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Effect of Irrigation Regimes on Alfalfa Productivity and Quality under Saline Calcareous Soil Conditions

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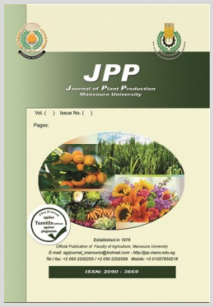

ABSTRACT

A field experiment was conducted at Nubaria Agricultural Research Station during 2016/2017 and 2017/2018 to study the effect of irrigation regimes under saline calcareous soil on fresh and dry yields, quality, water requirements and productivity. Four irrigation regimes with amount of water equals potential evapotranspiration were used as irrigation with amount of water equal potential evapotranspiration (ETp) plus 10%, 20%, 30% and/or 40% as leaching requirements (LR). Average of calcareous soil salinity treatments were S_1 equal 2 dSm^{-1}, S_2 equal 6 dSm^{-1} and S_3 equal 10 dSm^{-1}. Results indicated that there were significant effects among irrigation and soil salinity treatments on fresh and dry alfalfa yields through the combination of two years. The highest values of fresh and dry yields were 217.736 and 49.861 ton/ha, respectively that was obtained by I_1S_1 interaction, while the lowest values were 140.0 and 35.91 ton/ha was obtained by I_4S_2 interaction. Fresh and dry yields were decreased by 28.4 and 18.13% at I_1S_2 and by 14.6 and 13.19% at I_1S_3, respectively compared with that obtained by I_1S_1. Results of I_3S_3 and I_4S_3 were given the highest values of N and CP percentages. The water requirements values for alfalfa were 126.0, 135.2, 144.3 and 153.9 cm in the first year, while in the second year they were 128.8, 140.2, 152.0 and 163.8 cm for irrigation treatments, respectively. Also, the highest values of the productivity of irrigation water (PIW) were 8.93 and 8.17 kg/m^3 water in 1st and 2nd years, which was I_1S_1.

Keywords: alfalfa, Irrigation, Salinity, Productivity

INTRODUCTION

Perennial alfalfa (*Medicago sative* L.) is one of the most important legume forages all over the world. This plant is particularly important as a high quality forage crop and a source of value products (Schitea, 2010). Due to its capacity of symbiotic nitrogen fixation so, it is often used to improve soil fertility and particularly soil nitrogen content.

In arid and semi-arid lands, water deficit is the main constraint of agricultural production (Siam *et al.,* 2009). Salt problems occur on approximately one – third of all the irrigated land in the world.

Salt problems occur near the coasts and in soils of arid and semiarid. Some soils are salty because parent materials weather to from salts, while on croplands, salts may be carried in irrigation water, added as fertilizers or other soil amendments, or be present due to shallow saline ground water. To prevent harmful accumulation of salts and yield impacts, the soil profile must be leached periodically with an amount of water excess of what is used by plant ET. Leaching occurs when water is applied in excess of soil moisture depletion due to ET (Hanson *et al*., 2006).

The leaching fraction (L.f) is the fraction of the total applied water that passes below the root zone. This can be expressed as: $Lf = EC_w / EC_{dw}$

Where EC_w is the electrical conductivity of applied water, and EC_{dw} is the electrical conductivity of the drainage water at the bottom of the root zone, which is equal to 2 ECe (Ayers and westcot, 1985). Abid (2016), indicated that the drought application leading to an increase on water use efficiency of productivity of alfalfa (WUEp). Jafarian *et al*. (2016) indicated that as the severity of limited irrigation increased, cude protein percentage significantly increased. Additionally the forage yield followed a decreasing trend by enhancing the water scarcity. The highest forage yield (7500 kg/ha) under limited irrigation treatments was achieved by providing of 75% weekly evaporation and plant water requirement surfactant. Endo *et al*. (2014), found that the alfalfa production was low, and half of the plants withered and discarded under soil electrical conductivity of ≥ 4 dS m^{-1}, and found the sodium concentrations of sodium in the soil. Liu and Guo, (2013), indicated that alfalfa forage biomass and number of branches increased with increase in soil moisture level. It also increased the instantaneous WUE of alfalfa plants at all moisture levels. Farissi *et al*. (2014) indicated that the water deficit has negatively affected the plant height and forage yield. The decrease in leaf stem ratio was observed under water deficit conditions. However, the proteins and nitrogen contents were unaffected. Bouizgaren *et al*. (2011) indicated that, the drought stress is one of the major abiotic stresses that limit plant production and growth of many Medicago species. Kemper and Amemiya (1957), found that when the

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hydraulic moisture stress exceeded 200 centimeters of water. The growth rate of alfalfa as measured by increases in plant height, generally began to decrease. Hanson *et al*. (2008), indicated that alfalfa hay yields are directly related to crop evapotranspiration (ET). Rhoades, (1974), showed that to prevent the accumulation of excessive soluble salts in irrigated soils, more water than required to meet the evapotranspiration needs of the crops must pass through the root zone to leach excessive soluble salts. This additional irrigation water has typically been expressed as the leaching requirement (LR). Leaching requirement was originally defined as the fraction of infiltrated water that must pass through the root zone to keep soil salinity from exceeding a level that would significantly reduce crop yield under steady-state conditions, with associated good management and uniformity of leaching. Kidambi *et al*. (1990), indicated that soil moisture level affected the mineral concentrations of alfalfa but not the relationship among minerals. Concentration of Ca, Mg, Zn, and P increased with decreasing soil moisture supply.

