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The Impact of Irrigation Regime in Different Growth Stages and Irrigation with Magnetized Water on Vegetative Growth Characteristics and Leaf Chemical Constituents of Cowpea.

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ABSTRACT

Two field experiments were conducted at the Experimental farm, Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the two successive summer seasons of 2017 and 2018. The work aimed to study the impact of deficit irrigation during various growth stages with magnetized water and their interactions on parameters of vegetative growth and leaves chemical constituents of cowpea cv.Kafr El-Sheikh-1.The experimental layout was split-split plot system in a complete randomized block design with three replicates.The experiment in each season included 16 treatments, representing the combinations of two magnetized of irrigation water (Non-magnetized water(control),Magnetized water),two growth stages (vegetative & reproductive) and four irrigation regime%,i.e.100,75,50and25 % of full crop evapotranspiration (ETc),during the two growth stages.Results indicated that cowpea plants, which were irrigated with magnetized water, gave the highest values of vegetative growth parameters and leaf chemical constituents compared with plants irrigated with normal water in both seasons. As for deficit irrigation at different growth stages, all vegetative growth characters and leaf chemical constituents of leaves were decreased with water deficit at vegetive growth stage(v).The plants which irrigation at 100% ETc (2093.14 m^3/fed.),followed by 75% ETc (1569.86 m^3/fed.)or 50%(1046.57m^3/fed.)gave the highest values of vegetative growth parameters and leaf chemical constituent compared with the 25% ETc treatment, which recorded the lowest ones in both seasons.According to the mentioned results, it has been noted the cowpea plant is very sensitive to the water stress at the vegetative growth phase. The best vegetative growth parameters and chemical constituents of leaves were when irrigated the plants by magnetized water at 100% ETc during the vegetative growth stage (v).

Keywords: magnetized water, water stress, deficit irrigation, irrigation levels, water quantities, deficit irrigation at growth stages.

INTRODUCTION

Cowpea (*Vigna unguiculate* L. Walp.) is one of the most important vegetable legumes due to its high protein content, heat tolerant, low fertilizer requirements and it can grow easily in the new reclaimed lands. The new cowpea cultivar Kafr El-Sheikh-1 has a short growth period, an erect and determinate growth habit and resistance to drought (Metwally *et al*., 1998; Knany *et al*., 2002 and Masoud, 2002).

Magnetized water has been reported to change some of the physical and chemical properties of water, mainly hydrogen bonding, polarity, surface tension, conductivity, pH and solubility of salts. These changes in water properties may be capable of affecting the growth of plants has three main effects; increasing the leaching of excess soluble salts, lowering soil alkalinity and dissolving soluble salts such as carbonates phosphates and sulphates (Bogatin *et al*., 1999). Magnetized irrigation water they appear to induce an improved capacity for nutrients and water uptake, providing greater physical support to the developing shoot. Better root growth and development in young seedlings might lead to better root systems throughout the lifetime of a plant (De Souza *et al*., 2006).

Irrigation of common bean plants with magnetized water increased growth characteristics and photosynthetic pigments (chlorophyll a and b) as compared with control plants (Moussa, 2011). Sadeghipour and Aghaei (2013) studied the effect of irrigation with magnetized water on cowpea. They detected an increase in number of leaf as well as total biomass as compared to those values obtained by using ordinary water.

The water was and still the most critical and limited factor on growth of crop. So, agriculture consumes more than 85% of available fresh water, facing strong competition with the other uses of water, and so it is required to enhance its performance. In addition, during at watering regime for a crop, it is wise to understand the sensitive growth stages for water stress, and the water requirements, in order to achieve maximum yield and maintaining adequate soil moisture conditions during sensitive stages of growth, so irrigation water may be saved during certain growth stages without affecting yield, especially under the limited availability of water in Egypt.

Water deficit at vegetative growth stage reduced the rate of leaf expansion and inhibited the growth of new leaves. The negative effects of water deficit at the

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vegetative growth stage were removed after re-watering the plants (Ziska and Hall, 1983). Water stress caused reduction in cowpea leaf dry matter at maturity and/or increase in leaf senescence and abscission due to water stress have been reported in previous studies (Abidoye, 2004; Samson and Helmut, 2007 and Okon, 2013). Warrag and Hall (1984) found that applying water deficit at two subsequent growth stages (vegetative and pod filling stages) and (flowering and pod filling stages) reduced growth of cowpea plants. Mousa *et al.* (2014) reported that post-flowering water stress reduced the cowpea total dry matter.

The strong influence of increasing irrigation up to the maximum level on plant height could be explained as a result of enhancing cell division and enlargement which need more water supplies (Hammad, 1991), the reduction in plant growth may be due to the deficiency of irrigation water might be due to the lack of water absorption by plant which intern effect on the amount of nutrients elements absorbed and photosynthetic assimilation rate under insufficient water condition. El-Noemani *et al.* (2009) on pea, cleared that increasing irrigation level up to 100% evapotranspiration increased plant height and leaf area/plant.

