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SOIL PROPERTIES UNDER JACKFRUIT BASED AGROFORESTRY SYSTEMS IN MADHUPUR TRACT OF NARSINGDI DISTRICT

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Abstract

A field experiment was conducted during April 2017 to April 2018 at the jackfruit orchard in Madhupur tract of Shibpur, Narsingdi**.** To observe the soil physical conditions and to determine the changes in soil chemical properties aroid *(Colocasia esculenta)*, ginger *(Zingiber officinale)*, turmeric *(Curcuma longa)* and chilli *(Capsicum annuum)* were grown with jackfruit tree *(Artocarpus heterophyllus)*. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The results revealed that soil temperature was reduced by 3.37-9.25% in different crop associated agroforestry systems (AFs) than open seasonal crop field, while soil moisture was found to be increased by 10-20%. In general, all studied parameters of soil chemical properties both in agroforestry and non-agroforestry fields increased after experimentation from their respective initial fields. Soil pH was raised by 1.5-8.84% in Jackfruit based AFs than open field after experimentation. As compared to open crop field after study, total nitrogen of the soil was promoted by 9-19% in seasonal crop associated AFs. Jackfruit based agroforestry with different seasonal crops increased soil organic carbon (SOC) by 3-10% compared to open field after study. Results also revealed that soil organic matter (SOM) were increased by 3.35-8.62% in AFs fields after experimentation than open field and by 3.36-19.39% than AFs fields before study.

***Keywords*:** Open field, Soil temperature, Soil moisture, Total nitrogen, Soil organic matter.

Introduction

Fertile soil is one of the most critical resources for sustainable crop cultivation. Moreover, proper and balanced nutrition are crucial for satisfactory crop growth and production. But in Bangladesh the fertility status of the soils has been declining day by day and Khan *et al*. (2008) opined that it has already been severely declined. Almost all upland soils of the country are nitrogen deficient with low organic matter. In Bangladesh about 60% cultivable land has organic matter less than critical level of 1% (Hossain and Kashem, 1997) and deficient in N, P and K (Miah *et al*., 2008). World-wide, soil health has been threatened for the last several decades and there has been a renewed interest in protecting and enhancing this most important resource for future generations (Dollinger and Jose, 2018). At this alarming condition, it is necessary to practice sustainable cropping system for maintaining soil fertility to a standard level. Eco-friendly, demand oriented and climate smart agricultural technologies would apparently ensure sustainable crop production (Chowdhury and Hassan, 2013). Agroforestry system is such a practice which offers great scope to improve soil fertility for sustainable crop production. Agroforestry, as a multifunctional land use strategy has attracted considerable attention in recent years because of its potential to reduce poverty, improve food security, mitigate climate change and reduce land degradation. The potentiality of agroforestry as a sustainable land use system to improve soil quality has been greatly recognized as a major advantage since its inception (Young, 1989; Nair, 2011). Both poplar and guava based agroforestry systems increased SOC than under sole crop system (Dhaliwal *et al*., 2018). In agroforestry system tree species on farm lands may bring improvement in soil physical conditions and chemical properties (Nair, 1984).

Madhupur tract is recognised as one of the most exalted areas for agroforestry, because farmers of these areas have been widely practiced different types of agroforestry systems from ancient time (Rahman *et al*., 2018; Miah *et al*., 2018). Jackfruit based agroforestry is the most dominant one in Madhupur tract. The soil of Madhupur tract is strongly acidic with low organic matter and poor fertility status. Aroid, Ginger, Turmeric and Chilli are very important and ancient crops of Bangladesh; which are extensively grown as compatible agroforestry component in Madhupur tract. Considering the growing interest in Jackfruit based agroforestry systems in Madhupur tract and very limited

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information on the changing soils fertility status, the present study was conducted to test the changes in soil physical conditions and chemical properties.

