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LONG-TERM USE EFFECT OF ORGANIC, INORGANIC FERTILIZERS AND CROP ROTATION THROUGH NINETEEN YEARS ON SOME SOIL PROPERTIES IN PERMANENT EXPERIMENT AT BAHTIM.
2. SOIL CHEMICAL PROPERTIES.

El-Shafie, A. I. E.; H. M. Khalil and U. S. El-Bialy
Soils, Water and Environ. Res. Inst., Agric. Res. Center (ARC), Giza, Egypt

ABSTRACT

Representative disturbed soil samples of tow successive layers (0 – 30 and 30 – 60 cm) were collected from the permanent experimental plots at Bahtim to study the prolonged effect of permanent fertilization under two crop rotations namely, one and three years rotation on some soil chemical properties, i.e., electrical conductivity, soil reaction, soil organic matter content, total soluble ions and nutritional status (available N, P and K).

The obtained results indicated that the plots of 3-year rotation recorded significantly higher values of EC, pH and OM content. Sodium ion was the dominant cation in soil followed by Mg^{++}, Ca^{++} and K^{+}, respectively, while SO_4^{--} was the dominant anion followed by Cl^{-} and HCO_3^{-}. Also, all soluble cations except K^{+}, and anions as well as available N and P were relatively higher under the three-years rotation than the one-year rotation. The adverse trend was found for soluble and available K. Organic manuring resulted in significantly higher values of EC and appreciable values of OM content than the other mineral fertilizers or unfertilized one while the adverse trend was true for pH. Also, soluble cations and anions were relatively higher due to applying organic manuring than the other fertilizers except for NPK fertilizer, which gave the same soluble anions. Farmyard manuring improved nutritional status in the soil compared with the other mineral fertilizers, where available N, P and K were higher due to applying organic manuring. The soil surface layer contained significantly higher OM as well as available N, P and K than the subsurface one, while the adverse trend was found for soluble cations, also, no clear trend was noticed for pH and soluble anions with soil profile depth.

No clear variation was occurred in the studied soil chemical properties such as available nutrients (N, P and K), soluble Ca^{++} and Mg^{++}, soluble anions and soil organic matter content with a relative increase of such property as a result of crop rotation and long-term fertilization throughout the last nineteen years. On the contrary, an adverse trend of EC and soluble Na^{+} and K^{+} was found due to fertilization and crop rotation while pH value took different trends due to crop rotation only. Also, the dominant soluble ions in 2007 differed from those in 1989 where Na^{+} and So_4^{--} were the dominant ions in 2007.

INTRODUCTION

It is well known that an improving soil chemical property is one of the most keys to soil fertility. Many investigators have studied long-term fertilization as an organic and inorganic and/or crop rotation as well as profile depth on soil chemical properties. It is worthwhile to be discussed, herein such effect at Bahtim permanent experiments throughout the last nineteen years. Heggi (1976) found that soluble calcium and sodium ions increased with depth for the plots treated with mineral fertilizers, while they decreased with depth by applying organic manure. Abdel-Naim *et al.* (1981) mentioned that, in Bahtim permanent experiment, the plots received chemical fertilizers had significantly higher E.C. values than those of farmyard manure or untreated one. They added that all potassium forms were relatively low in the plots of 3-years rotation comparing with those of the 1-year one; also, such forms were increased by the application of farmyard manure. Hipp and Simpson (1982) pointed out that no effect of fertilization treatments could be realized on soil pH values. Steinbrenner and Smukalski (1984) found that soil organic matter was significantly affected by crop rotation, where the highest value of such property was realized in the plots of 3-years rotation compared to that of 1-year one. They added that crop rotation resulted in a slightly increase in available soil phosphorus. Also, the values of available nitrogen are higher in plots of 3- years rotation than those of 1-year rotation. Benbi *et al*. (1991) showed that the application of N fertilizer without P and K or in combination with only P resulted in higher NO_3-N concentration in the soil profile than the application of N with P and K. They added that the annual application of 10 tons farmyard manure (FYM)\ha. along with NPK resulted in a relatively lower NO_3-N content in the subsoil. Glendining *et al.* (1996) indicated that the long term application annually of 48, 96 and 144 Kg N\ha., in the Broadbalk Wheat Experiment at Rothamsted (UK) has increased total soil N content, relative to the plots never receiving fertilizer N, due to the greater return of organic N to the soil in roots, root exudates, stubble ,…etc. They added that the long-term fertilizer treatments appeared to have no effect on carbon content but have increased the specific mineralization rate of the biomass. Also, they concluded that after applying 144 Kg N\ha. for 144 years, up to half of the N mineralized each year was originally derived from N fertilizer. Clark *et al.* (1998) concluded that manure application for 8 years resulted in higher soil organic C, soluble P, exchangeable K, soluble Ca and Mg as well as pH. They added that crop rotation had a significant effect on organic C levels. Freixo *et al.* (2002) noted that crop cultivation led to a decrease in soil organic matter content, which was higher for conventional tillage soils (disc plough followed by light disc Narrow wings) and such decrease was approx. 60% in C and N contents than no tillage, which was 43% at 0.5 cm. Vigil *et al*. (2005) stated that an increase in soil organic matter at the soil surface, a decrease in soil pH has all been associated with the change from conventional winter wheat summer fallow to the intensive no-till rotations.

