

Full Length Research Paper

Impact of long-term intensive cropping under continuous tillage and unbalanced use of fertilizers on soil nutrient contents in a small holding village

Mohamed M. El-Fouly^{1*}, A. F. A. Fawzi¹, E. A. A. Abou El-Nour¹, M. S. Zeidan² and A. H. Firgany¹

¹Fertilization Technology Department, National Research Centre, 33, El-Bohouth St former El-Tahrir St. Dokki, Giza, Egypt.

²Field Crops Department, National Research Centre, 33, El-Bohouth St. Dokki, Giza, Egypt.

Received 7 October, 2015; Accepted 12 November, 2015

Long-term field studies are important to generate information on changes in soil, which help in understanding nutrients management strategies for sustainable crop production. The present study was carried out in Kafr El-Kadera village at El-Monofia governorate, Egypt located at Middle Delta. It started in 1981 and was repeated in 2008 to evaluate the effect of continuous cropping, tillage and unbalanced fertilizers use on soil properties. The village cultivates two irrigated crops/year. Fertilizers used are nitrogen (N) and phosphorus (P) only. No potassium (K) or micronutrients were used. Results showed that, electrical conductivity (EC) showed decrements, while organic matter (OM) and CaCO₃ showed increases with time. The average values of P content increased with time in all sites. On the other hand, potassium and micronutrients (Fe, Mn, Zn and Cu) showed decreases with time.

Key words: Intensive cropping, nutrient depletion, alluvial soil, unbalanced fertilization, potassium, iron, manganese, zinc, copper.

INTRODUCTION

The physical properties of any soil are function of climate, vegetation, parent material topography and time. Changes in frequency and intensity of tillage practices alter soil properties, distribution of nutrients and soil organic matter in the soil profile. These changes become stable with time and could affect availability of nutrients for plant growth, crop production and soil productivity (Turan et al., 2009).

Guo et al. (2000) reported that phosphorus (P) was significantly different among sites with time. Results suggested that variation within agriculture practices could influence soil nutrient changes among locations. Variation in texture could result from differences in mineralogy of parent materials; in this case variation is likely to affect the amount and distribution of phosphorus independent of cultivation history. This result suggested that shifting

*Corresponding author. E-mail: mohelfouly@link.net

Table 1. Location number, name and area/feddan.

Number	Site name	Area	
		Feddan	ha
1	El-Bahary	41	17.2
2	El-Tarbeah	35	14.7
3	El-Ramroma	80	33.6
4	El-Berka	30	12.6
5	El-Meadia	30	12.6
6	El-Areada	36	15.1
7	El-Fed El-Kabear	33	13.9
8	El-Fed El-Sageer	45	18.9
9	Kebalia	90	37.8
10	El-Tarabeah	75	31.5
11	El-Remia	90	37.8
12	El-Omeda	50	21.0
13	El-Metab	70	29.4
14	El-Elow	65	27.3
15	El-Taboot	70	29.4
16	El-Gofara	45	18.9
Total		885	371.7

1 Feddan=4200 m².

cultivators may have the more fertile sites originally and have only moved into a less fertile one.

Diaz-Zorita and Grove (2002) noted that available phosphorus increased also due to regular application of phosphatic fertilizer. Obviously, continuous use of N alone leads to sever depletion of other nutrient with corresponding decrease in grain yield. Without application of K, soil K eventually drop below the critical level (Zheng, 1999). Similar findings were reported by Elangovan (1984) who reported that K content in 100% NP was lower than that of 100% N alone and unfertilized soils due to the relatively higher crop yields and high removal of K. High K removal in the absence of K addition has resulted in drastic reduction of total K as well as available K under NP alone (Samra and Anand, 2008).

Due to the relatively higher crop yields and high removal of K, the K values were significantly decreased by time. Deficiency of Zn, Fe and Cu are the common feature of these soils. Being arid to semi arid area, about 75% of the cultivated area is irrigated while the rest is rain-fed. The micronutrients availability in soils is a function of the rate of replenishment from soil solids to soil solution. In all soils, replenishment of micronutrients takes place from earth minerals present in the pedosphere or lithosphere. The pedospheric variations due to parent material, topography, climate etc. lead to spatial variation of micronutrients in soils (Katyal and Sharma, 1991).