Materials and Methods

Study site description

The study was conducted at the jackfruit orchards (24° 04′ N latitude and 90° 50′ E longitude) from April 2017 to April 2018 in Shibpur upazila of Narsingdi district, which is characterized by terrace landscape. The topography is dissected by level upland and closely associated narrow-valleys, popularly known as *Chala* and *Baid*, respectively. The soil of the experimental site belonging to agro-ecological zone-28 (Madhupur Tract) and classified as shallow red-brown under Inceptisol soil category according to USDA Soil Taxonomy (Brammer, 1971; Shaheed, 1984). The soil texture is clay-loam and red-brown in color. However, the soil is moderately acidic with low organic matter and poor fertility status. The study area has subtropical climate characterized by heavy rainfall during May to September and scantly rainfall during rest of the year. The minimum and maximum mean temperatures during the summer vary from 26ºC to 29ºC and 19º C to 23.7ºC in winter, annual average rainfall is 2376 mm and the relative humidity is 60–70% (BBS, 2011).

Experimental design and treatments

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replication, comprising of four treatments. Two cropping systems (agroforestry and open field) were considered as factor A and two temporal factors (before and after experimentation) were considered as factor B. The treatment combinations were agroforestry before, agroforestry after, open before and open after.There were also two treatments viz. agroforestry and non-agroforestry (sole/open crop field) for evaluating soil physical properties. Almost similar aged jackfruit trees were selected for experimentation. Each individual jackfruit tree was considered as a unit plot.

Experimental details

To evaluate the changes of soil physical and chemical properties in agroforestry system, aroid (Mukhikachu), ginger, turmeric and chilli were grown under jackfruit trees. Seed rhizome of turmeric and ginger were planted on 3 April 2017 at a spacing of 45×25 cm^2 and 40×25 cm^2, respectively; whereas seed-tubers of aroid were planted by maintaining the spacing of 50×30 cm^2. Aroid, turmeric and ginger were grown as rainfed crop. Seedlings of chilli were transplanted on 25 October 2017 at a spacing of 60×60 cm^2.

All of the tested crops were fertilized by following fertilizer recommendation guide (FRG, 2012). Aroid plots were fertilized with cowdung, Urea, TSP and MoP @ of 5000, 150, 100 and 120 kg ha^{-1}, respectively. For ginger and turmeric, 5000 kg decomposed cowdung, 200 kg Urea, 150 kg TSP and 150 kg MoP were applied $hectare^{-1}$. Chilli field was fertilized with 10000 kg decomposed cowdung, 250 kg Mustard oil cake, 250 kg Urea, 200 kg TSP and 150 kg MoP $hectare^{-1}$. Weeding was done as and when needed. Three times earthing up were done in aroid, turmeric, ginger and chilli field depending upon their growth stages. Irrigation was done at every 7 days interval in chilli field.

Observation on soil physical properties during experimentation

Soil moisture (%) was recorded by using DSMM500 soil moisture meter and soil temperature (ºC) by Temp 4/5/6 Thermistor Thermometer at a depth of 10 cm in agroforestry and non-agroforestry field during noon.

Collection of soil sample and observation on soil chemical properties

Both before and after experimentation, soil samples were collected from 0-15 cm depth of all study plots to determine soil pH, total nitrogen, SOC and SOM. Soil pH was measured by Glass Electrode pH meter with maintaining soil water ratio of 1:2.5 (Mclean, 1982). Organic carbon in soil sample was determined by wet oxidation method. (Jackson, 1967). Organic matter content was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen Factor) and the results were expressed in percentage (Page *et al*., 1982).Total N content of soil was determined following the Micro Kjeldahl method (Page *et al*., 1982).

Statistical Analysis

Analysis of Variance (ANOVA) technique was used to find significance among the treatments with the help of computer package “Statistix 10”. The means were compared by Least Significant Difference (LSD) at 5% level of significance.

