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Effect of *Dhaincha* accessions on soil health and grain yield of rice

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ABSTRACT

To assess and compare the effect of different dhaincha accessions on soil health and grain yield of rice, nine dhaincha accessions were used as experimental materials along with a control (without dhaincha plant). The experiment was laid out in a randomized complete block design with three replications. Seeds of dhaincha accessions were sown in experimental plot @ 60 kg/ha. The 45 days old dhaincha plants were mixed up with soil. Soil samples were collected before sowing and after decomposition of dhaincha biomass and analyzed following standard procedure. There is a substantial increase in soil organic matter (up to 26%) and total nitrogen content (up to 25%) in soil after dhaincha incorporation. Thirty five days old, healthy rice seedlings were transplanted in the dhaincha incorporated plots at the spacing of 15cm X 25cm (plant-plant X row-row). The standard rice cultivation procedure was followed. Due to the incorporation of dhaincha biomass in soil, the grain yield was increased (up to 39%) compared to the control. Among the dhaincha accessions, number 95 showed the best performance in terms of grain yield. However, it is too early to make a conclusive remark based on only these very few number of dhaincha accessions. Therefore, a detailed study with a large number of germplasm collected from whole Bangladesh is obviously needed to reach in a precise conclusion.

Key Words: *Dhaincha, Soil organic matter, Nitrogen availability, Grain yield and Rice*

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I. Introduction

In Bangladesh, the organic matter content of soil is below 1% in more than 60% of the total cultivable lands compared to an ideal minimum value of 3% (Islam, 2006). Here, the population size is increasing rapidly and in contrary, agricultural land is decreasing at alarming rate (ca. 1% per year; UNDP 2003 in Hasan et al., 2013) due to different anthropogenic activities. This additional population creates threats to the food and nutritional security. Therefore, farmers of Bangladesh compelled to go for intensive cultivation, 3 to 4 crops every year in the same piece of land, resulting extra-pressure on

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crop lands. On the other hand, soil does not get enough time to replenish its organic matter component; as a result soil nutrients and organic matter status are deteriorating day by day. Organic matter plays an important role on increasing soil fertility, nutrients availability and towards fovourable changes in physical, chemical as well as biological properties of soil (Ray and Gupta, 2001). Green manure is the cheapest and best source of organic matter. Green manure enhances soil physical properties e.g., texture, structure, water holding capacity, etc. improves water permeability and reduces soil erosion (Heering, 1995). Green manure also reduces the leaching of nutrients and increases the crop yield (Abro and Abbasi, 2002).

Dhaincha (*Sesbania* spp.), belongs to the family Fabaceae, is well known for its diversified uses in Bangladesh (Sarwar et al., 2015). It is an ideal crop for green manure, as it is quick-growing, succulent, easily decomposable with low moisture requirements, and produces maximum amount of organic matter and nitrogen in the soil (Palaniappan and Siddeswaran, 2001). *Dhaincha* is also economically important and has shown promising possibilities in their use as animal feed and fodder (Shahjalal and Topps, 2000; Hossain and Becker, 2001), raw materials for paper pulp production (Sarker et al., 2017), ground cover, providing wood, firewood and other uses in traditional agroforestry systems (Ndoye et al., 1990). *Dhaincha* cultivation is one of the traditional practices to increase the organic matter content of soil. All parts of *dhaincha* plant e.g. stem, leaf, and root, are used for green manure. *Dhaincha* has a yield potential of up 20 t DM/ha/year under appropriate cultivation (Factsheet – *Sesbania sesban*, 2016). In Bangladesh condition, 60 days old *dhaincha* (*S. aculeata*) plants produced 5.2 t/ha dry matter which yielded 135 kg N/ha (Zaman et al., 1995). Cultivation of *dhaincha* green manure between harvesting of *Boro* rice/winter crops and transplanting of *Aman* rice may play a vital role for improving soil organic matter status and sustainable rice production in the existing cropping patterns of Bangladesh (Rahman et al., 2012, 2013). The present study was, therefore, undertaken to find out the effect of different *dhaincha* accessions on soil health and grain yield of subsequent rice crop, with a long-term objective to recommend suitable cultivar(s) for different purpose(s) e.g. green manure, animal feed, fire-wood, pulp production etc.

