-selected based on their biomass yield) from different locations of Bangladesh. The collection information of dhaincha accessions is shown in Table 1. The experiment was laid out in a randomized complete block design, having three replications. The treatment combinations were incorporation of different dhaincha accessions in soil and a control (without incorporation of dhaincha). The unit plot size was 2.5 m x 2 m. Dhaincha crop was cultivated in the (Boro) rice-fallow (Dhaincha)-rice (T. Aman) cropping pattern. Dhaincha seeds (@ 60 kg ha\(^{-1}\) and germination percentage above 80%) were sown first week of June and 60 days old dhaincha plants were incorporated into the soil as green manure before transplanting of Aman rice ‘BRRI dhan49’. Soil samples were collected before the sowing of dhaincha seeds (initial/pre-sowing) and after T. Aman rice harvest (post-harvest), following standard method. Both the initial and post-harvest soil samples were analyzed and compared with their initial soil nutritional status. Different soil component/nutrients, viz. organic matter (OM %), total nitrogen (N %), available phosphorus (P), exchangeable potassium (K), sulfur (S) and soil pH were determined in the Laboratory of Soil Resource Development Institute, Mymensingh, following standard analytical procedures.

Table 1 - Dhaincha accessions used as green manure and their sources

<table>
<thead>
<tr>
<th>Accession number</th>
<th>Collection information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acc. 25</td>
<td>Mymensingh, Shikarikanda</td>
</tr>
<tr>
<td>Acc. 27</td>
<td>Mymensingh, Chor Gobordia</td>
</tr>
<tr>
<td>Acc. 33</td>
<td>Khulna, Dumuria, Badurgacha</td>
</tr>
<tr>
<td>Acc. 57</td>
<td>Sirajganj, Kamarpur, Haluakandi</td>
</tr>
<tr>
<td>Acc. 82</td>
<td>Sirajganj, Kazipur, Sonamukhi</td>
</tr>
<tr>
<td>Acc. 87</td>
<td>Rangpur, Sadar, Panichorahat, Keshobpur</td>
</tr>
<tr>
<td>Acc. 95</td>
<td>Gaibandha, Thansinghpur</td>
</tr>
<tr>
<td>Acc. 96</td>
<td>Gaibandha, Thansinghpur</td>
</tr>
<tr>
<td>Acc. 109</td>
<td>Faridpur, Sadar</td>
</tr>
<tr>
<td>Control</td>
<td>No. dhaincha incorporation</td>
</tr>
</tbody>
</table>

For rice cultivation, the recommended dose (Urea-Triple Super Phosphate-Muriate of Potash-Gypsum (@ 20-7-11-8 kg/Bigha, respectively) of TSP, MOP and gypsum fertilizers was applied during final land preparation (BRRI, 2015). Forty five days old healthy rice seedlings were transplanted in the experimental plot at the spacing of 15 cm x 25 cm (plant-plant x row-row, respectively). The standard rice cultivation and management practices were followed (BRRI, 2015). The crop was harvested and data on rice yield and yield contributing descriptors were recorded. Harvest index (%) was calculated using the following formula:

\[
\text{Harvest index} = \left( \frac{\text{Economic yield}}{\text{Biological yield}} \right) \times 100
\]

Data were analyzed statistically following the analysis of variance (ANOVA) technique, using Statistix 10 software package and means were
RESULTS AND DISCUSSION

Status of soil pH and nutrients, viz. OM (%), total N (%), available P, S and exchangeable K value, in initial and post-harvest soils are presented in Table 2. Soil pH value ranges from 6.05 to 6.63 (initial) and 5.93 to 6.63 (post-harvest); the pH value changes could be due to the incorporation of dhaincha crop in soil. Nierves & Salas (2015) explained that the decomposed organic matter producing humic acid, nitric acid and sulfuric acid those increase the H⁺ ion in the soil. Rainfall which causes leaching that tends to wash away the basic cations viz. K⁺, Mg²⁺ and Ca²⁺ those are replaced by acidic cations like H⁺ making soil acidic. However, microbial activity and root respiration release CO₂, which is slightly acidic as a result enhance the acidity of the soil. The increased availability of P, and changes soil pH due to green manure application are also supported by Hundal et al. (1987). The soil OM varied from 2.30% to 2.95% at initial stage and 2.71% to 2.98% at post-harvest stage (Table 2). Organic matter status increased may be incorporation of dhaincha in soil and succeeding crop rice intake nutrients from it. The increase of OM content in soil could also be attributed root growth and crop debris addition after crop harvest (Sarwar et al., 2017). Thus crop residual effect increased higher soil nutrients in post-harvest soil. However, OM decreased in control plot (no green manure use) due to rice crop intake nutrient from soil and soil may become exhausted. Rahman et al. (2012) found similar result in maize-dhaincha-rice cropping pattern. Khalequzzaman et al. (2005) opined that OM resulted in the enhancement of organic carbon of the post-harvest soil in excess of the control. The total N status ranged from 0.13 to 0.17 at the initial soil and 0.16 to 0.17 at the post-harvest soil (Table 2). The increase in total N content of soil may be the effect of incorporation of dhaincha in soil. Green manure may be attributed to the mineralization of soil nutrients from organic matter. Islam et al. (2006) reported that nitrogen content increased in dhaincha incorporated plot, but static in unincorporated plot.

