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DIVERSITY OF SOIL ALGAE IN THE FARMLANDS OF KHASI HILLS, MEGHALAYA

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ABSTRACT

The present paper deals with the structure of soil algal community in four farmlands located in Khasi Hills, Meghalaya. The chosen farmlands were corn field (*Zea mays* L.), rice field (*Oryzasativa* Linn.), vegetable farm (*Solanumtuberosum* L., *Lactucasativa* L. and *Brassica oleracea* var. *capitata* f. alba) and citrus plantation (*Citrusreticulata* Blanco.). A total of 158 algal taxa have been identified**,** out of which Chlorophyta+Xanthophyceae members (64 taxa) form the major group, followed by Bacillariophyceae (62 taxa) and Cyanobacteria (32 taxa). Species diversity was recorded higher in rice field (1.55- 2.62) followed by vegetable farm (0.69-2.10), corn field (1.05-2.01) and citrus plantation (0.98-1.99). Use of fertiliser, insecticides and pesticides adversely affected the composition and abundance of the algal community in corn field, vegetable field and citrus plantation.

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INTRODUCTION

Algae are ubiquitous and vary widely in many habitats. Soil is one of the most important non-aqueous ecosystems for algae (Zenova *et al*., 1995). Unlike most other microorganisms, algae contain chlorophylls and are present in most of the soils where moisture and sunlight is available (Hoffman, 1989). In farmlands, soil algae and Cyanobacteria play important roles because they have tremendous potential to serve as sources of nitrogen and carbon for other organisms and improve soil fertility by adding organic matter (Mishra and Pabbi, 2004). They also help to stabilize the soil surface by reducing soil erosion (Hu *et al*., 2004). Soil algae mainly Cyanobacteria are known to associate with plant roots and enhance the activities of host plant. The structure and function of soil biota get affected significantly by different agricultural practices. Application of pesticides, chemical fertilisers and agronomic practices affect plants, animal life and soil community structure (Paoletti *et al*., 1988). Despite numerous studies on soil algae (Metting, 1981; Lukesova, 1993; Neustupa, 2001; Zanca*net al*. 2006; Lin *et al.* 2013; Ray and Thomas, 2013; Vijayan, 2015), it is still difficult to draw general conclusions on the diversity of the soil algae and their influence on ecosystem functions. Paoletti and Pimentel (1992) reported that changes in land management significantly influenced the soil biota resulting in certain transient or permanent signs in the system. Literature regarding role of soil algae are available from different parts of the world but information about the diversity and function of soil algae in Khasi Hills, Meghalaya is very limited. In the present study, a survey of soil algal diversity in different types of farmlands in Khasi Hills have been undertaken to established the importance of the soil algae in this region.

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MATERIALS AND METHODS

Study sites: Four different farmlands (corn field, rice field, vegetable farm and citrus plantation) were selected in Khasi Hills, Meghalaya (Table 1).

Collection of soil samples: Soil samples were collected on a monthly basis from January 2016 to December 2016. 10 random sites were selected from each farmlands and 500 g of soil was collected from the upper layer (0-2 cm) by removing the surface litter at each site. About 10 g of each soil sample was placed in a flask and diluted 100-fold with distilled water. Different culture media like Bold's Basal Medium (BBM) and

BG-11 were used. One ml of 0.11 N solution of $Na_2SiO_3.9H_2O$ was added to each litre of BBM to provide silicon for diatoms (Sukala and Davis, 1994). The number of algae appeared in culture media were determined by counting algal colonies and estimated per 1g dry weight (d.w.) of soil. Colonies of Chlorophyta (CH) and Xanthophyceae (X) (hereinafter CH+X) were counted together, Cyanobacteria (CY) and Bacillariophyceae (D) were counted separately (Zancan *et al.*, 2006). Algae were observed under trinocular microscope (Olympus BX41) and identified to the possible lower taxonomic level with the help of standard books and Monographs like Fritsch (1935), Desikachary (1959), Philipose (1967), Prescott (1982), Gandhi (1998), and John *et al*. (2002). Taxonomy was updated using the online database Algae Base (Guiry and Guiry, 2017) and ADIAC (1999). Species diversity was calculated using the Shannon-Wiener diversity index (1963) following the formula,

$$H' = \sum_{i=1}^{s} p_i \ln p_i$$

Where $p_i=n_i/N$, n_i= number of individuals of the i^{th} species; N= total number of individuals of all the species.