The distribution of micronutrients may differ among the profiles developed on different parent materials and landforms. With the introduction of high yielding varieties,

the removal of nutrients, including micronutrients from the soils, is very large. Continuous use of nitrogenous and phosphatic fertilizers in the intensive cropping system with less use of organic manures results in quick depletion of micronutrients from soils (Dhane and Shukla, 1995).

Previous studies showed depletions in micronutrients (El-Fouly et al., 2010a) and magnesium (El-Fouly et al., 2010b), under different cropping systems and in different soils.

The objective of this study was to examine the long-term effects of intensive cropping system and N or NP applications alone on soil physical and chemical properties after 27 years of continuous cropping. It compared soil properties in 2008 with those of the same soils in 1981 (El-Fouly, 1989).

MATERIALS AND METHODS

Soil and crop nutritional surveys were conducted in 1981 (El-Fouly, 1989) and repeated in 2008 to study the effect of continuous intensive cropping and addition of N or NP fertilizers on changes of physical and chemical properties on alluvial silty clay loamy textured soil.

Background of study site

The study area is located at the Middle of Nile Delta at El-Monofia Governorate, Egypt. The study area covers 880 feddan (about 350 ha) divided into 16 locations. The location number, area and site names are presented in Table 1. Field crops occupy 88% of the area, while vegetable and citrus occupy 12%. All farmers at all sites grow field crops and follow cropping systems as follows. Maize is the main crop in summer and wheat and/or clover in winter. Between summer and winter, some farmers cultivate potatoes, pea and/or maize as forage crop, all crops are irrigated. Irrigation water in this village comes through small canals. Fertilizers used for each crops are given in Table 2. Most of the holdings are below 1 ha. The agriculture system is intensive and farmers are market oriented.

Soil sampling

Soil samples (0 to 30 cm) were collected in September before planting and before fertilization in 1981 and 2008. Soils alluvial texture was generally silty clay loam.

Tillage and field practices

Before sowing each crop, mold board plowing of the soil was performed to a depth of 30 cm then disking and planting. Farmers used traditional crop varieties till 1989. Since 1990, farmers have been using high yielding varieties of crops. After harvest, farmers plow the soil to a depth 30 cm and after tillage the following crop is sown. Farmers use high rates of nitrogen and phosphorus fertilizers on all field crops and did not use potassium fertilizers for any crop. The crops in the village did not suffer from any water shortage during the study period. Relatively good quality irrigation water was available all the year.

Table 2. Average organic manure and fertilizers used.

1981-1995	System 1	System 2
Summer (June-Oct.)	Maize	Maize
Organic manure	50 m ³ /ha	50 M ³ /ha
N-(Urea or ammonium nitrate)	125-250 kg/ha	125-250 kg/ha
P- (single superphosphate)	75-125 kg/ha	75-125 kg/ha
Winter (Nov-May)	Wheat	Clover
Organic manure/ha	50 m ³ /ha	-
N-(Urea or ammonium nitrate)	125-250 kg/ha	40 kg/ha
P-(single superphosphate)	75-125 kg/ha	75-125 kg/ha
After 1995		
Summer (June-Oct.)	Maize	Maize
Organic manure/ha	75-100m ³	75-100 m ³
N- (Urea or ammonium nitrate/ha)	180-300 kg/ha	180-300 kg/ha
P- (single super phosphate)	38-55 kg/ha	38-55 kg/ha
Winter (Nov-May)	Wheat	Clover
Organic manure	100 m ³ /ha	85-100 m ³ /ha
N- (Urea/ammonium nitrate)	180-250 kg/ha	125-250 kg/ha
P- (Single super phosphate)	38 kg/ha	40-60 kg/ha

Laboratory analysis

The soil samples were collected and air-dried, ground, sieved to pass through 2 mm sieve and analyzed. Soil samples were analyzed for texture with a hydrometer (Bouyoucos, 1954), for pH and electric conductivity (EC) using water extract (1 soil : 2.5 water) method (Jackson, 1973). For total calcium carbonate (CaCO₃%), calcimeter method was used as described by Alison and Moodle (1965). Organic matter (O.M%) content was determined according to Walkley and Black (1934) using potassium dichromate (Chapman and Pratt, 1978). Phosphorus was extracted using sodium bicarbonate (Olsen et al., 1954). Potassium (K⁺) was extracted using ammonium acetate. Micronutrients were determined by atomic absorption spectrometer after extraction according to Lindsay and Norvell (1978). Same procedures were used in both years.