The available P value in soil varied from 6.08 to 9.45 ppm (initial) and 6.12 to 8.38 ppm (post-harvest) (Table 2). Available P value is decreased in the accessions number 25, 27, 33, 82, 95 and 109 incorporated plot. The form and availability of phosphorus in soil is highly depending on soil pH (McKenzie, 2003). In pH values less than 6 create a chemical bond between aluminum (Al) and phosphate; on the other hand, in higher values of soil pH (6-8), adsorption of phosphate ions occur on solid Al or Fe hydroxide (Georgantas & Grigoropoulou, 2006). The P value decrease may be due to the low pH and P fixation in soil. Nierves & Salas (2015) reported that cycling of organic
matter is slower due to acidic soil (low soil pH) and the amount of major elements, viz. N, P and S, is reduced. Moreover, decomposed organic matter releases organic molecules, which form complex compound with Fe and Al ions and those are also responsible for P fixation (Ghosal et al., 2011). Rahman et al. (2012) also obtained similar result in maize-

dhaincha-T. Aman cropping system in Bangladesh condition. Exchangeable K level was more or less static or equal in initial and post-harvest soils (Table 2). It indicates that the soil (of Mymensingh region) is rich in K minerals content. The S level of soil ranges from 9.29 to 14.35 ppm at initial stage and 11.31 to 13.85 ppm at the post-harvest soil. The available S was increasing in post-harvest soil might be due to the residual effect of dhaincha incorporation in soil (Table 2). Assefa et al. (2014) explained that microorganisms break down organic compounds to acquire organic C for their energy metabolism and S released sulfate as by-product. Moreover, the sulfate releases from sulfate-esters through enzymatic hydrolysis process. The mineralized S and C-bonded are strictly dependent on microbial activity. Sulfate-esters can be readily hydrolyzed by sulfatase enzymes in the soil; however, biochemical mineralization is controlled by the supply of S release from organic matter. Moreover, in Sesbania green manured soils, the leaching losses of sulfur were lower, as compared to control (Vaneet & Nayyar, 2000). Those might be the probable causes of increase in S content of dhaincha incorporated soils. The use of green manure slightly increased the organic matter, total N, available P, exchangeable K and S in the post-harvest soil reported by Ehsan et al. (2014) and Hoque et al. (2016). Green manure also contributes to long term residual effects on soil productivity (Becker et al., 1995).

Incorporation of dhaincha biomass significantly influenced the yield and yield contributing characters of subsequent T. Aman rice, as compared to the control (without dhaincha incorporation). Plant height, total number of tillers hill$^{-1}$, effective tillers hill$^{-1}$, primary branches panicle$^{-1}$, number of filled grains panicle$^{-1}$, grain yield and straw yield significantly differed, however, panicle length did not differ after biomass incorporation of different dhaincha accessions (Table 3). The morphological descriptors may be controlled by genetic make-up of the rice cultivars (BRRI, 2015). Sarwar et al. (2017) also reported similar results in (Boro) rice-dhaincha-rice (T. Aman) cropping pattern, where dhaincha was used as a green manure crop. The tallest plant height (84.90 cm) was found in Acc. 25 and shortest in control (79.40 cm). The highest number of tiller hill$^{-1}$ was recorded in Acc. 33 and lowest in control (Table 3). However, highest effective tiller hill$^{-1}$ was found in Acc. 95 and lowest in control.
### Table 2 - Initial and post-harvest soil nutrients status of *Dhaincha* incorporated plot