Mohammadi *et al*. (2008), showed that the growth of alfalfa yield inhibitions is due to a nutrient uptake alteration under saline conditions. Alkhatem and Gabr (2014), indicated that the cutting intervals (21, 28 and 35 day's) showed a significant difference at all levels of comparisons for all the growth attributes and fresh and dry weight of alfalfa.

The objective of this work to study the effect of different irrigation and salinity levels of soil treatments on alfalfa yield production, yield components, irrigation water requirements and productivity of irrigation water.

MATERIALS AND MEHTODS

A field experiment was carried out during two continued years of 2016 / 2017 and 2017/2018 at the Experimental Farm of Nubaria Agricultural Research Station. Samples of soil were taken before sowing to determine, soil chemical properties (Page *et al*., 1982), and some soil hydro-physical parameters. Results of analysis were presented in Tables 1, 2, and 3.

The experimental design was a strip plot design with four replicates, involving vertical treatment was irrigation and horizontal was salinity soils. Irrigation treatments were:

I_1 = Irrigation with amount of water equals potential evapotranspiration (ET_p) plus 10% of ET_p (as leaching requirements "LR").

I_2 = Irrigation with amount of water equals potential evapotranspiration (ET_p) plus 20% of ET_p "LR".

I_3 = Irrigation with amount of water equals potential evapotranspiration (ET_p) plus 30% of ET_p "LR".

I_4 = Irrigation with amount of water equals potential evapotranspiration (ET_p) plus 40% of ET_p "LR".

Irrigation water was controlled and measured by using water flow-meter connected to an irrigation pump placed very close to the experimental plots to ensure high water application efficiency.

The calcareous soils salinity were:

S_1 = Average soil electrical conductivity (EC) was 2 dS m^{-1},

S_2 = Average soil electrical conductivity (EC) was 6 dS m^{-1}

S_3= Average soil electrical conductivity (EC) was 10 dS m^{-1}

Table1. Chemical properties of soil samples (Average of EC = 2 dS/m^{-1})

Soil	EC	Soluble cations, meq/l				Soluble anions (meq/l)				pH	O.M	$CaCO_3$
Depth (cm)	dS/m^{-1}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO3	$HCO3^{-}$	CL^{-}	$SO4^{--}$		%	%
0-30	1.90	8.71	2.67	6.51	1.11	-	5.32	10.24	3.44	8.30	0.21	23.11
30 – 60	2.11	6.73	2.12	9.82	2.43	-	5.27	11.21	4.62	8.29	0.32	22.43

$$\text{Avrage EC} = \frac{1.90 + 2.11}{2} = \frac{4.01}{2} = 2.005 \simeq 2 \text{ ds/m}^{-1}$$

Table 2. Chemical properties of soil samples (Average of EC = 6 dS/m^{-1})

Soil	EC	Soluble cations, meq/l				Soluble anions, meq/l				pH	O.M	CaCO3
depth(cm)	ds/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO3	$HCO3^{-}$	CL^{-}	$SO4^{--}$		%	%
0-30	5.74	13.44	7.22	27.33	9.41	-	12.42	33.20	11.78	8.27	0.22	23.62
30 – 60	6.26	16.82	9.16	32.31	4.31	-	14.50	39.00	9.10	8.29	0.19	24.47

$$\text{Avrage EC} = \frac{5.74 + 6.26}{2} = 6.0 \text{ ds/m}^{-1}$$

Table 3. Chemical properties of soil samples (Average of EC = 10 dS/m^{-1})

Soil	EC	Soluble cations, meq/l				Soluble anions, meq/l				pH	O.M	CaCO3
depth(cm)	ds/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO3	$HCO3^{-}$	CL^{-}	$SO4^{--}$		%	%
0-30	10.13	17.63	6.44	68.13	9.10	-	10.78	77.20	13.23	8.27	0.18	23.13
30 – 60	9.94	14.39	5.12	67.62	12.27	-	9.63	76.40	13.37	8.31	0.12	24.36

$$\text{Avrage EC} = \frac{10.13 + 9.94}{2} = 10.035 \simeq 10 \text{ ds/m}^{-1}$$

The alfalfa seeds of Ramah cultivar were seeded on 7 Sep., 2016 in plot size of 42 m^2 with rows 20 cm apart and the seeding rate 20kg/fed. The seed was inoculated with *Rhizobium melilot*. Starter dose of nitrogen fertilizer of 48 kg/ha, was applied directly after emergence.