RESULTS AND DISCUSSION

Soil pH

In general, pH varied from 8.2 to 8.7 in both 1981 and 2008, at a depth of 0 to 30 cm (Table 3). Lopez et al. (2003) and Lopez and Pardo (2009) reported that soil pH can vary considerably from one spot in the field to another. It also varies with depth. Different geographic regions, as already mentioned, may have different pHs because of the five soil forming factors: (1) parent material, (2) climate, (3) living organisms, (4) topography, and (5) time.

Soil electrical conductivity (EC)

The electrical conductivity of the surface soil of all sites ranged between 0.19 to 0.54 and from 0.13 to 0.46 dSm⁻¹, respectively in 1981 and 2008 (Tables 3). In general, EC showed decrement in 2008 compared with 1981. This might be due to over irrigation of the soil and low use of chemical fertilizers. Similar results were obtained by Turan et al. (2009) who reported that EC dropped with time increase, also Manojlovis et al. (2008) found similar results.

Soil OM (%)

Soil organic matter content across sites was low to medium, ranging from 1 to 1.4% in top soil in 1981 and between 1.3 to 2.6% in 2008 (Table 4). Soil OM showed increment in 2008 than what was found in 1981. This increase could be attributed to the continuous supply with organic manure in each cultivation season. Zheng (1999) reported that soil receiving no fertilizer or farm yard manure (FYM) showed no consistent changes in organic matter at 0 to 20 cm depth, while application of FYM once in every cycle increased OM content by 0.29% in 12 years. NP application increased OM content by 0.30% in 12 years. Combination of FYM + NP increased organic matter content by 0.42% in 12 years. The soil OM was increased gradually with the cultivation time.

Table 3. Physico-Chemical Characteristics of surface soil layer in 1981 and 2008.

Site	pH				EC			
	1981	(%)	2008	(%)	1981	(%)	2008	(%)
1	8.2	100	8.5±0.1	104	0.29	100	0.24±0.02	83
2	8.3	100	8.2±0.1	99	0.34	100	0.14±0.03	41
3	8.4	100	8.5±0.1	101	0.27	100	0.20±0.04	74
4	8.3	100	8.6±0.13	104	0.19	100	0.23±0.1	121
5	8.5	100	8.5±0.04	100	0.42	100	0.20±0.04	48
6	8.5	100	8.7±0.04	102	0.32	100	0.46±0.8	144
7	8.2	100	8.6±0.1	105	0.24	100	0.22±0.01	92
8	8.2	100	8.7±0.02	106	0.22	100	0.22±0.01	100
9	8.7	100	8.6±0.10	99	0.32	100	0.23±0.04	72
10	8.7	100	8.7±0.22	100	0.33	100	0.13±0.04	39
11	8.5	100	8.7±0.10	102	0.34	100	0.31±0.05	91
12	8.7	100	8.5±0.10	98	0.32	100	0.20±0.04	63
13	8.3	100	8.6±0.10	104	0.54	100	0.30±0.01	56
14	8.4	100	8.6±0.13	102	0.28	100	0.23±0.01	82
15	8.5	100	8.6±0.13	101	0.27	100	0.16±0.01	96
16	8.2	100	8.6±0.11	105	0.49	100	0.24±0.02	50
Mean	8.4		8.6		0.32		0.23	
Range	8.2 - 8.7		8.2 - 8.7		0.19 - 0.54		0.13 - 0.46	

Table 4. Chemical characteristics of surface soil in surface soil layer in 1981 and 2008.