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil pH</th>
<th>OM (%)</th>
<th>N (%)</th>
<th>P (ppm)</th>
<th>K (meq/100 g)</th>
<th>S (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>before</td>
<td>after</td>
<td>before</td>
<td>after</td>
<td>before</td>
<td>after</td>
</tr>
<tr>
<td>Acc. 25</td>
<td>6.30</td>
<td>6.63</td>
<td>2.64</td>
<td>2.84</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>Acc. 27</td>
<td>6.29</td>
<td>6.44</td>
<td>2.50</td>
<td>2.98</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>Acc. 33</td>
<td>6.63</td>
<td>6.44</td>
<td>2.37</td>
<td>2.88</td>
<td>0.14</td>
<td>0.17</td>
</tr>
<tr>
<td>Acc. 57</td>
<td>6.45</td>
<td>6.21</td>
<td>2.91</td>
<td>2.84</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Acc. 82</td>
<td>6.05</td>
<td>6.43</td>
<td>2.36</td>
<td>2.81</td>
<td>0.14</td>
<td>0.16</td>
</tr>
<tr>
<td>Acc. 87</td>
<td>6.39</td>
<td>6.39</td>
<td>2.60</td>
<td>2.96</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>Acc. 95</td>
<td>6.25</td>
<td>6.29</td>
<td>2.78</td>
<td>2.74</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Acc. 96</td>
<td>6.29</td>
<td>5.93</td>
<td>2.30</td>
<td>2.81</td>
<td>0.13</td>
<td>0.16</td>
</tr>
<tr>
<td>Acc. 109</td>
<td>6.47</td>
<td>6.29</td>
<td>2.74</td>
<td>2.71</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Control</td>
<td>6.09</td>
<td>6.46</td>
<td>2.95</td>
<td>2.92</td>
<td>0.17</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### Table 3 - Yield and yield contributing descriptors of *T. Aman* rice

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Total tiller (No.)</th>
<th>Effective tiller (No.)</th>
<th>Panicle length (cm)</th>
<th>Primary branch panicle</th>
<th>Filled grain (No.)</th>
<th>Unfilled grain (No.)</th>
<th>Grain yield (g10h iii)</th>
<th>Straw yield (g10h iii)</th>
<th>Harvest index (%)</th>
<th>Grain yield (tha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acc. 25</td>
<td>84.90a</td>
<td>8.37abc</td>
<td>6.53c</td>
<td>22.17a</td>
<td>9.57bc</td>
<td>117.60c</td>
<td>16.70bcd</td>
<td>214.79a</td>
<td>230.11bcd</td>
<td>48.28</td>
<td>5.73</td>
</tr>
<tr>
<td>Acc. 27</td>
<td>81.17ab</td>
<td>7.73cde</td>
<td>6.67bc</td>
<td>22.30a</td>
<td>9.13c</td>
<td>109.33d</td>
<td>17.67ab</td>
<td>205.62de</td>
<td>46.08</td>
<td>4.69</td>
<td></td>
</tr>
<tr>
<td>Acc. 33</td>
<td>82.63ab</td>
<td>8.87a</td>
<td>7.20ab</td>
<td>22.30a</td>
<td>10.30a</td>
<td>135.07a</td>
<td>14.83d</td>
<td>217.78a</td>
<td>281.30a</td>
<td>43.64</td>
<td>5.81</td>
</tr>
<tr>
<td>Acc. 57</td>
<td>81.53ab</td>
<td>8.10ab</td>
<td>6.93abc</td>
<td>22.30a</td>
<td>9.27bc</td>
<td>116.30cd</td>
<td>15.20cd</td>
<td>188.85c</td>
<td>219.46cd</td>
<td>46.25</td>
<td>5.04</td>
</tr>
<tr>
<td>Acc. 82</td>
<td>80.57ab</td>
<td>7.77b-e</td>
<td>7.00abc</td>
<td>21.87a</td>
<td>9.57bc</td>
<td>116.50cd</td>
<td>17.57ab</td>
<td>200.69bc</td>
<td>243.86bc</td>
<td>45.14</td>
<td>5.35</td>
</tr>
<tr>
<td>Acc. 87</td>
<td>82.73ab</td>
<td>8.37abc</td>
<td>7.13ab</td>
<td>22.30a</td>
<td>9.47bc</td>
<td>127.43ab</td>
<td>15.90bcd</td>
<td>199.67bc</td>
<td>225.27cd</td>
<td>46.99</td>
<td>5.32</td>
</tr>
<tr>
<td>Acc. 95</td>
<td>82.53ab</td>
<td>8.40abc</td>
<td>7.47a</td>
<td>23.00a</td>
<td>9.87ab</td>
<td>121.23bc</td>
<td>16.17bcd</td>
<td>206.57ab</td>
<td>252.11b</td>
<td>45.04</td>
<td>5.51</td>
</tr>
<tr>
<td>Acc. 96</td>
<td>82.70ab</td>
<td>7.87de</td>
<td>6.83bc</td>
<td>22.33a</td>
<td>9.43bc</td>
<td>120.67bc</td>
<td>18.93a</td>
<td>200.71bc</td>
<td>221.00cd</td>
<td>47.59</td>
<td>5.35</td>
</tr>
<tr>
<td>Acc. 109</td>
<td>79.73b</td>
<td>7.70de</td>
<td>7.23ab</td>
<td>22.47a</td>
<td>9.87ab</td>
<td>118.73c</td>
<td>17.03abc</td>
<td>209.10abc</td>
<td>233.53bc</td>
<td>47.24</td>
<td>5.58</td>
</tr>
<tr>
<td>Control</td>
<td>79.40b</td>
<td>7.23e</td>
<td>6.50c</td>
<td>21.90a</td>
<td>9.20bc</td>
<td>108.77d</td>
<td>16.70bcd</td>
<td>162.98e</td>
<td>192.18e</td>
<td>45.89</td>
<td>4.35</td>
</tr>
<tr>
<td>LSD</td>
<td>4.47</td>
<td>0.66</td>
<td>0.58</td>
<td>1.50</td>
<td>0.71</td>
<td>8.14</td>
<td>1.91</td>
<td>11.91</td>
<td>24.68</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
The highest number of branch panicle\(^{-1}\) was observed in Acc. 33 and lowest in Acc. 27. The highest number of filled grain was recorded in Acc. 33 (135.07) and lowest in control (108.77). It may be occurred due to availability of nutrients released after incorporation of *dhaincha* biomass and other beneficial effect increased grain yield. Millan *et al.* (1985) opined that basal dose of N had been exhausted within 45-50 days and at that time, rice plant is incoming to panicle initiation stage. The incorporation of *Sesbania* spp. in soil influenced plant growth, yield and yield contributing parameters of rice was also reported by Hiremath & Patel (1998). Decomposed organic matter quickly released plant nutrients and transformed available form in soil (Sarwar *et al.*, 2017). Plant gets enough nutrients, as a result it showed a vigorous growth and increased grain yield.