Soil analysis

Soil samples were soaked in deionized water (1 water: 5 soil) to prepare a soil solution for the measurements of pH and electrical conductivity. pH and conductivity were read using digital pH meter and conductivity meter respectively. Moisture content of the soil was determined by oven dry method (drying 10 grams of soil in a hot air oven at 105^{o}C). Soil organic carbon was estimated following the method by Walkley and Black, (1934) while total nitrogen, phosphorus and potassium were estimated as per Jackson (1967).

Statistical Analyses

Data for different physico-chemical parameters and algal abundance were obtained on the basis of mean of ten independent samples. The data were statistically analysed using ANOVA with Microsoft Office Excel. Principal Component Analysis (PCA) was employed to compare the farmlands with soil characteristics in the first analysis and a second analysis was conducted to compare the algal community characteristics on the abundance of taxa in the farmlands. The data were also subjected to Pearson's correlation analysis. These analysis were carried out in PAST software version 1.93.

RESULTS

Physico-chemical characteristics of soil: Physico-chemical parameters except for phosphorus varied significantly in the four farmlands ($p<0.05$). The farmlands are acidic with pH ranging from 5.55 to 6.60. The lowest pH was measured for rice field while the highest for citrus plantation. Moisture content, organic carbon and total nitrogen were highest in rice field with 53.68%, 1.90 % and 0.22 % respectively and lowest in citrus plantation with 20.67%, 1.23% and 0.11% respectively. Conductivity recorded did not show much variation in all the farmlands. A value of 0.03mS^{-1} /cm was recorded for rice field, followed by 0.02mS^{-1} /cm for corn and vegetable farm anda value of 0.01 mS^{-1} /cm was observed in citrus plantation.

Table 1. Sampling plots with their locations

Sampling plots	Village	Elevation (m a.s.l)	Latitude Longitude	Fertiliser/pesticides/ Insecticides application
Corn field(*Zea mays* L.)	Mairang	1720	25^{0}32.713'N 91^{0}39.486' E	Urea and FYM (Farm Yard Manure)
Rice field (*Oryzasativa* Linn.)	Sohiong	1737	25^{0}30.440'N 91^{0}42.043'E	Urea
Vegetable farms potato (*Solanumtuberosum* L.), lettuce (*Lactucasativa* L.) white cabbage (*Brassica oleracea* var. *capitata* f. alba)	Mylliem	1685	25^{0}29.529'N, 91^{0}48.724' E	NPK
Citrus plantation (*Citrusreticulata* Blanco.)	Mawlai	1406	25^{0}35.214'N,91^{0}58.306'E	Occasional application of Insecticides and pesticides

Table 2. Physicochemical properties of soil in different farmlands of Khasi Hills

Parameters	Corn field	Rice field	Vegetable farm	Citrus Plantation	F-value	P-value
pH	6.32±0.59	5.55±0.35	5.86±0.44	6.60±0.25	7.19	0.0018*
Moisture content (%)	32.61±5.03	53.68±5.40	34.22±5.76	20.67±2.80	40.79	1.3E-10*
Conductivity (mS^{-1} /cm)	0.02±0.005	0.03±0.005	0.02±0.005	0.01±0.005	11.96	0.0001*
Organic carbon (%)	1.27±0.36	2.34±0.59	1.90±0.15	1.23±0.36	10.07	0.0002*
Total nitrogen (%)	1.18±0.07	1.76±0.24	1.10±0.16	0.11±0.02	117.33	7.28E-13*
Available Phosphorus (%)	0.0032±0.001	0.0038±0.00	0.0049±0.0	0.0056±0.001	0.57	0.64
Exchangeable Potassium (%)	0.02±0.005	0.02±0.005	0.03±0.01	0.08±0.008	24.48	6.7E-07*

*significant (P at 0.05and 0.01levels).