Hence, the main objective of this investigation was to study the impact of irrigation regime and irrigation with magnetized water in different growth stages on vegetative growth parameters and leaves chemical constituents of cowpea.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental farm, Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the two successive summer seasons of 2017 and 2018. The work aimed to study the impact of deficit irrigation during various growth stages (vegetative & reproductive) with magnetized water on parameters of vegetative growth and leaves chemical constituents of cowpea cv. Kafr El-Sheikh-1.

Soil and irrigation water analyses:

Soil samples were taken before sowing from a depth of 0-30 cm in both seasons for mechanical and chemical analysis. Mechanical soil analysis was determined according to Piper (1952). Determination of soluble cations, anions and available nitrogen, phosphorus and potassium were done according to Jackson (1973). Soil pH was achieved in a 1:2.5 soil–water suspension according to Cottenie *et al.* (1982). EC (dSm^{-1}) was determined in soil-water extract (1:5) according to Page *et al.* (1982). Samples of non- magnetized and magnetized water one for the same source was taken before irrigation and analysis for its chemical constituents. Soil and irrigation water were analyzed in The Central Laboratory for Soils, Water and plant Studies in Soils, Water and Environment Research Institute, Agricultural Research Center (ARC). The obtained results of soil and water analysis are presented in Tables (1 and 2), respectively.

Table 1. Mechanical and chemical soil characteristics at the experimental sites during the two growing seasons of (2017 and 2018).

Soil properties	2017 season	2018 season
A: Mechanical analysis		
Sand (%)	16.12	15.76
Silt (%)	31.50	31.76
Clay (%)	52.41	52.54
Texture	Clayey	clayey
B: Chemical analysis		
Soluble cations (meq/l) in 1:5		
Na^{+}	22.5	22.5
Ca^{++}	5.85	5.85
Mg^{++}	10.75	10.75
K^{++}	0.35	0.35
Soluble cations (meq/l) in 1:5		
HCO_3^-	4.7	4.7
Cl^-	12.0	12.0
SO_4^-	22.75	22.75
Available macro elements (ppm)		
N	46	46
P	10	10
K	251	251
pH (1:2.5 soil: water suspension)	8.42	8.42
EC (dS/m^{-1}) Soil extraction (1:5) at 25°C.	4.03	4.03

Table 2. Chemical analysis of magnetical treated water and non-magnetic at the experimental sites during the two growing seasons of (2017 and 2018).

Water type	pH	EC (mmohs/cm)	Soluble cations (meq^{-1})				Soluble anions (meq^{-1})		
			Na^+	K^+	Ca^+	Mg^+	Cl^-	HCO_3^-	SO_4^{-2}
2017 season									
Non-magnetized	7.29	0.43	1.77	0.62	1.16	0.71	1.42	1.52	1.31
Magnetized	7.07	0.41	1.66	0.64	1.23	0.81	1.38	1.45	1.40
2018 season									
Non-magnetized	7.24	0.44	1.76	0.63	1.14	0.72	1.43	1.54	1.30
Magnetized	7.09	0.40	1.68	0.66	1.24	0.80	1.37	1.45	1.42

Cowpea seeds (*Vigna unguiculate* L. Walp.) were sown on June 1st in the first season and may 1st in the second one on one side of the ridge (8 meters length and 0.66 meters width), at a spacing of 25 cm between hills within the same row, each hill contain 3:5 seeds and thinned to 2 plants/one, plant density was about 12 plants/m^2.The sub-sub experimental plot contained three ridges making an area of 15.84 m^2. The drip irrigation system was installed in the experimental field, it consists of a control unit and distribution lines, the control unit of the system contained a pump and venture injector (25.4mm), control valves, water flow meter, fertilizer tank, sand filter, disk filter and pressure devices. The distribution lines consisted of polyethylene pipe manifolds (display and discharge) for each plot. Drip laterals line 16 mm in diameter and 50 m in length had in-line emitters spaced 0.25 m part, each manufacturing discharge 4 L/h at pressure of 1 bar. Drip irrigation lines were spaced 0.66 m apart, equally spaced between each other rows under investigation.

All cultural practices; cultivation, irrigation, pests and diseases control etc., were carried out according to the recommendation of the commercial production of cowpea open field as outlined by Ministry of Agriculture and Land

Reclamation (1990). Harvesting started on September 1st and August 1st in both growing seasons, respectively.

