# EFFECT OF LAND USE PERIODS ON THE STATUS AND AVAILABILITY OF PHOSPHORUS AND SOME MICRONUTRIENTS IN NEWLY RECLAIMED SOILS OF EGYPT

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**Khadr, M. Y. A., Eid, M. A. M., and Mubarak, D. M. F.**

*Department of Soil Science, Faculty of Agriculture, Ain Shams Univ., Shobra El-Kheima, Cairo, Egypt.*

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## ABSTRACT

Soil profiles and plant samples from Typic Torripsamments (Dina agricultural project) and Calcids (Matco farm) were collected to evaluate and monitor changes of soil phosphorus forms and focusing on the status of some micronutrients after different agriculture production periods. Results revealed that, the increases of soil available P (Pa), inorganic P (Pi), available Fe, Mn, Zn and Cu were not significant, while organic P (Po) was significant with increasing the period of soil cultivation. In addition data obtained showed that, concentrations of P, Fe and Mn in all plant samples were generally in sufficient amounts, while Zn and Cu were low. Not only that but, very highly significant correlation between organic matter content and all P forms and micronutrient suggested the importance of organic matter application. Thus, it could be concluded that, organic matter seems to be very important for improving soil characteristics and increasing the availability of macro and micronutrients.

**Key words:** Newly reclaimed soil – Torripsamments – Calcids – Phosphorus fractions - Micronutrients availability – Cultivation period –Plant tissue analysis.

## INTRODUCTION

Agricultural security in Egypt depends largely on the horizontal extension by reclaiming sandy and calcareous soils. These soils are poor with respect to their physical, chemical and biological characteristics and nutrient economy. As soon as the soil is put under intensive cropping, many changes in its properties usually occur especially their nutrients availability. Westerman *et al.,* (1990) reported that the P fertilizer rate recommendation for a field must be based on local correlation and calibration information for soils, crops and cultural practices appropriate to the region.

The objective of this study was to evaluate the effects of cropping practices and periods for sandy (Torripsamment) and calcareous (Calcid) soils on the status of soil Fe, Mn, Zn, Cu, different forms of soil P and their availability to plants.

Fractionation of phosphorus has been used to identify P forms in soil and to evaluate their dynamics in relation to cropping practices.

Such work are required and needed to help the users of sandy and calcareous soils to establish proper soil and fertilization managements.

# MATERIALS AND METHODS

**Soil sampling:**

Two sites were selected to represent different soil characteristics and periods of cultivation for sampling. The first site lies west of the Nile Delta at 80 km of Cairo – Alexandria desert road and the second site is located in El-Nobariya area northwest of the Nile Delta, at 150 km from Cairo – Alexandria desert road, (western desert), Egypt.

From a private agricultural project (Dina farm) five soil profiles were selected to represent different periods of cultivation and two profiles were selected from private vegetable farm (Matco farm).

The selected areas covered a wide range of cultivation periods, i.e. virgin soil, 4, 7 and 9 years, different irrigation systems (sprinkler and drip irrigation) and soil management practices. Some characteristics of soil samples were shown in Table 1.

Samples of irrigation water were collected from Dina farm and Matco farm. Water samples are characterized by pH 7.7 and 8.0 and EC 0.34 and 0.67 $mScm^{-1}$ for Dina farm and Matco farm respectively. Samples of drainage water from Matco farm was also collected and characterized by pH 8.6 and EC 4.37 $mScm^{-1}$.

**Soil management:**

Fertilization management for the first location was based on the use of organic and mineral fertilizers. For soil planted with apple trees, $0.01m^3$ cow manure was mixed with 200 g ammonium sulfate,

**Table (1). Soil reaction (pH), saturation percent (SP), ECe, organic matter (OM) and calcium carbonate of different soil profiles.**