The aim of the present study is to study the probable changes of some chemical properties of the Bahtim permanent experimental plots, which have taken place through soil profile as a result of crop rotation, organic and inorganic fertilization throughout the last nineteen years.

MATERIALS AND MEATHODS

To achieve the aim of this study, soil samples were collected from the permanent fertilization experiment at Bahtim. The presentation of the used materials and methodology of Bahtim permanent experimental plots can be shown under the following subheadings:

1. Crop rotation: 1-years rotation = cotton yearly, 2- year rotation = cotton followed by wheat then corn and 3- year rotation = cotton followed by clover then corn followed by wheat then corn.
2. Fertilization treatments: 0 = without fertilizers (control), N with a rate of 15 kg N\fad. for cotton and wheat and 22.5 kg N\fad. for corn added as ammonium nitrate (33.5% N), NP = N with the same level + P with the level of 23.25 kg P_2O_5\ fed. in the form of calcium superphosphate (15.5 % P_2O_5), NPK = NP + K with 48 kg K_2O\ fed. as potassium sulphate (48% K_2O), while farmyard manure (FYM) is added at a rate of 15 ton\ fed. The rate of such fertilizers is added for each crop.
3. Soil sampling: Disturbed soil samples were collected from two successive layers namely: 0 - 30 and 30 – 60 cm of the various plots of different fertilization treatments mentioned above under 1- and 3 – year rotations.
4. Determination: soil samples were air dried, crushed and sieved through 2 mm sieve for chemical analysis according to Jackson (1973). Electrical conductivity (EC) as dS/m at 25 C° and soluble ions were determined in (1:5) soil water extract, while pH value was measured in soil paste using Beckman's pH meter. Organic matter percentage was determined using the modified Walkely and Black's method, Jackson (1973). Soluble nitrogen, available phosphorus and potassium were also measured according to Jackson (1973). Data obtained in 2007 were compared to those presented in 1989 (El-Shafie, 1989).

Statistical analysis was done for all properties according to Snedecor and Cochran (1980).

RESULTS AND DISCUTION

Soil chemical properties studied in this work can be discussed under the following sub-headings:-

1. Electrical conductivity (E.C.):

Data presented in Table (1) indicate that the three factors under study had a significant effect on soil EC. Soil samples taken from three-years rotation recorded significantly higher EC values than those of one-year rotation.

With respect to fertilization treatments, a highly significant increase of EC value could be seen for farmyard manure treatment compared to mineral fertilization treatments or untreated one. This result is probably due to the added farmyard manure itself, which may contain some salts in its raw material. In this connection and on the contrary, Clark *et al*. (1998) mentioned that the addition of animal manures for 8 years in California's Sacramento Valley did not increase salinity.

Concerning the effect of soil profile depth, EC of the surface layer (0 – 30) was significantly lower than that of the subsurface one. The increase of EC value in deeper layer may be due to the leaching of soluble salts from the surface layer as a result of the efficient drainage system established in the Bahtim experimental plots.

It is worthy to mention that, as a combined effect, the highest value of such property was observed in the deeper layer (30-60) of plots received farmyard manure under 3-years rotation, indicating a quite similar trend to that found in case of the individual factors.

From data in Table (1) noted that the trend of electrical conductivity (EC) recorded in 2007 differed much from that in 1989 where the adverse trend of rotation and fertilization treatments occurred throughout the last nineteen years.