Phosphorus was observed to be highest in citrus plantation with 0.0056% and lowest in corn with 0.0032%. In case of potassium, citrus plantation was recorded with a higher value of 0.08% as compared to lower value of 0.02% in corn and rice fields (Table 2).

Soil algal community structure: Based on morphology, a total of 158 taxa were identified from four different farmlands. The highest number of taxa belonged to CH+X group (64 taxa) followed by Bacillariophyceae (62 taxa) and then the Cyanobacteria (32 taxa). Out of 158 species, 71 taxa were recorded from rice field, 58 taxa in vegetable farms, 35 taxa in citrus plantation and 30 taxa from corn field (Table 3). Algal species diversity was richer in rice field and vegetable farms. Members of green algae were recorded in high number in vegetable farms while those of Bacillariophyceae and Cyanobacteria were higher in rice field. Diversity index was

Table 3. List of algal taxa recorded in four farmlands of Khasi Hills

Taxa	Corn field	Rice field	Vegetable farm	Citrus Plantation
Cyanobacteria				
Anabaena catenula Kützing ex Bornet&Flahault		+		
Anabaena constricta (Szafer) Geitler			+	
Anabaena spiroides Klebahn	+			+
Anabaena variabilis Kützing ex Bornet&Flahault	+	+	+	+
*Anaebaenopsis*sp		+		
Aphanocapsaelachista West &G.S.West			+	
Chroococcusminimus (Keissier) Lemmermann				+
Cylindrospermummichailovskoense Elenkin		+		
Cylindrospermummuscicola Kützing ex Bornet&Flahault		+		
*Leptolyngbya*sp				
Lyngbyadendrobya Brühl&Biswas		+		
Lyngbyapalmarum Brühl&Biswas			+	
Lyngbyasemiplena J. Agardh ex Gomont			+	
Lyngbyaspiralis Geitler			+	
*Merismopedia*sp				+
Microcystissmithii Komarek & Anagnostidis		+		
*Nostoccarneum*C. Agardh ex Bornet & Flahault		+	+	+
Nostoc commune Vaucher ex Bornet & Flahault			+	
Nostocmuscorum C. Agardh ex Bornet&Flahault	+			
Nostocpruneforme C. Agardh ex Bornet&Flahault			+	
*Oscillatoriacurviceps*C. Agardh ex Gomont	+			
Oscillatoriagerminata Schwabe ex Gomont		+		
Oscillatorialimosa C. Agardh ex Gomont	+	+		
Oscilltorianigra Vaucher ex Gomont		+		
Oscillatoriarubescens De Candolle ex Gomont		+		
*Oscillatoria*sp		+		+
Oscillatoriatenuis C. Agardh ex Gomont				+
Phormidiumabronema Skuja		+		
Phormidiuminundatum Kützing ex Gomont			+	
Phormidiumtenue Gomont			+	
*Stigionemaocellatum*Thuret ex Bornet & Flahault		+		
*Synechococcusaeruginosus*Nägeli		+	+	+
Baccilariophyceae				
Achnantheslanceolata (Brébisson ex Kützing) Grunow				+
Achnanthidiumexiguum(Grunow) Czarnecki				+
Amphora elliptica(Agardh) Kützing			+	
Craticulasubhalophila(Hustedt) Lange-Bertalot				+
Cymbellaaffinis Kützing		+		
Cymbellacistula (Ehrenberg) O. Kirchner		+	+	
Cymbellaleptoceros (Ehrenberg) Kützing		+		+
Cymbellanaviculiformis Auerswald ex Heiberg	+	+	+	
*Ecyonema*sp				+
Eunotiabilunaris (Ehrenberg) Schaarschmidt			+	
Eunotia crista-galli Cleve		+		
Eunotiaexigua (Brébisson ex Kützing) Rabenhorst			+	
Eunotiapaludosa Grunow		+		
Eunotiasubarcuatoides Alles, Nörpel& Lange-Berta		+		
Frustuliacrassinervia (Brébisson ex W. Smith) Lange-Bertalot&Krammer				+
Frustuliasaxonica Rabenhorst			+	
Gomphonemagracile Ehrenberg	+	+		
Gomphonemaolivaceum (Hornemann) Brébisson			+	
Gomphonema vibrio Ehrenberg			+	
Hantzschiaabundans Lange-Bertalot	+		+	
Hantzschiaamphioxys (Ehrenberg) Grunow	+			+
*Melosira*sp	+		+	
Naviculaanglica Ralfs				+
Naviculaconfervacea (Kützing) Grunow				+
Naviculacryptocephala Kützing		+		
Naviculadicephala Ehrenberg			+	
Naviculaexigua (Gregory) Grunow			+	
Naviculakotschyi Grunow		+		
Naviculaveneta Kützing	+	+		
Neidiumamphigomphus (Ehrenberg) Pfizer			+	
Neidiumampliatum (Ehrenberg) Krammer			+	
Nitzschiadenticula Grunow	+	+		
Nitzschiadissiata (Kützing) Rabenhorst		+		
Nitzschiaintermedia Hantzsch		+		
Nitzschialinearis W. Smith		+		
Nitzschiapalae (Kützing) W. Smith				+
Pinnulariaanglica Krammer		+		
Pinnulariabrauniana (Grunow) Studnicka	+			
Pinnulariadivergens W. Smith		+		