| No | Irrigation system | Veget -ation | Depth (cm) | pH S. paste | SP % | ECe dS/m | OM % | $CaCO_3$ % |
|---|---|---|---|---|---|---|---|---|
| | | | Soil profiles of Torripsamment | | | | | |
| | | | Virgin soil | | | | | |
| 1 | Non | Non | 0-20 | 7.3 | 28 | 12.3 | 0.83 | 9.1 |
| | | | 20-40 | 7.4 | 27 | 10.7 | 0.05 | 9.2 |
| | | | 40-60 | 7.5 | 23 | 11.7 | 0.10 | 3.5 |
| | | | Soil cultivated for 7 years | | | | | |
| 2 | Drip | Apple | 0-10 | 7.5 | 29 | 2.90 | 0.64 | 4.2 |
| | | | 10-20 | 7.6 | 31 | 0.87 | 0.29 | 9.8 |
| | | | 20-50 | 7.8 | 36 | 0.55 | 0.11 | 6.5 |
| | | | 50-75 | 8.1 | 41 | 0.51 | 0.08 | 3.8 |
| 3 | Sprink -ler | Maize | 0-20 | 7.0 | 25 | 4.21 | 0.86 | 4.2 |
| | | | 20-30 | 7.5 | 24 | 3.00 | 0.17 | 2.5 |
| | | | 30-65 | 7.6 | 26 | 2.40 | 0.04 | 1.9 |
| | | | >65 | 7.6 | 25 | 2.78 | 0.03 | 1.0 |
| | | | Soil cultivated for 9 years | | | | | |
| 4 | Drip | Apple | 0-10 | 7.4 | 31 | 6.57 | 1.43 | 8.6 |
| | | | 10-20 | 7.3 | 33 | 1.60 | 1.55 | 6.9 |
| | | | 20-40 | 7.2 | 40 | 1.66 | 3.65 | 5.9 |
| | | | 40-60 | 7.7 | 26 | 0.79 | 0.14 | 2.8 |
| 5 | Sprink -ler | Maize | 0-10 | 7.5 | 27 | 4.70 | 0.86 | 2.5 |
| | | | 10-20 | 7.4 | 24 | 6.52 | 0.32 | 1.3 |
| | | | 20-30 | 7.8 | 23 | 2.50 | 0.03 | 0.8 |
| | | | 30-50 | 8.0 | 26 | 2.12 | 0.01 | 0.7 |
| | | | 50-70 | 7.5 | 24 | 2.80 | 0.01 | 1.0 |
| | | | 70-90 | 7.6 | 22 | 2.86 | 0.02 | 1.4 |
| | | | Soil profiles of Calcid | | | | | |
| | | | Virgin soil | | | | | |
| 6 | Non | Non | 0-30 | 7.6 | 33 | 7.41 | 0.25 | 12.3 |
| | | | 30-60 | 7.7 | 48 | 8.25 | 0.12 | 21.6 |
| | | | 60-80 | 7.9 | 49 | 3.58 | 0.11 | 24.6 |
| | | | 80-100 | 8.1 | 64 | 2.56 | 0.12 | 25.3 |
| | | | Soil cultivated for 4 years | | | | | |
| 7 | Drip | Potato | 0-30 | 7.8 | 41 | 1.7 | 0.19 | 17.9 |
| | | | 30-60 | 7.6 | 45 | 6.53 | 0.18 | 34.9 |
| | | | 60-80 | 7.8 | 50 | 6.35 | 0.07 | 25.7 |
| | | | 80-100 | 7.7 | 65 | 5.12 | 0.07 | 27.5 |

750 g super phosphate and 200 g potassium sulfate then applied to subsoil around each tree for only the first four years.

Mineral fertilizer was added during irrigation. The yearly total amount was 63 kg N as ammonium nitrate, 63 kg K as potassium sulfate and 8.4 kg P as phosphoric acid /fed. Foliar micronutrients were applied as 1 kg of mixed Fe, Mn and Zn as chelated form in 600 l/fed 3 times yearly.

For the soil planted with field crops, fertilizer was applied before vegetation. Mineral fertilizers were generally added at rates of 100 kg/fed ammonium sulfate, 100 kg/fed potassium sulfate and 200 kg/fed super phosphate with culture practice and 100 kg/fed ammonium nitrate during growth season. The crop rotation in the 7 years cultivated soil was maize, clover and barley and in the soil cultivated for 9 years was alfalfa, maize, potato, maize, barley and maize.

The chosen profiles from the second location were cultivated with field crops. Fertilization management was based on addition of cow manure as organic fertilizer at rate of 20 $m^3$/fed with culture's practice. The crop rotation includes vegetable crops. The used mineral fertilizers were generally similar to the mineral fertilizers management which was mentioned in the first location. Foliar micronutrients were applied as 1 kg of mixed Fe, Mn and Zn as chelated form in 600 l/fed. This practice was applied depending on the deficiency symptoms of plants.

**Methods of analysis:**

Soil samples (from 3 to 6 samples for each profile) were taken, air dried, ground and sieved through a 2 mm stainless steel sieve and stored in plastic bags for different analysis.

Particle size distribution was carried out by international pipette method for the coarse – textured soils (Baruah and Barthakur, 1997). The textures of soil samples varied from sand to sandy loam (data not shown).

All soil chemical properties were determined according to Page *et al.,* (1982). Calcium carbonate content was measured volumetrically using Collin's Calcimeter. Organic matter was determined by oxidizing with potassium dichromate technique. Soil pH were determined in the soil paste using pH – meter. Electrical conductivity (ECe) was determined in the saturated extract by using standard conductivity bridge at 25$^{o}$C.