Table (1): Effect of crop rotation, fertilization practices and soil depth on electrical conductivity (EC), soil reaction (pH) and organic matter (OM) % of the Bahtim permanent experimental plots since 1989 till 2007

Fertilization treatments	1989 Rotation One - year 0-30	30-60	Three - years 0 -30	30 - 60	Fertl. Treat. (AV.)	2007 Rotation One - year 0 -30	30 - 60	Three - years 0 -30	30 - 60	Fertl. Trea. (AV.)
	EC in soil water extract 1 :5 (dS/m) at 25 C°									
Unfertl.	0.55	0.65	0.51	0.43	0.54	0.47	0.48	0.50	0.70	0.54
N	0.68	1.00	0.60	0.47	0.69	0.44	0.51	0.52	0.63	0.53
NP	0.44	0.82	0.55	0.76	0.64	0.46	0.56	0.62	0.55	0.55
NPK	0.48	0.73	0.78	0.63	0.66	0.49	0.53	0.64	0.56	0.56
FYM	0.76	0.48	0.65	0.64	0.63	0.70	0.78	0.73	0.90	0.78
Depth (Av) 0-30	0.60					0.56				
Depth (Av) 30-60	0.66					0.62				
Rotation (Av)	0.66		0.60			0.54		0.63		
L.S.D at 5%	*A=0.02 **B=0.04 ***C=0.02					A=0.02 B=0.03 C=0.02				
	Soil reaction (pH)									
Unfertl.	8.30	8.15	8.18	8.50	8.28	8.20	8.19	8.41	8.22	8.26
N	8.25	8.35	8.03	8.20	8.21	8.12	8.11	8.03	8.12	8.10
NP	8.30	8.20	8.10	8.15	8.19	8.07	8..05	8.26	8.37	8.19
NPK	8.25	8.30	7.95	8.45	8.24	8.12	8.04	8.19	8.25	8.15
FYM	7.73	8.30	8.03	8.15	8.05	8.00	8.01	8.00	7.99	8.00
Depth (Av) 0-30	8.11					8.14				
Depth (Av) 30-60	8.28					8.14				
Rotation (Av)	8.21		8.17			8.09		8.18		
L.S.D at 5%	A=0.02 B=0.04 C=0.02					A=0.04 B=0.04 C=Ns				
	organic matter (OM) %									
Unfertl.	0.89	0.72	1.19	0.72	0.88	1.12	1.04	1.20	1.23	1.15
N	0.65	0.55	0.90	0.78	0.72	1.61	1.52	1.66	1.50	1.57
NP	0.79	0.61	0.86	0.78	0.76	1.40	1.61	1.90	1.63	1.64
NPK	0.95	0.67	0.98	0.80	0.85	1.60	1.46	1.48	1.66	1.55
FYM	1.74	0.69	1.55	1.01	1.25	2.36	2.28	2.31	2.41	2.34
Depth (Av) 0-30	1.05					1.66				
Depth (Av) 30-60	0.73					1.63				
Rotation (Av)	0.82		0.95			1.60		1.70		
L.S.D at 5%	A=0.09 B=0.14 C=0.09					A=0.02 B=0.04 C=0.02				

***A= crop rotation** ****B=fertilization** *****C=depth (cm)**

2. Soil reaction (pH):

Data illustrated in Table (1) show that crop rotation and fertilization affected significantly soil reaction (pH), while the effect of soil profile depth didn't reach the significance level on such trait. The plots of 1-year rotation recorded the lower pH values than those of 3- years one. On the other hand, the plots fertilized with organic manure (FYM) had the lowest values of such property, while the highest ones were recorded for the unfertilized plots. The elucidation of the last result could be based on the higher content of organic matter in plots received FYM as buffering agent, which plays an important role on soil buffering action.

Results also revealed that the lowest pH value was noticed in the plots receiving farmyard manure either in one-year rotation or three-year one. This result may be due to that the most important role, herein, on such property is attributed to fertilization factor.

It could be noticed that as a general pattern, the pH values estimated in 2007 are nearly in similarity to those determined in 1989, however, the trend of such pH values was a little bit different due to the effect of crop rotation and soil depth, where the adverse trend of crop rotation effect occurred in 2007 as mentioned previously, while the effect of fertilization was the same throughout the last nineteen years.