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*Pinnulariamacilenta*Ehrenberg				
Pinnularia major (Kützing) Rabenhorst		+	+	
Pinnulariamesolepta (Ehrenberg) W. Smith	+			
Pinnulariamicrostauron (Ehrenberg) Cleve		+		
Pinnulariaobscura Krasske				+
Pinnulariapseudogibba Krammer		+		
Pinnulariarhombarea Krammer		+		
Pinnulariarivularis		+		
Pinnulariasimilis Krammer & Lange Bertalot	+			
Pinnulariasubanglica Krammer		+		
Pinnulariasubcapitata W. Gregory		+	+	
Pinnulariasubstomatophora Hustedt		+		
Pinnulariaviridis (Nitzsch) Ehrenberg	+		+	
*Pnnulariamesolepta (*Ehrenberg) W. Smith			+	
*Stauroneis*sp		+		
Surirellasaxonica Auerswald ex Rabenhorst		+		
Suririelladidyma Kützing		+		
Suririellalinearis W. Smith		+		+
Suririellarobusta Ehrenberg		+		+
Tabellariafenesrata (Lyngbye) Kützing		+		
Synedraacus Kützing		+		
Tabellariaflocculosa (Roth) Kützing		+		
Tryblionellaparvula (W. Smith) T. Ohtsuka & Y. Fujita			+	
Chlorophyceae				
Ankistrodesmusfalcatus (Corda) Ralfs		+		
Asterococcussuperbus (Cienkowski) Scherffel				+
Bracteacoccus minor (Schmidle) ex Chodat			+	
Chlamydomonasdeasonii Ettl		+		
Chlamydomonasreinhardii P.A. Dangeard				+
Chlamydomonassnowiae Printz	+			
Chlorococcumacidum P.A. Archibald & Bold	+		+	
Chlorococcumechinozygotum Starr				+
Chlorosarcinopsisgelatinosa Chantanachat& Bold				+
Desmodesmusmaximus (West & G.S. West) Hegewald		+		
*Elliptochlorisbilobata*Tschermak-Woess				+
Gloeocystisampla (Kützing) Rabenhorst		+		
Gloeocystispolydermatica (Kützing) Hindak			+	
Gloeocystisvesiculosa Nägeli			+	
Microsporafloccosa (Vaucher) Thuret		+	+	
Microsporapachyderma (Wille) Lagerheim			+	
Microsporatumidula Hazen	+			
Neospongiococcumgranatum Deason			+	
Neospongiococcumvacuolatum Deason&E.R.Cox			+	
Scenedesmusabundans (O.Kirchner) Chodat	+	+		
Scenedesmusaculeolatus		+		
Scenedesmusarcuatus (Lemmermann) Lemmermann		+		
*Scenedesmusbijuga*Kützing		+		+
Scenedesmusdimorphus (Turpin) Kützing		+		
Scenedesmusflavescens Chodat			+	
Scenedesmus perforates Lemmermann			+	
Scenedesmusquadricauda (Turpin) Brébisson		+		
Tetrasporalacustris Lemmermann	+			
Trebouxiophyceae				
Chlorella ellipsoids Gerneck		+		
Chlorella saccharophila (Krüger) Migula			+	
Chlorella vulgaris Beyerrinck (Beijerinck)	+	+		+
Dictyochloropsissplendida Geitler				+
Monoraphidiumcontortum (Thurut) Komarkova-Legnerova	+			
Monoraphidiumgrafithii (Berkeley) Komarkova-Legnerova		+		
Monoraphidiumiregulare (G.M. Smith) Komarkova		+		
Monoraphidiumminutum (Nägeli) Komarkova-Legnerova			+	
Monoraphidiumsaxatile Komarkova-Legnerova	+	+		+
Monoraphdium tortile (West & G .S. West)			+	
Murielladecolor Vischer	+			
Oocystisborgei J. W. Snow			+	
Oocystiselliptica West			+	
Oonephrisobesa (West & G.S.West) Fott	+			
Pseudococcomyxa simplex (Mainx) Fott				+
Stichococcusbacillaris Nägeli			+	
Trebouxiaarboricola Puymaly			+	
Ulvophyceae				
Geminellamutabilis (Brébisson) Wille				+
*Rhizoclonium*sp				+
*Ulothrix*sp			+	+
Ulothrixtenerrima (Kützing) Kützing			+	
Klebsormidiophyceae				
Klebsormidiumcrenulatum (Kützing) Lokhorst			+	
Klebsormidiumelegan Lokhorst	+			
Klebsormidiumflaccidum (Kützing) P.C.Silva, K.R.Mattox & W.H.Blackwell	+	+	+	+