Results and Discussion

Soil physical Properties

Soil temperature

The agroforestry system had a greater influence on soil temperature as evident lower temperature was recorded in agroforestry system than open field (Table 1).The cumulative average soil temperatures were significantly reduced by 6.36%, 6.96%, 3.37% and 9.25%, respectively in jackfruit associated aroid, ginger, turmeric and chilli field than respective open crop field. This reduction of soil temperature might be due to shade provided by the jackfruit tree canopy. Lower soil temperature in agroforestry than mono-cropping was observed by Singh *et al.* (2012) and Rahman *et al.* (2018).

Table 1. Effect of different crop associated jackfruit based AFs on soil temperature

Treatments	Soil Temperature (ºC)			
	***Aroid**	***Ginger**	***Turmeric**	***Chilli**
AF	31.09 (±0.18)	28.88 (±0.31)	28.59 (±0.33)	23.34 (±0.34)
OPEN	33.20 (±0.17)	31.04 (±0.35)	29.69 (±0.19)	25.72 (±0.04)
% change in AF	-6.36	-6.96	-3.37	-9.25

*Significant at 5% probability level, (± Standard error) (n=3)

Soil moisture content

Soil moisture is one of the most important factors during crop production. It was positively influenced by jackfruit based agroforestry system as evident by higher moisture content in agroforestry system than open crop fields (Table 2). In comparison to that of open crop field, soil moisture was increased by 17.60%, 19.81%, 19.70% and 9.85%, respectively in jackfruit coupled aroid, turmeric, ginger and chilli field. It might be attributed to the lower rate of evaporation from the soil surface under agroforestry system. Litter incorporation from jackfruit tree increased organic matter content in the soil, thus increasing moisture holding capacity of soil. The present findings are in agreement with the findings of Miah *et al.* (2018) and Lin *et al.* (2015).

Table 2. Effect of different crop associated jackfruit based AFs on soil moisture

Treatments	Soil Moisture (%)			
	Aroid	**Turmeric**	***Ginger**	**Chilli**
AF	14.03 (±0.31)	11.49 (±0.40)	10.33 (±0.27)	8.25 (±0.08)
OPEN	11.93 (±0.30)	9.59 (±0.43)	8.63 (±0.14)	7.51 (±0.20)
% change in AF	+17.60	+19.81	+19.70	+9.85

*Significant at 5% probability level, (± Standard error) (n=3)

Soil Chemical Properties

Soil pH

Soil pH as was remarkably increased after experimentation in all seasonal crop associated agroforestry systems (Fig. 1). Soil pH was found to be increased by 6.47, 1.15 and 9.13% in open field before experimentation, open field after experimentation and agroforestry field before experimentation respectively in aroid linked jackfruit field after experimentation. Similar increasing trends were observed in ginger (9.86, 8.84 and 6.83%), turmeric (19.65, 6.67 and 15.7%) and chilli (8.50, 3.56 and 7.4%) associated agroforestry systems. The increase in soil pH in agroforestry may be explained as a function of the concentration of the organic matter content in soil. Better cycling of basic cations in agroforestry system might assist in the amelioration of soil acidity. Previous study on 2 to 4 years old plantations of *A. auriculiformis* showed remarkable improvement in soil pH (ICRAF, 1991).

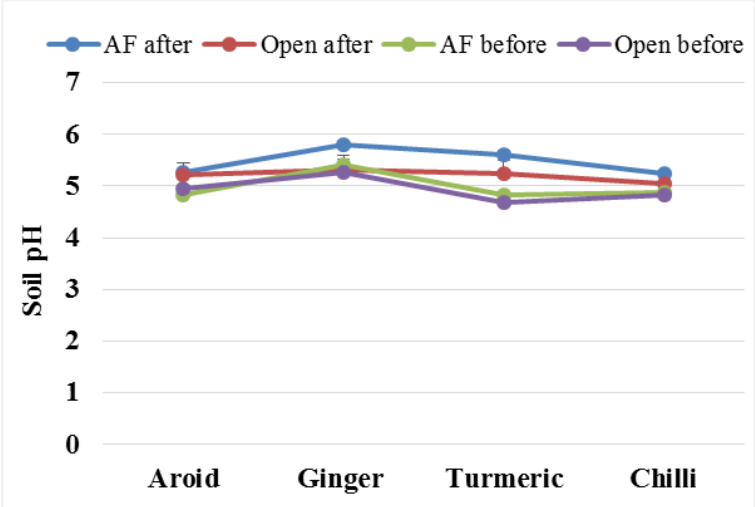

Fig. 1. Effect of different crop associated jackfruit based AFs on Soil pH
(Vertical bars indicate standard error)