3- Soil organic matter content (OM) %:

Data in Table (1) revealed that all variables under study had a significant effect on the percentage of soil organic matter. Apparently, such property of 3- years rotation was significantly higher than that of 1- year rotation. These may be attributed to the different plant types and higher amounts of roots, which remain after harvesting, consequently produce more organic matter. This result is coinciding with that obtained by Steinbrenner and Smukalski (1984). In this connection, Benjamin and Mikha (2007) concluded that a winter wheat, corn, millet rotation had greater organic carbon than the winter wheat, fallow rotation in the cropping intensity in the Central Great Plains.

Concerning the effect of fertilization treatments, results postulated that the effect of organic manure on organic matter content % preceded significantly the mineral fertilization treatments or unfertilized one, since it revealed an average increase amount to about 50% more than the treatments mentioned before. This result is acceptable because of the annual application of farmyard manure, which contains a larger amount of organic matter (Clark *et al.*, 1998). On the other hand, all mineral fertilization treatments gave a significant increase in OM content compared to the unfertilized one. The latter result may be due to the higher crop yield resulted from mineral fertilization, and consequently higher decayed roots remained after harvesting, which produced more organic matter. In this respect, Rudrappa *et al.* (2006) indicated that in semi-arid sub-tropical India, there was an improvement in total organic carbon in 100% NPK or 100% NP over 100% N in the surface soil.

Regarding the effect of soil profile depth, soil surface layer (the ploughed layer) showed a significant increase in soil organic matter than the subsurface one. This result agrees, to some extent, with Vigil *et al*. (2005).

It is worthy to mention that the highest values of OM % were realized with the application of organic manure (FYM) regardless to either crop rotation or soil depth that confirms the most important effect on such property is fertilization.

Generally, results referred that soil organic matter content during the period of 1989-2007 differed, to some extent, where they were increased throughout that period estimated to about a fold as a result of long – term fertilization. However, the trend of such property due to the studied factors in 2007 is similar to that recorded in 1989.

4- Total soluble ions:

4-1 Total soluble cations.

Data in Table (3) revealed that soluble sodium was the dominant cation in all soil samples followed by magnesium, calcium and potassium.

Table (2): Effect of crop rotation, fertilization practices and soil depth on water soluble ions (meq/L) in the Bahtim permanent experimental plots in 1989

Fertil. treatments	Depth (cm)	1989													
		One-year							Three-years						
		Cations				Anions			Cations				Anions		
		Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}
	Water soluble cations and anions as meq/L (Soil : water extract 1 : 5)														
Unfertl.	0 -30	4.50	2.96	0.54	4.54	5.50	5.51	1.53	4.92	3.56	0.43	2.82	5.80	2.76	3.17
	30 - 60	3.40	2.56	0.45	3.80	5.08	4.50	0.63	1.18	3.80	0.45	3.78	4.16	3.00	2.05
N	0 -30	3.54	2.64	0.34	2.57	3.90	1.85	3.34	6.12	2.85	0.31	2.52	5.51	1.90	4.39
	30 - 60	3.70	2.48	0.38	3.70	4.00	3.60	2.66	4.42	1.30	0.22	1.28	4.72	1.40	0.92
NP	0 -30	2.89	2.08	0.33	3.50	3.53	2.76	2.51	5.14	3.69	0.45	3.30	4.96	2.64	4.98
	30 - 60	2.10	2.55	0.38	5.60	5.10	4.24	1.30	3.64	4.66	0.41	2.80	6.65	2.40	2.51
NPK	0 -30	4.07	1.86	0.62	4.68	3.94	2.79	4.50	6.01	2.98	0.58	3.61	6.34	2.25	4.60
	30 - 60	4.52	1.44	0.42	3.70	5.60	3.04	1.44	3.00	2.72	0.48	2.56	5.24	3.14	0.38
FYM	0 -30	8.04	4.55	1.20	4.28	5.55	3.83	8.69	8.52	4.56	1.47	4.88	6.70	4.99	7.74
	30 - 60	5.96	3.90	0.38	1.92	3.80	3.92	4.44	6.82	4.42	1.02	3.62	7.10	7.26	1.52

- **Results obtained showed no response of soluble carbonate.**
- **Sulfate values were calculated by difference between total soluble cations and total soluble anions.**

Table (3): Effect of crop rotation, fertilization practices and soil depth on water soluble ions (meq/L) of the Bahtim permanent experimental plots in 2007