Fertilizers applied were 360 kg/ha, of super phosphate P_2O_5 (15.5%) and 120 kg/ha of potassium sulphate (K_2SO_4 48%). The super phosphate fertilizer was applied prior to seeding on Sep. in 2016 and 2017 season. The amount of potassium sulphate was divided into three doses. Annually

alfalfa cultivar was harvested at 1/10 bioom stage of maturity or when crown shoots reached 4-5 cm in length. The first cutting began on 21 Nov. 2016 and the last one was on 28 Aug. 2018. The cutting in first year was 8 cuts; while in the second year was 9 cuts, with 17 cuttings in the total during the two successive experimental years.

Plant height was measured, from the crown region to the top leaves, before each cut. The plants in each plot were harvested and weighted to determine the forage yield (t/h).

Representative samples of the different treatments were taken at each cutting to determine the dry matter percentage (DM %). Fresh samples from each cut were oven dried at 65ºC up to constant weight to determine the DM%, then fresh yield was transformed into dry forage yield (t/h). Chemical analysis as crud protein (CP %) was determined using standard methods (A. O. A. C., 2019). In the dried samples, Na%, P% and Na/P ratio were determined using standard methods (A. O. A. C., 2019).

The potential evapotranspiration (ET_p) in mm/day values, that were calculated according to class A pan evaporation method (F.A.O.1979),

$$ETp = E\,pan \times K\,pan$$

Where:

ET_p = potential evapotranspiration in mm day-^{1}

E_{pan} = pan evaporation daily values in mm day^{-1}

K_{pan} = pan coefficient, depended on the relative humidity, wind speed and condition, Kpan value of 0.75 was used for the experimental site.

Daily water requirements (WR) in mm/day were calculated as follows:

$$WR = \frac{ETp \times Kc}{Ea\,(1 - LR)}$$

Where:

Kc = crop coefficient for alfalfa crop as reported by F.A.O 1984).

Ea = application efficiency % (70% for control surface irrigation system).

LR = leaching requirements, (10, 20, 30 and 40 % of WR according to the irrigation treatments)

The productivity of irrigation water (PIW) was calculated according to the following equation (Ali *et al.*, 2007).

$$PIW = \frac{Y}{WR}$$

Where:

PIW= productivity of irrigation water (kg of alfalfa /m^3 water)

Y = alfalfa yield (kg/fed)

WR = water requirements (m^3/fed)

The obtained data were statistically analyzed as a strip plot design with four replicates by analysis of variance (ANOVA) according to the procedure outlined by Snedecor and Cochran (1994), using the statistical package software SAS (SAS Institute Inc. Cary, NC, USA). Comparisons between means were made by using the newly least significant differences test at 5% level of probability as mentioned by Waller and Duncan (1969).

RESULTS AND DISCUSSIONS

1- Fresh alfalfa yield:

Results of fresh alfalfa yield for two growing years and summation of two years were presented in tables 4 and 5. Tables 4 and 5 showed that the fresh alfalfa yield was significantly affected by soil salinity and irrigation treatments through the two growing years.

For cuttings production; there were significant effected for soil salinity treatments on fresh alfalfa yield at all cuts in the first year (Table 4), while in the second year, there was significant affected at all cuts, except at the 7th cut (Table 5). Also, there was significant effected for irrigation treatments on fresh alfalfa yield at all cuts except at the 2nd, 4th and 7th cuts in the 1st year, while in the 2nd year the significant effected was at all cuts except at the 4th ,5th , 6th and 8th cuts. The interaction between soil salinity and irrigation treatments was affected significantly on fresh alfalfa yield through the two growing years. The highest value of the interaction was obtained by I_1S_1, interaction (23.5 ton/ha) in the 6th cut and the lowest value was obtained with I_4S_2 interaction (3.383 ton/ha) in the cut 7th , in the 1st year, while in the 2nd year, the highest value was obtained by I_1S3, interaction (20.0 ton/ha in the 7th cut) and the lowest value was obtained by I_4S_2 interaction (3.331 ton/ha).

The summation of 8 cuts in the 1st year and summation of 9 cuts in 2nd year showed that, the fresh alfalfa yield was significantly affected by soil salinity treatments. S_1 soil salinity treatment produced the highest value of fresh alfalfa yield (107.412 ton/ha) in the first year, while in the second year the highest value was 106.098 ton/ha as compared to both S_2 and S_3 treatments. Irrigation treatments had not affected significantly on fresh alfalfa yield in the 1st year, while in 2nd year, the irrigation treatments were significantly affected on fresh alfalfa yield. I_2 irrigation treatment produced the highest value of fresh alfalfa yield (99.235 ton/ha) as compared to I_1, I_3 and I_4 treatments. In addition the interaction between soil salinity and irrigation treatments was significantly affected on fresh alfalfa yield in 1st and 2nd years. The highest value was obtained by I_1S_1 interaction (112.515 ton/ha), and the lowest value was obtained by I_4S_2 interaction (57.882 ton/ha) in the first year, while in the second year, the highest value was obtained by I_4S_1 interaction (108.825 ton/ha) and the lowest value was obtained by I_4S_2 interaction (82.112 ton/ha).

