EFFECT OF USING MAGNETIZED TREATED WATER UNDER CENTER PIVOT IRRIGATION SYSTEM ON POTATO YIELD

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ABSTRACT: With the rise in the cost of producing crops, the increase in fuel price and high soil, and water salinity, all these factors resulted to loose in yield and less benefit cost of the potato crop. To implement this purpose, the following procedures were carried out; the effect of using magnetized irrigation water (MIW) under a center pivot irrigation system on potatoes through a management irrigation system to reduce the quantity of the used irrigation water, and reduce the effect of soil salinity on potato yield. To achieve the main objective of this study, three experimental factors were studied. The first factor is irrigation water (treated and non-treated by magnetized irrigation water), the second factor is crop evapotranspiration level (four levels of evapotranspiration 110, 100, 90, and 80%), the third factor is soil salinity (two levels of soil salinity low 1.46 and high 4.56 dS/m), with potato seeds Santana cultivar. Three measurements before and after planting were conducted; water and soil chemicals analysis, foliage of plants (leaf area index), tubers yield (Mg/ha.), and tuber diameters of the new yield. Compared between MIW and N-MIW under center pivot irrigation system on potato. the reported results showed that, decrease in soil salinity between 10 and 17%, and a decrease in soil pH between 3.4 and 5.7%. Increase in leaf area index of plants during growing of plants between 13.5 and 11.5 %. Increase production in yield by about 11.5 and 22.5%, increase in seed diameters of new tubers (10-20%), and decrease 10% from the use of irrigation water.

Keywords: Magnetized treated water, center pivot irrigation system, leaf area index, water use efficiency, potato crop evapotranspiration (ETc), low and high soil salinity, potato seed diameters and potato yield,

INTRODUCTION

Potato (*Solanum tuberosum, L.*) tubers follow only rice and wheat in world importance as a food crop for human consumption. Egypt is one of the top 20 producers of potatoes worldwide and the first largest producer and exporter of potatoes in Africa in 2019, it grows under different environmental conditions. The cultivated areas of potatoes in Egypt were 209,417 hectares producing 6.9×10^6 Mg with an average of 30 Mg/ha (FAO, 2023).

Magnetic treatment of water has been reported to change some of the physical and chemical properties of water, polarity, pH, and solubility of salts conductivity, (Grewal and Maheshwari, 2011). Various environmental stresses, high winds, extreme temperatures, soil salinity, drought, and flood have affected the production and cultivation of agricultural crops, (Shahbaz and Ashraf, 2013). Magnetic irrigation water had a positive effect on decreasing; both soil salinity (ECe), and sodium adsorption ratio (SAR), after harvesting, (Amer *et al.,* 2014). Leaf area index (LAI) values are used to determine sowing time (so that the highest leaf area coincides with the highest availability of solar radiation) when applying pesticides, plant spacing, and fertilization (Favarin *et al.,* 2002).

Magnetized treated water with sugar beet could be used as the most important modern

technology, which helps in saving irrigation water and improving yield and quality under the sandy soil (Hozayn *et al.,* 2013). Potato plants with Magnetized treated Water significantly increased the potato tubers yield, number of new tubers, and size of tuber as compared to using ordinary water with nonmagnetic water, (Moussa and Hozayn 2018). Studied the combinations between the application of magnetized treated water and water regimes enhanced the water use efficiency, tubers quality from dry matter, content of elements, and yield of potato (Ahmed and Abd El-Kader 2016).

This study aimed to evaluate the performance effect of using magnetized treated water under a center pivot irrigation system on potatoes through:

- Management of irrigation system to reduce the quantity of used irrigation water and increase water use efficiency.
- Improvement in production yield and quality of potatoes.
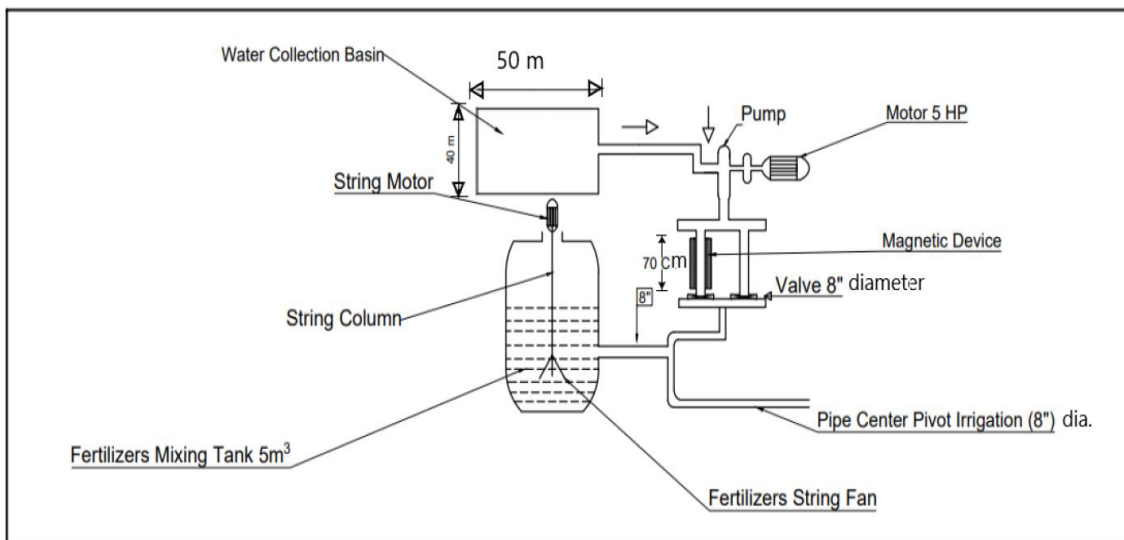
MATERIALS AND METHODS

1. Experimental Site

To achieve the purpose the study includes conducted the following parameters. Study the effect of using magnetized treated water under a center pivot irrigation system on potatoes. The study was carried out at the International Company for Agriculture Development (Farm Frites, Egypt) in El-Hashemeia farm –Wady El-Natroon – Elbehira governorate during two consecutive seasons, namely the winter season 2018 and the summer season 2019 as a field indicator. The latitude angle was E (30° 01$^\backslash$ 14 $^{\backslash\backslash}$), N (30° 18$^\backslash$ 30$^{\backslash\backslash}$). Magnetized irrigation water (MIW) treatment device was installed at the main entrance of the main pipe located in the center pivot irrigation system.