Total nitrogen

A significant increase in the content of total N percentage was recorded in aroid (19.04%), ginger (18.18%), turmeric (22.35%) and chilli (18.66%) associated agroforestry fields after practices over initial open field. In AFs, total N was enhanced by 9.52, 10.38, 18.82 and 9.33%, in aroid, ginger, turmeric and chilli associated jackfruit field respectively, compared to open field after experimentation. Compared to the agroforestry field before experimentation, total N was also increased in aroid (16.27%), turmeric (15.55%), chilli (5.95%), and ginger (2.24%) associated agroforestry field after experimentation (Fig. 2).The increased total nitrogen content of soil in agroforestry could be explained as a function of the higher concentration of the organic matter and direct N input as well as litter mineralization. Fadl (2010) and Islam (2015) reported that total nitrogen was higher in agroforestry than monocropping system.

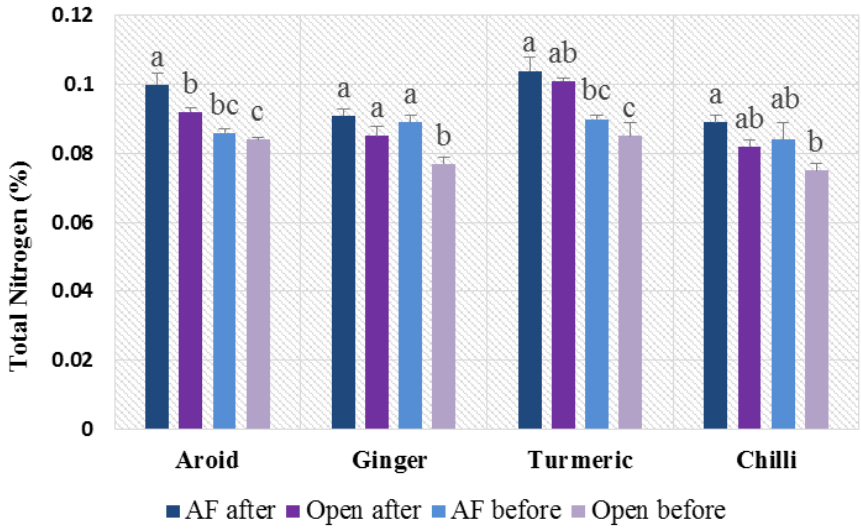

Fig. 2. Effect of different crop associated jackfruit based AFs on total N of Soil
(Vertical bars indicate standard error and different alphabetical letters indicate significant differences among the treatments).

Soil organic carbon (SOC)

After execution of field experiment, jackfruit based agroforestry systems notably increased the SOC percentage as compared to open crop field (Table 3). After practicing of agroforestry, SOC was augmented by 14.22, 7.05, 19.03 and 3.12%, in aroid, ginger, turmeric and chilli associated AFs respectively compared to the same field before agroforestry practice. SOC was also increased in jackfruit based agroforestry fields attached with aroid, ginger, turmeric and chilli by 10.14, 4.81, 6.06 and 3.13%, respectively when compared to open field after experimentation. These results might be due to application of organic fertilizers and incorporation of leaf litter from jackfruit tree and crop residues into soil. Similar positive effects of agroforestry system on SOC were reported in different AFs (Lu *et al*., 2015; Rahman *et al*., 2009; Dhaliwal *et al*., 2018).