The combination of the two years of fresh alfalfa yield was presented in Table 5. Table 5, showed that the fresh alfalfa yield was significantly affected by soil salinity and irrigation treatments. Fresh alfalfa yield was decreased by 28.6% at S_2 salinity treatment and 10.96% at S_3 salinity treatment as compared with S_1 treatment that is due the osmotic pressure in soil solution for S_2, S_3 treatments were greater than osmotic pressure inside the root cells, so it is prevented the elements adsorption. Fresh alfalfa yield had not affected significantly by irrigation treatments, so alfalfa plants can be irrigated with the amount of irrigation water equals ET_p +10% of ET_p (I_1) for getting the maximum yield. Fresh alfalfa yield was decreased by 28.4 at I_1S_2 and by 14.6% at I_1S_3, interaction as compared with I_1S_1 interaction. Also; I_2S_2 and I_2S_3 interactions were decreased by 24.9 and 10.8% as compared with I_2S_1 interaction, respectively. In addition, I_3S_2 and I_3S_3 interactions were decreased by 26.7 and 6.2 % as compared with I_3S_1 interaction, respectively. Finally, I_4S_2 and I_4S_3, interactions were decreased by 34.4 and 12.1% as compared with I_4S_1, respectively. These results were agreement with those reported by Endo *et al*. (2014), Farissi *et al.* (2014), and Mohammadi *et al*. (2008).

Table 4. Fresh yield of alfalfa (ton/ha) as affected by irrigation regimes under saline calcareous soil conditions during 2016 /2017 growing year.

Treatments		1st Cut	2nd Cut	3rd Cut	4th Cut	5th Cut	6th Cut	7th Cut	8th Cut	Σ Cuts
I_1		13.53	7.89	13.01	10.64	9.75	17.16	6.82	9.61	88.40
I_2		13.50	8.26	12.66	10.56	9.72	16.75	6.88	10.37	88.69
I_3		15.53	8.16	11.96	9.31	11.31	17.10	6.71	10.30	90.36
I_4		14.89	7.58	10.58	9.78	10.33	15.03	6.21	8.78	83.19
LSD 0.05		0.90	NS	NS	NS	1.5	NS	0.80	NS	
S_1		16.01	8.15	12.04	13.23	14.22	21.13	8.36	14.27	107.41
S_2		9.12	6.19	9.00	9.06	6.48	12.56	4.68	6.93	64.84
S_3		17.16	9.57	15.08	7.92	10.14	15.84	6.92	8.10	90.72
LSD 0.05		1.90	1.70	2.4.00	1.80	2.50	2.9	1.90	2.3	
Interactions (IS)										
	S_1	17.50	7.28	12.08	12.75	14.58	23.50	9.18	15.63	112.52
I1	S_2	8.16	7.02	9.10	10.83	6.46	12.65	4.90	6.58	65.71
	S_3	14.92	9.37	17.83	8.33	8.21	15.33	6.38	6.60	86.97
	S_1	14.75	8.77	11.81	14.58	14.33	20.08	8.10	14.47	106.90
I2	S_2	9.75	6.50	8.92	9.58	6.83	14.75	5.52	7.47	69.32
	S_3	16.00	9.50	17.25	7.50	8.00	15.42	7.02	9.18	89.87
	S_1	15.75	8.08	12.50	12.50	14.67	19.85	7.98	14.37	105.69
I3	S_2	10.91	5.90	9.04	7.92	6.92	12.92	4.92	7.96	66.48
	S_3	19.92	10.48	14.33	7.50	12.33	18.54	7.24	8.57	98.92
	S_1	16.04	8.47	11.75	13.10	13.29	21.10	8.20	12.60	104.55
I4	S_2	10.83	5.35	9.08	7.92	5.71	9.92	3.38	5.69	57.88
	S_3	17.79	8.93	10.89	8.33	12.00	14.08	7.06	8.03	87.13
LSD at 5%		1.19	0.88	0.59	0.80	0.77	1.19	0.52	0.76	1.95

Table 5. Fresh yield of alfalfa (ton/ha) as affected by irrigation regimes under saline calcareous soil conditions during 2017/ 2018 growing year.

