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EFFECTS OF OLD JUTE SEEDS ON SOIL FERTILITY AND JUTE PRODUCTION

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Abstract

A field experiment was conducted to evaluate the effects of old jute seed powder (≥3 years old) on soil fertility and jute production using the high yielding variety of jute (*Corchorus olitorius* L.) O-9897 as the test plant. Six treatments of jute seed powder (JSP) and recommended dose of chemical fertilizers (RDF) with three replications were as T_1: Control, T_2: JSP 5 t/ha + ¼ RDF, T_3: JSP 5 t/ha + ½ RDF, T_4: JSP 5 t/ha + ¾ RDF, T_5: RDF, and T_6: JSP 5 t/ha. The growth and yield of jute were found to be the maximum for the treatment T_4 (JSP+ ¾ RDF), where the plant height, base diameter, fiber yield and stick weight were increased 147, 85, 177, and 125%, respectively over the control. The highest contents of organic carbon, nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium in soil were also observed for the treatment T_4. The sole application of jute seed powder increased the growth and yield of jute as well as the contents of nutrients in soil compared to the control; however, inputs of the jute seed powder in combination with the chemical fertilizers showed better results in improving soil fertility and jute production.

Key words: Jute seed; Jute plant; Soil fertility; Organic matter; Nutrient elements.

INTRODUCTION

Plant and animal residues, such as root exudates, plant seeds, partially decomposed materials and dead soil organisms, are usually incorporated into soil to improve soil health (Moebius-Clune *et al.* 2016). Soil organic matter serves as a store house of slow-release nutrients, particularly nitrogen, phosphorous, sulfur and boron. The stable soil organic matter increases the cation exchange capacity of soil as well as its ability to hold potassium, calcium, magnesium, and a range of micronutrients. Soil organic matter helps to buffer micronutrient levels, ameliorating both deficiency and toxicity (Brady and Weil, 2008). Addition of organic matter in soil has also been found to increase soil microbial biomass (Linford *et al.* 1938).

The organic matter content of Bangladeshi soils is generally very low as compared to desired 2.5% and above (Islam 1999, BARC 2018). The average organic matter content of the top soil has been declined by 20-46% over the past 20 years due to intensive agricultural practices (Gani *et al.* 2017). The depletion of soil organic matter is the main cause of low crop productivity which is considered one of the most serious threats to the future sustainability of agriculture in Bangladesh. It is believed that the declining productivity of the soils in Bangladesh is the result of declining organic matter caused due to intensive agricultural practices; lack of organic recycling through addition of crop residues, animal waste, and other organic manures; use of plant residues including shoots and even roots, and cow dung as fuel; disturbing soils through tillage operation like ploughing, puddling, and laddering during intensive cultivation leading to increased soil organic matter decomposition; higher oxidation rate of organic matter added to soil due to relatively higher temperature and monsoonal rainfall; and, use of imbalanced chemical fertilizers in soil (Bhuiya 1987, Bhuiyan 1992, Mia and Karim 1995, Moslehuddin *et al*. 1997, Gani *et al.* 2017). Considering these situations, it is very essential to incorporate different sources of organic matter in soil to improve soil health and crop productivity.

About 0.6 million tons of jute seeds are produced and about 0.2 - 0.3 million tons of jute seeds remain unused every year because of farmers' lack of interest in jute cultivation due to adverse environmental conditions like flooding and drought (Anonymous 2014). Jute seeds provide lipid, fatty acid, lignin, and inorganic nutrients (Siriamornpun *et al.* 2006). Incorporation of crop seeds to soil has been found to increase the contents of organic matter, nitrogen, phosphorus, potassium, and sulfur in the soils (Gani *et al.* 1999). In this study, a field experiment was conducted where the unused old jute seeds (≥3 years old) were applied to soil as a source of organic matter and essential nutrient elements to assess its effects on the cultivation of jute in Bangladesh.

MATERIAL AND METHODS

Location

The field experiment was conducted at the central station of Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka. The site belongs to the AEZ-8, Young Brahmaputra and Jamuna Floodplain.

Collection of jute seeds

Old unused jute seeds (≥3 years old) were collected from BJRI to make jute seed powder.

Land preparation

The land was prepared with power tiller followed by harrowing and laddering. The individual plots were made 7.5 cm high and 10 cm deep drainage was made around each plot to restrict the lateral run-off of irrigation and/or rain water. The total experimental area was divided into three blocks and within each block there were six experimental plots. There were six treatment levels including control, with three replicates. In total, there were 18 experimental plots. The treatments were allocated to the plots following a randomized complete block design. The dimension of each plot was 3 m × 2.1 m having space between the plots as well as between the blocks.