Site	CaCO ₃ (%)				OM (%)			
	1981	(%)	2008	(%)	1981	(%)	2008	(%)
1	1.40	100	1.5±0.7	107	1.2	100	1.4±0.2	117
2	1.05	100	1.0±0.2	95	1.2	100	2.2±1.0	183
3	0.98	100	1.4±0.2	142	1.4	100	2.6±0.2	186
4	1.43	100	1.8±0.5	126	1.0	100	2.2±0.5	220
5	1.42	100	1.5±0.2	106	1.2	100	2.4±0.2	200
6	1.30	100	1.3±0.3	100	1.3	100	1.9±0.2	146
7	1.69	100	1.9±0.4	112	1.0	100	2.3±0.2	230
8	1.70	100	1.9±0.4	168	1.1	100	2.3±0.2	209
9	1.07	100	1.8±0.4	61	1.4	100	1.8±0.2	129
10	1.80	100	1.1±0.2	100	1.2	100	2.2±0.6	183
11	1.50	100	1.5±0.6	108	1.3	100	1.8±0.2	138
12	1.39	100	1.5±0.5	73	1.2	100	2.3±0.2	192
13	1.50	100	1.1±0.4	111	1.3	100	1.8±0.3	138
14	1.62	100	1.8±0.5	117	1.2	100	2.2±0.5	183
15	1.63	100	1.9±0.8	99	1.1	100	2.3±0.3	209
16	1.61	100	1.6±0.7	104	1.2	100	1.3±0.3	108
Mean	1.44		1.5		1.2		2.1	
Range	0.98 - 1.80		1.0 - 1.9		1.0 - 1.4		1.3 - 2.6	

Xiaorong et al. (2006) reported that soil organic matter was higher in cropped and fertilized soil after 18 years.

Other factors may also influence the degree of change in organic matter.

Table 5. Soil phosphorus and potassium (mg/100 g soil) in surface soil layer in 1981 and 2008.

Site	P				K			
	1981	(%)	2008	(%)	1981	(%)	2008	(%)
1	1.2	100	3.4±0.4	383	57.8	100	55.3±4.2	96
2	1.3	100	4.0±1.0	308	47.7	100	24.5±16.2	51
3	0.6	100	3.7±0.34	617	81.1	100	42.6±5.6	53
4	1.0	100	3.5±0.4	350	70.7	100	47.6±7.9	67
5	0.9	100	2.9±0.6	322	63.0	100	46.9±4.1	74
6	1.0	100	3.9±0.2	390	80.8	100	55.5±3.4	69
7	1.0	100	3.0±0.6	300	63.0	100	53.9±5.2	86
8	0.7	100	3.96±0.6	679	67.0	100	53.5±5.1	80
9	1.4	100	3.6±0.32	257	48.6	100	54.4±8.1	112
10	1.3	100	3.7±0.9	285	57.3	100	23.3±14.3	41
11	1.0	100	3.82±0.2	380	57.0	100	54.3±4.0	95
12	0.7	100	2.7±0.3	386	58.7	100	54.6±5.6	93
13	0.8	100	2.9±0.22	363	57.6	100	36.6±4.3	64
14	0.9	100	3.5±0.4	389	49.3	100	47.6±7.9	97
15	0.7	100	3.4±0.4	486	57.5	100	55.3±4.0	96
16	0.8	100	3.2±0.54	400	51.5	100	55.3±4.0	107
Mean	1.0		3.4		60.5		48.2	
Range	0.6 -1.4		2.7- 4.0		47.7 - 81.1		23.3 - 55.5	

Soil CaCO₃ (%)

Table 4 shows that means of CaCO₃% were different among locations in 1981 and 2008. CaCO₃% ranged between 0.98 and 1.80 in 1981 and between 1.0 and 1.9 in 2008 at surface soil layer. On the other hand, William (2006) found that after 18 years, soils CaCO₃ contents decreased with time.

Phosphorus (mg/100 g soil)

The results presented in Table 5 show that the surface soil P concentration ranged from 0.6 to 1.4 in 1981, and from 2.7 to 4.0 in 2008. The average values of P content increased with time among sites. These results suggest that variation within agriculture practices can influence soil nutrient content. The increase can be attributed to the continuous use of P fertilizers.

Hung et al. (2001) found that long-term P application in the form of single superphosphate caused significant increments. Increases in soil P only in the 0- to 10-cm depth suggest that residual P fertilizer has accumulated mainly in the soil surface. Setia et al. (2009) reported that available P in the control plot decreased whereas in plots with added P, available P increased significantly after 11 and 22 years.

