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Full Length Research Paper

Depletion of magnesium in Egyptian soils, its content in crops and estimated needs

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Soil and leaf analyses were used to survey magnesium status of different soils and crops in different governorates of Egypt during the period from 1986 - 2006. Results show that large areas in different governorates were suffering from decreasing magnesium content. Mg content of crops grown in new lands is generally lower than of same crops grown in old lands. However, both are in need of adding magnesium to grow crops giving high yields. Mg in cultivated soils decreases year after year. It can be concluded that there is a continuous depletion of magnesium from Egyptian soils and adding magnesium fertilizers would help in sustaining the soil fertility, prevent its deterioration in soils and increase yields without harming the environment.

Key words: Egypt, magnesium, soils, old land, new land, fruit crops, maize, wheat, potato, tomato.

INTRODUCTION

A large number of studies in Egypt have been carried out reporting on mineral nutrition, fertilizer use and soil/plant relationship (NRC-GTZ, 1991b, 1992, 1993 a and b and 1994 a, b). Few, however, have been devoted to magnesium, though it is one of the essential secondary nutrients (Marschner, 1995). It has been believed that sufficient magnesium contents are available in Egyptian soils to meet the needs of the cultivated crops and is regenerated yearly through the addition of Nile suspended matter coming with water. Therefore, no recommendations were given for magnesium fertilization; and little work was done on it.

As a result of constructing the High Dam, large quantities of Nile alluvial, which was renewing soil fertility annually, were precipitated in Lake Nasser in the south of Egypt. In the mean time, the increase in population and the need to produce more food pressed very much on the limited fertile area in the Nile Valley and Delta. For getting out of this situation, new areas were reclaimed and put under cultivation, which are normally sandy and calcareous soils, poor in their nutrient contents including magnesium. Lately studies started to investigate magnesium nutrition and to determine Mg needs of economically important crops in Egypt (FAO, 2000; El-Dahshouri, 2007; Salem, 2007; El-Fouly et al., 2010). Magnesium deficiency was reported in some Egyptian soils (clay or newly reclaimed soils). Haggag et al. (1987), Rezk and Rezk (1994). Attala et al. (1997), El-Safty and Rabii (1998), Abou Aziz et al. (2000) and Dawood et al. (2001) indicated that fruit crops responded positively and pronouncedly to $MgSO_4$ supply. The objective of this study was to monitor the magnesium status of different crops grown under different soil conditions in different sites either in old or new lands of Egypt, and compare collected data since 1986 (NRC-GTZ 1991 a - k).

MATERIALS AND METHODS

Soil and leaf magnesium content surveys were carried out at different sites in new and old lands of Egypt during 20 years (1986 - 2006) within the Egypto-German Project, Micronutrients and Plant Nutrition Problems. (NRC - GTZ reports in the references) (Tables 1 and 2). Tens of thousands of samples of soils and leaves of major vegetable, fruit crops were collected during this period to study the

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Table 1. The locations and soil types in new lands for different crops examined in the study.

Crop	Location		Soil type
	District	**Governorate**	
Grape Vine	El-Sadat	Menofeya	Loamy sand
Apple	El-Sadat	Menofeya	Loamy sand
Peach	El-Sadat	Menofeya	Sandy loam
	El-Nubaria	Behera	Sandy loam
Apricot	El-Sadat	Menofeya	Loamy sand
	El-Khatatba	Menofeya	Sandy loam
Pear	Kafr Dawoud	Menofeya	Loamy sand
Vegetables			
Tomato	El-Sabaa Abar El-Gharbia ,	Isamilia	Loamy sand,
	El-Sabaa Abar El-Sharkia		Sandy
	Abo Swear		Loamy sand
	El-Mahsama		Sandy
	Ain Ghosn		Sandy
	El-Manayef		Sandy
Pepper	Belbes	Sharkia	Sandy
	El-Sadat	Menofeya	Loamy sand
Potato	El-Sadat	Menofeya	Sandy
Field crops			
Maize	El-Manayef	Ismailia	Sandy
	El-Cassia		Loamy
	El-Delengat	Behera	Sandy Loam
	Hosh Essa		Loamy
	Ganaklis		Sandy Loam
	Kom Hamada		Sandy
Wheat	El-Sabaa Abar El-Sharkia	Ismailia	Sandy
	Abo Homos		Sandy
	Hosh Issa,	Behera	Sandy loam
	Rashid		Sandy loam
	Kom Hamada	Mehofeya	Sandy loam
	El-Sadat		Sandy loam