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Klebsormidiumfluidans (F.Gay) Lokhorst			
Klebsormidiumnitens (Kützing) Lokhorst			+
Zygnematophyceae			
Closteriumacutum Brébisson		+	
Closteriumkuetzingii Brébisson		+	
Closteriumnavicula (Brébisson) Lütkemüller			+
Closteriumparvulum Nägeli		+	
Cosmariumabbreviacium Raciborski	+		
Cosmariumvariolatum P. Lundell	+		
Zygnemasp			+
Xanthophyceae			
Tribonemaviride Pascher			+
Vaucheriasp		+	
Xanthonemaquafrata (Pascher) P.C. Silva			+

Table 4. Pearson's Correlation coefficient (r) values obtained between different algal class diversity (CH+X- Chlorophyta+ Xanthophyceae), CY-Cyanobacteria, D -Bacillariophyceae) with soilphysic-chemical parameters

pH	pH	Moisture	Conductivity	Organic carbon	Total nitrogen	Phosphorus	Potassium
Moisture	-0.52						
Conductivity	-0.60	0.63					
Organic carbon	-0.54	0.59*	0.67*				
Total nitrogen	-0.59*	0.86	0.78*	0.66*			
Phosphorus	-0.22	-0.07	0.35	0.56	0.13		
Potassium	-0.45	0.19	0.19	0.52	0.16	0.27	
CH+X	-0.51*	0.83*	0.67	0.61	0.70	-0.07	0.07
CY	-0.53	0.84*	0.68	0.62*	0.72*	-0.09	0.11
D	0.57*	0.87	0.71	0.68	0.78*	-0.02	0.14*

