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IMPACT OF MANAGEMENT SYSTEMS ON SOME SOILS QUALITIES IN EGYPT

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ABSTRACT

The current work aims to evaluate the effect of different periods of organic farming on some soils qualities compared with the traditional system. Several farms varied in their soil nature and periods of practicing organic farming system were chosen. The farms are located in Belbes, El-Manayef, El-Fayoum and El- Behera areas. Moreover, the study also involved adjacent traditional managed farms. The evaluation was based on the weighted values of the physical, chemical and biological properties of the 0-50 cm and 0-100 cm soil depths. The considered soil properties were soil organic matter (SOM); bulk density; porosity; available water; penetration resistance, mean soil particles weight diameter (MWD), cation exchange capacity and total microbial count. The obtained results indicated that soil biological parameters were less important than the physical or the chemical factors. Principle component1, (PC1) scores indicated that 79.97% and 78.05 % of total variance are attributed to the 0-50 cm soil depth of the organic and conventional managed soils, respectively. In the meantime, 75.72 and 71.94 % are related to the 0-100 cm soil depth for the two farming systems, (Organic and conventional) in the same sequence. The only significant factor contributing to PC2 was total count; PC2 indicated that (10.29 and 10.87% of the total variance are accounted for 0-50 and 0-100 cm soil depth of organic farming as well as 15.3 and 16.68% of the total variance for 0-50 and 0-100 cm soil depth of conventional farming system, respectively.

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INTRODUCTION

It is well know that the inherent soil characteristics are those related to the soil forming factors; i.e., climate, parent material, … etc, whereas the dynamic soil properties are influenced by the management practices imposed by mankind.

Both are very important to sustainability. Evaluating inherent soil properties and their effect on land use and the suitability of each soil for various uses are the basic concern of soil surveyors. On the other hand, dynamic soil quality focuses on the status of specific soil due to the relatively recent management practices **(Karlen *et al* 1997; Doran and Parkin 1994)**.

Doran and Parkin (1994) defined soil quality as ″the capacity of a soil to function″. Meanwhile a more complete definition of soil quality was offered by a committee appointed by the Soil Science Society of America (SSSA) as ″soil quality is the capacity of a specific Kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation″.

Doran and Parkin (1994) also stated that soil quality assessment is conducted by evaluating indicators. These indicators can be physical, chemical and biological properties, processes or characteristics of soils.

Jawson (2001) mentioned that physical properties include soil structure, aggregate stability, wind and water erosion. Chemical properties include pH, total plant nutrients, and salinity. Biological properties include root microbial count and other organism-driven processes such as respiration, mineralization, immobilization and denitrification.

Since it is impractical to measure every ecosystem or soil property, many researchers proposed a minimum data set which is the smallest set of soil properties or indicators needed to measure or characterize soil quality.

Larson and Pierce (1994), Doran and Parkin (1996) proposed a minimum data set (MDS) consisting of an array of soil chemical, physical, and biological characteristics as basic indicators of soil quality. The soil physical indicators include soil texture, rooting depth, infiltration, water holding capacity and bulk density. Soil chemical indicators embarrasses electrical conductivity, pH and extractable N, P, K. Soil biological indicators evolve microbial biomass, C and N, potentially mineralizable; N and soil respiration. However, **Seybold *et al* (1996)** reported that the proposed indicators should be related to soil function and quality.

On the other hand, **Vance (2000) and Doran (2002)** stated that because of its positive influence on several soil processes, crop productivity and environmental quality; therefore soil organic matter (SOM) is often considered the single most important indicator of soil quality and sustainable land management. Moreover, **Van Noordwijk *et al* (1997)** stated that SOM is a soil property that is generally most sensitive to crop management.

The current work aims at evaluating the impact of organic farming system on soil properties, especially the physical ones that determine soil quality.