**Forms of soil phosphorus:**

a- bicarbonate-extractable (available) phosphorus (Pa) was extracted by shaking 2.5 g of air dried soil for 30min. with 50 ml of 0.5 M $NaHCO_3$ (pH 8.5) and then filtering. b- Inorganic phosphorus (Pi) was estimated from the 1 N $H_2SO_4$ extractable P in soil samples, where shaking 1 g soil for 16 h with 50 ml $H_2SO_4$ 1 N and centrifuging at ~ 1.500 x g for 15 min. c- Organic phosphorus (Po) was estimated by subtracting inorganic P from the phosphorus in ignited samples. One g of soil sample ignited in the muffle furnace at 550 $^{o}$C for 1 h, then phosphorus extracted as the same way at (Pi). The collected supernatants from b and c were neutralized with 5 N NaOH to pH 3. The 3 forms of phosphorus determined colorimetricaly by spectrophotometer using the ascorbic acid method at 880 nm. as described by Page *et al.,* (1982).

Available Fe, Mn, Zn and Cu were determined according to Lindsay and Norvell (1978) by shaking 30 g of soil with 60 ml of DTPA solution (pH 7.3) for 2h, filtering, and then analyzing the filtrate by atomic absorption spectroscopy.

**Plant sampling and analytical techniques:**

Plant samples of apple (Malus sylvestris var. Anna), onion (Allium sp.), potato (Solanum tuberosum var. Necola) and barley (Hordeum vulgare) were collected from the areas where soil samples had been obtained. Plant samples were collected according to the recommended parts by Jones *et al.,* (1971). Apple samples (from 7 and 9 years cultivation of sandy soils) were taken from leaves near base of currently year's growth, potato, onion and barley samples (from 4 years cultivation of calcareous soils) were shoots in early mature stages.

The plant samples were dried at 70 $^{o}$C at least 48 h, ground in stainless steel mill to pass through 1 mm sieve and kept in plastic containers for analysis.

Plant tissue contents of P, Fe, Mn, Zn and Cu were determined after 0.5 g samples were wet ashed in $H_2SO_4$-$H_2O_2$ mixtures and the digests were brought to 50 ml. Phosphorus content was determined by ascorbic acid-reduced molybdophosphoric blue colourimetry, Page *et* *al.,* (1982). Iron, Mn, Zn and Cu were measured by atomic absorption spectroscopy.

**Statistical analysis:**

Simple correlations were conducted between characteristics of studied soil samples and different soil forms of P and available of Fe, Mn, Zn and Cu. Also matrix correlation coefficients were conducted between all soil forms of P and available micronutrients according to Steel and Torrie (1980), using statgraph computer program.

## RESULTS AND DISCUSSION

**Phosphorus forms:**

The distribution of available phosphorus (Pa), inorganic phosphorus (Pi) and organic phosphorus (Po) forms among pools obtained from extractions of soil P is presented in Table 2. The amounts of Pa extracted by $NaHCO_3$ varied from 0.3 – 20.0 mg/kg and represented values from 0.6 – 11.7 % of total soil phosphorus (Pt) (Table 3). The amounts of Pi and Po varied from 19 – 1128 and from 2 – 334 mg/kg respectively. Inorganic P and Po represented 35.6 – 95.8 % and 2.4 – 65.4 % of Pt respectively. These differences of wide ranges could be attributed to cultivation period, soil type, soil management and soil depth.

It is interesting to note that there were high contents of Pi and Po with increase of OM in profile 4 at about 40 cm of soil depth (Table 1) in the first location with 9 years apple cultivation, which could be due to mixing of organic fertilizers with soil in ditches near the trees. But in the sprinkler irrigation system organic fertilizers was mixed with the soil surface by plowing. This observation was not found for the different profiles irrigated with drip system especially for the calcareous soil (Table 1) which may be due to the poor organic fertilizers application or the soil sampling did not include organic fertilizer ditches soils.

Correlation coefficients between different phosphorus forms and soil characteristics were represented in Table 4. These correlations indicated significant increases of all soil phosphorus forms with increasing contents of soil organic matter, but decreased significantly with increasing soil pH and soil depth. This showed that management practices of new reclaimed soils including irrigation, inorganic and organic fertilization and cultivation increased soil phosphorus