*Indicates significance at p<0.05

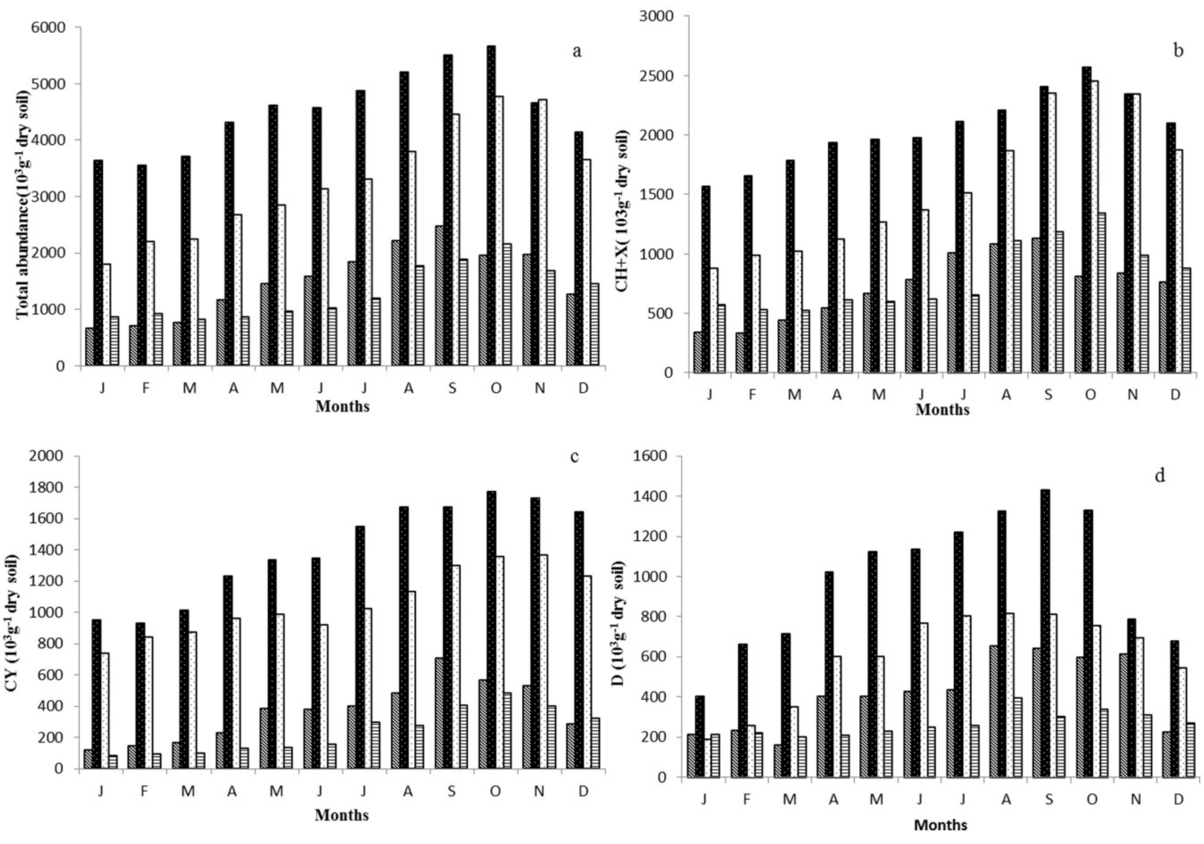

Figure 1. Algal abundance in corn field ( ), rice paddy ( ) vegetable farm ( ) and citrus plantation ( ). (a). total algal abundance (b). abundance of CH+X(green algae +Xanthophyceae) (c). abundance of CY (Cyanobacteria) (d). abundance of D (Bacillariophyceae)

highest in rice field(1.55- 2.62) followed by vegetable farm (0.69-2.10) corn field (1.05-2.01) and lowest in citrus plantation (0.98-1.99) (Figure 2). The distribution of CH+ X members closely reflected the total abundance because this group accounted for high abundance (400 x 10^3 to 2500 x 10^3 algal cells g $^{-1}$ soil d.w) in all samples analysed, Cyanobacteria were more abundant in rice field (<1800 x 10^3 algal cells g $^{-1}$ soil d.w), followed by vegetable farm (1300 x 10^3 algal cells g $^{-1}$ soil d.w) while abundance was low in corn field (700 x 10^3 algal cells g $^{-1}$ soil d.w) and in citrus plantation (500 x 10^3 algal cells g $^{-1}$ soil d.w). Diatom members were also most abundant in the rice field (1400 x 10^3 algal cells g $^{-1}$ soil d.w) followed by vegetable farms (800 x 10^3 algal cells g $^{-1}$ soil d.w) while it was low in corn field (700 x 10^3 algal cells g $^{-1}$ soil d.w) and in citrus plantation (400 x 10^3 algal cells g $^{-1}$ soil d.w) (Figure 1). The occurrence of common species varied in different farmlands. Common species recorded in rice field were mostly Cyanobacteria members such as *Anabaena variabilis,* genera of *Oscillatoria,* along with member of diatom like *Cymbella*, *Nitzschia*, *Pinnularia,* and genera of green algae like *Scenedesmus* and *Chlorella,* while in vegetable farms Cyanobacteriagenus *Lyngbya*, genera of diatom like *Navicula* and *Hantzschia* and green filamentous genus *Microspora* were the common species.