Application of jute seed powder and fertilizers

Old jute seed powder (JSP) was applied as a source of organic matter at the rate of 5 t/ha. Chemical fertilizers, such as urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum as the sources of nitrogen, phosphorous, potassium, and sulfur, respectively, were applied in different combinations on the basis of the recommended dose of the fertilizers (RDF) (200 kg urea + 50 kg TSP + 60 kg MP + 100 kg Gypsum) (BARC, 2005). Six treatment combinations of JSP and RDF were: Treatment T_1 = Control (without JSP and chemical fertilizers), Treatment T_2 (JSP + ¼ RDF) = 5 t/ha JSP + 50 kg urea + 12.5 kg TSP + 15 kg MP + 25 kg gypsum, Treatment T_3 (JSP + ½ RDF) = 5 t/ha JSP + 100 kg urea + 25 kg TSP + 30 kg MP + 50 kg gypsum, Treatment T_4 (JSP + ¾ RDF) = 5 t/ha JSP + 150 kg urea + 37.5 kg TSP + 45 kg MP + 75 kg gypsum, Treatment T_5 (RDF) = 200 kg urea + 50 kg TSP + 60 kg MP + 100 kg gypsum, and Treatment T_6 (JSP) = 5 t/ha JSP. Old jute seed powder was applied to soil 15 days prior to the sowing of new jute seeds to let the old jute seed powder to be decomposed. For the nitrogen fertilizer, half of the dose was applied to each of the plots before sowing of jute seeds and the remaining half was applied 45 days after germination of jute seeds.

Sowing

The seeds of an approved high yielding variety of jute O-9897 were sown at a distance of 10 cm in line maintaining a 30 cm gap between the lines in the plots. Irrigation was done in furrow irrigation system to maintain water supply to the plots. Loosening of the soil was done using hoe 25 days after sowing the seeds. After germination of the jute seeds, gap filling was done by re-sowing of jute seeds. Weeding and thinning were done at 8, 25 and 45 days after sowing of seeds.

Harvesting

The plants were harvested at the age of 120 days where about 80% of the plants showed the sign of maturity. After harvesting, the jute plants from each of the experimental plots were tied separately with tagged rope into bundles and a number of plant parameters, such as plant height, base diameter, fiber weight, and stick weight of the randomly selected 10 harvested jute plants, was measured. Fiber weight was taken after retting and drying of the jute fibers. Stick weight was taken after drying of the jute sticks in the sun. Surface soil samples (0-15 cm) were collected from the experimental plots prior to the application of JSP for background analysis. After harvesting of the jute plants, the residual soil samples were also collected from each of the experimental plots for chemical analysis. The soil samples were processed and analysed following the methods described in Chowdhury *et al.* (2010).

Sample analysis

Various physical, chemical and physico-chemical properties of the soil samples (e.g. moisture content, particle size analysis, bulk density, particle density, pH, organic matter content, total contents of calcium, magnesium, nitrogen, phosphorous, potassium, sulfur and zinc, and available nitrogen, phosphorous, potassium and sulfur) were analysed in the laboratory following the procedures described in Huq and Alam (2005).

Statistical analysis

Statistical analysis and graphical presentation of the data were performed using the statistical software Minitab v.18 and Microsoft Excel 2016.

Table 1. Physical, chemical and physico-chemical properties of the soil used.

Characteristics	Values
Moisture content (%)	27
Sand (%)	9
Silt (%)	61.16
Clay (%)	29.82
Textural class	Silt loam
Bulk density (g/L)	1.24
Particle density (g/L)	2.37
Porosity (%)	53.20
pH	6.20
Organic carbon (%)	0.68
Organic matter (%)	1.18
Total nitrogen (%)	0.32
Available nitrogen (%)	0.03
Total phosphorous (%)	0.07
Available phosphorous (mg/kg)	15.60
Total potassium (%)	0.23
Available potassium (mg/kg)	34.70
Total sulfur (%)	0.02
Available sulfur (mg/kg)	9.40
Total calcium (mg/kg)	58
Total magnesium (mg/kg)	35
Total zinc (mg/kg)	25

RESULTS AND DISCUSSION

Soil properties and elemental composition of the old jute seeds

A range of physical, chemical and physico-chemical properties of the initial soil from the experimental plots was analyzed in order to determine the background properties of the soil (Table 1). The jute seeds were also analyzed to determine the nutritional qualities of the seeds (Table 2).