2. Source of magnetized water

Magnetized field strength is 14000 gauss (1.4 Tesla), which is the strongest magnetic field force available in this period. Magnetized strips installed from inside, 70 cm long and weighing 80 kg. Effective charging of magnetized equipment is 300 m^3/h, fixed magnetized tube with the main tube of center pivot irrigation. As shown in Figure 1.

Fig. 1: Magnetized water treatment device installed in the center pivot main pipe.

3. Source of irrigation water:

Ground water, through two wells, charged in the water collection Basin, the rate of discharge of the two deep wells together is 220 m^3/h, length of the center pivot irrigation device is 380 m.

Soil and irrigation water analysis procedures, the soil samples were collected from a depth of zero to fifty cm (root zone area) with completely random sampling from each quarter separately of the center pivot irrigation for analysis of the sample of irrigation water from each well, the obtained data for chemical analysis of soil and irrigation water were listed in Tables 1 and 2.

Table 1: Chemical analysis of soil located at the experimental site.

Quarter	Soil salinity	pH	EC (dS/m)	Soluble cations (mmol/L)				Soluble anions (mmol/L)		
				Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO^{-3}	$SO^{=4}$
A	Low	8.8	2.56	4.15	2.23	9.97	0.73	7.6	4.9	4.58
B	High	8.94	4.86	8.05	8.25	19.32	1.4	14.05	9.25	13.72
C	Low	8.83	2.6	4.26	2.37	10.02	0.74	7.7	4.77	4.92
D	High	8.94	4.8	7.77	7.95	19.65	1.36	14.02	8.96	13.75

Table 2: Chemicals analysis of the used irrigation water.

Well N.O	Water pH	EC (dS/m)	Soluble cations (mmol/L)				Soluble anions (mmol/L)		
			Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO^{-3}	$SO^{=4}$
1	7.74	1.43	4.08	3.15	5.14	0.29	3.88	3.06	5.72
2	7.74	1.4	3.96	3.03	5.02	0.26	3.77	2.95	5.55

Potato seeds that were used in cultivation, Potato Santana cultivar were used in both two growing seasons 2018 and 2019.

4 Experimental treatments

To achieve the main objective of this study, three factors were studied and changed at different levels; these factors were:

The first magnetized treated irrigation water has two levels magnetized irrigation water and non-magnetized irrigation water. The second factor was irrigation levels, four irrigation levels were used which were 80, 90, 100, and 110 % of ETc.

The amount of water application rate can be derived. Water application rate or crop evapotranspiration (ETC) was computed with crop coefficient (Kc) by Allen *et al.,* (1998) according to the following equation:

$$ETc = Kc \times ET_O \qquad …………. [1]$$

Where: ET_c is the crop evapotranspiration (mm/day), K_c is the crop coefficient, and ETo is the reference evapotranspiration (mm/day), according to the following equation of Allen (2011) FAO 56 and ET_o was calculated according to Snyder, (1992) using the Class A evaporation pan (Figure 2). The third factor was soil salinity, with two levels which were low and high soil salinity.
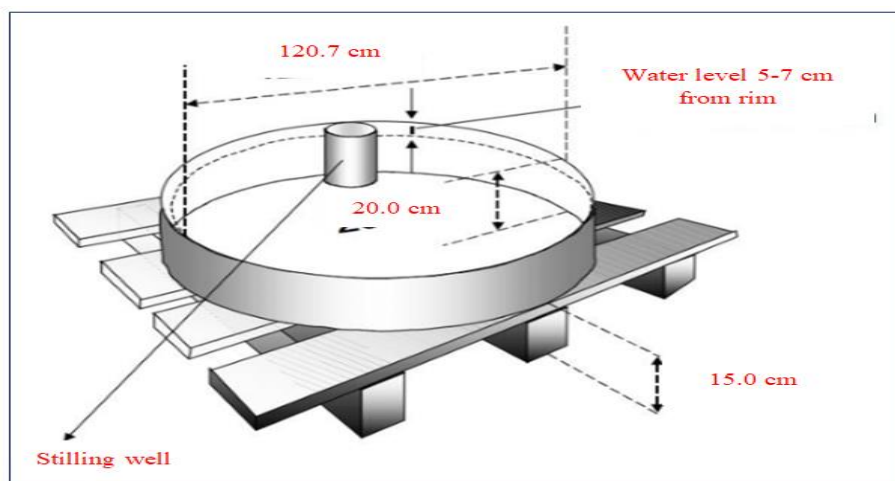
Fig. 2: Evaporation pan class A

5 Experimental Procedures

Procedures followed before and during planting

1- Leaching requirement of soil salinity and filling the field capacity of the soil to a depth of 60 cm with the following equation of Ayers and Westcot (1985).

$$LR = \frac{ECw}{5\,(ECe) - ECw} \quad \text{…….……. [2]}$$

Where: LR = the minimum leaching requirement needed to control salts within the tolerance (ECe) of the crop with surface methods of irrigation. ECw = average soil salinity related by the crop as measured on a soil saturation extract above which yield begins do decline.

2- Preparing of soil for planting by machinery from soil plowing with subtractive inversion, adding fertilizers from macro elements (N-P-K) and followed by soil leveling and smoothing with rotary harrow before planting directly then planting seed tubers by planter machinery 4 rows fully automatic with GPS, distances between each row 90 cm, each one square meter = 110 cm length* 90 cm (wide /row of planting).