New lands soils: mostly sandy or calcareous soils with pH ranging from 7.5 - 8.2.

nutritional status of crops and soils.

Soil samples

Representative soil samples were taken before fertilization at depth of 0 - 30 cm as surface soil layer for field crops and vegetables and from 0 - 30 cm as surface soil layer and 30 - 60 cm as subsurface soil layer for fruit crops.

Leaf samples

Representative leaf samples were taken from terminal young fully expanded leaves as following:

Fruit crops

Orange: 5 - 7 month old spring cycle leaves from fruit bearing terminals.
Grape: After the end of blooming by two weeks
Pear, Apricot, Peach, Apple: At the mid of growing season (June)
Olive: At the mid of growing season (September)

Vegetable crops

Tomato, Pepper: At the start of blooming.

Table 2. The locations and soil types in old lands for different crops examined in the study.

Crop	Location		Soil type
	District	Governorate	
Fruits			
Citrus	Ramsis co.	Sharkia	Sandy
	El-Manayf	Ismailia	Sandy
	El-Sadat	Menofeya	Sand
Vegetables			
Potato	Kafr-El-Zayat	Gharbia	Clay,
	El-Bagour	Menofeya	Clay loam
Field crop			
	Abo Homos		Silty loam
Maize	Abo El-Matamir		Silty loam
	Shobrakhiet Damanhour	Behera	Silty loam
	Etko		Silty loam
	El-Mahmoudia		Silty loam
	El-Rahmania		Silty loam
	Itay El-Baroud		Silty loam
	Rashid		Clay loam
Wheat	Kwesna.		Clay loam
	El-Rahmania		Clay loam
	El-Mahmoudia		Silty clay
	Abo Homos		Clay
	Rashid	Menofeya	Silty clay
	El Delengat	Behera	Clay loam
	Shobrakhiet		Silty clay
	Kafr El-Dawar		Clay
	Damanhour		Silty clay
	Kom Hamada		Silty clay
	Etko		Silty clay

Old land soils: alluvial sediments with pH 8.0 - 8.5.

Potato: At the start of tuber formation.

Field crops

Maize: Ear-leaf was used for analysis, at teaseling - silking stage
Wheat: During stem elongation stage

Determination of soil and leaf magnesium

Soil and leaf analysis for magnesium determination were carried out as described by Chapman and Pratt (1961) and Bowen (1978) using atomic absorption apparatus. The soil and plant analysis were conducted at the Laboratories of the Micronutrients Project, National Research Centre, Cairo, Egypt. Adequate levels of Mg for soil and each crop are given in the graphs. Figure 1 shows the sampling location.

Calculation of the yearly requirements for different crops:

1. Average Calculated areas for each crop (A) are taken from the statistical yearly book of the Ministry of Agriculture.
2. Estimated area requiring Mg (B) is estimation based on own results and observations (%).
3. Estimated area requiring Mg (C) = A × B
4. Estimated removal (kg/fed) based on data the reference (D) calculated as MgSO4.
5. Total $MgSO_4$ requirements (E) = (C × D) as 1000 tons/year/area in (B) to balance the removal.