Guo et al. (2000). and Diaz and Grove (2008) found that the increase in P which accumulated at all locations

in 2008 may be attributed to the repeated application of the N+P. McCollum (1991) documented that annual addition of 45 kg P/ha for 20 or 40 years to continuous smooth brome (*Bromis inermis*) on a silt loam soil resulted in increasing soil P concentration (150 to 250 mg P/kg soil) as compared to unfertilized. The concentration of phosphorus in soil is influenced by some other factors. A study conducted by Chen et al. (2003) concluded that the recycling of P was mainly driven by plant P demand and sustained by root and leaf litter inputs. Besides, seasonal changes in environmental conditions such as rainfall, soil moisture and temperature are also involved in the P availability. Microbial biomass also plays an important role in P availability.

Potassium (mg/100 g soil)

Data in Table 5 show that mean values of K varied between 47.7 to 81.1 in 1981 and from 23.3 to 55.5 in 2008 in surface soil layer. The decrease in soil K after 27 years of intensive cropping may be due to the continuous use of N or N+P fertilizer without any K addition in the soil at any cycle. Obviously, continuous use of N or P alone leads to severe depletion of other nutrients. The decreases in total K content were due to crop removal in the absence of external source of K supply through fertilizers and manure.

Ishaq et al. (2002) reported that the decrease was due

Table 6. Soil iron and manganese (ppm) in surface soil layer in 1981 and 2008.

Site	Fe				Mn			
	1981	(%)	2008	(%)	1981	(%)	2008	(%)
1	14.3	100	5.7±0.1	40	23.7	100	4.2±0.3	18
2	17.6	100	4.3±2.2	24	21.7	100	7.8±6.5	36
3	11.3	100	8.7±2.13	77	19.1	100	4.8±3.03	25
4	7.8	100	6.1±2.6	98	12.7	100	4.1±0.9	32
5	10.7	100	16.9±1.4	158	12.2	100	1.9±0.2	16
6	10.8	100	6.9±0.3	64	14.0	100	4.3±0.3	31
7	11.3	100	6.9±0.3	61	19.6	100	4.6±0.2	23
8	10.0	100	6.9±0.24	69	21.9	100	4.3±0.23	20
9	9.0	100	6.3±0.44	70	18.4	100	4.31±0.5	23
10	10.6	100	5.5±2.8	52	17.7	100	7.1±4.4	40
11	12.4	100	6.2±0.24	50	34.5	100	4.6±0.23	13
12	14.5	100	5.3±0.6	37	40.2	100	3.8±0.7	9
13	22.1	100	5.9±0.3	27	35.2	100	5.0±1.5	14
14	21.4	100	6.5±0.5	30	44.4	100	3.9±0.4	9
15	21.4	100	6.9±2.4	32	39.3	100	6.2±3.1	16
16	19.3	100	5.9±0.5	31	35.3	100	4.1±0.3	19.3
Mean	14.0		6.9		25.6		4.7	
Range	7.8 - 22.1		4.3 - 16.9		12.2 - 44.4		1.9 - 7.8	

to the relatively higher crop yields and high removal of K. High K removal in the absence of K addition has resulted in drastic reduction of total K as well as available K under only NP addition (Harry et al., 2000).

Available Fe

Mean values of Fe content varied from 7.8 to 22.1 among sites in 1981 and from 4.3 to 16.9 at depth of 0 to 30 cm in 2008 (Table 6). In general, mean values of Fe content decreased in 2008 in comparison with 1981. The decline in Fe status with continuous cropping occurred because of Fe removal by the successive crops from the native soil reserve. Khan et al. (2002) reported that continuous application of increasing level of N significantly depleted the available Fe content in the soil. These results agreed with the findings of Nayyar et al. (2001), Li et al. (2007), Machado et al. (2007) and Santiago et al. (2008).

Available Mn

Table 6 indicates that there were drastic differences among locations in Mn content in 1981 and 2008. In general, Mn contents at all locations showed decrement in 2008 compared with 1981. Mn content ranged between 12.2 to 44.4 in 1981 and between 1.92 to 7.8 in 2008 (Table 6). Khan et al. (2002) reported that intensive

fertilization and cropping for a long time have brought remarkable decreases in available Mn in soil. The decrease in Mn content due to continuous cropping can be ascribed to Mn removal by successive crops without any addition from the external source. Cropping sequence year after year have created a favorable environment for strains of Mn oxidizing bacteria or fungi leading to faster depletion. Malhi et al. (1998), Cox et al. (2003) and Carter (2005) found that Mn was negatively correlated with pH and sand, whereas a positive correlation existed with EC, OM, CaCO₃ and clay. From this association, it can be inferred that addition of organic matter encourages the availability of Mn and as the soil become coarser, Mn deficiency become a problem (Setia and Sharma, 2004).