The experimental design and treatments

The experimental layout was split-split plot system in a complete randomized block design with three replicates. The experiment in each season included 16 treatments, representing the combinations of two magnetized of irrigation water, two growth stages and four irrigation regime treatments as follows:

I. First factor (Magnetized irrigation water):

1. Non-magnetized water (control).
2. Magnetized water:

II. Second factor (Growth stages):

1. Deficit at vegetative growth stage (V).
2. Deficit at reproductive growth stage (R).

III. Third factor (Irrigation regime %):

Were: 100, 75, 50 and 25 % of full crop evapotranspiration (ETc), during two growth stages as follow:

-The regulated water deficit treatments during vegetative growth stage were 100, 75, 50 and 25 % ETc with 100% irrigation during reproductive growth stage, Table (3).

1) T1 = V100% + R100%
2) T2 = V 75% + R100%
3) T3 = V 50% + R100%
4) T4 = V 25% + R100%

-The regulated water deficit treatments during reproductive growth stage were 100, 75, 50 and 25 % ETc with 100% irrigation during vegetative growth stage**.**

1) T1 = V100% + R100%
2) T2 = V 100% + R75%
3) T3 = V 100% + R50%
4) T4 = V 100% + R25%

The water requirements of the cowpea crop in open field were calculated using FAO CROPWAT software. The irrigation requirement treatments were supplied to the crop daily through inline drip system.

Magnetized water was obtained by passing the water through 1000 gauss magnetron unit, 1 inch diameter (supplied by Delta water Company, Alexandria, Egypt.

Magnetized water treatments were randomly distributed in the main plots, which were sub-divided to two sub-plots, each of them contained one of growth stage. The plant growth stage treatments were divided into two phonological stages as follows:

1-Water deficit at vegetative growth stage (V): start from germination to beginning of flowering.

2- Water deficit at reproductive growth stage (R): start from appear the first flowering to the end of harvesting.

The sub-sub plots were assigned to four irrigation regime treatments (100, 75, 50 and 25 % ETc. The water application rates in different growth stages were calculated from meteorological climatic Table (3), data according to the data recorded at the Experimental Farm of Sakha agriculture Research Station, Agriculture Research Center, Kafr EL-Sheikh Governorate. Water consumptive was calculated from Penman- Monteith equation as follow:

ETc = ETo x Kc. (Allen *et al*., 1998).

Where:

ETc, crop evapotranspiration; ETo, reference evapotranspiration and Kc, crop factor (FAO, 1990).

Quantity of crop water requirements (ETo) values were determined according to (FAO, 1991), water consumptive and total amount of applied water (m^3/fed.) during different growth stages of cowpea crop as affected by different irrigation regime treatments during two growing seasons are presented in Tables (4 &5).

Table 3. Monthly air temperature, relative humidity, wind speed, sun hours and total radiation at the experimental site during 2017 and 2018 seasons

Month	Air temperature (°C)			Relative humidity (RH %)	Wind speed (km/day)	Sun hours	Radiation. (µJ/m^2/day)
	Max.	Min.	Mean				
				2017 season			
May	-	-	-	-	-	-	-
June	28.1	32.5	30.3	66	103	13.0	29.5
July	29.0	34.2	31.6	71	81	13.0	29.2
August	28.4	33.9	31.2	71	70	12.1	26.8
				2018 season			
May	23.8	31.6	27.7	71	68	13.4	29.7
June	25.3	32.6	28.9	62	99	14.0	30.7
July	25.4	34.2	29.8	67	89	14.0	30.7
August	-	-	-	-	-	-	-

Source: Sakha Agricultural Research Station, Kafr El-Sheikh Governorate (The site is located at 31°07 N latitude and 30°57 E Longitude with an elevation of about 6 meters above mean sea level).

Table 4. Values of Kc, transpiration rate and water consumptive in different growth stages of cowpea plants during two growing seasons (2017 and 2018).

Growth stages	Initial	Crop development	Mid-season	Late season
	1-15 (day)	16-45 (day)	46–70 (day)	71-90 (day)
	Vegetative stage		Reproductive stage	
	2017 Season			
Kc	0.40	1.15	1.15	0.55
ETo (mm/day)	98.61	166.12	153.11	58.43
ETc	311.64	802.36	739.52	202.08
M^3/Fed.	311.64	802.36	739.52	202.08
	2018 Season			
Kc	0.40	1.15	1.15	0.55
ETo (mm/day)	94.18	164.99	167.23	65.99
ETc	298.12	796.90	807.72	227.94
M^3/Fed.	298.12	796.90	807.72	227.94

Table 5. Amount of applied water (m^3/fed.) during vegetative and reproductive growth stages of cowpea crop as affected by different irrigation regime treatments during two growth seasons (2017/2018).