Fertilization treatments	Depth (cm)	2007													
		One-year							Three-years						
		Cations				Anions			Cations				Anions		
		Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{--}
	Water soluble cations and anions as meq/L (Soil : water extract 1 : 5)														
Unfertl.	0 -30	1.00	1.50	0.14	2.25	1.00	1.00	2.89	1.00	1.50	0.01	3.25	1.00	2.00	2.76
	30 - 60	1.00	1.50	0.10	2.50	0.50	1.50	3.10	1.00	2.00	0.26	4.00	1.50	2.00	3.76
N	0 -30	0.50	1.50	0.12	2.50	1.00	1.25	2.37	1.50	1.50	0.04	2.50	1.00	1.00	3.54
	30 - 60	1.00	2.50	0.11	3.00	1.00	1.50	3.11	0.50	1.50	0.13	4.50	2.00	2.00	2.63
NP	0 -30	1.00	1.25	0.11	2.50	1.00	1.00	2.86	1.00	2.00	0.12	3.50	1.50	1.50	3.62
	30 - 60	1.50	2.00	0.13	2.50	1.00	1.25	3.88	1.00	2.50	0.12	2.25	1.00	1.00	3.87
NPK	0 -30	1.00	1.50	0.11	2.50	1.00	1.00	3.11	1.50	2.00	0.13	4.00	1.50	2.00	4.13
	30 - 60	1.58	2.00	0.11	2.50	1.00	1.25	3.86	1.50	1.50	0.11	3.00	1.00	1.50	3.61
FYM	0 -30	1.25	1.40	0.26	4.25	2.00	2.00	3.16	2.00	2.60	0.12	3.00	1.00	1.50	5.22
	30 - 60	1.00	1.50	0.14	4.25	2.00	2.00	2.89	2.00	3.00	0.19	4.00	1.00	2.50	5.89

With regard to the effect of crop rotation, soluble cations of soil samples taken from 3-year rotation plots were relatively higher than those of 1-year rotation, except for those of potassium, which took the adverse trend. This result is in agreement, to somewhat, with that obtained by Abdel-Naim *et al*. (1981).

Dealing with the effect of fertilization treatments, all soluble cations were higher in the plots treated with farmyard manure than those of mineral fertilization treatments or unfertilized one. Such result may be due to the higher organic matter content (Table, 1) in the plots fertilized with farmyard manure which resulted in more soluble cations (Clark *et al*., 1998). On the other hand, no clear differences in soluble Mg^{++}, Na^{+} and K^{+} could be noticed among the plots received mineral fertilizers, however, soluble calcium was relatively higher in the plots of NP or NPK than those of N or unfertilized one. This result may be attributed to the continuous application of phosphates' fertilizer (calcium superphosphate) which contains calcium salts.

Regarding the effect of soil profile depth, in general, no clear difference in soluble cations could be noticed between the surface and subsurface layers, but it could be said that soil subsurface layer contained a little increase in soluble cations compared to surface one.

Data also scored that the highest values of soluble cations were existed in the subsurface layer of the farmyard manure plots under 3-years rotation, with exception of Na^{+} concentration, which was the highest in the subsurface layer of N treatment under 3-years rotation. This result may be attributed to the effect of individual factor, mentioned above on such cations. This result stand in accordance, to somewhat, with that of Heggi (1976).

In general, it can be concluded that the most effective factor on soil soluble calcium, magnesium concentration was soil organic matter, while sodium was mainly affected by soil salinity (Table, 1).

To shed light on the influence of the factors under study throughout the period of 1989-2007, the results in Tables (2&3) show that the trend of soil soluble Ca^{++} and Mg^{++} in 2007 is nearly similar to that found in 1989 especially the effect of fertilization, while the trend of soil soluble K^{+} or Na^{+} is different. The values of K^{+} were the highest in the surface layer by using organic manuring under 1-year rotation while those recorded in 1989 were the highest in the surface layer of the plots treated with NPK fertilizer or farmyard manure. For Na^{+}, the highest values were recorded in the subsurface layer of the plots fertilized with farmyard manure under 1-year rotation or the plots treated with N fertilizer under 1-year rotation while in 1989, values of Na^{+} were the highest in the subsurface layer of NP treatment or the surface one of FYM treatment, indicating the effect of soil salinity on such cation (Table, 1).