MATERIALS AND METHODS

Investigation sites

Due to the fact that organic farming in Egypt still in transition from conditions developed under the conventional system, this study has focused on the beneficial impact of organic farming, if any, on soil properties which enhance soil quality, compared to those obtained under the adjacent conventional farming conditions. The impact of soil type and time – scale on assessing soil quality under organic farming conditions. The chosen farms were selected to represent two soil textural categories, i.e. sandy soils present in Sharkia and Ismailia governorates and the relatively fine soils present in El- Fayoum and El-Behera governorates and to represent different periods from starting organic cultivation. The soil samples depths were 0-50 cm and 0-100 cm for both organic and conventional farming systems were statistically analyzed as well as soil quality index،SQI، was obtained.

Three main steps were followed to assess soil quality index (SQI)

(i) Select a minimum data set (MDS) of indicators that best represent soil function.

(ii) Score the MDS indicators based on performance of soil functions.

(iii) Integrate the indicator scores into a comparative index of soil quality.

A) To select a representative minimum data set (MDS) **(Doran and Parkin 1994)** for the organic and conventional systems, the first performed standardized principal component analysis (PCA) of all untransformed data that showed statistically significant differences between management systems using ANOVA. Principal components (PCs) for a data set are based on their linear combinations of the variables that account for maximum variance within the set by describing vectors of closest fit to the *n* observations in *p*-dimensional space, subject to being orthogonal to one another. PCs are assumed receiving high values best represent system attributes. Therefore, the PCs were examined only with eigenvalues >or =1 **(Brejda *et al* 2000).**

For a particular PC, each variable received weight or factor loading that represents its contribution to the PC. Only the highly weighted variables from each PC were retained for the MDS. Highly weighted is defined as that within 10% of the highest factor loading using absolute values. When more than one variable was retained within a PC, linear correlations were calculated to determine whether the variables could be considered redundant and, therefore, eliminated from the MDS **(Andrews 1998)**. If the highly weighted variables were not correlated (assumed to have a correlation coefficient <0.60), then each was considered important and was retained in the MDS. Among well-correlated variables within a PC, the variable with the highest sum of correlation coefficients (absolute values) was chosen for the MDS **(Andrews and Carroll 2001)**.

B) Scored each of the MDS variables based on their performance of soil functions using SPSS ver. 10.0 for windows **(SPSS 2002)**. The following classical statistic parameters were calculated: minimum, maximum, mean, standard deviation and coefficient of variation **(Webster 1977 and Wilding & Drees 1983).**

Once transformed, the MDS variables for each observation were weighted using the PCA results. Each PC explained a certain amount (%) of the variation in the total data set. This percentage, divided by the total percentage of variation explained by all PCs with eigenvectors >1, provided the weighting factor for variables chosen under a given PC.

C) The weighted MDS variable scores were summed for each observation in the following formula: ***SQI = ∑Wi x S***

Where Wi is the PC weighting factor and *S* is the indicator score. It was compared the calculated SQI organic and conventional means for 0-50 cm and 0-100 cm soil depths. Higher index scores was assumed to mean better soil quality or greater performance of soil functions.

RESULTS AND DISCUSSION

Soil layers physical, chemical, and biological characteristics were determined for the chosen organic and conventional farming sites the obtained data are given in **Tables from (1 to 4).**

The results in **Tables (1 and 2)** indicate that Galvina and El-Adlia (Belbes area) as well as El-Manayef (Ismailia area) represent varying periods of organic farming. The soils of the chosen farms are generally, non saline except for few cases, and sandy to sandy loam in texture. Organic matter content, except for the uppermost layers, is less than 1%. Thereby, CEC, total aggregates and their MWD is considerably low. Meanwhile, the basic infiltration rate is appreciably high. The data also reveal that the OM content, MWD, Total aggregates, CEC and total microbial count in the organically managed farms, are relatively higher than their corresponding values in the traditionally managed ones.