Deficit irrigation at growth stages	Irrigation regime treatment			
	100 %	75 %	50 %	25 %
	2017 season			
Vegetative growth stage (V).	1114.00	835.50	557.00	278.50
Reproductive growth stage (R).	941.60	706.20	470.80	235.40
Total m^3/fed.	2055.60	1541.70	1027.80	513.90
	2018 season			
Vegetative growth stage (V).	1095.02	821.26	547.51	273.755
Reproductive growth stage (R).	1035.66	776.74	517.83	258.915
Total m^3/fed.	2130.68	1598.01	1065.34	532.67

Data recorded:

Vegetative growth parameters:

Ten plants from each sub–sub plot were randomly taken after 45days from sowing and the following data were recorded:

1- Plant height.
2- Plant fresh weight.
3- Plant dry weight.
4- Number of leaves plant^{-1}.
5- Number of branches plant^{-1}.
6- Leaf area plant^{-1}: It was calculated according to Koller (1972).
7- .Leaves Total chlorophyll content (SPAD): It was determined by using a SPAD 501 leaf chlorophyll meter (Yadava, 1986 and Marquard and Timpton, 1987).

Chemical constituents of leaves:

Total nitrogen: It was determined in the digestion product using the micro-Kjeldahl method (Pregel, 1945).

Total phosphorus: It was determined calorimetrically by using a spectro- photometer at 650 µm (King, 1951).

Total potassium: It was determined using a flame photometer (Jackson, 1967).

Statistical analysis:

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez (1984) and Duncan's multiple range test was used for the comparison among treatment means (Duncan, 1955).

RESULTS AND DISCUSSION

Vegetative growth parameters

1-Effect of magnetized irrigation water:

Data presented in Table (6) show that the vegetative growth characteristics of cowpea plant (plant height, plant dry weight, number of leaves, number of branches, leaf area per plant and total chlorophyll) were highly significant affected by applying the magnetized irrigation water during the two seasons. The highest values of abovementioned characters were obtained from the magnetized irrigation water, on the other hand, the lowest records were obtained from the non-magnetized water treatments in both seasons. Magnetized water has been reported to change some of the physical and chemical properties of water (Table, 2), these changes in water properties may be capable of affecting the growth of plants (Bogatin *et al*., 1999). Magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile nutrient uptake by plant (Esitken and Turan 2004). A similar trend was observed by Sadeghipour and Aghaei (2013) on cowpea. Irrigation of common bean plants with magnetized water increased growth characteristics and photosynthetic pigments (chlorophyll a and b) as compared with control plants (Moussa, 2011).

Table 6. Effect of magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on some vegetative parameters of cowpea plant during 2017 and 2018 seasons.

Treatments	Plant height (cm)		Plant dry weight (g)		No. of leaves plant^{-1}		No. of branches plant^{-1}		Leaf area plant^{-1} (dm)		Total chlorophyll (SPAD)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
A-Magnetized irrigation water												
Non magnetized (NMW)	65.54 b	79.54 b	24.48 b	28.13 b	23.94 b	24.03 b	3.63 b	3.92 b	42.52 b	50.43 b	21.75 b	25.29 b
Magnetized (MW)	82.34 a	84.07 a	28.08 a	32.00 a	30.78 a	31.37 a	4.42 a	4.62 a	54.14 a	66.65 a	23.06 a	26.80 a
F. test	**	**	**	**	**	**	**	**	*	**	**	**
B- Deficit irrigation at growth stages												
Vegetative stage (V)	69.03 b	76.78 b	24.65 b	27.97 b	24.30 b	26.86 b	3.82	3.89 b	46.02	50.20 b	20.72 b	24.33 b
Reproductive stage (R)	78.85 a	86.82 a	27.92 a	32.15 a	28.53 a	30.42 a	4.44	4.45 a	50.65	66.88 a	24.09 a	27.77 a
F. test	*	*	*	*	*	**	NS	*	NS	**	*	*
C- Irrigation regime												
100 %	96.74 a	102.67 a	31.00 a	35.43 a	29.97 a	35.75 a	4.83 a	5.25 a	63.86 a	77.77 a	27.43 a	30.89 a
75 %	72.98 b	78.29 b	26.54 b	30.21 b	27.16 b	27.86 b	4.13 b	4.21 b	46.09 b	57.96 b	22.24 b	26.07 b
50 %	66.59 b	76.34 b	24.65 c	28.10 c	26.19 c	26.78 c	3.84bc	3.87bc	42.28 bc	51.84 bc	21.26 b	24.8 bc
25 %	59.43 c	69.90 c	22.93 d	26.52 d	22.81 d	23.72 d	3.46 c	3.59 c	41.09 c	46.58 c	18.69 c	22.42 c
F. test	**	**	**	**	**	**	**	**	**	**	**	**

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

2-Effect of different growth stages:

Data presented in Table (6) clear that, the treatment of water deficit at vegetative growth stage (v) recorded the lowest vegetative growth parameters in both seasons. Water deficit at vegetative growth stage reduced the rate of leaf expansion and inhibited the growth of new leaves. The negative effects of water deficit at the vegetative growth stage were removed after re-watering the plants (Ziska and Hall, 1983).The same trend was obtaind by Warrag and Hall (1984), they found that applying water deficit at two subsequent growth stages (vegetative and pod filling stages) and (flowering and pod filling stages) significantly reduced growth of cowpea plants. In addition, Mousa *et al.* (2014) reported that post-flowering water stress reduced the cowpea total dry matter. Ndiso *et al.* (2016) found that cowpea plants subjected to water stress the vegetative and flowering stages had lower chlorophyll content than non-water stressed plants.