The results of present study are in consequence with the results of Sarwar *et al.* (2017). They reported that the highest number of filled grain panicle\(^{-1}\), obtained from *dhaincha*, incorporated plot over the control (Rahman *et al.*, 2012). However, the highest unfilled grain was counted in Acc. 96 and lowest in Acc. 33.

The highest grain yield (5.81 t ha\(^{-1}\)) was produced in *dhaincha* Acc. 33 incorporated plot, followed by Acc. 25 (5.73 t ha\(^{-1}\)) and the lowest in control (4.35 t ha\(^{-1}\)) (Table 3). Sarwar *et al.* (2017) found that Acc. 95 (4.00 t ha\(^{-1}\)) produced highest grain yield, followed by Acc. 96 (3.74 t ha\(^{-1}\)) and Acc. 87 (3.67 t ha\(^{-1}\)). Though the accession number 95 simultaneously performed better, no significant yield difference with Acc. 33, this year compared to the previous year experiment (Table 3) (Sarwar *et al.*, 2017). These variations in grain (and straw) yield, due to incorporation of same *dhaincha* accessions in two consecutive years, may be due to differences in prevailing weather condition during the growing periods. The highest amount of straw also produced in Acc. 33 and lowest in control (Table 3). It may occur due to the sufficient nutrients availability in soil from *dhaincha* incorporated plots. The slow released of nutrients from organic matter remains available throughout the growing periods of rice. These results are supported by Rahman *et al.* (2012) and Sarwar *et al.* (2017). They have reported that the highest grain and straw yield of T. Aman rice obtained from *dhaincha* incorporated plots over the control. However, harvest index (HI) of rice was higher in Acc. 25 and lower in Acc. 33 (Table 3). It may be occurred due to the different nutrients status remains in different *dhaincha* accessions. Due to the incorporation of *dhaincha* green manure in the plot, the rice grain yield increased 7.82% to 33.56% over the control (Table 3). The findings are matched with Sarwar *et al.* (2017). They stated that recommended doses of PKS with *dhaincha* green manuring in T. Aman plot, grain yield increased 6.60% to 38.89% over the control. In the rice based cropping system, rice grain
yield increased 32% to 77% over control due to dhaincha incorporation with different doses of NPK fertilizers application (Ehsan et al., 2014; Noor-A-Jannat et al., 2015). In Indian perspective, the yield of high yielding rice varieties was increased from 0.65 to 3.1 t ha\(^{-1}\) due to use of green manure (Singh et al., 1991).

**CONCLUSION**

The pH value, organic matter and total nitrogen slightly increased, however, available phosphorus and potassium more or less static, and available sulfur increased due to dhaincha incorporation in post-harvest soil, compared to initial soil sample. Out of nine dhaincha accessions, the accession number 33 incorporation produced the highest grain yield (5.81 t ha\(^{-1}\)), followed by accession number 25 (5.73 t ha\(^{-1}\)) and accession number 109 (5.58 t ha\(^{-1}\)). A precise conclusion to be built up through collection of large number of germplasms from Bangladesh is needed.

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