On the contrary, data obtained for El- Fayoum and El- Behera farms, presented in **Tables (3 and 4)** indicates that their texture are finer than the previous ones. Their textural classes range from sandy loam to clay. Also these soils are non- saline, exceptional for Abu El Matameer site as it is considered slightly saline. Due to the fine texture of such soils, CEC, Total aggregate, and their MWD as well as the retained soil moisture at 0.1 bar and the amount of available water for plant growth are appreciably high for organic farming system especially in the surface soil layer. Therefore, the soil bulk density is low. The data delineate in all chosen sites that the values organic matter content, BD, total aggregates, MWD and total microbial content are considerably higher in the organic managed soils compared to that of the conventional managed ones.

Principal Components Analysis (PCA) for soil properties

To explore the multivariate relationships among soil properties for organic and conventional farming systems, a Principal Components Analysis (PCA) for the physical, chemical, and biological characters was performed using for the whole profiles of the organic system soil variables separately for each soil depth. The same analysis was also performed using all of the weighted attributes for 0-50 cm and 0-100 cm soil depth, under both organic and conventional farming systems.

Form the PCA of the standardized values of the determined eleven soil variables for both soil depths under organic and conventional farming; it is found that the characteristics of the first two principal components are significant. In all cases, it reached from 86.6 to 93.4 % of the total variation.

Following univariate analysis, it retained parameters were assessed using PCA. The PCA output for the physical, chemical, and biological characters is given in **Tables (5 &6)**, Only PCs with eigenvalues >1 explained that at least 5% of the total variance, were retained for interpretation. Ninety five and ninety four percent of the variance, indicated by the first three PCs, are related to 0-50 cm and 0-100 cm soil depth for organic farming system. Also ninety seven and ninety five percent of the variance are attributed to 0-50 cm and 0-100 cm soil depth for conventional farming system respectively.

The PC1 explained that 79.97 and 78.05% are related to the total variance of 0-50 cm organic and conventional farming systems, and 75.72 and 71.94 % are attributed to 0-100 cm soil depth for organic and conventional farming systems, respectively. There were nine variables that had significant response on PC1, eight scores that were > 0.98, positive weighted (OM %, porosity, moist at 0.1 bar, available water, penetration resistance, MWD, silt+ clay and CEC) and two negatively weighted (Bulk density, basic infiltration rate). These finding align with those for **Harris *et al* (1996)** who stated that soil quality decreased with increasing bulk density and increased with total stable aggregates (mean weight diameter). It is diminished by increasing the time required for water to infiltrate.

The PC1 had significant positive response on soil penetration resistance variable. The strong dependence of penetration resistance suggests that soils with higher PC1 scores were more consolidated. **Hussain *et al* (1999)** found penetration

Table 5. The Principal Components (PC) from the principal component analysis (PCA) of the standardized values of eleven soil variables and their weights based on eleven simultaneous correlated variables from all minimum data set of organic farming system (Only principal components with eigenvalues >1)

Measurements	Organic farming system, 0-50 cm			Organic farming system, 0-100 cm		
	Principal component					
	PC 1	PC2	PC3	PC 1	PC2	PC3
Eigenvalue	8.797	1.132	0.562	8.33	1.195	0.800
Proportion of variance	79.97	10.289	5.112	75.724	10.865	7.273
Cumulative proportion	79.97	90.259	95.371	75.724	86.590	93.863
Rotated scores of two retrained eigenvectors						
OM%	.897		-.924	.669	-.131	-.948
Bulk Density (Mg/m^3)	-.990		.789	-.991		.711
Porosity %	.994		-.754	.997		-.678
Moisture content at 0.1bar	.989	-.138	-.734	.982		-.728
Available water	.986	-.112	-.724	.965		-.746
Penetration resistance (Mpa)	.899	.214	-.702	.674	.588	-.608
MWD	.950	.154	-.641	.948		-.484
Infiltration rate (cm/hr.)	-.683	.218	.956	-.640		.946
CEC (meq/100 gm soil)	.974		-.751	.931		-.683
Total bacterial count	-.114	.992	.209	-0.355	.889	.392
Silt +clay%	.983		-.804	.976	-.146	-.767

PC1= the first principal component PC2 = the second principal component PC3 = the third principal component

