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Application of Magnetic Technologies in Desert Agriculture: III. Effect of Magnetized Water on Yield and Uptake of Certain Elements by Citrus in Relation to Nutrients Mobilization in Soil

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APPLICATION of magnetic technologies in Egyptian Agriculture led to several positive results. Using magnetized water in irrigation increased the leaching of soluble salts, reduced soil alkalinity and dissolved more of the slightly soluble soil components such as $CaCO_3$ and gypsum. Magnetized water irrigation has also induced changes in ionic balance in soil, which is more favorable to plant growth. Besides magnetizing seeds proved to increase seed germination and seedling emergence through surface soil crusts.

In this work, the deferential accelerating effect of magnetized water on nutrients mobility in soil and on their uptake by citrus, were evaluated. Response of fruit yield to magnetized irrigation water for 3 successive growth seasons, was also evaluated.

A magnetic unit for water treatment (magnetron) was installed in a 90 acres - citrus -orchard such that to irrigate 20 acres with normal water and 70 acres with magnetized water. The effect of travelling distance of magnetized water through a drip system of irrigation on its induced changes on soil and trees was also evaluated.

Obtained results have indicated that the effect of magnetized water on the mobility of nutrient elements in root zone differed greatly from element to another according to element magnetic susceptibility. Induced magnetic increase of nutrient extraction from soil was the highest for iron; extracted Fe reached 9 times as much as that extracted from normal plots. Zinc increased 5 times, P increased 3 times and that increase in Mn was only 80%. However, Mn content

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of leaves showed the maximum increase, followed by Zn while that of Fe was the least affected. It should be mentioned that the activity of iron rather than its total content in leaves is important for plant growth.

Besides, leaves content of P was tripled and that of K was considerably increased while N was not affected by magnetized water. Fruit yield reached maximum at a water traveling distance of 600 m beyond the magnetron. On the other hand the magnetron ceased to exert significant effect at a water traveling distance exceeding 700m. Similar trend was observed for nutrients extraction from root zones; minimum changes in nutrients water in a way similar to nutrient extraction.

Keywords: Magnetization of water, magnetic susceptibility, nutrients mobilization, nutrients uptake, citrus response, water travailing distance.

Investigations of magnetic field Effects on soil and plant systems started more than 40 years ago. However, the concept of using magnetized water and solutions is relatively recent.

Oleshko *et al.* (1980) has reported that soil scientists have shown great interest in the effect of the magnetic field on soil and plants. The reaction of the soil to magnetic action is attributable to the presence in it of paramagnetic and ferromagnetic minerals which change their magnetic state under the effect of a magnetic field, and affect the nonmagnetic minerals surrounding them. The prospect of using cheap magnetic energy to improve the properties of soil and plant growth and development may be of great practical importance, They demonstrated that a magnetic field of 1500 and 3500 Oe produces considerable changes in the micro aggregate composition of soils. Magnetic treatment of soil proved to have a favorable effect on plant growth and development. The enzymatic system of the plants changed. The magnetic field induced by the ferromagnetic components of soil had also a favorable effect on plant growth and development.

Numerous studies of magnetic field effects on germination, growth, and metabolism of plant seeds have been made in Canada and also in Russia . On seeds of winter wheat Pittman as reported by Cope (1981) studied the combined effects of magnetic field strength and temperature on growth of the seedling for a 10 - day period after planting. He showed that at a temperature of 22°C, a magnetic field of 100 gauss (G) approximately doubled the growth rate compared to the rate seen in the earth magnetic field (0.5 G). Increase of magnetic field to 1500 G produced no significant increase in growth stimulation. Cope (1981) concluded that the Growth of winter wheat seeds **was** stimulated by a magnetic field of 100 G, with no additional stimulation in fields as high as 1500 G. Growth. stimulation due to increased temperatures observed in the absence of applied magnetic field are not observed if the seed is subjected to 1500 ***G.*****Krylov** and Taraknova (1960) proposed an auxin-like effect of a magnetic field on germinating seeds. They called this effect magnetotropism. Auxins or synthetic plant growth regulators have been used to stimulate ripening immature fruits. Boe and **Sawnkhe** (1963) studied the effects of magnetic fields on tomato ripening. Four permanent magnets of considerable strength were utilized. Fruits of uniform maturity were placed between the magnetic poles. The ripening rates of treated fruits were compared with those of untreated controls in the same room under similar conditions. A numerical value for color (1 green, 2 = breakers, 3= pink and 4 = red) was assigned for each fruit in a given sample. In all cases the **treated** fruits ripened faster than the controls. Speculations as to mechanisms associated with this phenomenon could be (1) an auxin - like character of the magnetic field; (2) magnetic activation of the enzyme . systems could enhance respiration; **(3)the** possibility that fruit ripening is initiated by a hormone is well known.