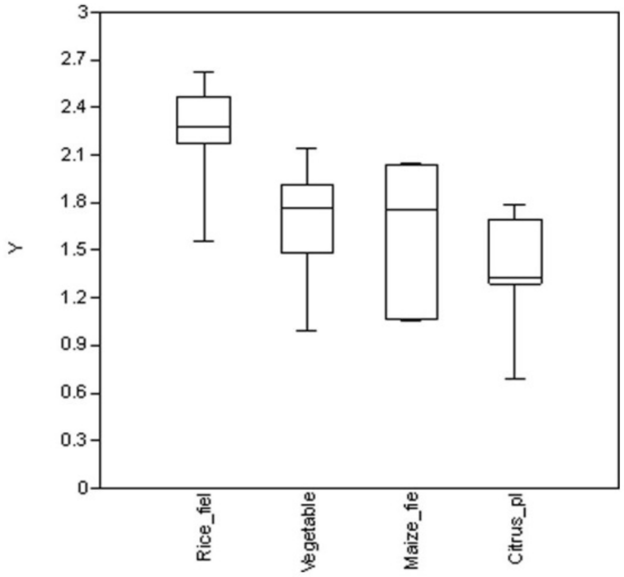

Figure 2. Boxplot of Shannon diversity index in rice field, vegetable farm, corn field andcitrus plantation

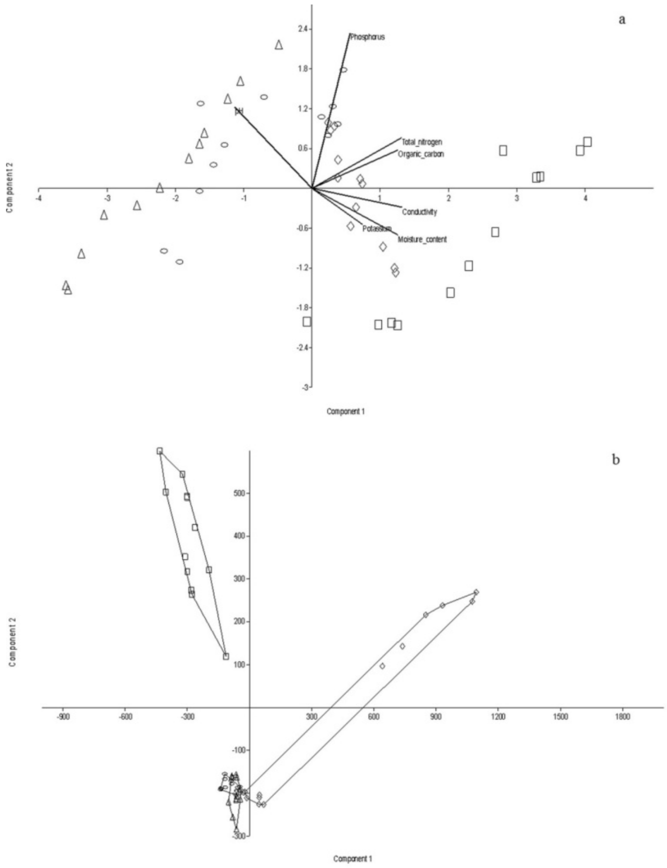

Figure 3.Ordination diagram based on (a).pH, moisture content, conductivity, organic carbon, total nitrogen, potassium and phosphorous (b). algal community variables, total algal abundance, CH+X (Chlorophyta+ Xanthophyceae) , CY (Cyanobacteria) and D(Bacillariophyceae. (□) indicates rice field,◇) vegetable farm, corn field (△) and citrus plantation (⬭).