Available Zn

Table 7 indicates that all locations showed decreases in soil Zn content in 2008 compared with 1981. Mean values of Zn ranged between 0.87 and 2.6 and from 0.4 and 2.2 in surface soil of 0 to 30 cm depth through 1981 and 2008, respectively. With the introduction of high yielding varieties, the removal of nutrients, including micronutrients from the soils are very large. Continuous use of nitrogenous and phosphatic fertilizers in the intensive cropping system, with low use of organic manures, resulted in quick depletion of micronutrients from soils

Table 7. Soil zinc and copper contents (ppm) in surface soil layer in 1981 and 2008.

Site	Zn				Cu			
	1981	(%)	2008	(%)	1981	(%)	2008	(%)
1	2.03	100	0.5±0.1	25	2.73	(100)	0.4±0.04	15
2	1.45	100	1.7±0.6	117	5.40	(100)	0.9±0.6	17
3	1.34	100	2.2±0.7	164	4.43	(100)	1.4±0.53	32
4	2.02	100	1.5±1.13	74	4.38	(100)	1.2±0.98	27
5	0.87	100	1.8±0.2	207	3.99	(100)	1.7±0.5	43
6	1.60	100	0.4±0.1	25	3.40	(100)	0.4±0.1	14
7	2.02	100	0.5±0.12	25	3.62	(100)	0.5±0.1	14
8	1.99	100	0.4±0.12	20	4.48	(100)	0.4±0.1	9
9	1.44	100	0.5±0.14	35	3.01	(100)	0.4±0.1	13
10	1.63	100	1.7±0.9	104	3.32	(100)	1.1±0.6	33
11	1.42	100	1.4±0.12	99	3.62	(100)	0.5±0.1	14
12	2.02	100	0.5±0.11	25	4.89	(100)	0.3± 0.1	6
13	2.60	100	0.5±0.1	19	4.35	(100)	0.4±0.1	9
14	1.05	100	0.5±0.1	48	4.84	(100)	0.4± 0.1	8
15	0.97	100	1.5±2.4	155	6.34	(100)	2.0±0.6	32
16	1.20	100	0.5±0.1	42	5.36	(100)	0.4±0.1	7
Mean	1.6		1.0		4.3		0.8	
Range	0.87 - 2.60		0.4-2.2		2.73 - 6.34		0.3 - 2.0	

(Santiago et al., 2008). The accumulation of Zn in surface soil layers might be due to: (i) the addition through plant residues left over by the soils which have also been reported by Katyal and Sharma (1991), Setia and Sharma (2004) and Verma et al. (2005). Similar results were obtained by Khan et al. (2002), Wright et al. (2007) and Ewa et al. (2009), where available micronutrient contents decreased with time.

Available Cu

Mean values of Cu content (ppm) in soil were differed among locations in 1981 and 2008 (Table 7). All locations showed decreases in Cu content in 2008 compared with 1981. The Cu content in 1981 varied from 2.73 to 6.34 and from 0.3 to 2.0 in 2008. Fertilizer addition caused a considerable decline in available Cu status irrespective of the level of application. Different treatments, continuous use of N alone resulted in a significant decline in the Cu content. Nayyar et al. (2001) also reported a decline in Cu content with increasing level of N, P and K in a long-term experiment after 22 cycles.

Conclusion

Long term cultivation of alluvial silty clay loamy soils of small holding under continuous tillage surface irrigation and unbalanced fertilizers use led to negative changes in

nutrient contents in the soil. Balanced use of fertilizers, based on yield estimation, soil testing and plant analysis is recommended. Otherwise, continuous depletion of nutrients from the soil will continue, leading to yield decreases and low soil fertility.

Conflict of interest

The authors have not declared any conflict of interest.