Table 6. The Principal Components (PC) from the PCA of the standardized values of eleven soil variables and their weights based on eleven simultaneous correlated variables from all minimum data set of conventional farming system (Only principal components with eigenvalues >1)

Measurements	Conventional farming system 0-50 cm			Conventional farming system 0-100 cm		
	Principal component					
	PC 1	PC2	PC3	PC 1	PC2	PC3
Eigenvalue	8.585	1.683	0.419	7.941	1.835	0.72
Proportion of variance	78.049	15.301	3.806	71.941	16.678	6.546
Cumulative proportion	78.049	93.35	97.156	71.941	88.619	95.165
Rotated scores of two retrained eigenvectors						
OM%	.726	.820	-.140	.426	.322	.991
Bulk Density (Mg/m^3)	-.986	-.354	.281	-.961	-.308	-.527
Porosity %	.983	.367	-.318	.959	.336	.535
Moisture content at 0.1 bar	.983	.254	-.142	.991	.154	.423
Available water	.959	.203	-.274	.983	.165	.431
Penetration resistance (Mpa)	.706	.662	-.758	.568	.847	.475
MWD	.947		-.174	.892		.136
Infiltration rate (cm/hr.)	-.817	-.540	.700	-.805	-.668	-.371
CEC (meq/100 gm soil)	.981	.368	-.149	.987	.226	.499
Total bacterial count		.944	-.455		.937	.267
Silt +clay%	.986	.166	-.214	.978		.306

PC1= the first principal component PC2 = the second principal component PC3 = the third principal component

resistance is negatively correlated with the rooting relation function of soil quality. At the same time, soils with high PC1 scores had more surface residue and so may be less susceptible to erosion. Soils in the 0-50 cm soil depth for organic farming system had significant greater PC1 scores than the others.

It is concluded that soil physical, chemical and biological conditions increased with PC1 scores. Among organical and conventional cultivation systems, PC1 is represented by the following order: (0-50 cm) organic > (0-50 cm) conventional > (0-100 cm) organic > (0-100 cm) conventional. This order is due to the increase in the organic matter content of 0-50 cm soil depth for the conventional farming system from 0-100 cm of the organic.

The PC2 represented by 10.29, 10.87% the total variance for farming system for 0-50 and 0-100cm soil depths of the organic farming system and 15.3 and 16.68% for the 0-50 and 0-100cm soil depths for conventional farming system respectively. The PC2 had significant positive results for the total microbial count. The strong dependence of PC2 on the total microbial count suggests that soils with higher PC2 scores are more consolidated. According to **Harris *et al* (1996),** total biomass affects the environmental and production functions of soil quality.

The PCA of indicators that exhibited significant differences between management systems for the four areas, two PCs had eigenvalues >1. Highly weighted variables under PC1 included OM %, porosity, soil moisture at 0.1 bar, available water, penetration resistance, MWD, silt+ clay, IR and CEC Correlation coefficients among these variables revealed that IR is not correlated with the other highly weighted variables. Hence, IR was retained for the MDS of the remaining eight well-correlated variables. SOM was the most highly correlated and was chosen for the MDS as the most representative for that group.

This result indicates that organic matter; biological and physical aspects of soil quality were the most sensitive indicators of soil quality. Farming systems aspect of soil quality increased with PC1 scores.

The data in **Table (7)** reveal that, the SQI was calculated using weighting factors for each scored MDS variable according to the following formula: ***SQI = ∑Wi x S***

Where S is the score for the subscript variable and the coefficients are the weighting factors derived from the PCA. Weights were determined by the percent of variation in the data set explained by the PC that contributed the indicated variable divided by the total percentage of variation explained by all PCs with eigenvectors > 1.

The data in **Table (8)** reveal for organic and conventional farming systems that soil quality index for 0-50 cm soil depth in organic farming system > 0-100 cm soil depth in organic farming system > or ≈ 0-50 cm soil depth in conventional farming system > 0-100 cm soil depth in conventional farming system.

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