**Table (2). Distribution of available, inorganic and organic P fractions in different soil profiles.**

| No | Irrigation system | Veget -ation | Depth (cm) | Available P (Pa) | Inorganic P (Pi) | Organic P (Po) | Total P (Pt)=Pi+Po |
|---|---|---|---|---|---|---|---|
| | | | | mg/kg | | | |
| | | | Soil profiles of Torripsamments Virgin soil | | | | |
| 1 | Non | Non | 0-20 | 5.0 | 224 | 96 | 320 |
| | | | 20-40 | 1.4 | 46 | 47 | 92 |
| | | | 40-60 | 3.6 | 75 | 91 | 166 |
| | | | Soil cultivated for 7 years | | | | |
| 2 | Drip | Apple | 0-10 | 11.8 | 370 | 257 | 627 |
| | | | 10-20 | 9.0 | 187 | 128 | 315 |
| | | | 20-50 | 7.1 | 73 | 66 | 139 |
| | | | 50-75 | 4.4 | 44 | 42 | 87 |
| 3 | Sprink -ler | Maize | 0-20 | 3.4 | 227 | 79 | 306 |
| | | | 20-30 | 1.1 | 63 | 57 | 120 |
| | | | 30-65 | 0.6 | 43 | 65 | 108 |
| | | | >65 | 0.3 | 19 | 34 | 53 |
| | | | Soil cultivated for 9 years | | | | |
| 4 | Drip | Apple | 0-10 | 13.9 | 383 | 99 | 482 |
| | | | 10-20 | 11.6 | 375 | 129 | 504 |
| | | | 20-40 | 17.6 | 1128 | 239 | 1367 |
| | | | 40-60 | 6.3 | 56 | 59 | 115 |
| 5 | Sprink -ler | Maize | 0-10 | 11.8 | 322 | 53 | 375 |
| | | | 10-20 | 8.8 | 140 | 62 | 202 |
| | | | 20-30 | 2.4 | 60 | 69 | 129 |
| | | | 30-50 | 0.9 | 35 | 16 | 52 |
| | | | 50-70 | 1.8 | 175 | 334 | 509 |
| | | | 70-90 | 1.5 | 73 | 40 | 113 |
| | | | Soil profiles of Calcids Virgin soil | | | | |
| 6 | Non | Non | 0-30 | 8.0 | 76 | 36 | 112 |
| | | | 30-60 | 1.8 | 63 | 13 | 77 |
| | | | 60-80 | 1.5 | 83 | 2 | 85 |
| | | | 80-100 | 3.4 | 73 | 18 | 91 |
| | | | Soil cultivated for 4 years | | | | |
| 7 | Drip | Potato | 0-30 | 20.0 | 145 | 26 | 171 |
| | | | 30-60 | 3.8 | 55 | 22 | 76 |
| | | | 60-80 | 4.6 | 59 | 14 | 73 |
| | | | 80-100 | 3.8 | 60 | 21 | 81 |

**Table (3). Phosphorus forms as percentage of total phosphorus in different soil profiles.**

| No | Irrigation system | Veget -ation | Depth (cm) | Available P (Pa) | Inorganic P (Pi) % | Organic P (Po) |
|---|---|---|---|---|---|---|
| | | | Soil profiles of Torripsamments Virgin soil | | | |
| 1 | Non | Non | 0-20 | 1.6 | 68.9 | 29.5 |
| | | | 20-40 | 1.5 | 48.7 | 49.8 |
| | | | 40-60 | 2.2 | 44.2 | 53.6 |
| | | | Soil cultivated for 7 years | | | |
| 2 | Drip | Apple | 0-10 | 1.9 | 58.0 | 40.1 |
| | | | 10-20 | 2.9 | 57.7 | 39.5 |
| | | | 20-50 | 5.1 | 49.8 | 45.1 |
| | | | 50-75 | 5.1 | 48.5 | 46.3 |
| 3 | Sprink -ler | Maize | 0-20 | 1.1 | 73.4 | 25.5 |
| | | | 20-30 | 0.9 | 52.0 | 47.1 |
| | | | 30-65 | 0.6 | 39.6 | 59.9 |
| | | | >65 | 0.6 | 35.6 | 63.8 |
| | | | Soil cultivated for 9 years | | | |
| 4 | Drip | Apple | 0-10 | 2.9 | 77.2 | 19.9 |
| | | | 10-20 | 2.3 | 72.7 | 25.0 |
| | | | 20-40 | 1.3 | 81.5 | 17.2 |
| | | | 40-60 | 5.5 | 46.0 | 48.5 |
| 5 | Sprink -ler | Maize | 0-10 | 3.1 | 83.2 | 13.7 |
| | | | 10-20 | 4.4 | 66.3 | 29.4 |
| | | | 20-30 | 1.9 | 45.6 | 52.5 |
| | | | 30-50 | 1.8 | 67.4 | 30.8 |
| | | | 50-70 | 0.4 | 34.3 | 65.4 |
| | | | 70-90 | 1.3 | 63.7 | 34.9 |
| | | | Soil profiles of Calcids Virgin soil | | | |
| 6 | Non | Non | 0-30 | 7.1 | 63.2 | 29.7 |
| | | | 30-60 | 2.3 | 80.8 | 16.9 |
| | | | 60-80 | 1.7 | 95.8 | 2.4 |
| | | | 80-100 | 3.7 | 77.1 | 19.2 |
| | | | Soil cultivated for 4 years | | | |
| 7 | Drip | Potato | 0-30 | 11.7 | 74.9 | 13.4 |
| | | | 30-60 | 4.9 | 68.1 | 26.9 |
| | | | 60-80 | 6.2 | 75.5 | 18.2 |
| | | | 80-100 | 4.7 | 70.7 | 24.6 |