3-Effect of irrigation regime:

Concerning the effect of irrigation regime treatments on vegetative growth parameters, data presented in Table (6) reveal that there were highly significant differences of abovementioned characters among the treatments in both seasons. The highest values of vegetative growth were obtained from irrigation at 100 % followed by 75% Etc compared with the 25% followed by 50 % ETc treatments which recorded the lowest ones in both seasons . Similar results were recorded for El-Noemani, *et al*. (2009) and Mabhaudhia *et al.* (2013).

4-Effect of interactions:

Dealing with the effect of double interactions between magnetized irrigation water and deficit irrigation at growth stages or irrigation regime treatments, on vegetative growth characteristics, data in Table (7) demonstrate that the lowest values of vegetative growth parameters were obtained from irrigated plants by magnetized or non- magnetized water at vegetative growth stage (V). The differences were not significant in both seasons, except plant height and No. of leaves.

As the interaction between magnetized irrigation water combined with 100% ETc gave the highest values, on the other hand the lowest values were obtained from plants irrigated by non-magnetized water and 25% ETc in both seasons.

Regarding the effect of interaction between deficit irrigation at different growth stages and irrigation regime treatments on the most of vegetative growth characteristics, had significant differences in both seasons. In addition, the interaction between deficit irrigation at vegetative growth stage (v) treatment combined with 100% produced the highest records of the most vegetative growth characteristics compared with the interaction between deficit irrigation at vegetative growth stage (V) treatment and 25% ETc treatments which gave the least ones in both seasons.

Regarding to the effect of triple interaction among magnetized irrigation water, deficit irrigation during growth stages and irrigation regime % treatments on vegetative growth parameters, data in Table (8) indicate that the differences were not significant in both seasons.

The same data indicated that, the plants irrigated by magnetized water at 100% ETc tended to give the highest values of vegetative growth parameters during water stress at vegetative growth stage (v). On the other hand, the combined interaction among magnetized irrigation water or non-magnetized water with 25% ETc during deficit irrigation at vegetative growth stage treatment tended to give the lowest values in both seasons.

Table 7. Effect of interactions between magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on some vegetative parameters of cowpea plant during 2017 and 2018 seasons.

Treatments		**Plant height (cm)**		**Plant dry weight (g)**		**No. of leaves plant^{-1}**		**No. of branches plant^{-1}**		**Leaf area plant^{-1}(dm)**		**Total chlorophyll (SPAD)**	
Magnetized irrigation water	**Deficit irrigation at growth stages**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
NMW	V	61.50 d	74.11	22.93	26.03	21.71 d	23.29	3.44	3.57	40.78	42.47	19.93	23.54
	R	69.58 c	84.97	26.04	30.23	24.76 c	26.17	3.82	4.27	44.25	58.38	23.56	27.04
MW	V	76.55 b	79.46	26.36	29.92	26.88 b	30.44	4.19	4.21	51.25	57.93	21.51	25.11
	R	88.12 a	88.67	29.78	34.08	32.30 a	34.68	4.62	5.05	57.04	75.37	24.62	28.49
F. test		*	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Magnetized irrigation water	Irrigation regime (%)												
NMW	100	77.67 b	99.83	28.18 b	32.83	25.67	30.84 b	4.28	5.00	54.96	66.30	26.21	29.38
	75	66.50 c	75.41	24.90 cd	28.38	23.39	24.30 d	3.66	3.91	42.63	50.04	21.99	25.76
	50	62.00 cd	74.16	23.08 de	26.22	20.76	23.14 e	3.41	3.66	35.78	45.34	21.01	24.13
	25	56.00 d	68.75	21.78 e	25.07	20.78	23.00 e	3.11	3.17	36.69	40.02	17.79	21.90
MW	100	115.82 a	105.52	33.82 a	38.02	34.28	40.67 a	5.39	5.50	72.76	89.24	28.66	32.39
	75	79.47 b	81.17	28.18 b	32.04	30.93	31.42 b	4.33	4.75	49.56	65.88	22.49	26.37
	50	71.19 bc	78.52	26.22 c	29.98	26.68	30.41 c	4.03	4.33	48.77	58.33	21.51	25.51
	25	62.85 cd	71.06	24.08 d	27.96	24.84	29.39 d	3.80	4.02	45.48	53.14	19.60	22.93
F. test		**	NS	*	NS	NS	*	NS	NS	NS	NS	NS	NS
Deficit irrigation at growth stages	Irrigation regime (%)												
V	100	96.74 a	102.67 a	31.00 a	35.43 a	29.97	35.75 a	4.83 a	5.25 a	63.86	77.77 a	27.43	30.88
	75	65.22 c	71.41 de	24.36 de	27.20 d	23.72	26.69 d	3.83 bc	3.94 bc	44.60	46.87 d	20.11	23.80
	50	62.30 c	69.08 de	22.63 e	25.08 e	19.39	25.78 e	3.44 cd	3.55 c	38.05	39.99 de	19.15	22.88
	25	51.83 d	63.97 e	20.59 f	24.17 e	18.33	25.03 e	2.92 d	3.05 d	37.53	36.16 e	16.20	19.74
R	100	96.74 a	102.67 a	31.00 a	35.43 a	29.97	35.75 a	4.83 a	5.25 a	63.86	77.77 a	27.43	30.88
	75	80.75 b	85.17 b	28.72 b	33.21 b	29.03	30.60 b	4.41 ab	4.47 b	47.59	69.05 ab	24.36	28.33
	50	70.89 c	83.61 bc	26.67 c	31.12 c	27.78	28.06 c	4.14 ab	4.30 bc	46.50	63.68 bc	23.37	26.76
	25	67.02 c	75.83 cd	25.26 cd	28.86 d	27.30	27.36 c	4.00 b	4.14 bc	44.65	57.00 c	21.19	25.09
F. test		*	*	**	**	NS	**	*	*	NS	**	NS	NS