RESULTS AND DISCUSSION

The results of analytical data of soils and leaves indicated that, the soils in the new and old lands are more or less clayey to sandy in texture; pH values are high around 8.0. Magnesium deficiency symptoms were detected on leaves of different crops either in old or new lands, which is more pronounced in the last period of study (location, soil type and pH are given in Table 1).

Depletion of magnesium in soils

Trying to interpret results of magnesium content according to the guide values given by Ankerman and

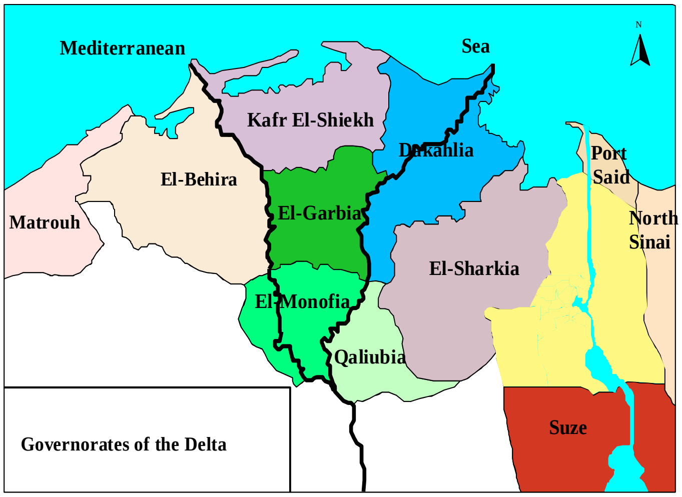

Figure 1. Locations of sampling regions.

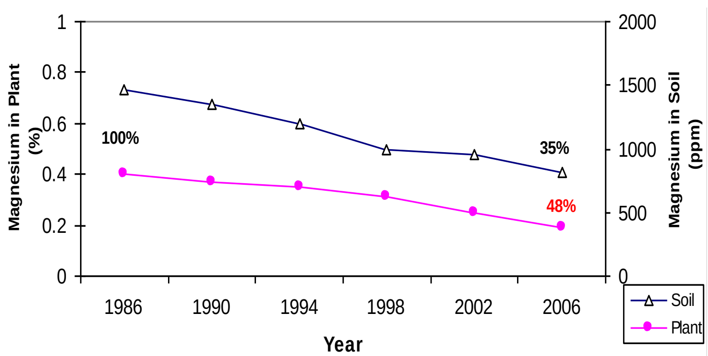

Figure 2. Magnesium status of soil (ppm) and plant (%) of the citrus during 1986 - 2006 (old land).

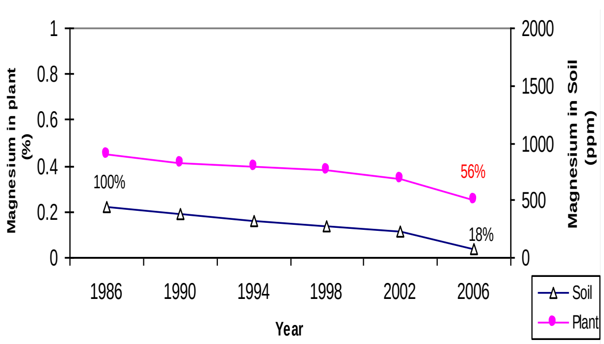

Figure 3. Magnesium status of soil (ppm) and plant (%) of the grape vine during 1986 - 2006 (New land).

Large (1974), it is clearly noticeable from Figure 2-13 that magnesium content in old soils is generally decreasing from one period to another, but still in sufficient limits. While, magnesium content in new land was decreased

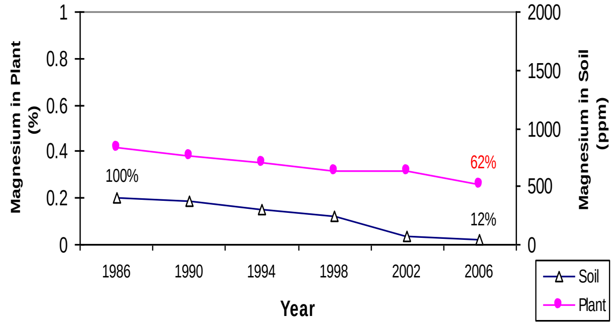

Figure 4. Magnesium status of soil (ppm) and plant (%) of the olive during 1986 - 2006 (New land).