4.2. Total soluble anions:

Data in Table (2) indicated that soluble sulphate was the dominant anion in all samples. The effect of the studied factors on soluble anions is nearly parallel to that of soluble cations. The plots of 3-years rotation contained more soluble anions than those of 1-year rotation and such effect was remarkable on sulphate anion. At the same time, long–term fertilization of farmyard manure resulted in the highest concentrations of soluble anions in compared with the addition of mineral fertilizers or no addition, however, application of complete mineral fertilizer (NPK) existed in nearly similar sulphate anion to that of organic manureing. This may be due to the continuous application of potassium in the form of potassium sulphate and that reflected on more sulphate anion. No obvious trend could be observed due to the effect of soil depth.

It is quite interesting to mention that the influence of long-term fertilization, crop rotation and soil sampling depth on soluble anions in 2007 in comparison with 1989 took nearly a similar trend. However, the values of such soluble anions were lower in 2007 than those in 1989.

5- Nutritional status:

5-1-Available nitrogen

Results presented in Table (4) show that fertilization treatments and soil depth affected significantly available soil nitrogen but the effect of crop rotation did not reach the significance level.

Concerning the effect of fertilization treatments, the permanent addition of mineral fertilizer increased significantly available nitrogen compared to no addition of such fertilizers but these increases were significantly lower than that in the plots treated with farmyard manure. Considering soil depth, soil surface layer contained significantly higher available nitrogen content than the subsurface one. It is worthy to note that, as combined effect, the soil surface layer of the plots fertilized with farmyard manure under 3-years rotation contained the highest available nitrogen of the other treatments.

This finding could be elucidated to the fact that farmyard manure contains a quite respectable ratio of organic nitrogen, which therefore, is more effective in raising total soil nitrogen especially in the surface layer where mineralization process increases as a result of increasing biological activities, consequently more available nitrogen.

Comparing the effect of the studied factors on available soil nitrogen in 2007 and that in 1989, it could be noticed that the values of such nutrient in 2007 were slightly higher than those in 1989. The effect of long-term organic and inorganic fertilization and soil depth was nearly similar throughout such period (Table 4). However, the influence of crop rotation has been different since the crop rotation didn't significantly affect available nitrogen in 2007. Moreover, the combined effect of the factors under study has not nearly changed.

5.2. Available phosphorus:

Data in Table (4) indicated that 3-years rotation resulted in a slight increase in available phosphorus comparing with 1-year rotation but such increase didn’t reach the significance level. Such slight decrement of available phosphorus in the plots of 1-year rotation may be due to the continuous cropping of cotton plants yearly in that rotation along more than 95 years wich resulted in the depletion of available phosphorus. On the other hand, the slight increase in available P under 3-year rotation may be due to the better soil management under such rotation which favors soil aggregation, consequently increase the availability of applied phosphorus.

This finding agrees with that concluded by Steinbrennen and Smukalski (1984).

Table (4): Effect of crop rotation, fertilization practices and soil depth on available nitrogen, phosphorus and potassium content (mg/100 g soil) of the Bahtim permanent experimental plots since 1989 till 2007