Table 2. Elemental composition of the old jute seeds.

Elements	Content
Total nitrogen (%)	2.17
Total phosphorous (%)	0.56
Total potassium (%)	0.75
Total sulfur (%)	1.12
Total calcium (mg/kg)	280
Total magnesium (mg/kg)	50
Total zinc (mg/kg)	80

Growth and yield of jute plants

Incorporations of jute seed powder and chemical fertilizers into soil significantly increased the growth and yield of the plants compared to the control (Fig. 1). The plant height, base diameter, fiber yield and stick weight of the jute plants were found to be the maximum for the treatment T_4 (JSP+ ¾ RDF), whereas the lowest values were observed for the treatment T_1 (Control) where no fertilizer was applied (Table 3).

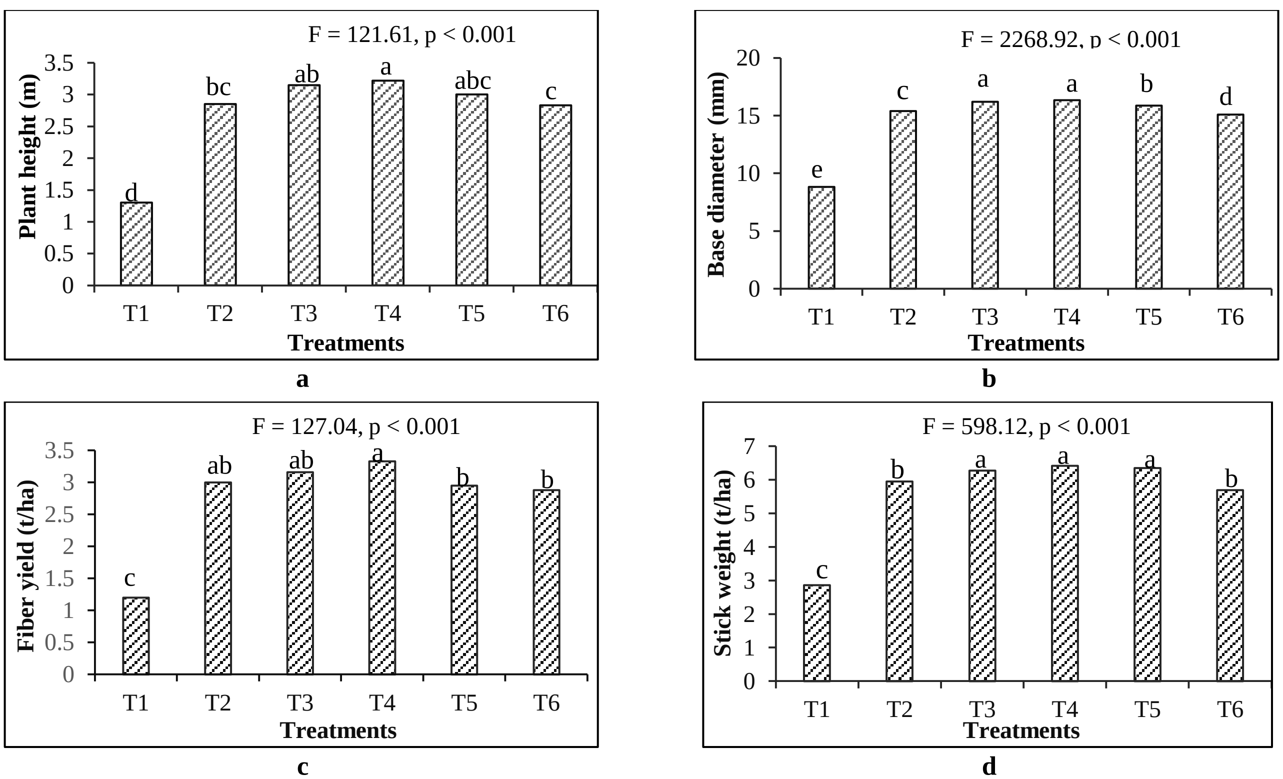


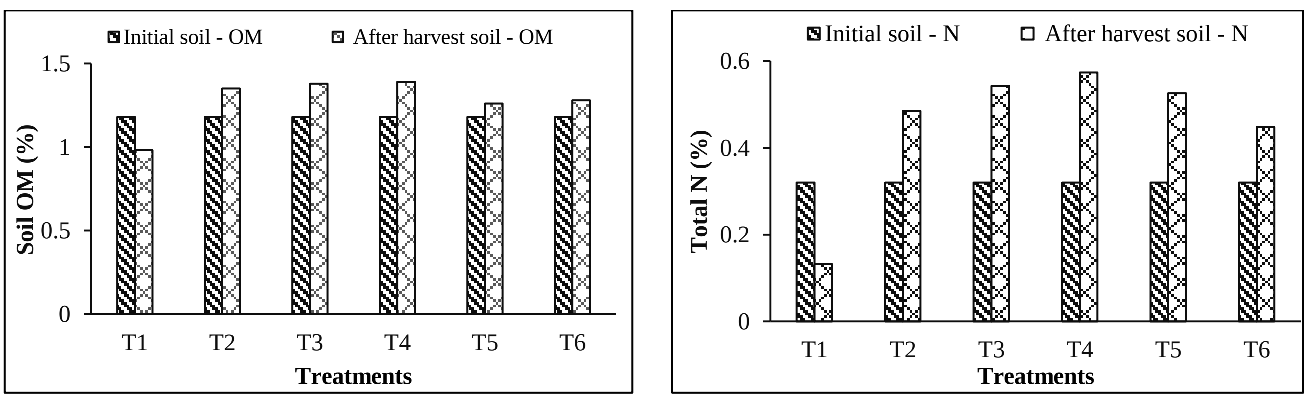
Fig. 1. Variations in growth and yield parameters of jute plants: **a**. plant height; **b**. base diameter; **c**. fiber yield; and **d**. stick weight at different fertilizer treatments (T_1, Control; T_2, JSP + ¼ RDF; T_3, JSP + ½ RDF; T_4, JSP + ¾ RDF; T_5, RDF; and T_6, JSP). One-way analysis of variance was used to compare pair-wise the means of the plant parameters at each of the treatment levels. Treatments that share the same letter (a-e) are not significantly different. The letters indicate Turkey groupings for treatments with respect to their mean yields of the plant parameters.

Plant height, base diameter, fiber yield and stick weight increased by 147, 85, 177, and 125%, respectively, in the treatment T_4 (JSP+ ¾ RDF) over the control. In the plots of the treatment T_4 where a combination of jute seed powder (5 t/ha) and ¾ of the recommended dose of chemical fertilizers were applied, the plant height, base diameter, fiber and stick weight of the jute plants were significantly higher compared to those in the plots of the treatment T_6 where only jute seed powder (5 t/ha) was applied (Fig. 1). Base diameter and fiber yield were significantly higher for the T_4 (JSP+ ¾ RDF) plants than for the T_5 plants where only the recommended dose of chemical fertilizers was applied. Similar observations were also reported by Gani *et al.* (2002) and Gani (2014) for the same variety of jute, where chicken litter as organic matter was applied to soil solely and in combination with chemical fertilizers.