Table 3. Effect of different crop associated jackfruit based AFs on soil organic carbon

Treatments		Soil Organic Carbon (%)			
		Aroid	Ginger	Turmeric	^{NS} Chilli
AF	After	1.108(±0.030)^{a}	1.002(±0.033)^{a}	1.138(±0.031)^{a}	0.890(±0.004)
	Before	0.970(±0.005)^{bc}	0.936(±0.024)^{ab}	0.956(±0.020)^{bc}	0.863(±0.040)
Open	After	1.006(±0.020)^{b}	0.956(±0.008)^{ab}	1.073(±0.041)^{ab}	0.863(±0.023)
	Before	0.916(±0.003)^{c}	0.883(±0.044)^{b}	0.926(±0.040)^{c}	0.830(±0.058)

Values are means (± standard errors) (n = 3). Values followed by the same letter in a column are not significantly different at $P < 0.05$ (LSD test). ^{NS}Non-Significant

Soil organic matter (SOM)

The soil organic matter (SOM) content before and after experimentation are presented in Fig. 3. As compared to the soil of jackfruit fields before practicing agroforestry, OM was increased by 13.17, 6.80, 19.39 and 3.36%, in aroid, ginger, turmeric and chilli affiliated AFs after experimentation. SOM was also promoted by 8.62, 4.85, 6.49 and 3.35%, in jackfruit accompanied aroid, ginger, turmeric and chilli fields respectively after practicing AFs as compared to the respective open field after experimentation. Similar results were observed by Lehmann *et al*. (2002) and Sarvade *et al.* (2014). Application of organic manures and decomposition of leaf litter and crop residues are responsible for the augmentation of SOM. The decomposition rate in agroforestry might be relatively higher due to application of irrigation water and tillage operations. Changes in soil properties can be attributed to tillage, organic matter inputs, residue decomposability, and fertilizer application (Zhang *et al*., 2013). In poplar-based agroforestry systems, soil organic matter increased through tree leaf and root litters decomposition as reported by Mao *et al*. (2010).

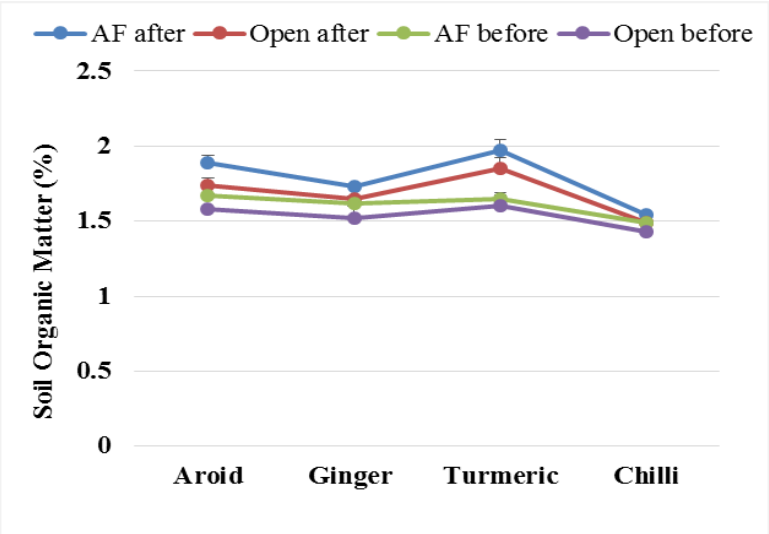

Fig. 3. Effect of different crop associated jackfruit based AFs on Soil organic matter
(Vertical bars indicate standard error)

The findings of the study revealed that, in agroforestry system soil temperature significantly decreases and soil moisture content increases as compared to open crop field. Soil chemical properties in term of soil pH, total nitrogen,

SOC and SOM were increased remarkably in different crop associated jackfruit based agroforestry system than their respective open crop field i.e. monocropping system after experimentation. These results indicate that jackfruit based agroforestry systems could improve soil fertility by positive changing of soil physical and chemical properties.

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