The experiments carried by **Krylov** and Taraknova (1960) have demonstrated the similaritv of the magnetic effect to the effects of plant growth regulators.

Magnetization of water

As any para or Dia-magnetic material water, water solutions and water colloids are easily magnetized when passing a magnetic field and will acquire a magnetic moment for 48 to 72 hours after crossing the magnetic field. However, such time is good enough for magnetized irrigation water to impose magnetic effect **on** the soil plant - water system. Magnetic activation of irrigation water depends on several factors **i.e.**: **(1)** Magnetic field intensity H and induction B, (2) temps, (3) velocity of water while crossing the field **and** (4) composition of dissolved salts ,(Takatchenko,1997).

A magnetic field is generated when ever there is electrical charge in motion such as a current flowing in a conductor or due to orbital motions and spins of electrons within the permanent magnet material (Jiles 1992). Several magnetic systems for treatment of water has been recently developed namely: monopol,(1) dipole(2) and polyple(3) magnextic systems.

After studying the influence of magnet -treated nutrient solution on maize plants. Kuderev (1977) indicated that an artificially created magnetic field permanent or variable - has an essential influence on the vital processes in the plant cell and in the plant as a whole. Attention has been focused on studying the physiological effect of water and nutrient solutions afier magnetic treatment. The results obtained testify to the existence of stimulation effect as regards the growth manifestations of the roots and of the top part of the plants and also as regards the increase in the yields of maize, sunflower, soya, tomatoes and cucumbers.

Within a complete program for the application of magnetic technologies in Egyptian desert agriculture, Hilal and Hilal (2000) carried a cross magnetization of seeds and sowing water for tomatoes, pepper and cucumber. Seedling tests have indicated that direct magnetization of seeds alone has doubled pepper germination. On the other hand, tomato seeds have responded more to sowing with magnetized water. More over the germination of cucumber came to be the best in case of double magnetization of seeds and sowing water. They also indicated that magnetized water irrigation of saline calcareous soil pots has delayed the formation of surface crust, weakened soil compaction and hardness and consequently tripled wheat seedling emergence.

In another field trial Hilal and Hilal (2000) have shown 3 main effects for magnetizing moderately saline irrigation water: (1) increasing the leaching of excess soluble salts; (2) lowering soil alkalinity; (3) dissolving slightly soluble salts such as carbonates, sulphates and phosphates. They indicated that the degree of effectiveness of magnetizing irrigation water on soil salinity and on ionic balance in soil solution and in citrus leaves depended greatly on the traveling distance of magnetized water along the drip irrigation system.

(1) Magnetizer a Monopole system has been developed by Mundamax, Miami, Folirida.

(2) Magnetotrones dipole magnetic units of different dialneters has been developed by Magnetic Technologies (L.L.C) Dubai.

(3) A polypole system for the magnetic treatment of water used for agriculture appeared in a U.S patent (1991)

In this work the accelerating effect of magnetized water on nutrients mobility in soil and on their uptake by citrus, were evaluated. Response of fruit yield to magnetized irrigation water was also evaluated.

Experimental

A field experiment was conducted in a 90 acre **citrus** orchard at Wadi El Molake, **Ismalia,** Egypt where the soil is sandy loam and the irrigation water is slightly saline of E.C. value of 1.5 **m. mohs/cm. A** magnetron unit of 6 diameter type **U.T.** 6* **was** placed within the main irrigation line, such that 20 acres are irrigated with normal well water before passing through the magnetron and 70 acres are irrigated with magnetized water **afier** passing the magnetron.