NMW= non-magnetize water, MN= magnetized water, V= Deficit at vegetative growth stage and R= Deficit at reproductive growth stage.
Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Table 8. Effect of the combined interactions among magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on some vegetative parameters of cowpea plant during 2017 and 2018 seasons.

Treatments			Plant height (cm)		Plant dry weight (g)		No. of leaves plant^{-1}		No. of branches plant^{-1}		Leaf area plant^{-1}(dm)		Total chlorophyll (SPAD)	
Magnetized irrigation water	**Deficit irrigation at growth stages**	**Irrigation regime (%)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
NMW	V	100	77.66	99.83	28.18	32.83	25.67	30.84	4.28	5.00	54.96	66.30	26.21	29.38
		75	62.44	68.38	23.23	25.46	21.28	23.48	3.50	3.56	41.26	41.43	19.92	23.42
		50	57.22	66.72	20.84	23.46	17.91	22.05	3.17	3.33	34.26	34.59	19.00	22.48
		25	48.66	61.50	19.46	22.34	16.83	21.94	2.83	2.39	32.63	27.55	14.61	18.90
	R	100	77.66	99.83	28.18	32.83	25.67	30.84	4.28	5.00	54.96	66.30	26.21	29.38
		75	70.55	82.44	26.57	31.29	25.11	25.50	3.83	4.27	44.00	58.66	24.05	28.11
		50	66.78	81.61	25.32	28.99	23.61	24.22	3.66	4.00	37.30	56.10	23.02	25.78
		25	63.33	75.99	24.10	27.81	24.05	24.73	3.50	3.83	40.76	52.48	20.97	24.89
MW	V	100	115.81	105.52	33.82	38.02	34.28	40.67	5.39	5.50	72.76	89.24	28.66	32.39
		75	68.00	74.44	25.48	28.94	26.17	29.89	4.39	4.11	47.95	52.30	20.30	24.19
		50	67.39	71.44	24.42	26.71	20.87	29.50	3.72	3.78	41.84	45.40	19.29	23.28
		25	54.99	66.44	21.73	26.01	19.83	28.11	3.27	3.44	42.43	44.78	17.78	20.58
	R	100	115.81	105.52	33.82	38.02	34.28	40.67	5.39	5.50	72.76	89.24	28.66	32.39
		75	90.94	87.89	30.87	35.13	32.94	35.70	5.11	4.56	51.17	79.45	24.68	28.56
		50	75.00	85.61	28.02	33.24	31.33	32.50	4.94	4.28	55.71	71.27	23.72	27.74
		25	70.72	75.67	26.42	29.92	29.86	30.66	4.78	4.17	48.53	61.51	21.42	25.28
F. test			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NMW= non-magnetize water, MN= magnetized water, V= Deficit at vegetative growth stage and R= Deficit at reproductive growth stage.
Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Chemical constituents of leaves

1-Effect of magnetized irrigation water:

Data in Table (9) indicate that the treatment of magnetized irrigation water had a highly significant effect on mineral constituents of cowpea leaves. The magnetized water treatment caused an increase in chemical constituents compared with the un-treated plants, which gave the lowest values in both seasons. Magnetized water has been reported to change the most of the physical and chemical properties of water (Table, 2). In addition, magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile nutrient uptake by plant (Esitken and Turan 2004). Also, magnetized irrigation water improved capacity for nutrients, water uptake and improved both roots and shoots (De Souza *et al*., 2006).