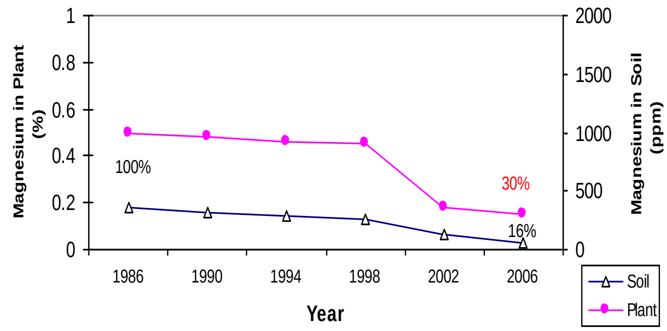

Figure 5. Magnesium status of soil (ppm) and plant (%) of the apple during 1986 – 2006 (New land).

and reached deficient levels. FAO (2000) mentioned that the different crops need different amounts of nutrients. Furthermore, the quantity of any nutrient needed depends largely on the crop yield obtained or expected. Different varieties of a crop are also different in their nutrient requirements and their response to fertilizers. Other factors have to be taken into account in order to determine the real fertilizer requirement, e.g. soil nutrient reserves, possible unavailability of the applied nutrient, leaching or other loss factors. Therefore, the nutrient requirements are in general higher than the nutrient removal by crops, and the presence of so called "adequate" amounts of a nutrient in soil does not mean that it satisfies the needs of all crops and cultivars.

Magnesium status in crops

Fruits

The data presented in Figure 2 show that magnesium values of citrus plant are decreasing to become deficient by time progressing. However, in grapes and olives in spite of the decrease it is still sufficient Figures 3 and 4 in

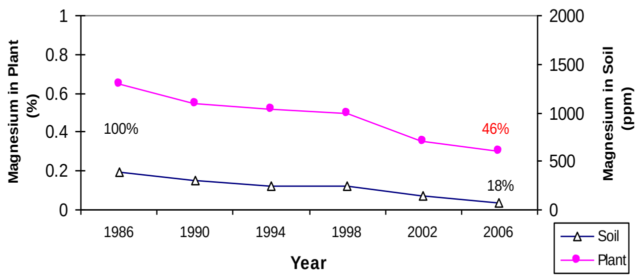

Figure 6. Magnesium status of soil (ppm) and plant (%) of the peach during 1986 – 2006 (New land).

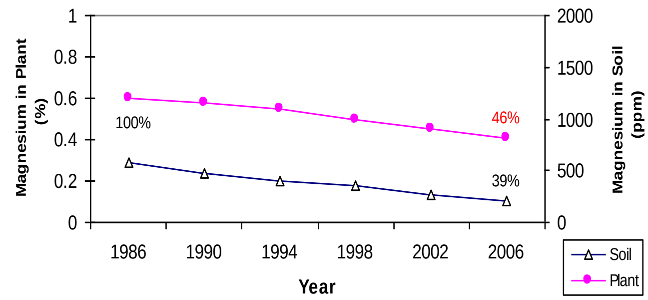

Figure 9. Magnesium status of soil (ppm) and plant (%) of the potato during 1986 - 2006 (old land).