ACKNOWLEDGMENT

This study was conducted as a part of the Egypt-German project "Micronutrients and Other Plant Nutrition Problems in Egypt, implemented by the National Research Centre (NRC) Fertilization Technology Department (coordinator Prof. Dr. M.M. El-Fouly) and the Plant Nutrition Chire Dep. for Plant Sciences, TU Munich (Prof. Dr. U. Schmidhalter). The project was supported by the Egyptian Academy of Scientific Research and Technology (ASRT) and the German Federal Ministry of Technical Cooperation (BMZ) through the German Agency for Technical Cooperation (GIZ).

REFERENCES

Alison LE, Moodle CD (1965). Carbonate. In: Black CA (ed.) "Methods of Soil Analysis". America Society of Agronomy. Inc. Madison,

- Wisconsin, USA. pp. 1379-1396.
- Bouyoucos HH (1954). A recalibration of the hydrometer for making mechanical analysis of soils. *Agron. J.* 43:343-348.
- Carter MR (2005). Long-term tillage effects on cool-season soybean in rotation with barely, soil properties and carbon and nitrogen storage for fine sandy loams in the humid climate of Atlantic Canada. *Soil Till. Res.* 81:109-120.
- Chapman HD, Pratt PF (1978). "Methods of analysis for soils, plants and waters", 309 p. Division of Agric. Sci., Univ. California, Berkeley, USA.
- Chen CR, Condrón LM, Davis MR, Sherlock RR (2003). Seasonal changes in soil phosphorus and associated microbial properties under adjacent grassy land and forest in New Zealand. *For. Ecol. Manage.* 177:539-557.
- Cox MS, Gerard PD, Wardlaw MC, Abshire MJ (2003). Variability of selected soil properties and their relationship with soybean yield. *Soil Sci. Soc. Am. J.* 67:1296-1302.
- Dhane SS, Shukla LM (1995). Distribution of DTPA-extractable Zn, Cu, Mn and Fe in some soil series of Maharashtra and their relationship with some soil properties. *J. Indian Soc. Soil Sci.* 43:597.
- Diaz-Zonita M, Grove JH (2002). Duration of tillage management affects carbon and phosphorus stratification in phosphatic Paleudalfs. *Soil Till. Res.* 66:165-174.
- Elangovan K (1984). Potassium transformation under continuous cropping and fertilization. M. Sc. (Ag) thesis, Tamil Nadu Agric. Univ. Coimbatore, India.
- El-Fouly MM (1989). Micronutrients (Zn, Mn, Fe, Cu) status in field crop production on village level. Proc. 6th Intern. Trace Element Symposium 2:613-620. Eds. Anke AS, Baumenn W, Braeunlich H, Bruchner CH.
- El-Fouly MM, Gad AM, Hassanien AMA, El-Dahshouri MF (2010a). Depletion of Zn, Fe, Mn and Cu from cultivated Egyptian soils by field crops. *J. Food Agric. Environ.* 8:713-720.
- El-Fouly MM, Rezk AI, Nofal OA, Abou-El-Nour EAA (2010b). Depletion of magnesium in Egyptian soils, its content in crops and estimated needs. *Afr. J. Agric. Res.* 5:1060-1076.
- Guo F, Yost RS, Hue NV, Evensen CI, Silva JA (2000). Changes in phosphorus fractions in soil under intensive plant growth. *Soil Sci. Soc. Am J.* 64:1681-1689.
- Harry HS, John AS, Alan JF, Stanley RW (2000). Spatial Distribution of Extractable Phosphorus, Potassium, and Magnesium as Influenced by Fertilizer and Tall Fescue Endophyte Status. *Agron. J.* 92:981-986.
- Hung NJJ, Schoenau KVR, Dang N, Qian P (2001). Long-term nitrogen, phosphorus and potassium fertilization of cassava influences soil chemical properties in North Vietnam. *Can. J. Soil Sci.* 81(4):481-488.
- Ishaq M, Irahim M, Lal R (2002). Tillage effects on soil properties at different levels of fertilizer application in Punjab. *Pak. Soil Till. Res.* 68:83-99.
- Jackson KL (1973). *Soil Chemical Analysis*. Prentice Hall of India Private limited, New Delhi, India.
- Katyal JC, Sharma BD (1991). DTPA extractable and total zinc, copper, manganese and iron in Indian soils and their association with some soil properties. *Geoderma* 49:165-179.