These results agreement with that of Tian *et al.* (1991) and Kleps (1996) magnetically treated water showed higher values for mobile forms of nitrogen, phosphorus and potassium.

2-Effect of different growth stages:

Data in Table (9) clear that the lowest values of chemical constituents were obtained from the treatment of deficit irrigation at vegetative growth stage (V) in both seasons.

3-Effect of irrigation regime:

With regard to the effect of irrigation regime on mineral constituents of cowpea leaves, data presented in Table (9) show that there were highly significant differences among the treatments in both seasons. The irrigation at 100% or 75% ETc had a positive effect on chemical constituents compared with 25% ETc treatment.

The reduction in plant growth may be due to the deficiency of irrigation water might be due to the lack of water absorption by plant which intern effect on the amount of nutrients elements absorbed and photosynthetic assimilation rate under insufficient water condition (Hammad, 1991). Such results are in harmony with those obtained by Mahouachi (2007) found that water stress reduced the concentrations of N, P and K on strawberry.

Table 9. Effect of magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on mineral constituents of cowpea leaves during 2017 and 2018 seasons.

Treatments	N %		P %		K %	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**
A-Magnetized irrigation water						
Non magnetized (NMW)	3.00 b	3.02 b	0.312 b	0.331 b	2.85 b	2.90 b
Magnetized (MW)	3.08 a	3.09 a	0.320 a	0.334 a	2.93 a	2.98 a
F. test	**	**	**	**	**	**
B- Deficit irrigation at growth stages						
Vegetative stage (V)	3.02 b	3.04 b	0.303 b	0.318 b	2.83 b	2.88 b
Reproductive stage (R)	3.08 a	3.08 a	0.329 a	0.348 a	2.95 a	3.00 a
F. test	*	*	*	*	*	*
C- Irrigation regime						
100%	3.07 a	3.09 a	0.341 a	0.353 a	2.96 a	3.00 a
75%	3.05 b	3.07 b	0.330 b	0.343 a	2.91 b	2.96 b
50%	3.02 c	3.05 c	0.305 c	0.323 b	2.87 c	2.94 c
25%	3.01 d	3.02 d	0.288 d	0.313 b	2.81 d	2.86 d
F. test	**	**	**	**	**	**

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

4-Effect of interactions:

As for the double interactions between the studied factors, data in Table (10) indicate that the differences were not significant in both seasons. Except, of K dealing with the effect of interaction between magnetized irrigation water and irrigation regime treatments and the interaction between deficit irrigation at different growth stages and the irrigation regime. Although, the treatment of magnetized irrigation water with 100% or 75 % ETc gave the highest values, on the other hand, the lowest ones were obtained from plants irrigated by non-magnetized water and 25% ETc in both seasons.

Regarding to the interaction among magnetized irrigation water, deficit irrigation during growth stages and irrigation regime treatments on mineral constituents of cowpea leaves, the differences were not significant in both seasons.

Table 10. Effect of interactions between magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on mineral constituents of cowpea leaves during2017 and 2018 seasons.

Treatments		N (%)		P (%)		K (%)	
Magnetized irrigation water	**Deficit irrigation at growth stages**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
NMW	V	2.98	3.00	0.291	0.310	2.78	2.83
	R	3.02	3.04	0.333	0.353	2.92	2.97
MW	V	3.06	3.08	0.315	0.326	2.87	2.93
	R	3.10	3.11	0.326	0.343	2.99	3.02
F. test		NS	NS	NS	NS	NS	NS
Magnetized irrigation water	Irrigation regime (%)						
NMW	100	3.04	3.07	0.337	0.350	2.94	2.98 b
	75	3.01	3.03	0.325	0.340	2.88	2.93 c
	50	2.98	3.00	0.305	0.330	2.82	2.89 d
	25	2.96	2.98	0.280	0.305	2.77	2.82 e
MW	100	3.10	3.12	0.345	0.355	2.99	3.03 a
	75	3.09	3.11	0.335	0.345	2.95	2.99 b
	50	3.07	3.09	0.305	0.315	2.91	2.99 b
	25	3.06	3.06	0.297	0.322	2.86	2.91 cd
F. test		NS	NS	NS	NS	NS	**
Deficit irrigation at growth stages	Irrigation regime (%)						
V	100	3.05	3.09	0.327	0.340	2.92 cd	2.97 cd
	75	3.03	3.06	0.315	0.330	2.86 e	2.92 e
	50	3.00	3.03	0.295	0.310	2.80 f	2.89 f
	25	2.98	2.99	0.275	0.292	2.73 g	2.77 g
R	100	3.09	3.10	0.355	0.365	3.01 a	3.04 a
	75	3.06	3.08	0.345	0.355	2.97 b	3.00 b
	50	3.05	3.07	0.315	0.335	2.94 c	2.99 bc
	25	3.03	3.05	0.302	0.335	2.90 d	2.96 d
F. test		NS	NS	NS	NS	**	**

NMW= non-magnetize water, MN= magnetized water, V= Deficit at vegetative growth stage and R= Deficit at reproductive growth stage.