Distribution of available nutrients (**DTPA** extracts) in root zone and uptake of certain macro and micronutrient by citrus leaves were determined at different distances from the magnetron placement. Samples were collected from the plots centers. The area of each plot was 20 acres (200 x 400m) except for plot No.5 which was only 10 acres (100 X400m) Fig. **1.**

The effect of the travelling distance of magnetized irrigation water along the drip lines on its magnetic strength and its induced changes on **soil** and trees, was also evaluated.

Results and Discussion

Effect of magnetic treatment of irrigation water on salt balance and redistribution around dripper

Hilal & *Hilal* (2000) has previously compared the salinity of surface and subsurface soil at different locations around the drippers before and after installation of a magnetron, in an olive farm imgated with moderate saline water, Non cultivated areas were found to be free of salts, while the salinity increase under drippers was limited in surface layer and much greater in root **zone.** Moreover the salinity increased 10 to 12 folds at the edges of wetted areas around the drippers.

* **Magnetrons of different diameters are produced by Magnetic Technologies (L.L.C.) Dubai**

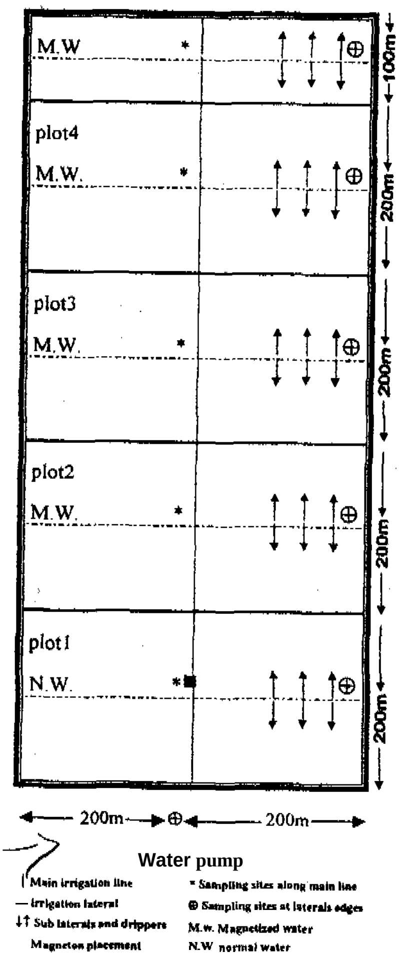

Fig.1. Lay out of **citrus** orchard **of** *90* **acres** showing **locations** of **magnetron** placement and sampling sites.

Six months after fixing the magnetron, within the main irrigation line, salinity at the wetting front decreased by 60% while that under drippers increased. However, soil alkalinity has dropped considerably at all tested locations after the setting of magnetrons.

In a second field evaluation, carried in a citrus orchard where the soil is also sandy loam but the irrigation water was slightly saline.

It was shown that the travelling distance of magnetized irrigation water **through** the irrigation line should be considered in application. However all magnetized samples were higher in E.C values and lower in pH compared to non magnetized one.

Mobilization of micronutrients and P due to magnetization of irrigation water

Magnetic treatment of water, using magnetron **T.U.6** has extensively increased the extraction of **Fe,** Zn, **Cu, Mn** and P. The peaks of extraction were obtained from locations within 400m distance from magnetron placement. **However,** very sharp reductions in the extraction values of these nutrients have occurred in sites located at distances exceeding 400m from the magnetron (Table 1). **However,** all values of extracted nutrients in magnetized sites were considerably higher than that of non magnetized site.

TABLE 1. Effect of magnetic treatment **of** irrigation water **on soil supplying** power of certain nutrient **elements** 14 **weeks after magnetron** placement.

Sample Site	Extractable micronutrients and P (ppm)				
	Fe	Mn	Zn	Cu	P
(1) N.W	4.0	3.8	0.70	0.45	73
(2) M.W	34.0	6.9	2.50	1.30	220
(3) M.W	36.2	6.1	3.50	1.45	149
(4) M.W	10.7	5.7	3.00	1.21	130
(5) M.W	8.2	5.0	0.91	1.05	119

N W = normal irrigation water
M.W = magnetized water
2.3.4.5 = different distances from magnetron placement

It seems that magnetized water lose, at least partially its magnetization effect after hundreds of **meters.** In that respect, Jiles (1992) indicated that the retention of magnetization distinguishes ferromagnets from paramagnets and diarnagnets, ferromagnets retain their magnetization for long time after removing the magnetic field while para and diamagnets (such as water) can retain magnetization for a very short time (1 to 2 days) after the field is removed.