- Khan MS, Abedin MJ, Akhter A, Hossain MF, Siker MSI (2002). Effect of long-term fertilization and cropping on micronutrient cations of soils in Bangladesh. *Pak. J. Biol. Sci.* 5(5):543-544.
- Li BY, Zhou DM, Cang L, Zhang HL, Fan XH, Qin SW (2007). Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. *Soil Till. Res.* 96:166-173.
- Lindsay WL, Norvell WA (1978). Development of a DTPA micronutrient soil tests for zinc, manganese and copper. *Soil Sci. Soc. Am. J.* 42:421.
- Lopez-Bellido RJ, Lopez-Bellido L, Castello JE, Lopez-Bellido FJ (2003). Nitrogen uptake by sunflower as affected by tillage and soil residual nitrogen in a wheat-sunflower rotation under rain fed Mediterranean conditions. *Soil Till. Res.* 72:43-51.
- Lopez-Fando C, Pardo MT (2009). Changes in soil chemical characteristics with different tillage practices in a semi-arid environment. *Soil Till. Res.* 104:278-284.
- Machado LD, Lana AMQ, Guimaraes EC, Ferreira CV (2007). Spatial variability of soil chemical attributes in areas managed under conventional tillage. *Rev. Bras. Cien. Solo* 31:591-599.
- Malhi SA, Nyborg M, Harapiak JT (1998). Effect of long-term N fertilizer induced acidification and liming on micronutrients in soil in boron grass hay. *Soil Till. Res.* 48:91-101.
- Manojlović M, Asin V, Neremenis S (2008). Long-term effects of agronomic practices on the soil organic carbon sequestration in Chernozem. *Arch. Agron. Soil Sci.* 54:353-367.
- McCullum RE (1991). Buildup and decline in soil phosphorus: 30 year trends on a typical Umprabult. *Agron. J.* 83:77-85.
- Nayyar VK, Arora CL, Kataki PK (2001). Management of soil micronutrient deficiencies in the rice-wheat cropping system. *J. Crop Prod.* 4:87-131.
- Olsen SR, Cole CW, Watnabe SS, Dean LA (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA. *Agric. Circular* 930:1-19.
- Samra JS, Anand S (2008). Impact of long-term intensive cropping on soil potassium and sustainability of crop production. *Geoderma* 148(2):173-179.
- Santiago DA, Quintero, JM, Delgado A (2008). Long-term effects of tillage on the availability of iron, copper, manganese, and zinc in Spanish Vertisol. *Soil Till. Res.* 98:200-207.
- Setia R, Sharmaa KN, Marschner P, Singh H (2009). Changes in Nitrogen, Phosphorus, and Potassium in a Long-Term Continuous aize-Wheat Cropping System in India. *Commun. Soil Sci. Plant Anal.* 40:3348-3366.
- Setia RK, Sharma KN (2004). Effect of continuous cropping and long-term differential fertilization on profile stratification of DTPA-extractable micronutrients. *Food Agric. Environ.* 2(1):260-265.
- Turan Y, Ceyhan GF, Esin EY (2009). The effect of land use changes on soil properties : The conversion of alder coppice to tea plantations in the Humid N orthern Blacksea Region. *Afr. J. Agric. Res.* 4:665-674.
- Verma VK, Kumar K, Setlai PK, Sharma CS, Ashok K (2005). Pedospheric Variations in Distribution of DTPA-extractable Micronutrients in Soils Developed on Different Physiographic Units in Central Parts of Punjab India. *Int. J. Agric. Biol.* 7:243-246.
- Walkley A, IA Black (1934). An examination of the Degtjareff method for determining organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37:29.
- William JG (2006). Changes in soil properties and availability of soil micronutrients after 18 years of cropping fertilization. *Soil Till. Res.* 91:120-130.
- Wright AL, Hons FM, Lemon RG, McFarland ML, Nichols RL (2007). Stratification of nutrients in soil for different tillage regimes and cotton rotations. *Soil Till. Res.* 96:19-27.
- Xiaorong WU, Hou M, Shao M, Gale WJ (2006). Changes in soil properties and the availability of soil micronutrients after 18 years of cropping and fertilization. *Soil Till. Res.* 91:120-130.
- Zheng T (1999). Long-term Changes in Soil Fertility and Fertilizer Efficiency under Different Fertilizer Practices. *Better Crops Int.* 13(2):14-18.