Irrigation procedures (Crop evapotranspiration) after planting

Water supply and scheduling are important in terms of quality. An irrigation program was carried out during the growing season using a center-pivot irrigation system for all tested treatments. The irrigation schedule for all treatments is presented in Figures 3 and 4.
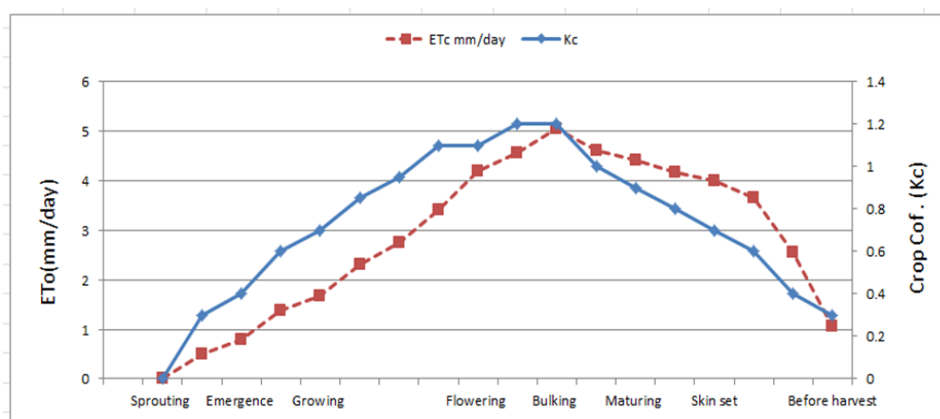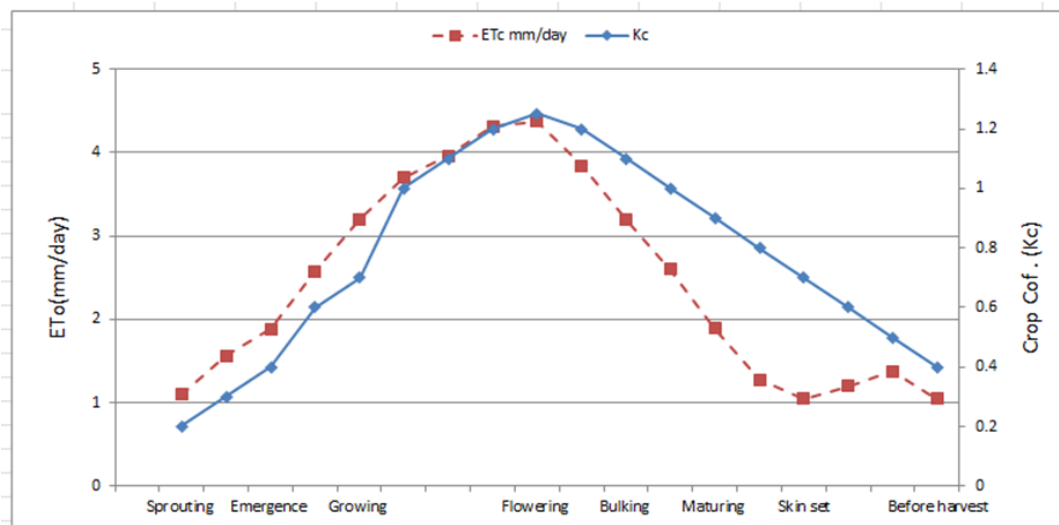

Figure 3: Irrigation schedule for winter season 2018.

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Figure (4): Irrigation schedule for summer season 2019

Fertilization program

The most important macronutrients are nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg). Fertilization units are required for plants during the growing stage of plants according to the recommendation of the soil analysis laboratory (STUKENHOLTZ LABORATORY).

6 Parameters which measured on plants and tuber yield

Samples were taken randomly for each treatment of the sample. The average of one sample is 9 m^2, as it contains 3 replicates, and the area of each replicate is 3 m^2 to get the final average for one square meter.

Leaf area index (LAI) was estimated by using the free software Image J. Seven evaluations for each treatment were carried out, the first measures at forty-two days after planting and subsequently every seven days until 84 days from the age of the plant. Average leaf area index per plant and from number of plants /m2 calculated total leaf area index according to Martin *et al.* (2020).

$$\text{Leaf Area Index} = \frac{A}{a} \quad \text{.............................. [3]}$$

Where:

A is the mean leaf area of plants measured by ImageJ software program (m^2)

a is the mean area of plants grow in the soil to each treatment of sample (m^2).

Seed diameters of yield for new tubers

The samples were graded before harvest directly, three samples and each sample is three square meters (9 m^2), collected in a completely random way, to each level from evapotranspiration and graded potatoes to four levels according to seed diameters by grading station to four levels 28-35, 35-45, 45-50 and 50 up mm, and divided by 9 to get on average number of new tubers per one square meter from each treatment.

Tubers yield (Mg/ha) was measured during the harvest stage, and these measurements were relied upon for each variable in assessing the expected yield.

7 Chemicals analysis of soil and irrigation water

Chemicals analysis of soil samples, after harvest directly. Chemicals analyzed of irrigation water, before and after adding fertilizers to irrigation water by injection tank.

8 Economic and Financial indicators

Internal Rate of Return (IRR)

It shows the annual rate of return earned by the project, which is compared with the interest rate at commercial banks. IRR is defined as the discount rate that makes the present value of the net cash flow equal to zero, i.e. IRR = 0.

Pay Back Period (PBP)

PBP could be defined as the time period (years) during which the project will recover all its investments. PBP = 1/ IRR

Benefit / Cost ratio (B/C Ratio)

It is the present value of benefits divided by the present value of costs.

If B/C = 1 no profit, no loss, If > 1 profits and < 1 losses, reported by James (1981) and FAO Investment Centre (2009).

RESULTS AND DISCUSSION

1 Chemicals properties of irrigation water, before and after adding the fertilizer

Data in Table 3 shows the chemical properties of irrigation water, before and after adding the fertilizer.

Table 3: Effect of magnetic field (MIW) on the chemical properties of irrigation water and the chemical properties of fertilizers treatment.