**Table (4). Correlation coefficients between some soil available nutrients and the characteristics of newly reclaimed soil samples (29).**

| | Pa | Pi | Po | Pt | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|---|
| Depth | -0.56** | -0.38* | -0.29 | -0.37* | -0.31 | -0.59*** | -0.39* | -0.39* |
| Time | 0.24 | 0.31 | 0.37 | 0.35 | 0.24 | 0.26 | 0.34 | 0.33 |
| pH | -0.26 | -0.53** | -0.47* | -0.56** | -0.43** | -0.59*** | -0.40* | -0.40* |
| ECe | -0.17 | -0.13 | -0.16 | -0.15 | -0.20 | -0.10 | -0.13 | -0.11 |
| OM | 0.64*** | 0.97*** | 0.47* | 0.91*** | 0.90*** | 0.86*** | 0.61*** | 0.65*** |
| $CaCO_3$ | -0.01 | -0.16 | -0.40* | -0.11 | -0.11 | -0.16 | -0.20 | -0.11 |
| CSand | -0.10 | 0.02 | 0.30 | 0.05 | 0.05 | -0.10 | 0.04 | -0.07 |
| F.Sand | 0.31 | 0.02 | -0.16 | -0.01 | -0.01 | 0.13 | -0.03 | 0.07 |
| Silt | -0.22 | -0.15 | -0.20 | -0.25 | -0.25 | -0.06 | -0.16 | -0.16 |
| Clay | 0.04 | 0.05 | -0.24 | -0.03 | 0.11 | 0.11 | 0.08 | 0.19 |

*, **and *** significant at P < 0.05, 0.01 and 0.001 respectively.

contents. In near neutral to alkaline fertilized soils, the commonly occurring phosphate minerals are hydroxyapatite (HAP), tricalcium phosphate (TCP), octacalcium phosphate (OCP) and dicalcium phosphate (DCP) (Lindsay, 1979). Calcium phosphate transformations in fertilized soil may affect by both soil properties and management practices. Fixen *et al*., (1983) found that long term equilibrium activities were consistent with the presence of TCP. Olsen *et al*., (1983) examined 23 fertilized calcareous soils and observed that P activities were in near equilibrium with OCP. or slightly supersaturated with TCP. Soils under long-term manure treatments consistently maintained equilibrium with the more soluble OCP. This also demonstrate that Pi is a dominate phosphorus forms in studied soil. Mckenzie *et al.,* (1992) found that phosphorus fertilizers and manure applied annually for many years resulted in the accumulation of inorganic P and organic P in soil. However, Campbell *et al.,* (1986) did not observe a significant change in the soil Po fraction when manure was applied every 3 years, whereas labile Pi levels were increased. The influence of fertilizer and manuring on P transformation depended also on soil texture (O' Halboran *et al.,* 1987). Long-term manure application increases microbial activity and potential for mineralization of soil organic matter and consequently, may induce the transformation of soil Po fractions to Pi fractions (N' dayegamiye and Angers 1990). Sharpley (1985) also indicated that mineralization of Po during the growing season was very informant for P availability to plants. Chinault and O'Connor (2008) reported that the phosphorus release from biosolids depends on biosolids treatment type (digestion) and P chemistry. Thereafter, the incorporation of plant residues generally increases soil organic matter and that results in an increase in Po content. Long-term crop rotation associated with N and P fertilization also had a positive effect on P cycling in cultivated soils (Mackenzie *et al.,* 1992) Cumulative effects of long-term application of dairy cattle manure and fertilizers on the forms and availability of soil phosphorus have been studied also by Tran and N'dayegamiye (1995). They found that 20 t/ha from dairy manure in all 6 years of the study increased resin-$NaHCO_3$ (Pa), NaOH-Pi and total P (Pt), but maintained organic P (Po) fractions about the same level.

The correlation between $CaCO_3$ contents and the different forms of phosphorus were not significant, possibly due to the lower number of Calcid soil samples. However the correlations between soil pH and both Pi, Po and Pt were negatively highly significant (Table 4). The influence of pH on P behavior in calcareous sediments is often associated with sorption and coprecipitation with $CaCO_3$ (Olila and Reddy, 1995). The reaction of P with calcite involves a surface adsorption that consumes $H^+$ ions, followed by precipitation of $CaHPO_4.2H_2O$ at higher P concentrations (Avnimelech, 1980).