Magnetization and citrus leave uptake of ions and nutrients

Cations uptake

Citrus leaves content of Ca, Mg and Na were determined in different locations 4 and 14 weeks after magnetron setting. Slight variations among locations were obtained after 4 weeks. On the other hand, a great increase in

Ca concentration was obtained at 200 m distance with little increase in Mg concentration while that of Na was surprisingly decreased to one half (Table 2).

TABLE 2. Uptake of some cations and anions by citrus leaves 4 and 14 weeks after magnetron placement (Dec.11 & Mar. 2,1998).

Sampling site	Uptake of ions by leaves (ppm)					
	Ca^{+2}	Mg^{+2}	Na^{+}	Ca^{+2}	Mg^{+2}	Na^{+}
	4 weeks			14 weeks		
(1) N.W	650	246	28.0	510	470	57.5
(2) M.W	762	257	30.0	1210	540	27.0
(3) M.W	605	259	29.0	860	525	30.0
(4) M.W	685	258	26.0	810	520	31.0
(5) M.W	595	249	27.0	670	480	407.0

Uptake of macronutrients

Data in Table 3 indicate the response of NPK contents in citruss leaves to magnetized irrigation water at 4 and 14 weeks after magnetron placement.P content was almost tripled, K was considerably increased while that of N was not affected.

TABLE 3. Uptake of fertilzer elements by citrus leaves as affected by magnetic treatment of Irrigation water, 4 and 14 weeks after magnetron placement.

Sample Site	Nutrients uptake (mg/g)					
	4 weeks			14 weeks		
	N	P	K	N	P	K
(1) N.W	13.3	2.00	13.0	21.0	1.60	16.0
(2) M.W	15.2	2.40	15.9	22.1	3.30	20.0
(3) M.W	14.0	2.50	14.7	21.5	4.41	23.3
(4) M.W	13.0	2.40	14.9	22.1	3.40	18.4
(5) M.W	12.5	1.90	18.5	21.9	2.65	15.2

Micronutrients uptake

Data in *Table* 4 indicated that even though Fe extraction from root zone has increased 9 folds due to magnetization, the increase of Fe concentration in leaves 14 weeks after setting was slight (36%) Mn content of leaves showed the maximum increase (190%) followed by Zn & Cu.

In gneral, the uptake of all micronutrient were accelerated in all sites beyond the magnetron at the two sampling times (4 & 14 week after setting).

TABLE 4. Effect of Magnltizing irrigation water on citrus leaves content of micronutrients at 2 sampling times after placement of magnetron.

Sample site	Elements content in citrus leaves (ppm)							
	Fe	Mn	Zn	Cu	Fr	Mn	Zn	Cu
	4 weeks				14 weeks			
(1) N.W	500	19.2	5.8	7.5	405	28.0	32	13.0
(2) M.W	538	22.2	10.1	17.0	576	73.0	45	23.0
(3) M.W	490	22.1	9.8	11.8	539	51.0	47	20.0
(4) M.W	568	26.8	12.0	22.0	501	46.0	44	17.0
(5) M.W	582	25.7	10.2	21.0	448	40.0	34	16.0

As explained in the Indah water report (Takoshinko 1995) the magnetic filed energy E per volume unit can be described in this equation

$$E = \frac{U H^2}{2}$$

Where U is the magnetic susceptibility of the medium and H is the magnetic field strength.

In a water dispersed micro system, like soil colloids, magnetic field arranges the particles in such a way that their energy has the value of U', U'', U''' .. etc which are different from the energy U° outside the magnetic field. Magnetic field weakens the bonds between certain ions with subsequent bonding amplification of others. Such changes in magnetic susceptibility of elements due to magnetized irrigation water is thought to be a major factor affecting their activity in soils and plants.

It should also be mentioned that material magnetic susceptibility differs due to hydration, oxidation reduction, temperature and magnetic field intensity.