Treatments		1st Cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9t cut	Σ Cuts	Combination at two years
I1		8.75	6.78	6.00	9.25	9.82	15.37	18.13	12.25	11.81	98.14	186.54
I2		9.98	6.42	4.96	9.56	9.49	15.44	17.64	12.69	13.06	99.24	187.93
I3		8.92	6.41	4.63	9.64	9.26	15.08	16.44	12.28	13.58	96.24	186.60
I4		8.68	7.13	4.31	9.39	9.38	15.21	16.47	12.92	13.64	97.13	180.31
LSD 0.05		0.93	0.09	1.10	NS	NS	NS	1.24	NS	1.7	1.9	
S1		9.75	7.63	4.23	10.90	11.74	16.69	17.88	13.33	13.96	106.10	213.51
S2		7.62	5.97	4.65	9.40	8.49	13.93	15.19	11.15	11.04	87.58	152.43
S3		9.72	6.46	6.04	8.09	8.23	15.21	18.44	13.12	14.06	99.38	190.10
LSD 0.05		1.20	0.82	1.50	1.20	1.90	2.05	NS	1.70	1.20	5.60	
Interactions:												
	S1	10.29	8.30	4.50	11.25	11.70	16.76	17.50	13.25	11.67	105.22	217.74
I1	S2	7.67	5.58	6.25	8.92	8.75	13.75	16.88	11.25	11.25	90.29	156.01
	S3	8.30	6.45	7.25	7.58	9.00	15.58	20.00	12.25	12.50	98.92	185.88
	S1	10.13	7.17	3.95	10.33	12.00	16.83	18.75	13.92	13.33	106.41	213.30
I2	S2	9.15	6.78	4.75	9.42	8.46	14.33	15.00	11.25	10.83	90.81	160.12
	S3	10.65	5.32	6.17	8.94	8.00	15.17	19.17	12.92	14.17	100.49	190.36
	S1	8.96	7.27	4.05	10.92	11.33	16.42	17.50	12.17	15.33	103.94	209.63
I3	S2	8.33	5.68	4.25	9.67	8.54	13.42	15.14	11.25	10.42	87.12	153.59
	S3	9.47	6.28	5.58	8.33	7.92	15.42	16.67	13.42	14.58	97.67	196.58
	S4											
	S1	9.63	7.77	4.43	11.08	11.92	16.75	17.75	14.00	15.50	108.83	213.37
I4	S2	5.90	5.85	3.33	9.58	8.23	14.22	13.75	10.25	11.67	82.11	140.00
	S3	10.50	7.78	5.17	7.50	8.00	14.67	17.92	13.92	15.00	100.45	187.58
LSD 0.05		0.80	0.66	0.30	0.59	0.41	0.39	0.92	1.29	0.87	2.07	3.08

2- Dry alfalfa yield:

Results of dry alfalfa yield for two growing years and summation of cuts of two years were presented in Table 6 and 7. Table 6 and 7 showed that dry alfalfa yield was significantly affected by soil salinity and irrigation treatments during two growing year.

For cuttings production there were significant affected of soil salinity treatments on dry alfalfa yield at all cuts except at 1st cut in the first years (Table 6), while in the 2nd year there was significant affected at all cuts (Table 7). Also, there was significant affected of irrigation treatments on dry alfalfa yield at all cuts except at 2nd, 4th cuts in the 1st year (Table 6), while in the 2nd year the significant affected was at all cuts except at 4th, 5th and 8th cuts (Table 7). The interaction between soil salinity and irrigation treatments was affected significantly on dry alfalfa yield during the two growing years. The highest value was obtained by I_1S_1 interaction (5.44 ton/h in the 6th cut) and the lowest value was obtained with I_4S_2 interaction (0.820 ton/h) in the 1st year, while in the 2nd year the highest value was obtained by I_4S_3 interaction (5.57 ton/h in the 7th cut) and the lowest value was obtained by $I3S_2$ interaction (0.73 ton/h in the 3rd cut).

The summation of 8cuts in the 1st year and summation of 9 cuts in the 2nd year indicated that dry alfalfa yield was significantly affected by soil salinity and irrigation treatments. S_1 produced the highest value of dry alfalfa yield (22.050 ton/ha) in the first year, while in the 2nd year the highest value was 26.391 ton/ha as compared to S_2 and S_3 treatments. Irrigation treatments had not affected significantly on dry alfalfa yield in the 1st year, while in the 2nd year, the irrigation treatments were significantly affected on dry alfalfa yield, and so, $I_1$and I_4 produced the highest values of dry alfalfa yield as

compared with I_2 and I_3 treatments. The interaction between soil salinity and irrigation treatments were significantly affected on dry alfalfa yield in the 1st and 2nd years the highest value was obtained by I_1S_1 (23.152 ton/ha), while the lowest value was obtained by I_4S_2 (12.141 ton/ha) in the first year, while in 2nd year the highest value was obtained by I_4S_1 (27.136 ton/ha) and the lowest value was obtained by I_3S_2 (21.502 ton/ha).