Table 5 showed very highly significant correlations between all different soil P forms (Pa, Pi and Po) and total phosphorus (Pt), in addition to the correlations between Pi and both Pa and Po are very highly significant. This indicated a dynamics equlibria between soil phosphorus forms. Only the correlation between Pa and Po was not significant. These reveal presence of relation between Pa and Po is equilibrium indirect or slower than Pa and Pi. There have been many attempts to quantify the relationship between unavailable and available soil P. Kinetic studies such as the work by Cox *et al.,* (1981) provided a descriptive model to show the change in extractable soil P levels with time. The amount of P applied that does not remain in soil solution or is not removed by plants, is thus retained on the soil fraction in certain forms. A more direct approach for identifying the labile P has been to measure the different soil P species during the course of many cropping years. Recently, soil phosphorus dynamics during seventeen years of continuous cultivation fractionation analyses were studied by Schmidt *et al.,* (1996). They found that both inorganic soil P (extracted with $NaHCO_3$) and Po (extracted with NaOH) were increased due to excess P additions and decreased with lower addition of phosphorus fertilizer. Inorganic P extracted by $NaHCO_3$ and organic P by NaOH, represented the biologically dynamic P fractions.

Statistical analysis revealed highly significant correlation coefficient found in Table 5 between different forms of P and micronutrients (Fe, Mn, Zn and Cu). These highly significant correlations may be attributed to applied organic matter to cultivated soil compared to virgin one.

Although data in table 2 show increases of available phosphorus with the time of cultivation, in most cases these levels of the studied surface samples were not more than 12 mg P /kg as extracted by $NaHCO_3$. These levels fall in the fertilizer response probable for indicative available P values as reported by (Landon 1991). This indicated that in the new reclaimed soils phosphorus fertilizer must be seasonally applied.

**Table (5). Matrix correlation coefficients between phosphorus forms and micronutrients for studied soil samples (29).**

| | Pa | Pi | Po | Pt | Fe | Mn | Zn |
|---|---|---|---|---|---|---|---|
| **Pi** | 0.67*** | - | | | | | |
| **Po** | 0.32 | 0.60*** | - | | | | |
| **Pt** | 0.63*** | 0.97*** | 0.77*** | - | | | |
| **Fe** | 0.71*** | 0.92*** | 0.51** | 0.88*** | - | | |
| **Mn** | 0.70*** | 0.83*** | 0.52** | 0.82*** | 0.74*** | - | |
| **Zn** | 0.50** | 0.54** | 0.33 | 0.53** | 0.57** | 0.79*** | - |
| **Cu** | 0.53** | 0.57** | 0.37* | 0.56** | 0.59*** | 0.81*** | 0.95*** |

*, **and *** significant at P < 0.05, 0.01 and 0.001 respectively

Generally, it could be concluded that, both organic matter applications and all soil practices which decrease pH value are significant factors increased the availability of soil phosphorus.

**Status of micronutrients in new reclaimed soils:**

The amounts of available Fe, Mn, Zn and Cu extracted by DTPA from all soil samples (Table 6) ranged between 0.26 – 8.04, 0.60 – 41.60, 0.03 – 4.00 and 0.06 – 13.00 mg/kg in Typic Torripsamment soils and 0.24 – 2.84 , 2.10 – 8.00, 0.16 – 0.41 and 0.02 – 0.12 mg/kg in calcid soils respectively. Generally the available levels of Fe, Mn, Zn and Cu were deficient in many soil samples especially in those having organic matter less than 1.0%, Westerman *et al.,* (1990) and Landon (1991). They mentioned that the deficiency levels of Fe, Mn, Zn and Cu in soil extracted by DTPA were 4.5 – 5.0, 0.2, 0.5 -1.0 and 0.5 mg/kg respectively. Available content of Mn was higher than Fe, Zn and Cu due to geochemical characteristics of these studied soils.

Data matrix correlation in Table 5 showed highly significant correlation between Fe, Mn, Zn and Cu. Also the correlation coefficients between these elements and different soil characteristics (Table 4) were almost the same. This proved that the chemical behaviors of Fe, Mn, Zn and Cu in the studied soils are similar.

Correlation coefficients between available Fe, Mn, Zn and Cu with soil depth were negative to very highly negative significant as shown in table 4. Surface soil samples (n = 7) increased had 31.7%, 144.5%, 55.9% and 122.9% higher than subsurface soil samples (n = 22) for available Fe, Mn, Zn and Cu respectively. This result indicates that the application of these elements accumulated in the surface soil layer and their movement through soil profile are very slow. Williams *et al.,* (1987) reported that after 9 years micronutrients moved from 5 to 10 cm soil depth.