II. Materials and Methods

The experiment was carried out at the Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during April to December 2015. Nine *dhaincha* accessions collected (and preselected based on their biomass yield) from different locations of Bangladesh were used as experimental materials along with the control. The collection information of *dhaincha* accessions is presented in Table 01. The experiment was laid out in randomized complete block design with three replications. The treatment combinations were incorporation of different *dhaincha* accessions 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*)–(T. *Aman*) rice, one of the most common cropping patterns in Bangladesh. *Dhaincha* seeds (@ 60 kg/ha and germination percentage >80%) were sown last week of April. The 45 days old *dhaincha* plants were incorporated into soil as green manure before transplanting of *Aman* rice (cv. BRRI dhan49). Soil samples were collected before sowing (initial) and after decomposition of *dhaincha* biomass and analyzed for organic matter (%) and total nitrogen content (%) in the Humboldt Soil Testing Laboratory, Department of Soil Science, Bangladesh Agricultural University, Mymensingh, following standard analytical procedures.

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). No N-fertilizer was used in *Dhaincha* incorporated plots. Healthy rice seedling of 35 days old were transplanted in the *Dhaincha* incorporated soil at the spacing at plant-plant X row-row of 15cm x 25cm, respectively. The standard rice cultivation procedure was followed (BRRI, 2015). Data on rice yield and yield components were recorded. Harvest index (%) was calculated using the formula, Harvest Index (%) = (Economic yield/Biological yield) x 100.

Data were analyzed statistically following the analysis of variance (ANOVA) technique using MSTAT-C computer package (Russell, 1991) and means were separated by Duncan's new multiple range test (DMRT) at 5% level of significance.

Table 01. Dhaincha accessions used as green manure and their sources

Accessions Number	Collection Information
Control	None
Acc. 25	Mymensingh, Sadar, Shikarikanda
Acc. 27	Mymensingh, Sadar, Chor Gobordia, opposite to the Bangladesh Agricultural University campus
Acc. 28	Mymensingh, Sadar, Bangladesh Agricultural University campus, Agronomy Farm
Acc. 33	Khulna, Dumuria, Badurgacha
Acc. 57	Sirajganj, Kamarpur, Haluakandi
Acc. 82	Sirajgang, Kazipur, Sonamukhi
Acc. 87	Rangpur, Sadar, Panichorahat, Keshobpur
Acc. 95	Gaibandha, Thansinghpur
Acc. 96	Gaibandha, Thansinghpur