The common Cyanobacteria incorn field were *Nostocmuscorum, Oscillatoriacurviceps,* diatom species *Hantzschiaamphioxys, Hantzschiaabundans*and green algal species *Chlorella vulgaris*. In citrus plantation, diatom species like*Naviculaanglica*, *Hantzschiaamphioxys* and green filamentous algae *Klebsormidiumflaccidum* and *Ulothrix*sp. were common. Correlation between CH+X diversity index with different soil parameters showed a significant positive correlation moisture content and negative correlation with pH. Cyanobacteria diversity index showed a significant positive correlation with moisture content, carbon and nitrogen. A significant positive correlation was obtained between diversity of diatoms and pH, nitrogen and potassium (Table 4). Principal Component Analysis (PCA) employed to compare the soil characteristics of the different farmlands accounted for 73% variation. Rice field could be distinguished from the other farmlands by higher moisture content, organic carbon and total nitrogen. The first principal component analysis represented 53% of the total variable which primarily reflected the effect of moisture content, organic carbon, total nitrogen, phosphorus, potassium and electrical conductivity while the second PC (20%) reflected the effect of pH. The first two components of the variance analysis based on algal community variables justified 64% of the variance in the data. This analysis enabled the corn field samples to be grouped together with citrus plantation samples because of limited number of Cyanobacteria and diatoms in these farmlands. Rice field and vegetable farm are placed separately because of higher diatoms and chlorophytes. The intra-sites difference was greater in vegetable farm and lower in corn field (Figure 3).

DISCUSSIONS

In the present study, pH of the soil was acidic in all the four farmlands. This is in conformity to observation bySahu*et al*. (2016) that farmlands undergo intensive anthropogenic activity including tillage and application of fertilisers, pesticides and herbicides which affect the physico-chemical environment of soil and change pH to acidic condition in cultivated lands. Lin *et al*. (2013) also reported acidic soil condition in rice and vegetable farm in Taiwan and also related to the possible result of fertiliser application. Moisture content is an important factor in determining the composition of algal communities in all the farmlands. Dirborne and Ramanujam, (2017) reported that moisture content play an important role in distribution and diversity of soil algae. In the present case, a comparison between soil characteristics and its relation to soil algal flora revealed highest algal diversity in rice field which remain under high moisture content throughout the rice growing cycle while comparatively lower algal diversity was recorded in citrus plantation with relatively low moisture content compared to other types of farmlands. Regular application of fertilisers, pesticides and insecticides in the citrus plantation, corn field and vegetable field affected the physico-chemical parameters of soil and could be responsible for low diversity of soil algae. In citrus plantation, occasional application of insecticides and pesticides were recorded to keep the trees healthy. Such activity reduced the diversity and growth of soil algae (Mostafa and Helling, 2002; Zancan*et al*. 2006). Application of fertilisers to enhance productivity resulted in acidic nature of the soil, which could be the reason for negative correlation of pH with nitrogen ($p<0.05$). It is known from literature that Cyanobacteria show the most evident response to different land use patterns, and therefore considered as suitable soil bioindicator in different agroecosysems.Absence of common Cyanobacteria such as *Scytonema*and rare occurrence of *Cylindrospermum* could be due to their susceptible nature to pesticides. According to Zancan *et al.* (2006) Cyanobacteria like *Scytonema* and *Cylindrospermum* occurred rarely in soil where regular application of fertilisers, pesticides and insecticides are common for better yield. Green algae like *Chlorella, Klebsormidium* and diatoms like *Hantzschia, Navicula, Nitzschia* and *Pinnularia* were found in all the four different farmland. All these algal species are considered as cosmopolitan and widespread in different soil types by many authors (Khaybullina *et al*., 2010; Lin *et al*., 2013). *Hantzschiaamphioxys* and *Hantzschiaabundans* diatom species are reported to have high tolerance to disturbances (Antonelli *et al.,* 2017). These two diatom species were also recorded in abundance in corn, vegetable farm and citrus plantation.

Conclusion

The structure of soil algal community is affected more by soil usage than by physic-chemical parameters of soil. The presence of adequate moisture content is one of the most important criteria for the distribution and growth of the algae. The maximum soil algal diversity was recorded in rice field where waterlogged condition is required during a part of the growing cycle. The use of fertiliser, herbicides and insecticides affected adversely the structure of algal communities.

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