Data of simple correlation between each of the available Fe, Mn, Zn and Cu and soil organic matter content were very highly significant as shown in table 4. These results refer to the importance of the organic matter application from different sources to enrich the new reclaimed soil with the available micronutrients. Organic matter addition is not only a source of these available nutrients but also to improve the soil characteristics that increased availability of micronutrients e. g., decreased soil pH, increased soil CEC, increased water holding capacity and etc.,. Highly significant correlation

**Table (6). Available Fe, Mn, Zn and Cu (DTPA-extractable) in different soil profiles .**

| No | Irrigation system | Veget -ation | Depth (cm) | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|
| | | | | ← mg/kg → | | | |
| | | | Soil profiles of Torripsamments Virgin soil | | | | |
| 1 | Non | Non | 0-20 | 0.74 | 28.3 | 0.61 | 0.76 |
| | | | 20-40 | 0.62 | 1.7 | 0.46 | 0.14 |
| | | | 40-60 | 1.74 | 1.8 | 0.50 | 0.14 |
| | | | Soil cultivated for 7 years | | | | |
| 2 | Drip | Apple | 0-10 | 2.30 | 31.0 | 1.63 | 3.82 |
| | | | 10-20 | 1.42 | 12.3 | 0.61 | 1.06 |
| | | | 20-50 | 0.58 | 5.9 | 0.45 | 0.20 |
| | | | 50-75 | 0.88 | 4.3 | 0.75 | 0.20 |
| 3 | Sprink -ler | Maize | 0-20 | 1.44 | 15.9 | 0.35 | 0.16 |
| | | | 20-30 | 0.68 | 4.5 | 0.54 | 0.10 |
| | | | 30-65 | 0.26 | 0.6 | 0.20 | 0.08 |
| | | | >65 | 0.38 | 0.7 | 0.82 | 0.06 |
| | | | Soil cultivated for 9 years | | | | |
| 4 | Drip | Apple | 0-10 | 1.60 | 35.8 | 2.16 | 9.28 |
| | | | 10-20 | 4.20 | 37.7 | 4.00 | 13.00 |
| | | | 20-40 | 8.04 | 41.6 | 1.50 | 4.96 |
| | | | 40-60 | 0.58 | 4.1 | 0.31 | 0.24 |
| 5 | Sprink -ler | Maize | 0-10 | 1.38 | 19.6 | 1.34 | 0.74 |
| | | | 10-20 | 0.86 | 8.7 | 0.32 | 0.38 |
| | | | 20-30 | 0.56 | 1.7 | 0.24 | 0.10 |
| | | | 30-50 | 0.46 | 1.0 | 0.16 | 0.06 |
| | | | 50-70 | 0.78 | 2.0 | 0.03 | 0.10 |
| | | | 70-90 | 0.84 | 2.2 | 0.45 | 0.10 |
| | | | Soil profiles of Calcids Virgin soil | | | | |
| 6 | Non | Non | 0-30 | 0.74 | 8.0 | 0.17 | 0.12 |
| | | | 30-60 | 0.68 | 2.8 | 0.23 | 0.06 |
| | | | 60-80 | 0.70 | 3.5 | 0.26 | 0.04 |
| | | | 80-100 | 0.68 | 4.2 | 0.17 | 0.02 |
| | | | Soil cultivated for 4 years | | | | |
| 7 | Drip | Potato | 0-30 | 2.84 | 7.4 | 0.16 | 0.12 |
| | | | 30-60 | 0.64 | 2.1 | 0.20 | 0.06 |
| | | | 60-80 | 0.24 | 2.2 | 0.27 | 0.08 |
| | | | 80-100 | 0.58 | 2.1 | 0.41 | 0.04 |

between available micronutrients and the different forms of P (table 5) are due to the effects of OM on both soil micronutrients and macronutrients. There are highly significant correlations between soil OM content and the different soil forms of P as represented in Table 4. This indicates that organic matter application plays an important role in supplying soil macro- as well as micronutrients and to improve these availabilities in the new reclaimed soil especially in the arid zones.

Available Fe, Mn, Zn and Cu were always higher in Typic Torrepsamment soils than Calcid soils (Table 6). Generally Typic Torrepsamment (n = 21) had 62%, 210%, 260% and 2328% higher Fe, Mn, Zn and Cu respectively than Calcid (n = 8 ). Table 4 showed negative correlation between available soil micronutrients and both soil pH and $CaCO_3$ content. This negative correlation was not significant with soil $CaCO_3$ content, which may be attributed to the low number of soil samples of Calcid (n = 8) than Typic Torrepsamment (n = 21). The inverse effect of soil pH and $CaCO_3$ content on the available Fe, Mn, Zn and Cu is due to precipitation of these nutrients as hydroxyls or carbonates forms (Hettiarachchi et al., 2008).

In conclusion, micronutrients periodical application must be taken into consideration to correct deficiency of these nutrients in the Egyptian new reclaimed soils. Soil factors affecting micronutrients availability have led to an increase in the use of foliar rather than soil application. Horticulture trees need more care with micronutrients fertilization than field crops. May be the appearance of micronutrients deficiency on fruit tree leaves due to absorb nutrients from the same area of the soil but this phenomena don't appear on intercrop plants because the absorption of nutrients changed from crop to an other. Organic matter application from different sources that are free from soil and plant pernicious diseases is very important to supply soil micronutrients and improve these availabilities.