Treatments	pH	EC (dS/m)	Soluble cations (mmol /L)				Soluble anions (mmol/L)		
			Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO^{-3}	$SO^{=4}$
N-MIW	7.74	1.43	4.08	3.15	5.14	0.29	3.83	3.06	5.77
MIW	7.86	1.46	4.55	3.5	5.78	0.32	4.36	4.74	5.05
Difference %	101.6%	102.1%	111.5%	111.1%	112.5%	110.3%	113.8%	154.9%	87.5%
LSD at 0.05	0.13 (NS)	0.16 (NS)	0.25	0.18	0.29	0.02	0.22	0.26	0.27
N-MIW- F	8.44	2.62	3.9	4.02	9.27	4.61	4.75	1.34	15.71
MIW-F	8.65	2.71	5.29	4.26	9.99	3.32	5.3	3.74	13.82
Difference %	102.5%	103.4%	135.6%	106.0%	107.8%	72.0%	111.6%	279.1%	88.0%
LSD at 0.05	0.18	0.29	0.58	0.21	0.42	0.2	0.22	0.16	0.25

EC – electrical conductivity; NS – not significant; N-MIW –non-magnetized irrigation water; MIW – magnetized irrigation water; MIWF – adding the fertilizer to the water after magnetized; N-MIWF – adding the fertilizers to water without magnetization., L S D least significant difference.

The value of pH

After exposing the N-MIW to magnetized directly the value of pH changed slightly and increased by about 1.5% not significant (NS), after adding fertilizers to N-MIW (N-MIWF) the value of pH increased by about 2.43% which means a significant difference existed between MIWF and N-MIWF, more pH for MIWF, as decided by Hassani *et al.* (2015).

The value of water salinity

The salinity of water slightly increased with the used MIW, it was 2.05% and 3.32% between N-MIW and MIW before and after added fertilizes to irrigation water respectively at (LSD) at 5% equal 0.29., so the significant difference existed between N-MIW-F and MIW-F for MIW-F more salinity. This EC increase was due to the addition of the fertilizers after the magnetization process disintegrated fertilizer to be more infinitely

small parts in water to be more soluble in the water.

The values all cations and anions for irrigation water:

Without added fertilizers, Ca^{++}, Mg^{++}, Na^+ and K increased by 11.29, 11.08, 12.45, and 11.65 %, respectively, and by 12.41, 54.53 and 18.96 % for Cl^-, HCO^3 and SO^4, respectively. For MIW treatment, the cation and anion values showed a higher after added fertilizers for Ca^{++}, Mg^{++}, and Na^+ increased by 26.3, 5.57, and 4.23, but with potassium decreased about 38.98 %, respectively, and 10.39, 64.18 and 23.33 % for Cl^-, HCO^3 and SO^4, respectively. Similarly, data were also obtained by Hozayn *et al.* (2015).

2 Chemical analysis of soil after crop harvesting

The reported data in Table 4 showed the effect of magnetized treated water on chemicals analyzed of soil after the harvest of potatoes.

Table 4: Effect of magnetized treated water on chemicals analyzed of soil after harvest of potatoes.

Treatments	pH	EC (dS)	SP	Soluble cations (mmol /L)				Soluble anions (mmol/L)		
				Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO^{-3}	$SO^{=4}$
Soil low EC before planting	8.84	2.6	22	4.27	4.37	10.24	0.75	7.7	4.91	7.02
Soil low EC after harvest N-MIW	8.53	2.48	2.07	4.91	4.09	6.65	0.82	9.54	4.63	2.3
Soil low EC after harvest MIW	8.07	2.11	23.2	4.58	3.97	5.75	0.77	6.63	4.11	4.33
Differentiate between MIW and N-MIW	94.6%	85.1%	150.4%	93.3%	97.1%	83.8%	93.9%	69.5%	88.8%	188.3%
LSD0.05	0.18	0.11	0.68	0.24	0.27	0.43	0.04	0.2	0.27	0.61
soil high EC before planting	8.67	4.8	22.01	8.05	8.25	19.32	1.41	14.53	9.26	13.24
Soil high EC after harvest N-MIW	8.46	4.27	22.11	8.72	7.27	11.82	1.4	16.96	8.24	4.01
Soil high EC after harvest MIW	8.18	3.77	24.48	8.18	7.1	10.28	1.32	11.85	7.34	7.69
Differentiate between MIW and N-MIW	96.7%	88.3%	110.8%	93.8%	97.7%	87.0%	94.3%	69.9%	89.1%	191.8%
LSD0.05	0.16	0.15	0.7	0.23	0.27	0.43	0.07	0.2	0.32	0.68

Small letters compare between treatments horizontal, EC – electrical conductivity; NS – not significant; N-MIW – normal water (non-magnetized treated water); MIW – magnetized treated water; a > b > c, L S D -least significance differences

Soil pH after potato harvesting

The results in Table 5 show a decrease in the soil pH after the potato was harvested by using the magnetized water treatments. The difference percentage between N-MIW and MIW after harvest in low soil salinity was

5.7% compared with the high soil salinity of 6.95% for MIW less values from soil pH. These results agree with Ghernaout (2018) as mentioned, these differences between pH

before and after the use of MIW repack to the volume of the molecules in the magnetized treated water (MIW) is half that of the non-magnetized treated water (N-MIW).