Fertilization treatments	1989				Fertl. Treat. (AV.)	2007				Fertl. Treat. (AV.)
	Rotation					Rotation				
	One - year		Three - year			One - year		Three - years		
	0 -30	30 - 60	0 -30	30 - 60		0 -30	30 - 60	0 -30	30 - 60	
	Available Nitrogen(mg N/100 g soil)									
Unfertl.	6.88	4.50	6.63	5.50	5.88	3.75	3.75	3.75	3.70	3.74
N	6.13	5.50	7.38	6.50	6.38	6.25	5.15	6.25	5.25	5.73
NP	6.50	4.75	7.88	7.00	6.53	6.25	5.75	5.80	5.15	5.74
NPK	7.00	5.50	7.75	7.50	6.94	5.75	5.50	6.00	5.70	5.74
FYM	8.63	4.25	9.13	7.25	7.32	6.25	5.00	6.50	5.80	5.89
Depth (Av) 0-30	7.39					5.66				
Depth (Av) 30-60	5.83					5.08				
Rotation (Av)	5.96		7.25			5.34		5.39		
L.S.D at 5%	A=0.03 B=0.05 C=0.03					A=Ns B=0.12 C=0.08				
	Available phosphorus (mg P/100 g soil)									
Unfertl.	0.94	0.30	1.29	0.48	0.75	1.28	1.28	1.35	1.28	1.30
N	0.87	0.57	1.75	0.36	0.89	1.45	1.44	1.44	1.45	1.45
NP	1.65	0.78	2.73	1.02	1.55	1.52	1.52	1.60	1.52	1.54
NPK	1.91	1.07	2.67	0.42	1.52	1.60	1.44	1.60	1.45	1.52
FYM	2.43	2.25	2.65	1.08	2.10	1.60	1.52	1.70	1.44	1.57
Depth (Av) 0-30	1.89					1.51				
Depth (Av) 30-60	0.83					1.43				
Rotation (Av)	1.50		1.74			1.46		1.48		
L.S.D at 5%	A=0.01 B=0.02 C=0.01					A=Ns B=0.05 C=0.03				
	Available potassium (mg K/100 g soil)									
Unfertl.	3.81	3.58	3.40	2.25	3.26	1.24	1.22	1.41	1.34	1.30
N	4.35	3.53	3.43	2.46	3.44	1.16	1.18	1.18	1.18	1.18
NP	3.89	2.40	3.25	2.71	3.06	1.23	1.35	1.23	1.19	1.25
NPK	5.14	3.38	3.79	2.97	3.82	1.50	1.31	1.45	1.18	1.36
FYM	6.45	4.04	5.23	4.71	5.11	1.50	1.50	1.50	1.38	1.47
Depth (Av) 0-30	4.27					1.36				
Depth (Av) 30-60	3.20					1.28				
Rotation (Av)	4.05		3.42			1.32		1.30		
L.S.D at 5%	A=0.02 B=0.03 C=0.02					A=0.02 B=0.03 C=0.02				

With regard to the effect of fertilization, data indicate that available soil phosphorus of the unfertilized plots followed by that received nitrogen alone were lower than those of the other mineral or organic treatments. At the same time, the highest values of such nutrient were realized in the plots treated with P or organic fertilizer with no significant differences among them. These results are quite logic indicating that the soil supplying power for available phosphorus was affected during long history of the experiment, so the effect of superphosphate applications affected significantly the available phosphorus content. Meanwhile, N applications and organic one which increase biological activity in soil on one side, and enhanced plant growth on the other side, reflects on transferring non available P to available forms. Such result is in agreement with that obtained by Clark *et al.* (1998).

The effect of soil depth is respectable, as the soil surface layer significantly contained higher available P than the subsurface one regardless different factor under study. This result may be due to, on one hand the effect of higher organic matter content in the surface layer mentioned previously and on the other hand to the slow movement of that nutrient through soil profile.

Results also revealed that soil surface layer of the plots fertilized with organic manuring or P fertilizer under the 3-year rotation contained the highest available soil phosphorus. Such finding is similar to that found in case of individual factors.

It is obvious that the influence of long – term fertilization and soil sampling depth during the period of 1989 to 2007 was similar while that of crop rotation was similar, to somewhat, where that effect didn't reach the significance level.

5.3. Available potassium:

Data in Table (4) show that all the three variables undur studies are of significant effect on available soil potassium. For rotations, available K of 1-year rotation was significantly higher than that of 3-year one. Similar result was obtained by Abdel-Naim *et al*. (1981).

Concerning fertilization treatments, the highest values of such element were significantly realized by the addition of farmyard manure. This result could be due to the effect of continuous and annual addition of farmyard manure (Clark *et al.*, 1998). On the other hand, potassium application in the NPK treatment increased significantly the available soil potassium compared to any other mineral treatments or unfertilized one.

Regarding the effect of soil depth, available K in the soil surface layer was higher than that in the deeper one. This result may be interpreted to the high absorption of available K in the depth of 30-60 cm which is considered as the active soil zone of root growth.

The combined effect among the studied factors was similar to that found in case of individual ones. In other words, the highest value of available K was realized in the surface layer of the plots fertilized with farmyard manure or complete mineral fertilizer (NPK) and located under 1-year rotation while the lowest one was found in the subsurface layer of the plots treated with N fertilizer alone and located under the 3-years rotation. Such result could be elucidated to the accelerated exhaustion of the available K by successive crops grown under the 3-years rotation system with no adequate compensation comparing with those grows under 1-year rotation.