III. Results and Discussion

The effect of incorporation of *dhaincha* biomass in soil is presented in Table 02. Both the organic matter content and total nitrogen (%) were increased due to *dhaincha* incorporation in soil. The amount of organic matter (%) varied from 1.582 to 2.133 before incorporation and 1.995 to 2.271 after incorporation of *dhaincha* biomass in soil (Table 02). The value of organic matter (%) increase varied from 3.23 to 26.11% except in control and Acc. 87. This increment may be temporary, will not persist for a long time. However, it is found to be very beneficial for subsequent rice crop yield (Table 03). Mann et al. (2000) reported that after three years of continuous green manuring, the soil organic matter and N increased up to 1.09% and 0.37%, respectively. These variations in organic matter increase in soil may be depended on the biomass producing ability of different *dhaincha* accessions (Sarwar et al., 2015). Root, leaf and stubbles of *dhaincha* after decomposition improved the organic matter status of soil. Rahman et al. (2013) also reported that organic matter and total N status of soil ranged from 1.42 to 1.58% (initial level 1.51%) and from 0.075 to 0.098% (initial level 0.078%), respectively after three years of continuous *dhaincha* biomass incorporation. The total N (%) in soil varied from 0.088 to 0.118 before incorporation and 0.106 to 0.126 after incorporation of *dhaincha* biomass (Table 02). Like the organic matter (%), the amount of total N (%) in soil increased due to incorporation of all *dhaincha* accessions except Acc. 87 (Table 02). The increase in total N content of soil due to application of organic manure may be attributed to the mineralization of N by *dhaincha* green manure in soil and greater multiplication of soil microbes, which could convert organically bond N to inorganic form (Rahman et al., 2013). Ehsan et al. (2014) also reported similar results for *S. aculeata* green manure in rice-based cropping system. Khalequzzaman et al. (2005) reported that organic manure resulted in the improvement of organic carbon in soil over the control (without manure). Total N (%) was higher in the treatments where organic manure and crop residues were added. Bouldin (1988) opinioned that green manure decomposes rapidly and releases nitrogen quickly in soil and incorporation of organic matter is an excellent sources of nitrogen for the first crop sequence. The results revealed that the incorporation *dhaincha* biomass also significantly influenced the yield and yield contributing characters of subsequent transplant *Aman* rice as compared to the control (Table 03). It was observed that *dhaincha* has positive influence on the rice grain yield. Accession number 95 and 96 performed better than others. Plant height, panicle length, and number of primary branch/panicle did not show any significant variation after biomass incorporation of different *dhaincha* accessions (Table 03). These morphological descriptors might mostly be controlled by genetic make-up of the rice cultivar (BRRI, 2015). The highest number of total tiller (15.07) was recorded in Acc. 96 and the lowest (11.20) in control (Table 03). The highest number of effective tiller was found in also treatment number Acc. 96 and the lowest in Acc. 28. The highest number of filled grain was recorded in both Acc. 57 and Acc. 87 and the lowest in Acc. 82 and Acc. 28 (Table 03). It may be due to higher availability of nitrogen, released after incorporation of *dhaincha* biomass and other beneficial effects increased grain yield. Milan et al. (1985) reported that basal dose of nitrogen had been exhausted in 45-50 days, and at that time, rice is entering to panicle initiation stage. They have needed additional nitrogen for their growth and tiller development. Decomposed organic matter released nitrogen and quickly transformed into available form in soil. Crop uptake nutrients and

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showed a vigorous growth and as resulting increased crop yield. The results of present study are in consonance with the results of Rahman et al. (2012). They reported that the number of filled grain/panicle obtained from green manuring plot was higher and the lowest from control. The highest grain yield (4.00 t/ha) was produced in Acc. 95 incorporated plot followed by Acc. 96 (3.74 t/ha) and the lowest (2.88 t/ha) in control (Table 03). The highest amount of straw yield obtained from Acc. 25 and the lowest from control. It may be occurred due to the sufficient nitrogen efficiency and organic matter in *dhaincha* incorporation plots. The slow released nitrogen remains available throughout the growth period of rice. These results are supported by Rahman et al. (2012). They stated that the maximum straw yield of T. *Aman* obtained from *dhaincha* green manuring treatment over the control. Harvest index of rice was also higher in Acc. 95 and the lowest in Acc. 25 (Table 03). Due to incorporation of *dhaincha* biomass in the field, the rice grain yield increased 7 to 39% over the control. The findings are supplemented by Rahman et al. (2012). They reported that green manuring of *dhaincha* gave highest yield of T. *Aman* over the control (no fertilizer used). In rice-based cropping system, the rice grain yield increased 32% to 77% over control due to (*dhaincha*) green manure incorporation with different doses of NPK fertilizers application (Ehsan et al., 2014; Noor-A-Jannat et al., 2015). This may be due to the efficient and adequate nutrients supply from *dhaincha* biomass decomposition and released nutrients for the crop.