Table 3. Growth and yield characteristics of jute plants.

Treatment(s)	Plant height (m)	Base diameter (mm)	Fiber yield (t/ha)	Stick weight (t/ha)
T_1 (Control)	1.30	8.83	1.20	2.86
T_2 (JSP + ¼ RDF)	2.88	15.40	3.00	5.95
T_3 (JSP + ½ RDF)	3.15	16.20	3.16	6.28
T_4 (JSP + ¾ RDF)	3.22	16.35	3.33	6.42
T_5 (RDF)	3.00	15.87	2.95	6.35
T_6 (JSP)	2.83	15.10	2.88	5.70

However, the growth and yield of jute plants were insignificantly different, in most cases, in the plots with sole application of jute seed powder and the applications of lower doses of chemical fertilizers in combination with jute seed powder, as seen particularly in the treatment T_2. In the present study, the soil application of the jute seed powder and chemical fertilizers increased the growth and yield of the jute plants, with the treatment T_4 (JSP+ ¾ RDF) being superior to the other treatments for getting the maximum growth and yield of the jute plants.



a **b**

Fig. 2. Organic matter and nutrient contents in the initial and after harvest soils: **a**. soil OM (%); **b**. total N (%).

Residual values of the soils

Organic matter content in the soil was higher in the residual soils after harvesting the jute plants compared to that in the initial soil at all the treatment levels except the control (Fig. 2). The total contents of nitrogen, phosphorous, potassium, sulfur, calcium and zinc of the soils after harvest also increased in all the treatment plots except control (Fig. 2). Similar observations were observed for the available concentrations of nitrogen, phosphorous, potassium and sulfur. However, the total content of magnesium in the soil after harvest decreased in all the treatments. The results indicated that the incorporation of organic jute seed powder alone or along with inorganic chemical fertilizers at different rates has potential to increase organic matter content as well as a range of essential nutrient elements in agricultural soils.