Table 5: Effect of MIW on quality of potatoes (seed diameters) in low and high soil salinity at the four levels from ETc

season	ETc	N.O Tubers / Seed Diameter (mm))																				
		Low Ec (dS/m)										High Ec (dS/m)										
		MIW					N-MIW					MIW					N-MIW					
		28-35	35-45	45-50	55 UP	total	28-35	35-45	45-50	55 UP	total	28-35	35-45	45-50	55 UP	total	28-35	35-45	45-50	55 UP	total
2018	ETc 110%	1.3	5.9	8.9	5.6	21.7	1.6	7.3	6.7	4.2	19.8	1.7	7.9	6.2	3.1	18.9	1.7	6.8	5.7	1.6	15.7
	ETc 100%	1.5	5.7	9.2	5.4	21.8	1.7	6.8	6.8	4.1	19.3	1.6	7.3	6.4	3.3	18.7	1.8	6.4	5.3	1.7	15.2
	ETc 90%	1.4	6.1	8.2	3.9	19.5	1.8	7.4	5.5	3.0	17.7	1.8	8.0	5.3	1.8	16.7	1.9	6.2	4.8	0.5	13.5
	ETc 80%	1.4	5.8	7.8	2.7	17.7	1.7	7.1	5.0	2.8	16.5	1.7	7.8	4.1	1.7	15.2	1.8	6.2	3.3	0.9	12.2
Average		1.4	5.9	8.5	4.4	20.2	1.7	7.2	6.0	3.5	18.3	1.7	7.8	5.5	2.5	17.4	1.8	6.4	4.8	1.2	14.1
%		7%	29%	42%	22%	100%	9%	39%	33%	19%	100%	10%	45%	32%	14%	100%	13%	45%	34%	8%	100%
2019	ETc 110%	1.0	3.6	10.8	8.6	24.0	1.3	4.8	9.6	6.1	21.8	1.9	7.6	7.2	4.3	21.0	1.5	6.5	5.4	2.9	16.4
	ETc 100%	1.1	3.8	10.5	6.9	22.2	1.4	5.0	8.4	5.2	20.1	1.9	6.4	5.9	5.1	19.3	1.3	5.7	4.5	3.4	14.9
	ETc 90%	1.2	4.3	9.1	6.0	20.7	1.5	6.4	6.4	4.0	18.2	2.1	6.4	6.5	2.6	17.5	1.9	6.2	3.4	1.4	12.9
	ETc 80%	1.5	4.4	6.7	6.5	19.2	1.6	4.9	5.0	4.7	16.3	2.3	7.2	5.7	1.1	16.3	2.0	6.3	2.5	0.4	11.2
Average		1.2	4.0	9.3	7.0	21.5	1.4	5.3	7.3	5.0	19.1	2.0	6.9	6.3	3.3	18.5	1.7	6.2	3.9	2.1	13.8
%		6%	19%	43%	33%	100%	8%	28%	39%	26%	100%	11%	37%	34%	18%	100%	12%	45%	28%	15%	100%

N-MIW: means non magnetized water, MIW: means magnetized treated water, Ec: means soil salinity, ETc: means crop evapotranspiration and seed diameters 28-35, 35-45, 45-50 and 50 up mm.

Soil salinity after potato harvested

Difference between MIW and N-MIW on changing of EC in low soil and high salinity, different percentage between MIW and N-MIW on changing in soil salinity 6.0% and 13.28% in low and high soil salinity respectively and least significant difference between Ec at 5% equal 0.11 dS/m find significant difference between used MIW and N-MIW from effected on leaching of soil salinity to be more with used MIW is more

effect on leaching in low and high soil salinity as reported by Surendran *et al.* (2016).

Soil saturation point after potato harvested (SP)

The values of soil saturation point, before and after harvest with normal irrigation in high soil salinity with used N-MIW compared with used MIW to be more values for soil saturation point before planting and after harvest and these resulted to with used MIW it can effect on the ability of soil to be more

saturated for liquid, gases, chemicals, and energy. In high soil salinity, more ability of roots to uptake more elements, decreased leaching of fertilizers from the soil, saved for irrigation water, more yield, and lower costs these results were confirmed by Maheshwari and Grewal (2011).

Cations and anions of soil after harvest

Values of Sodium cation and chloride anion, With Sodium cation difference between N-MIW and MIW, to be more 7.2% and 6.68 compared between N-MIW and MIW in low and high soil salinity respectively; with chloride anion compared between used N-MIW and MIW, to be less 43.84% and 43.15 compared between N-MIW and MIW in low and high soil salinity respectively after harvested and these resulted to more efficient of plant to uptake remains of macro and microelements, also these values decreased from sodium and calcium chloride from the soil.

Values of bicarbonates and sulfate anions, values of bicarbonate ion decreased between used MIW and N-MIW by about 12% followed by a decrease in ratio of sodium and calcium bicarbonate from soil and finally less soil salinity, values of sulfate ion found significant difference between N-MIW and MIW for MIW lowest values of SO=4 anion after harvest by about 8% and resulted to roots of plants to uptake micro of elements and these results agree with Noran *et al.* (1996).

3 Potato leaf area index

The ability of a potato plant to intercept solar radiation is closely related to tuber yield. Leaf Area Index (LAI) and ground cover measurements are frequently used to estimate light interception. Data presented in Figure 5 shows the effect of MIW on the average leaf

area index for 7 treatments at the age of 42 to 84 days for the foliage of potatoes.

(a) Leaf area index (m^2/m^2), in low soil salinity

The difference average for leaf area index, between MIW and N-MIW is 1.98 and 1.63m2/m2 with a difference percentage of 17.8% for MIW.

The average difference between MIW and N-MIW for leaf area index with four levels from crop evapotranspiration achieved average leaf area index (m^2/m^2) at ETc1 (2.51 and 1.96), ETc2 (2.43 and 1.91), ETc3 (1.74 and 1.55) and ETc4 (1.22 and 1.09) m^2/m^2, and difference percentage between MIW and N-MIW with ETc1, 2, 3 and 4 respectively 22.1, 21.2, 11.3 and 11.2%, achieved more leaf area index with used magnetized irrigation water.