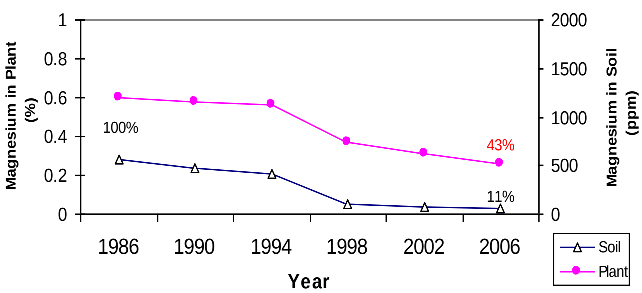

Figure 7. Magnesium status of soil (ppm) and plant (%) of the tomato during 1986 – 2006 (New land).

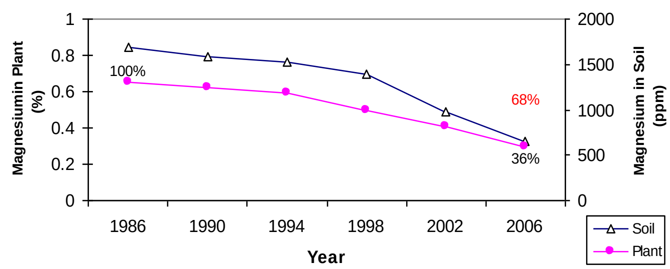

Figure 10. Magnesium status of soil (ppm) and plant (%) of the potato during 1986 - 2006 (New land).

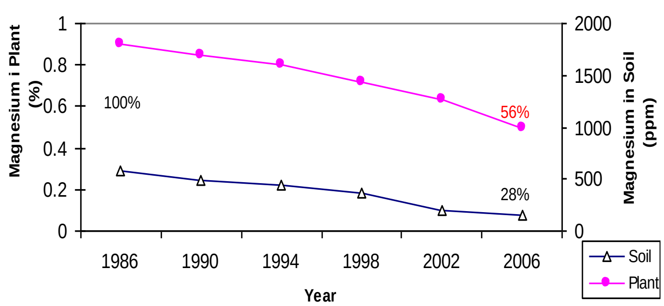

Figure 8. Magnesium status of soil (ppm) and plant (%) of the pepper vine during 1986 – 2006 (New land).

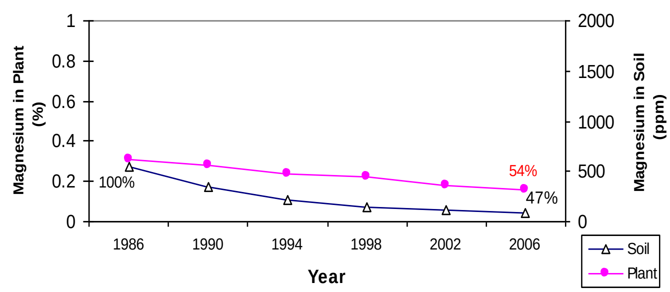

Figure 11. Magnesium status of soil (ppm) and plant (%) of the maize during 1986 - 2006 (old land).

the different periods. On the other hand, it became deficient in apple and peach in the last periods Figure 5 and 6. In addition, decreasing rate of magnesium content in citrus leaves was higher than in its soil; however the opposite was true with the other fruit crops.

Vegetables

Results in Figure 7, 8, 9 and 10 indicate that magnesium content is decreasing gradually from one period to another. Regarding the magnesium in soils decreasing rate, results show that values for soils for the three vegetables are higher than the plant grown in the new land. In addition, in potato plants, the magnesium deficiency rate in old land was higher than in the new land. It is interesting to note that Mg-content of potato grown in new lands is generally lower than in old lands Figure 9 and 10. The decrease in Mg content of potato leaves in the last ten years in old lands is more pronounced than in earlier periods Figure 9.