Table 02. Soil nutrients status as influence by *dhaincha* biomass incorporation in soil

Treatment	Organic Matter (%)			Total Nitrogen (%)		
	Before incorporation	After incorporation	Increase (%)	Before incorporation	After incorporation	Increase (%)
Control	2.064	2.064	0	0.106	0.106	0
Acc. 25	1.995	2.133	6.92	0.112	0.118	5.35
Acc. 27	2.133	2.202	3.23	0.118	0.122	3.39
Acc. 28	1.582	1.995	26.11	0.088	0.112	25.00
Acc. 33	1.926	1.995	3.58	0.107	0.112	2.80
Acc. 57	1.721	2.064	19.93	0.095	0.114	20.00
Acc. 82	1.995	2.133	6.92	0.112	0.118	5.35
Acc. 87	1.995	1.995	0	0.112	0.112	0
Acc. 95	1.858	2.271	22.23	0.103	0.126	22.33
Acc. 96	1.995	2.202	10.38	0.112	0.122	8.92

Table 03. Effect of different *dhaincha* accessions on yield and yield components of rice

Treatments	Plant height (cm)	Total no. of tiller	No. of effective tiller	Panicle length (cm)	No. of primary branch/panicle	No. of filled grain/panicle	No. of unfilled grain/panicle	Grain Yield (g/10 hill)	Straw Yield (g/10 hill)	Harvest Index (%)	Grain Yield (t/ha)
Control	96.33a	11.20d	9.87cd	21.67a	10.67a	175.4b	15.53e	108.0e	108.2d	49.95	2.88
Acc. 25	99.07a	13.13bc	11.67ab	22.13a	12.00a	175.8b	17.47c-e	133.3a-d	157.7a	45.81	3.55
Acc. 27	99.87a	12.27cd	9.60cd	22.27a	11.33a	165.3bc	21.87a	115.0de	122.1cd	48.50	3.07
Acc. 28	96.13a	11.27d	9.40d	20.73a	11.33a	151.2c	20.07a-c	118.5b-e	133.8bc	46.97	3.16
Acc. 33	100.5a	13.73a-c	11.27a-c	21.27a	10.47a	149.3c	16.27de	126.2b-e	141.3a-c	47.18	3.37
Acc. 57	101.1a	12.53cd	10.33b-d	22.20a	11.07a	195.5a	22.73a	117.9c-e	137.0a-c	46.25	3.14
Acc. 82	96.87a	13.13bc	9.93cd	21.20a	12.13a	151.6c	20.53ab	121.8b-e	132.4bc	47.92	3.25
Acc. 87	98.60a	12.53cd	10.93b-d	20.73a	11.67a	195.8a	18.53b-d	137.7a-c	142.8a-c	49.02	3.67
Acc. 95	99.73a	14.27ab	11.93ab	22.20a	11.53a	177.6b	21.00ab	150.0a	141.0a-c	51.55	4.00
Acc. 96	101.1a	15.07a	12.73a	23.60a	11.27a	176.1b	23.00a	140.3ab	149.9ab	48.35	3.74
CV (%)	*3.36*	*6.7*	*8.2*	*7.24*	*9.75*	*5.89*	*8.09*	*8.63*	*8.97*	-	-

In a column figure(s) followed by same letter do not differ significantly at 5% level by DMRT.

IV. Conclusion

Dhaincha biomass incorporation through the appropriate cropping pattern, (*Boro*) rice/Winter vegetables- *dhaincha*-(T. *Aman*) rice, has potential effect on soil fertility and nutrient availability as well as the increment of crop production. Among the accessions studied, Acc. No. 95 incorporation produced the highest grain yield (4 t/ha) without applying any additional nitrogenous fertilizer. However, it is too early to make a conclusive remark with only these very few number of *dhaincha* accessions. Therefore, a detailed study with a large number of germplasm collected from whole Bangladesh is obviously needed to reach in a precise conclusion.

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