(b) Leaf area index (m^2/m^2), in high soil salinity

The difference average for leaf area index, between MIW and N-MIW is 1.52 and 1.34 m^2/m^2 with a difference percentage of more than 12.2% for MIW. The average of leave area index between MIW and N-MIW, with four levels from crop evapotranspiration, achieved average at ETc1 (1.95 and 1.7), ETc2 (1.88 and 1.58), ETc3 (1.23 and 1.13) and ETc4 (1.03 and 0.93) m^2/m^2, and difference percentage between MIW and N-MIW with ETc1, 2, 3 and 4 respectively 12.7, 15.7, 8.7 and 9.3%, achieved more leaf area index with used magnetized irrigation water. These results are in harmony with the findings of Hozayn *et al.* (2016) found that all growth parameters of potato crops were improved by magnetized water (plant height stems of plant, stem diameter, number of internodes, number of branches per stem, fresh and dry weights leaves) compared to control.
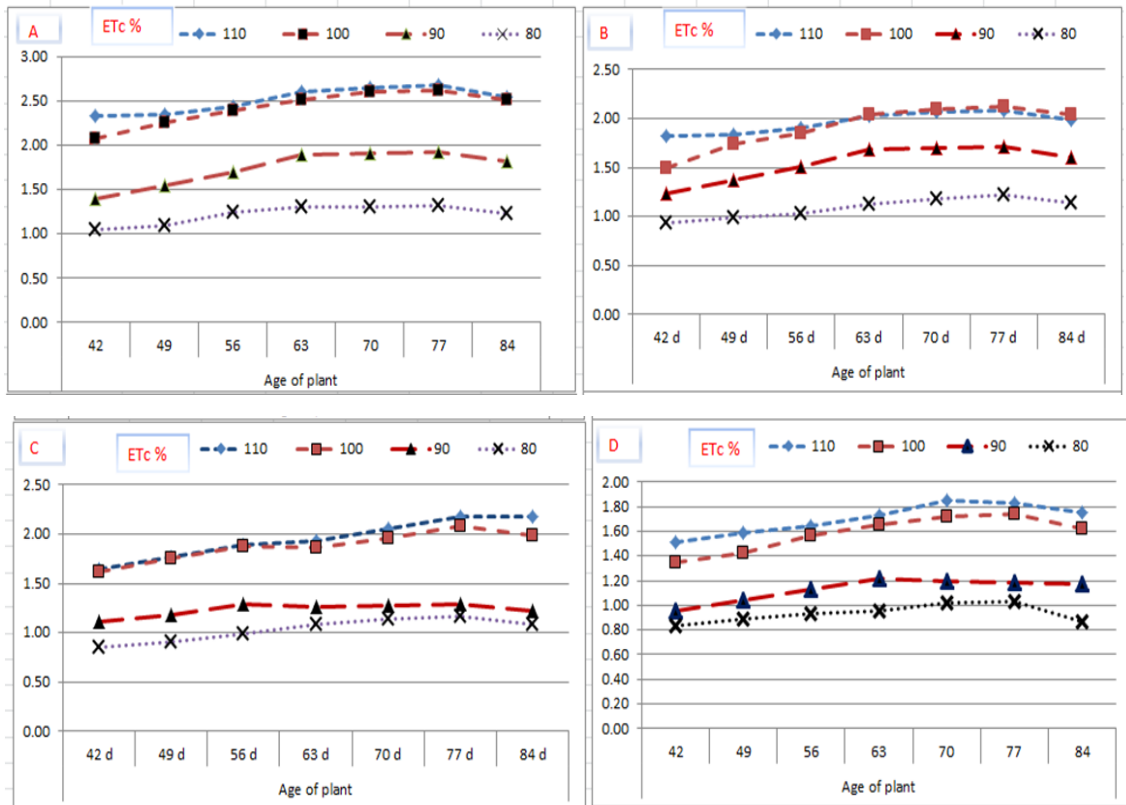
Figure 5: (A) mean leaf area index for MIW in low soil salinity, (B) mean leaf area index for N-MIW in low soil salinity, (C) mean leaf area index for MIW in high soil salinity, and (D) mean leaf area index for N-MIW in high soil salinity.

4 Potato yield

Data presented in Figure 6 show the effect of MIW on the yield of potatoes.

4.1 Effect of magnetized irrigation water on yield of potatoes.

In low soil salinity:

In summation, the total average of the four levels of seed diameter difference yield percentage between MIW and N-MIW in low soil salinity with four levels from ETc in first season 9.43, 10.73, 7.3, and 8.63% (total average 9.0%) but in second season 11.19, 10.19, 9.7 and 11.53 % (total average 10.7%). The ratio between MIW and N-MIW, in the first and second seasons, yields about 2.3 Mg/ha and 9.0 % in the 1st season and 2.8 Mg/ha, 10.7% in the 2nd season.

In high soil salinity

In summation, the total average of the four levels of seed diameter difference yield percentage between MIW and N-MIW in low soil salinity at the four levels from ETc in 1st season was 14.83, 17.54, 14.88 and 18.79 % (total average 16.5%) but in 2nd season 22.22, 21.78, 22.42 and 24.91 % (total average 22.8%). The ratio between MIW and N-MIW, in the 1st and 2nd seasons, yields about 3.4 Mg/ha and 16.5 % in the 1st season and 5.0 Mg/ha, 22.8% in the 2nd season.