Field crops

The data in Figure 11, 12, 13 and 14 show that magnesium status in maize and wheat is decreasing by

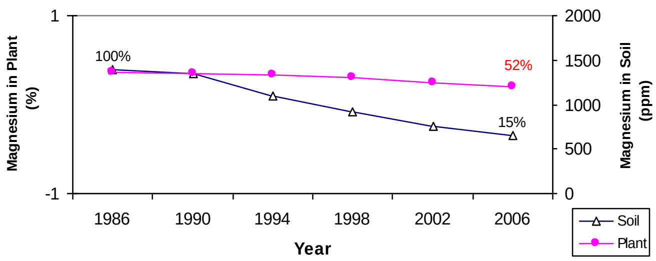

Figure 12. Magnesium status of soil (ppm) and plant (%) of the maize during 1986 - 2006 (New land).

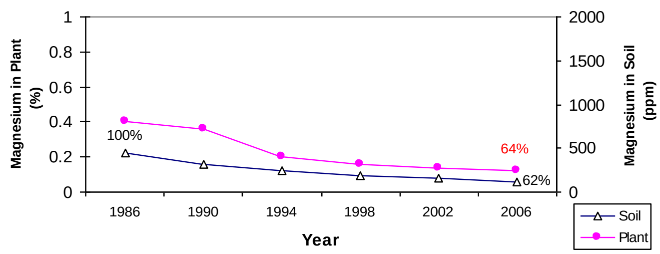

Figure 13. Magnesium status of soil (ppm) and plant (%) of the olive during 1986 – 2006 (old land).

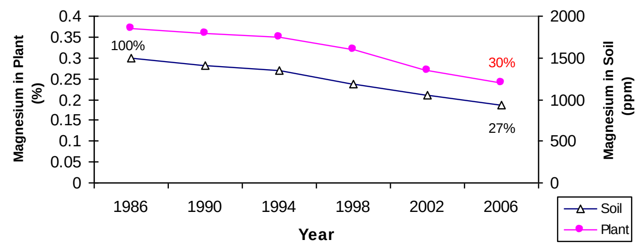

Figure 14. Magnesium status of soil (ppm) and plant (%) of the wheat during 1986 - 2006 (New land).

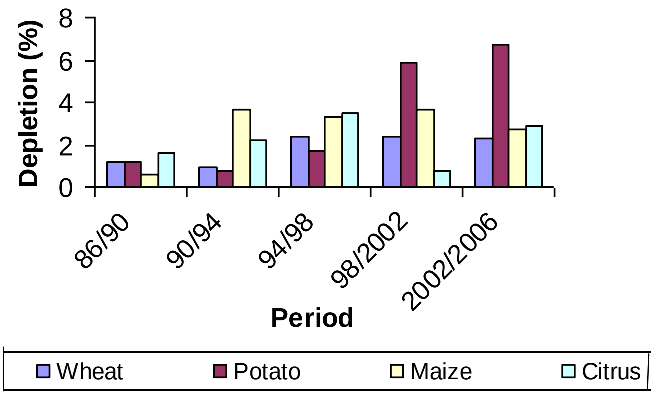

Figure 15. Mean yearly depletion of crop soil-Mg in different periods (old lands).

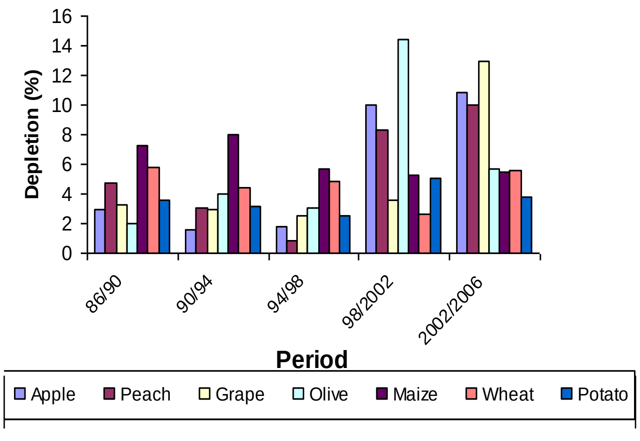

Figure 16. Mean yearly depletion of crop soil-Mg in different periods (new lands).