The combination of two years of dry alfalfa yield was showed in Table 8. Table 8, showed that the dry alfalfa yield was significantly affected by soil salinity and irrigation treatments. Dry alfalfa yield was decreased by 25.3% at S_2 and by 8.9% at S_3 as compared with S_1. The irrigation treatments had not affected significantly on dry alfalfa yield. The interactions I_1S_2 and I_1S_3 were decreased in dry alfalfa yield by 18.3% and 13.19% as compared with that obtained by I_1S_1, respectively, Also, I_2S_2 and I_2S_3 were decreased in dry alfalfa yield by 21.95% and 17.16% as compared with I_2S_1 respectively. In addition, I_3S_2 and I_3S_3 were decreased by 16.60% and 6.69% as compared with I_3S_1 respectively.

Finally I_4S_2 and I_4S_3 were decreased by 20.21% and 0.70% as compared with I_4S_1 respectively. These results are agreement with these obtained by Alkhatem and Gabr (2014).

Table 6. Dry yield of alfalfa (ton/ha) as affected by irrigation regimes under saline calcareous soil conditions during 2016 /2017 growing year.

Treatments		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	Σ Cuts
I_1		2.13	1.41	1.90	2.87	2.06	4.43	1.68 a	2.05	18.51
I_2		2.21	1.50	2.06	2.79	2.03	3.99	1.72 a	2.36	18.65
I_3		2.64	1.38	1.80	2.58	2.34	4.32	1.60 a	2.19	18.86
I_4		2.70	1.38	1.69	2.31	2.23	3.84	1.53 a	1.94	17.62
LSD at 5%		0.35	NS	0.09	NS	0.02	0.11	NS	0.26	
S_1		2.67	1.46	1.74	3.39	2.84	5.00	1.92	3.03	22.05
S_2		1.69	1.14	1.47	2.38	1.41	3.27	1.20	1.58	14.14
S_3		2.90	1.65	2.38	2.14	2.24	4.17	1.76	1.80	19.04
LSD at 5%		NS	0.27	0.59	0.83	0.51	0.65	0.14	1.6	
Interaction (IS)										
	S1	2.66	1.29	1.70	3.72	3.00	5.44	2.06	3.29	23.15
I1	S2	1.21	1.34	1.63	2.87	1.37	3.60	1.37	1.44	14.83
	S3	2.51	1.58	2.36	2.00	1.80	4.27	1.60	1.44	17.55
	S1	2.31	1.67	2.02	3.36	2.84	4.57	1.87	3.34	21.98
I2	S2	1.61	1.22	1.34	2.95	1.46	3.64	1.49	1.70	15.42
	S3	2.70	1.61	2.81	2.05	1.80	3.75	1.78	2.04	18.54
	S1	2.74	1.36	1.59	3.47	2.97	4.72	1.85	2.86	21.56
I3	S2	1.93	0.99	1.61	1.93	1.54	3.26	1.36	1.79	14.18
	S3	3.26	1.80	2.20	2.33	2.53	4.98	1.82	1.92	20.84
	S1	2.96	1.51	1.63	2.99	2.57	5.30	1.91	2.64	21.50
I4	S2	1.03	1.02	1.29	1.78	1.26	2.56	0.82	1.39	12.14
	S3	3.11	1.62	2.13	2.18	2.85	3.68	1.86	1.80	19.23
LSD at 5%		0.26	0.17	0.22	0.50	0.16	0.36	0.16	0.18	

Table 7. Dry yield of alfalfa (ton/ha) as affected by irrigation regimes under saline calcareous soil conditions during 2017/ 2018 growing year.

Treatments		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9th cut	Σ Cuts	Combination at two years
I_1		1.78	1.51	1.21	2.25	2.21	4.27	4.90	3.68	3.10	24.91	43.42
I_2		2.15	1.36	0.98	2.25	2.08	4.02	4.44	3.64	3.19	24.10	42.75
I_3		1.87	1.43	0.93	2.20	2.16	3.99	4.24	3.42	3.60	23.84	42.70
I_4		1.68	1.52	0.86	2.27	2.23	4.39	4.79	3.71	3.75	25.21	42.83
LSD at 5%		0.66	0.24	0.16	NS	NS	0.26	0.04	NS	0.09	0.74	
S_1		2.00 a	1.59	0.82	2.50	2.67	4.78	4.73	3.92	3.55	26.39	48.44
S_2		1.66 b	1.33	0.99	2.35	1.96	3.74	4.00	3.15	2.90	22.08	36.22
S_3		1.95	1.46	1.17	1.88	1.89	3.98	5.05	3.92	3.77	25.07	44.12
LSD at 5%		0.23	0.09	0.18	0.63	0.45	0.38	0.70	0.09	0.55	2.4	
Interaction (IS)												
	S1	2.02	1.80	0.87	2.70	2.60	4.84	4.73	4.23	2.93	26.71	49.86
I1	S2	2.27	1.43	0.74	2.40	2.65	4.84	4.66	3.68	3.32	25.99	47.98
	S3	1.82	1.57	0.79	2.52	2.62	4.57	4.49	3.38	3.96	25.73	47.29
	S1	1.89	1.54	0.88	2.38	2.79	4.87	5.03	3.76	3.99	27.14	48.64
I2	S2	1.63	1.26	1.32	2.28	2.01	3.68	4.55	3.12	3.08	22.92	37.75
	S3	1.99	1.52	0.99	2.27	1.85	3.70	3.88	3.19	2.75	22.15	37.57
	S1	1.74	1.24	0.91	2.14	2.01	3.59	3.78	3.06	3.02	21.50	35.68
I3	S2	1.29	1.31	0.73	2.70	1.96	3.99	3.77	3.24	2.75	21.73	33.87
	S3	1.70	1.48	1.43	1.77	2.03	4.28	5.42	3.70	3.30	25.10	42.66
	S1	2.18	1.14	1.18	2.08	1.75	3.52	4.79	4.05	3.48	24.16	42.70
I4	S2	2.06	1.48	1.09	1.93	1.86	3.80	4.44	3.83	3.80	24.29	45.13
	S3	1.85	1.71	0.97	1.75	1.95	4.32	5.57	4.13	4.50	26.75	45.98
LSD at 5%		0.14	0.07	0.15	0.13	0.17	0.46	0.41	0.35	0.51	0.74	0.91