These agree with Hozayn *et al.* (2016) who indicated that irrigation of potato plants with water passed through a magnetic device (Magnetron, two inches) induced a positive significant effect on the yield components (number of tuber/plants, average tuber weight (g/tuber) and tuber weight/ plant) as compared with plant irrigated with normal water.
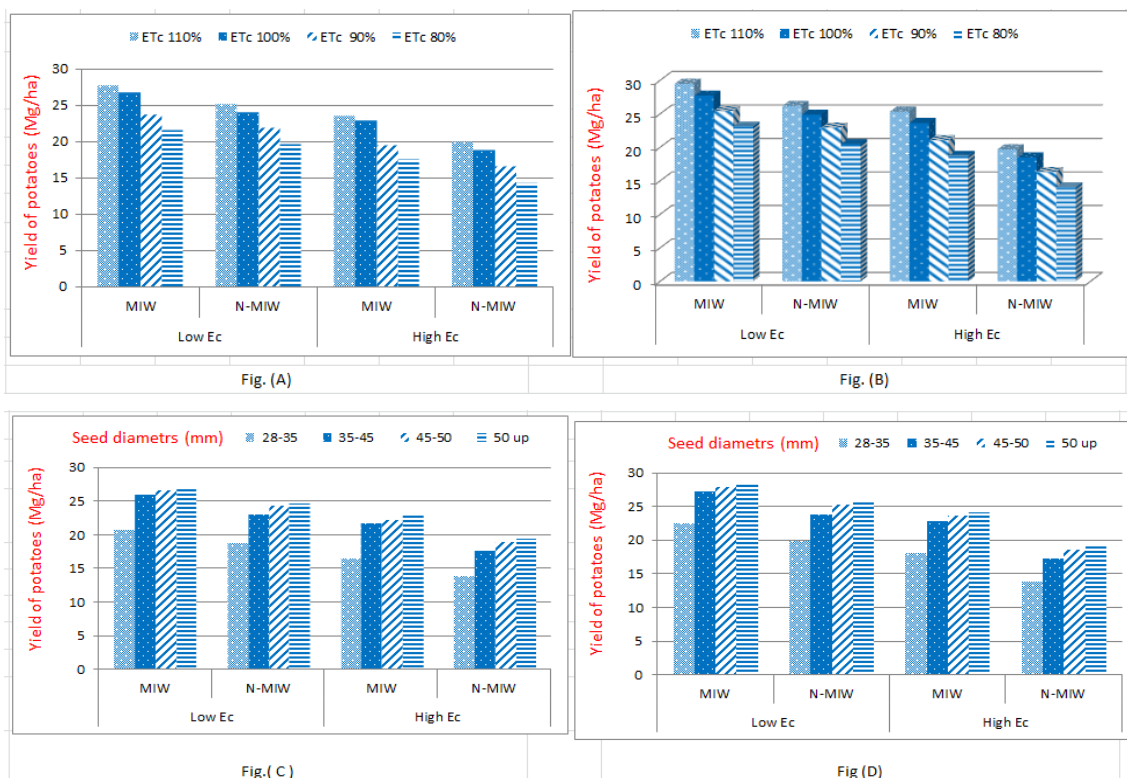
Fig. 5: (A) mean effect of MIW on yield of potatoes (Mg/ha) , season 2018/2019, (B) mean effect of MIW on yield of potatoes (Mg/ha) , season 2019, (C) effect of MIW on yield of potatoes (Mg/ha) , with total average yield of four levels from ETc , season 2019 and (D) Effect of MIW on yield of potatoes (Mg/ha) , with total average yield of four levels from ETc , season 2018/2019.

4.2 Effect of soil salinity on yield of potatoes (Mg/ha)

MIW in high soil salinity with seed diameter 28-35 mm

We can save quantity from irrigation water by about 10% from a dosage of water at ETc1 and ETc2; no significant difference between ETc1 and ETc2 with used MIW in low and high soil salinity compared with used N-MIW find significant different between ETc1 and ETc2 in low and high soil salinity. Find S.D. between ETc2 and ETc3 for ETc2 more yield in low and high soil salinity with MIW and N-MIW, also find S.D. between ETc3 and ETc4 for ETc3 more yield in low and high soil salinity with MIW and N-MIW. With seed diameters of 28-35 mm difference in yield percentage between MIW and N-MIW in low soil salinity with four levels from ETc in 1st season 13.4, 16.2, 18.9 and 17.0

% (total average 16.4%) but in 2nd season 20.0, 22.7, 27.3 and 26.2 % (total average 24.0%).

In low soil salinity, with seed diameters 28-35 mm

Difference yield percentage between MIW and N-MIW in low soil salinity with four levels from ETc in 1st season 7.8, 10.1, 11.8 and 8.6% (total average 9.6%) but in 2nd season 8.5, 11.0, 15.0 and 12.6 % (total average 11.8%).

4.3 Effect of Evapotranspiration (ETc) on yield of potatoes (Mg/ha)

By using magnetized treated irrigation water difference in yield between low and high soil salinity in 1st season at four levels from ETc, ETc1, 2, 3 and 4, respectively 4.32, 4.19, 4.41 and 4.33 Mg/ha and in 2nd season 4.23,4.11, 4.39 and 4.37 Mg/ha. Percentage difference in yield between low and high EC

with MIW in 1st season 14.7, 14.5, 17.4 and 19.3% and in 2nd season 13.6, 13.9, 16.4 and 18.2 % with ETc1, 2, 3 and 4, respectively.

5. Effect of magnetized treated water on seeds diameters (size yield of potato tubers)

The main quality characteristics of interest to both French fry and crisp producers are tuber size and shape, flesh color, dormancy and storability, dry matter content, and reduced sugar content. For the production of French fries, the tuber shape most closely resembling a rectangle in cross-section results in minimum wastage (offcuts and slivers). Long tubers satisfy the demand of fast food chains for long fries (Genet 1992). Table 5 shows the effect of MIW on the quality of potatoes (seed diameters) after harvest and grading the samples in low soil salinity.

In low soil salinity

Compared between MIW and N-MIW, four levels from ETc achieved number of new tubers; with ETc 1 1.3, 5.9, 8.9 new tubers with MIW and 5.6 and 1.6, 7.3, 6.7 and 4.2 new tubers with N-MIW to seed diameters 28-35, 35-45, 45-50 and 50 up; with ETc2 1.5, 5.75, 9.2 and 5. new tubers with MIW and 1.7, 6.8, 6.8 and 4.1 new tubers with N-MIW; with ETc3 1.4, 6.1, 8.2 and 3.9 new tubers with MIW and 1.8, 7.4, 5.5 and 3.0 new tubers with N- MIW; with ETc 4 1.4, 5.8, 7.8 and 2.7 new tubers with MIW and 1.7, 7.1, 5.0 and 2.8 new tubers with N-MIW.