progressing time, not only in plants but also in soils of both new and old lands Mg-content of maize and wheat grown in the new lands tended to decrease more than in the old land. The calculated yearly depletion of Mg% during the different periods is given in Figure 15 and 16. Data in Table 3 states clearly that the total magnesium sulphate requirements for fruit crops from both old and new lands reached 29.7 thousand tons/year (for about 400 thousand fed.) however, for vegetables and field crops approaches to 158.6 thousand tons, and the approximate requirements of all crops are equal to 188.3 thousand tons/area/year. These amounts are needed to guarantee average obtained yields, and to stop the depletion of Mg and keep soils Mg contents around the level of 2006. The needs shall be higher, if we want to increase magnesium content of the soil in those soils whose content is inadequate.

Leaf application is used to overcome problems in soils. In other terms, reducing losses through fixation, decomposition and leaching. While leaf application can help to overcome Mg deficiency, long term magnesium shortage should be corrected using soil application in standard maintenance programmes (Salem, 2007). In this concern, values in Table 4 show that the fruit crops (grown in both soils) need nearly to 8.5 thousand tons/area/year of magnesium sulphate. While, the quantity required for vegetables and field crops not less than 9.4 thousand tons/year and thus, the final quantity is around 17.9 thousand tons in case of using Mg as spray. The estimated data in Tables 3 and 4 indicate that the total magnesium requirement for soil and leaf application might reach 206.2 thousand tons. The marketed available magnesium fertilizers are mostly imported. It is of great importance to produce magnesium fertilizer locally for domestic use and for export to neighboring Arab countries which in general have similar situation like Sudan, Yemen, Saudi Arabia, and others. Therefore, the close cooperation between research and industry to produce magnesium sulphate to satisfy local and regional

Table 3. The approximate yearly requirements of crops from magnesium sulphate (16% MgO) in case of soil application to restore and maintain soil fertility.

Crop	Cultivated area (1000 fed.) (A)	Estimated area requiring Mg		Estimated removal Kg/fed. (D)	Total $MgSO_4$ requirements (1000 tons/year/area in column 4) E = (C × D)
		(%) (B)	(1000 fed.) C = (A × B)		
Fruit					
Old lands	686	10	68.6	60	4.1
New lands	534	60	320.4	80	25.6
Sub-total	1220		389.0		29.7
Vegetables and field crops					
Old lands	11459	10	1145.9	60	68.8
New lands	1872	60	1123.2	80	89.8
Sub - total	13331		2269.1		158.6
Total	14551		2667.1		188.3

Feddan is 4200 m^2 = 0.42 ha.

Table 4. The approximate yearly requirements of crops from magnesium sulphate (16%MgO) in case of leaf application to satisfy yearly needs of crops.

Crop	Cultivated area (1000 fed.)	Estimated area requiring Mg		Estimated needs Kg/fed. (D)	Total $MgSO_4$ requirements (1000 tons/year/area in column 4) E = (C × D)
	(A)	(%) (B)	(1000 fed.) C = (A × B)		
Fruit					
Old lands	686	25	171.5	12	2.1
New lands	534	100	534.0	12	6.4
Sub-total	1220		705.5		8.5
Vegetables and field crops					
Old lands	11459	25	2864.8	2	5.7
New lands	1872	100	1871.0	2	3.7
Sub- total	13331		4735.8		9.4
Total	14551		5441.3		17.9

needs should be encouraged. Adding it to the soil helps in sustaining the soil fertility and prevents its deterioration. It is worthy to note that detailed data of other areas in Egypt indicate similar situation for other nutrients (El-Dahshouri, 2007 and El-Fouly et al., 2010), which is alarming and needs to reconsider the practices of using fertilizers in Egypt.

Conclusion

These results for fruits, vegetables and field crops indicated that the content of magnesium of the reported crops is generally decreasing. In the meantime Mg content in old and new lands is depleting. Crops cultivated on both new and old lands need to be fertilizered with Mg.

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