3- Alfalfa plant height (cm).

Results of alfalfa plant height in cm for two growing years, summation of cuts and combination of two \years were presented in Tables 8 and 9. Tables 8 and 9 showed that the alfalfa plant height was significantly affected by soil salinity and irrigation treatments during two growing years.

For cuttings production there were significant affected of soil salinity treatments on alfalfa plant height at all cuts in the 1st year (Table 8), while in the 2nd year, the

significant effected was at all cuts (Table 9). The interaction between soil salinity and irrigation treatments was affected significantly on alfalfa plant height during two growing years. The highest value was obtained by I_4S_3 (96.62 cm in the 7th cut) and the lowest value was obtained by I_1S_2 (36.67 cm in the 2nd cut), in the 1st year, while in 2nd year the highest value was obtained by I_3S_1 (94.75 cm in the 7th cut) and the lowest value was obtained with I_2S_3 (38.00 cm).

The summation of 8 cuts in the 1st year and summation of 9 cuts in the 2nd year showed that the alfalfa plant height was significantly affected by soil salinity and irrigation treatments. S_1 produced the highest value of plant height in 1st and 2nd years as compared to S_2 and S_3 irrigation treatments were significantly affected on plant height in 1st and 2nd years the interactions between soil salinity and irrigation treatments were significantly affected on alfalfa plant height in 1st and 2nd years. The highest value of plant height was obtained by I_2S_1 (77.28 cm) while the lowest value was obtained by I_1S_2 (64.5 cm) in 1st year, while in 2nd year the highest value was obtained by I_1S_1 (73.34 cm) and the lowest value was obtained by I_1S_2 (62.98 cm).

The combination of two years of alfalfa plant height was presented in Table 9. Table 10 showed that the alfalfa plant height was significantly affected by soil salinity and irrigation treatments. The highest value of plant height was obtained by S_1 as compared with S_2 and S_3. Also the highest values of plant height were obtained by I_2, I_3 and I_4 as compared with I_1. The interaction of I_1S_1, I_2S_1, I_3S_1 and I_4S_1were obtained the highest values of plant height was significantly taller under soil salinity treatment of 2 ds/m (S_1) and with irrigation with amount of water equal ET_p+ 10%ET_p (I_1), ET_p+20% ET_p (I_2), ET_p+30%ETp (I_3) and ET_p+40% ET_p (I_4). Those results were agreement with these reported by Farissi *et al.* (2014)

Table 8. Plant height (cm) of alfalfa as affected by irrigation regimes and soil salinity treatments during 2016 /2017 growing year.