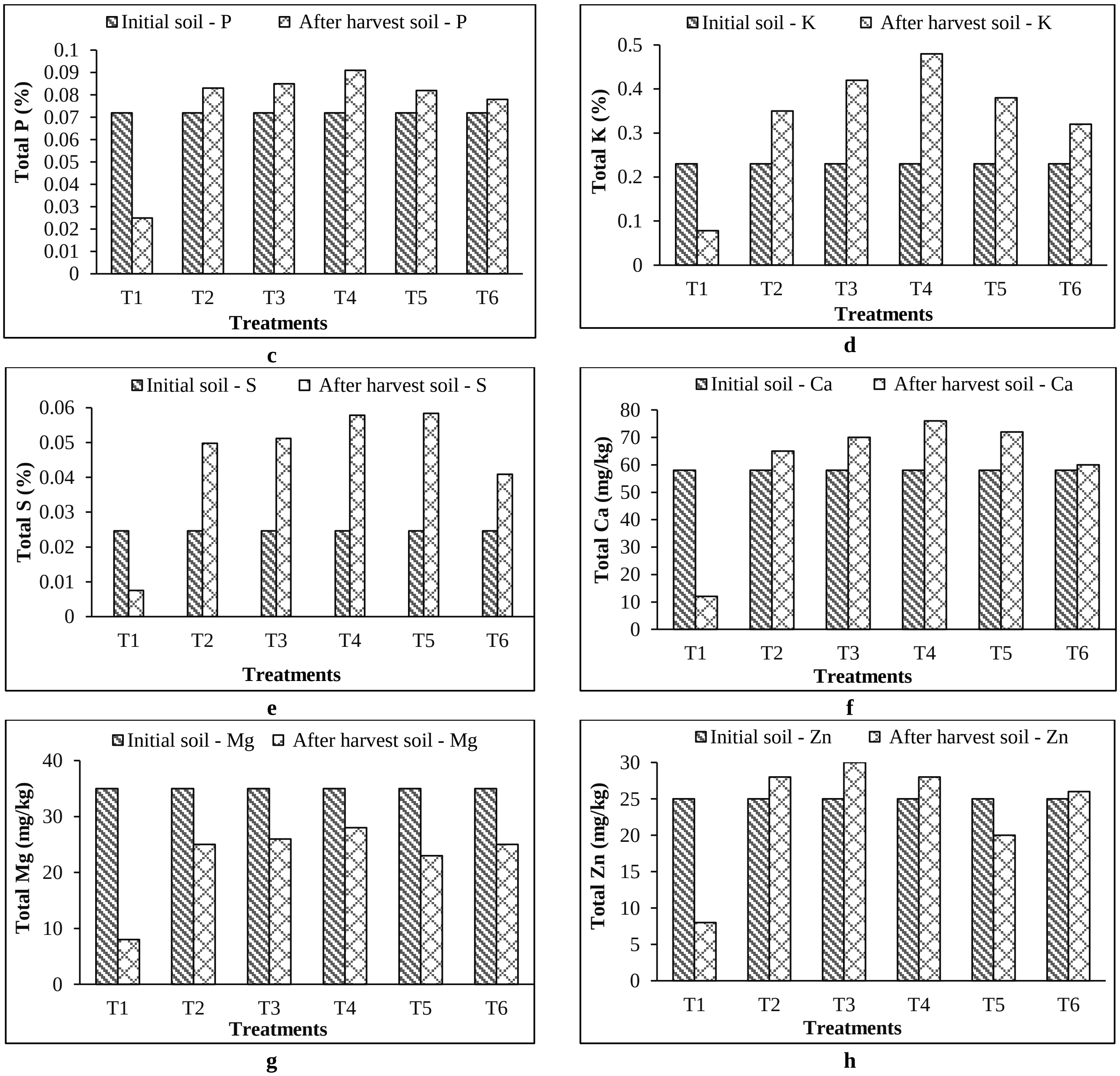


Fig. 2. Organic matter and nutrient contents in the initial and after harvest soils: **c**. total P (%); **d**. total K (%); **e**. total S (%); **f**. total Ca (mg/kg); **g**. total Mg (mg/kg); and **h**. total Zn (mg/kg).

The present study revealed that the unused old jute seed powder could be considered as a potential sustainable source of organic matter in soil, which could also reduce the amount of chemical fertilizers, when used in combination, required for the production of jute as well as other agricultural crops in Bangladesh. This also has implications for environmental sustainability and it can help mitigating the impacts of global climate change through increasing soil carbon stock.

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