a) In low soil salinity with N-MIW

The percentage of tubers to each seed diameter with total number achieved with MIW in low soil salinity 7.0, 29.0, 42.2, and 21.9% and 9.2, 39.0, 32.6, 19.1%. Total percent of numbers of tubers 28-35 and 35-45 with MIW 36% and 48% with N-MIW; total % of numbers of tubers 45-50 and 50 up mm with MIW 64% and 51.7% with N-MIW (with MIW 12% less numbers with small diameters and 12.3% more with big sizes compared with used N-MIW. In low soil salinity with use of magnetized irrigation water (MIW) resulted to increasing in big sizes of seed diameters for potato seeds by

about 12% and a decrease in small sizes seed diameters for potato seeds by about 12%, improved finally by using MIW to more about 24% compared with N-MIW.

b) In high soil salinity:

Compared between MIW and N-MIW, the four levels from ETc achieved the number of new tubers; with ETc 1.7, 7.9, 6.2, and 3.1 new tubers with MIW and 1.7, 6.8, 5.7, and 1.6 new tubers with N-MIW to seed diameters 28-35, 35-45, 45-50 and 50 up; with ETc2 1.6, 7.3, 6.4 and 3.3 new tubers with MIW and 1.8, 6.4, 5.3 and 1.7 new tubers with N-MIW; with ETc3 1.8, 8.0, 5.3 and 1.8 new tubers with MIW and 1.9, 6.2, 4.8 and 0.5 new tubers with N- MIW; with ETc 1.7, 7.8, 4.1 and 1.7 new tubers with MIW and 1.8, 6.2, 3.3 and 0.9 new tubers with N-MIW. The percentage of tubers to each seed diameter with total number achieved with MIW in high soil salinity 9.7, 44.5, 31.6 and 14.2% and 12.8, 45.2, 33.8 and 8.2% with N-MIW. Total percentage of numbers of tubers to small and medium sizes (28-35 and 35-45 mm) with MIW 54.2% and 58% with N-MIW; total % of numbers of tubers with big sizes (45-50 and 50 up mm) with MIW 45.8% and 42.0% with N-MIW (with MIW 4.2% less numbers with small diameters and 3.8% more with big sizes compared with used N-MIW.

The high soil salinity with the use of magnetized irrigation water (MIW) resulted to increasing in big sizes of seed diameters for potato seeds by about 3.8% and a decrease in small sizes seed diameters for potato seeds by about 4.2%, improved finally with the use of MIW to be more about 8% compared with N-MIW.

CONCLUSIONS

The obtained results showed that:

1- Magnetized irrigation water (MIW) achieved more yield of about 10-15% in low soil salinity compared with N-MIW, which leads to saving about 10% from electrical energy.

2- Evapotranspiration with used magnetized irrigation water at a third level from the

irrigation rate (90%) is equivalent to the level of irrigation water required at 2nd level from evapotranspiration (100%).

3- In high soil salinity, MIW at the 2nd level from ETc (100%) in the winter season achieved the same yield as N-MIW at the 1st level from ETc (110%) and saved 10% of irrigation water.

4- In high soil salinity, and in the summer season, it is not suitable to grow potatoes at any level from irrigation with non-magnetized irrigation water (N-MIW), compared with used magnetized irrigation water (MIW) at 1st and 2nd levels from evapotranspiration, (110 and 100%), we can plant potatoes and achieve the required return.

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تأثير إستخدام الماء الممغنط تحت نظام الري المحوري على إنتاجية البطاطس.

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الملخص العربي

أجريت هذه الدراسه بمزرعة الشركة العالمية للتنمية الزراعية (فارم فريتس مصر) بوادي النطرون بمحافظة البحيرة واستهدفت تحقيق انتاجية جيدة وجودة عالية مع زيادة كفاءة معدل الاستهلاك المائي لمحصول البطاطس وكان الهدف الرئيسي من هذا العمل هو دراسة تأثير استخدام الماء الممغنط تحت نظام الري المحوري على انتاجية محصول البطاطس وذلك بمعالجة مياه الري مغناطيسيا من خلال مرورها عبر جهاز المعالجة المغناطيسية بقوة ١,٤ تسلا وذلك تحت مستويين من ملوحة التربة العالية والمنخفضة وأربع مستويات مختلفة من كمية ماء الري المضافة في كل رية وهي ١١٠، ١٠٠، ٩٠، ٨٠% من إجمالي البخر ـ نتح من الري لمحصول البطاطس (ETc)

وتم التوصل الي النتائج التالية: ـ

1- زراعة محصول البطاطس وريها بماء الري الممغنط عند المستوي الثالث من الري (٩٠%) من معدل البخر ـ نتح اليومي تعادل مستوي ماء الري غير الممغنط المطلوب عند المستوي الأول (١٠٠%) وبالتالي توفير ١٠% من كلا من ماء الري وكذلك الطاقة الكهربائية المستخدمة في تشغيل نظام الري المحوري.

2- يمكن زراعة محصول البطاطس مع ملوحة التربة العالية والتي قد تصل الي ٤,٥ ديسيمنز/م، وباستخدام ماء الري الممغنط في الموسم الشتوي فقط عند المستوي ١٠٠% من ماء الري. واستخدام ١١٠% من معدل الري عند الزراعة في الموسم الصيفي لتحقيق أفضل إنتاجية وللوصول إلى العائد المطلوب.

3- زيادة كفاءة إستخدام مياه الري من ١٠-١٥% مما يترتب عليه إمكانية توفير حوالي ١٠% من مياه الري سنويًا عند زراعة محصول البطاطس.

وأوصت الدراسة بما يلي:

1- استخدام الماء الممغنط على البطاطس في ملوحة التربة العالية او العادية لتحقيق العائد المادي المطلوب من الإنتاجية والتوفير في ماء الري والكهرباء بنسبة تتعدي ال ١٠%.

2- اجراء المزيد من الأبحاث لمعرفة مدي استخدام مستويين أو أكثر من شدة المجال المغناطيسي على إنتاجية البطاطس تحت نظام الري المحوري وتحت مستوي من التربة ملوحة تتعدي الأربعة والنصف ديسيمينز/متر.