Yield response

Performance of citrus tree, irrigated with magnetized water for more than 3 growth seasons; was evaluated. Fruit yield presented in Table 5 indicated a trend similar to that of nutrients response in magnetized sties. In the first growth season after applying the magnetic application, citrus yield increased gradually to reach a **peak in plot 4 located** *500* to **700m** from the magnetron where the yield increase per plot (20 acres) reached 45 tons. Such effect diminished completely in **plot(5),** at a distance exceeding **750m** from the magnetron.

However, the yield response was extended to this last plot in the 3rd growth season. It should be mentioned that magnetrons usually keep their magnetic power for 10 years at least.

In general, the cost of magnetic units can be covered in one season with extra benefit of more than 80%.

TABLE 5. Yield of citrus fruits (summer orange) in 1997 & 1999 growth seasons.

Treatment and area	Distace form magnetron	Yield of fruits tons per acre	
Non magnetized (1) 20 acres	Ahead of the magnetron	1st season 12.0	3rd season 8.7
Magnetized			
(2) 20 acres	100 to 300	13.0	9.2
(3) 20 acres	300 to 500	13.3	10.3
(4) 20 acres	500 to 700	14.3	10.5
(5) 10 acres	700 to 800	12.0	11.0

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تطبيقات التقنيات المغناطيسية فى الزراعة الصحراوية.٣- استجابة الموالح للرى بالماء الممغنط وعلاقته بحركة العناصر الغذائية بالتربة

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أدى استخدام التقنيات المغناطيسية فى مجال الزراعة فى مصر إلى العديد من النتائج الإيجابية، فاستخدام الماء الممغنط فى الرى أدى إلى زيادة معدل غسيل التربة من الأملاح وتقليل قلوية التربة كما أدى إلى زيادة بسيطة فى ذوبان بعض المركبات مثل الجبس وكربونات الكالسيوم ، كما وجد أيضا أن ماء الرى الممغنط قد أدى إلى حدوث تغيير أو تحول فى التوازن الأيونى فى التربة حيث أصبح هذا التوازن أكثر ملاءمة لنمو النبات ، كذلك لوحظ أن مغنطة البذور قبل الزراعة قد أدى إلى زيادة نسبة الإنبات وزيادة قدرة البذور على اختراق سطح التربة بسهولة .

وتم فى هذا البحث تقييم التأثيرات المختلفة للماء الممغنط على حركة العناصر الغذائية وامتصاصها من التربة لأشجار الموالح وكذلك المحصول الناتج من موسمين متتاليين. كما درس أيضا العلاقة بين المسافة التي يقطعها الماء الممغنط في أنابيب الري ومدى تأثيراته المغناطيسية.

تدل النتائج المتحصل عليها على أن تأثير الماء الممغنط على حركة وامتصاص العناصر الغذائية يختلف كثيرا من عنصر إلى آخر حيث وجد أن تركيز الحديد والزنك والفوسفور والمنجنيز المستخلص من التربة قد تضاعف ٩، ٥، ٣، ٨ و. مرةعلى الترتيب باستخدام الماء الممغنط عن الرى بالماء ومع ذلك فقد وجد أن محتوى الأوراق كان أكبر فى حالة المنجنيز يليه الزنك بينما كان الحديد أقل تأثرا ويجب الإشارة إلى أن الحديد النشط فى النبات هو الاكثر فاعلية وتأثيرا على نمو النبات وليس محتوى النبات من الحديد الكلى . بجانب ذلك وجد أن تركيز الفوسفور قد تضاعف ٣ مرات وزاد محتوى البوتاسيوم زيادة كبيرة ، بينما لم يكن هناك تأثير على تركيز النيتروجين داخل النبات عند الرى بالماء الممغنط.

بالنسبة للمسافة التى يقطعها الماء فى أنابيب الرى مع الاحتفاظ بتأثيراته فقد وجد أن محصول الموالح كان أعلى ما يمكن عند مسافة ٥٥٠ مترا وتلاشى التأثير عند مسافة تزيد عن ٧٥٠ مترا من مكان تركيب الجهاز المغناطيسى "الماجنترون" ووجد نفس الاتجاه أيضا بالنسبة للعناصر الغذائية المستخلصة من منطقة انتشار الجذور.