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

Table 11. Effect of the combined interactions among magnetized irrigation water, deficit irrigation at different growth stages and irrigation regime treatments on mineral constituents of cowpea leaves during 2017 and 2018 seasons.

Treatments			N (%)		P (%)		K (%)	
Magnetized irrigation water	**Deficit irrigation at growth stages**	**Irrigation regime (%)**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
NMW	V	100	3.02	3.06	0.323	0.340	2.90	2.96
		75	3.00	3.02	0.310	0.330	2.83	2.89
		50	2.96	2.98	0.280	0.300	2.75	2.80
		25	2.94	2.96	0.250	0.270	2.67	2.70
	R	100	3.06	3.08	0.350	0.360	2.98	3.00
		75	3.02	3.05	0.340	0.350	2.94	2.97
		50	3.00	3.03	0.330	0.360	2.90	2.98
		25	2.98	3.01	0.310	0.340	2.87	2.95
MW	V	100	3.09	3.12	0.330	0.340	2.95	2.98
		75	3.07	3.10	0.320	0.330	2.90	2.95
		50	3.05	3.08	0.310	0.320	2.85	2.98
		25	3.03	3.02	0.300	0.313	2.79	2.84
	R	100	3.12	3.13	0.360	0.370	3.04	3.09
		75	3.11	3.12	0.350	0.360	3.00	3.04
		50	3.10	3.11	0.300	0.310	2.98	3.00
		25	3.09	3.10	0.290	0.330	2.94	2.98
F. test			NS	NS	NS	NS	NS	NS

NMW= non-magnetize water, MN= magnetized water, V= Deficit at vegetative growth stage and R= Deficit at reproductive growth stage.

Means followed by the same letter in the same column do not differ significantly by Duncan's multiple range test at 5% level.

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تأثير نظام الري في مراحل النمو المختلفة والري بالماء المعالج مغناطيسيا على صفات النمو الخضري والمحتوى الكيماوي لأوراق اللوبيا.

السيد احمد احمد طرطورة[1] ، يونس بيومى احمدالورقى[2]، السيد إبراهيم الجميلى[1] و مريم كامل يوسف كامل[2]

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اجريت تجربتان على نباتات اللوبيا صنف كفر الشيخ-1 بموقع المزرعة البحثية بمحطة بحوث البساتين بسخا بمحافظة كفر الشيخ – معهد بحوث البساتين – مركز البحوث الزراعية خلال الموسم الصيفى لعامى 2017 و 2018. وكان الهدف الرئيسى للبحث هو دراسه الاجهاد المائى خلال مراحل النمو المختلفة والرى بالماء المعالج مغناطيسيا وتفاعلاتها على صفات النمو الخضرى والمحتوى الكيماوى للأوراق. وقد اشتملت التجربة فى كلا الموسمين على 16 معاملة وهى عبارة عن الرى بالماء المعالج مغناطيسيا (.بدون مغنطة والمعاملة بالماء المعالج مغناطيسيا) خلال مرحلتي النمو الخضرى و الثمرى واربعة معاملات للإجهاد المائى (100%و75% و 75% و 25% من البخر النتح الكلى للنبات) خلال مرحلتى النمو . ويمكن تلخيص اهم النتائج المتحصل عليها كالاتى :- سجلت معاملة الرى بالماء المعالج مغناطيسيا أفضل القيم لمعظم صفات النمو الخضرى المحتوى الكيماوى للأوراق بينما كانت أقل القيم عند رى النباتات بالماء العادى (الماء غير معالج مغناطيسيا). اما بالنسبة الاجهاد المائى في مراحل النمو المختلفة، فقد انخفضت جميع صفات النمو الخضرى والمحتوى الكيماوى لاوراق اللوبيا عند الاجهاد المائى في مرحلة النمو الخضرى (v) . وجد أن نباتات اللوبيا التى تم ريها بمعدل 100% من البخر النتح الكلى (2093.14 م^3/فدان) ويلها بمعدل 75٪ (1569.86 م^3/فدان) او 50% (1046.57 م^3/فدان) من البخر النتخ الكلى التى أعطت أعلى القيم لمعظم قياسات النمو الخضرى والمحتوى الكيماوى للأوراق مقارنه بأقل القيم التى تم الحصول عليها مع النباتات المروية ب 25% من البخر النتح الكلى فى كلا الموسمين . ومن النتائج السابقة قد لوحظ ان نبات اللوبيا حساس إلى حد كبير للإجهاد المائي في مرحلة النمو الخضرى (V) . وكانت افضل النتائج لصفات النمو الخضرى والمحتوى الكيميائى للأوراق عند رى النباتات بمعدل 100% من البخر النتح الكلى خلال مرحلة النمو الخضرى.