Comparing the influence of the studied treatment on available potassium in 2007 and that in 1989, it could be noticed that the trend of available K was similar due to all factors under study. However, available K values recorded in 2007 were lower than those found in 1989.

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تأثير الاستخدام طويل المدي للاسمدة العضوية والمعدنيه والدورة الزراعية علي بعض خواص التربة خلال تسعة عشر عاما بالتجربة المستديمة ببهتيم
٢- الخواص الكيميائية.

عبد العزيز ابراهيم الدسوقي الشافعي ، حسين محمود خليل ، اسامه صلاح الدين البيلي
معهد بحوث الاراضي والمياه والبيئة – مركز البحوث الزراعية – الجيزة - مصر

أخذت عينات تربة مثارة تمثل الطبقة السطحية وتحت السطحية لقطع تجربة التسميد المستديم ببهتيم لدراسة تأثير التسميد المستديم خلال السنوات من ١٩٨٩الي ٢٠٠٧ تحت نظام دورة زراعية احادية وثلاثية علي بعض صفات التربة الكيماوية ممثلة في التوصيل الكهربائي ، تفاعل التربة ، محتوي التربة من المادة العضوية ، والأيونات الكلية الذائبة وكذالك الحالة الغذائية (ن ، فو ، بو الميسرة).

ولقد أشارت النتائج ان قطع الدوره الثلاثية سجلت اعلي قيم معنوية للتوصيل الكهربائي لمستخلص التربة ، تفاعل التربة وكذا محتوي التربة من المادة العضوية. وكان ايون الصديوم هو السائد في عينات التربة يليه ايونات الماغنسيوم ثم الكالسيوم ثم البوتاسيوم بينما كانت ايونات الكبريتات هي السائدة يليها الكلوريد ثم البيكربونات. ولقد كانت الكاتيونات الذائبة فيما عدا البوتاسيوم وايضا الانيونات بالاضافة الي النتروجين والفوسفور الميسر اعلي نسبيا تحت نظام الدورة الثلاثية عنه في الدورة الأحادية ، بينما كان هناك اتجاها مخالفا فيما يخص البوتاسيوم الذائب والميسر. ادي التسميد العضوي الي زيادة معنوية في قيم التوصيل الكهربائي وكذا زيادة معنوية عالية لمحتوي التربة من المادة العضوية مقارنة بالاسمدة المعدنية او بدون تسميد. فيما كان اتجاه تفاعل التربة عكسيا . ايضا ، كانت الكاتيونات والانيونات الذائبة اعلي نسبيا باستخدام السماد العضوي عن الاسمده الاخري فيما عدا المعاملة المتكاملة للسماد المعدني ، النيتروجين والفوسفور والبوتاسيوم والتي اعطت نفس الانيونات الذائبة.

أدي اضافة السماد العضوي الي تحسين الحالة الغذائية للتربة مقارنة بكافة معاملات التسميد المعدني حيث كانت قيم النيتروجين والفوسفور والبوتاسيوم الميسر اعلي باستخدام التسميد العضوي . احتوت الطبقة السطحية علي مادة عضوية وكذا النتروجين والفوسفور والبوتاسيوم الميسر اعلي من مثيلتها في الطبقة التحت سطحية بينما كان الاتجاه عكسيا بالنسبة للكاتيونات الذائبة ، ايضا ، لوحظ انه لم يكن هناك اتجاها واضحا لتأثير العمق علي تفاعل التربة وكذا الانيونات الذائبة.

لم تحدث اختلافات واضحة لبعض صفات التربة الكيماوية مثل العناصر الميسرة (ن ، فو ، بو) ، الكالسيوم والماغنسيوم الذائب ، الانيونات الذائبة وكذالك محتوي التربة من المادة العضوية مع زيادتها نسبيا كنتيجة للدوره الزراعية والتسميد علي المدي الطويل خلال التسعة عشر عاما الاخيرة . وعلي النقيض ، كان هناك اتجاها مخالفا للتوصيل الكهربائي والصوديوم والبوتاسيوم الذائب فيما يتعلق بتأثير التسميد والدورة الزراعية بينما اخذ تفاعل التربة اتجاها مخالفا بتأثير الدورة الزراعية فقط . ايضا حدث اختلاف للايونات الذائبة السائدة في التربة في عام ٢٠٠٧ عنها في عام ١٩٨٩ حيث كانت ايونات الصوديوم والكبريتات هي السائدة في عام ٢٠٠٧.