**Concentrations of phosphorus and some micronutrients in selected growing crops:**

Plant samples were taken from the growing crops in the region, where soil samples were collected. The growing crops were apple, potato, onion and barley. The contents of phosphorus in the tested plants ranged between 0.13 to 0.68% (table 7). Table 8 showed that these values are within optimum levels for most crops as mentioned by Reisenauer (1978) and Westerman *et al.,* (1990). Etc.

**Table (7). Concentrations of some nutrients in selected growing crops in new reclaimed lands.**

| Sample | Soil Type | Cultivation time | P % | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|
| | | | | ← | mg/kg | | → |
| Apple<br>Malus sylvestris, var. Anna | Torripsamments | 7 years | 0.26 | 64 | 91 | 18.6 | 2.5 |
| Apple | Torripsamments | 7 years | 0.20 | 107 | 85 | 10.9 | 3.0 |
| Apple | Torripsamments | 9 years | 0.15 | 38 | 83 | 6.6 | 3.0 |
| Potato<br>Solanum tuberosum var. Necola | Calcids | 4 years | 0.68 | 240 | 90 | 3.8 | 4.5 |
| Onion<br>Allium sp. | Calcids | 4 years | 0.13 | 54 | 53 | 1.1 | 2.0 |
| Barley<br>Hordeum vulgare | Calcids | 4 years | 0.26 | 110 | 105 | 14.5 | 3.0 |

**Table (8). Nutrient sufficiency ranges for tested plants.**

| Plant sample | Reference | P | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|
| | | % | ← | mg/kg | | → |
| Apple | Reisenauer 1978 | 0.1 – 0.3 | - | > 20 | > 18 | > 4 |
| Potato | Westerman 1990 | 0.2 – 0.4 | 70 – 150 | 30 – 50 | 20 – 40 | - |
| Onion | Westerman 1990 | 0.2 – 0.4 | - | - | > 15 | - |
| Barley | Westerman 1990 | 0.2 – 0.5 | - | > 25 | 15 -70 | 5 -25 |

Data in Tables 7 and 8 show that, Iron, manganese, zinc and copper concentrations in the tested plants ranged between 38 – 240 mg/kg, 52 – 105 mg/kg, 1.1 – 18.6 mg/kg and 2 – 4.5 mg/kg respectively. Concentrations of Fe and Mn generally fall in sufficient amounts (70 – 150 mg/kg and 20 – 50 mg/kg respectively), while Zn and Cu were lower than sufficient levels (20 – 40 mg/kg and 5 – 20 mg/kg respectively) according to Reisenauer (1978) and Westerman *et al.,* (1990). Except one apple sample out of three samples had Fe content (38 mg/kg) lower than a sufficient content, may be due to affecting factors on plant Fe content as example antagonistic action with other macronutrients, soil pH and soil $CaCO_3$ contents. Plant sufficient levels of Fe and Mn contents are possibly due to foliar application of these elements to plants.

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## تأثير فترة الاستزراع علي حالة و تيسر الفوسفور وبعض العناصر الصغرى في أراضي الاستصلاح الجديدة بمصر

**محمد يس عبد الرحيم خضر- محمد عبد الفتاح محمد عيد - داليا محمد فهمي مبارك**
قسم الأراضي – كلية الزراعة – جامعة عين شمس – شبرا الخيمة – القاهرة- مصر

يهدف هذا البحث إلي دراسة و توضيح حالة و تيسر الفوسفور و بعض العناصر الصغرى في أراضي الاستصلاح الجديدة بمصر و مدي تأثير فترة الاستزراع علي ذلك: و من اجل تحقيق هذا الهدف تم جمع عينات من قطاعات التربة و النباتات من نوعين من الأراضي أراضي Typic Torripsamment ( مشروع دينا الزراعي) و أراضي Calcid (مزرعة ماتكو) لتقييم و رصد التغيرات في صور الفوسفور المختلفة و حالة بعض العناصر الصغرى بالتربة بعد تعرضها لأنظمة استزراع مختلفة. حيث وجد أن الزيادة في الفوسفور الميسر و الفوسفور المعدني و الحديد و المنجنيز و الزنك و النحاس الميسر كانت غير معنوية بينما الزيادة في الفوسفور العضوي كانت معنوية و ذلك مع زيادة فترة الاستزراع . و لوحظ أن تركيزات الفوسفور و الحديد و المنجنيز في كل النباتات كانت عموما في المستوي الكافي بينما كانت تركيزات الزنك و النحاس منخفضة. و قد أظهرت النتائج وجود ارتباط عالي المعنوية بين محتوي التربة من المادة العضوية و كل صور الفوسفور و العناصر الصغرى مما يؤكد أهمية المادة العضوية في إمداد التربة بالعناصر الكبرى و الصغرى و تحسين تيسرها للنبات مع تحسين خصائص التربة الأخرى. وبناء علي ذلك توصي الدراسة بإعطاء أهمية كبيرة بالتسميد العضوي لمثل هذه الأراضي.