Treatments		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	Σ Cuts
I_1		64.93	46.19	63.55	56.33	83.33	93.81	70.54	76.46	69.39
I_2		63.33	48.55	67.10	59.33	85.78	92.45	73.44	78.80	71.02
I_3		64.10	51.33	67.55	64.43	82.79	93.51	71.87	80.32	71.99
I_4		62.82	49.10	70.10	65.10	83.19	92.39	70.35	76.65	71.21
LSD at 5%		1.5	0.48	0.35	1.5	0.88	NS	0.16	1.0	
S_1		69.08	56.39	74.66	70.58	89.07	95.13	72.40	84.81	76.52
S_2		62.45	42.41	60.74	57.90	77.06	89.39	68.92	76.26	66.89
S_3		59.83	47.57	65.83	\5\5.41	85.18	94.60	73.33	72.65	69.30
LSD at 5%		2.4	3.7	3.9	2.9	4.5	2.7	3.1	5.7	
Interaction (IS)										
	S1	68.67	55.25	74.32	69.32	88.32	94.00	72.65	85.00	76.04
I1	S2	64.37	36.67	57.32	52.65	76.67	90.65	64.65	73.07	64.50
	S3	61.72	46.65	59.00	47.00	85.00	96.00	74.32	71.32	67.62
	S1	69.00	56.67	75.00	72.32	90.65	95.00	74.32	85.30	77.28
I2	S2	61.67	42.65	64.00	56.00	82.32	90.25	69.67	76.00	67.82
	S3	59.32	46.32	62.32	49.67	84.37	92.10	76.32	73.32	67.97
	S1	67.00	60.65	74.00	71.32	89.32	95.87	70.65	85.32	76.68
I3	S2	62.50	43.67	61.32	60.32	75.00	91.00	72.32	78.00	68.01
	S3	62.80	50.32	67.32	61.65	84.05	93.67	72.65	77.65	71.26
	S1	71.67	53.65	75.32	69.35	88.00	94.87	72.00	83.65	76.06
I4	S2	61.32	46.67	60.32	62.65	74.25	85.67	69.05	78.00	67.24
	S3	55.47	47.00	74.67	63.32	87.32	96.62	70.02	68.32	70.34
LSD at 5%		2.10	1.78	2.05	2.88	1.27	2.69	2.07	3.58	

Table 9. Plant height (cm) of alfalfa as affected by irrigation regimes under saline calcareous soil conditions during 2017/ 2018 growing year.

Treatments		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9th cut	Σ Cuts
I_1		82.61	75.32	64.21	43.60	49.77	60.08	89.16	79.50	62.66	67.43
I_2		83.33	78.44	66.34	42.46	55.47	57.50	86.83	81.91	62.41	68.30
I_3		79.20	81.76	65.99	43.32	53.88	57.08	87.66	81.00	65.83	68.41
I_4		79.00	81.13	64.76	43.77	56.65	59.66	89.50	82.25	63.83	68.93
LSD at 5%		0.42	1.5	NS	0.54	2.5	1.6	NS	NS	2.4	
S_1		83.58	79.81	65.49	48.21	65.41	78.43	93.25	78.93	62.75	72.87
S_2		80.49	79.58	64.73	41.83	51.66	44.87	81.37	78.25	60.43	64.80
S_3		79.04	78.10	65.76	39.83	44.76	52.43	90.25	86.31	67.75	67.14
LSD at 5%		NS	NS	NS	2.7	3.9	12.6	5.26	2.7	1.9	
Interaction (IS)											
	S1	79.00	79.65	68.32	48.12	64.00	78.75	93.50	76.75	62.00	73.34
I1	S2	76.32	71.00	64.00	41.00	47.00	46.75	82.75	76.50	61.50	62.98
	S3	82.52	75.32	60.35	41.70	38.32	54.75	91.25	85.25	64.50	65.99
	S1	85.00	75.65	64.00	48.75	66.00	77.75	92.75	79.75	60.50	72.23
I2	S2	85.32	84.00	66.62	40.65	57.67	41.75	77.25	77.00	58.50	65.41
	S3	79.67	75.67	68.40	38.00	42.75	53.00	90.50	89.00	68.25	67.25
	S1	80.65	82.65	66.00	46.65	63.32	79.25	94.75	80.25	65.25	73.19
I3	S2	81.32	82.32	63.65	43.00	50.32	43.00	82.00	78.50	60.25	64.93
	S3	75.65	80.32	68.32	40.32	48.00	49.00	86.25	84.25	72.00	67.12
	S1	79.67	81.32	63.65	49.32	68.32	78.00	92.00	79.00	63.25	72.72
I4	S2	79.00	81.00	64.65	42.67	51.65	48.00	83.50	81.00	61.25	65.88
	S3	78.32	81.07	66.00	39.32	50.00	53.00	93.00	86.75	66.25	68.19
LSD at 5%		2.55	2.12	0.96	1.91	3.81	3.76	2.34	1.69	0.92	1.10

Quality of alfalfa:

The effect of irrigation regimes and soil salinity treatments on minerals and protein contents of alfalfa yield is presented in Table 10. The results indicated that the interaction of irrigation and soil salinity treatments had a significant effect on the percentage of potassium, phosphorous, sodium, nitrogen and protein contents in two growing years. The results showed also that, the interaction of I_3S_1, I_4S_1, I_1S_3, I_3S_3 and I_4S_3 were given the highest values of K, P, Na, N and protein%, respectively. Also the interaction of I_1S_3, I_1S_3, I_4S_1, I_1S_1 and I_1S_1 were given the lowest values of K, P, Na, N and protein %, respectively.

The increasing of N% and protein % in alfalfa yield may be due to the excess of irrigation water under high salinity soil condition. Also, sodium concentration in alfalfa increases with increasing sodium concentration in the soil. The obtained results are agreement with the results of Kidambi *et al*. (1990) and Endo *et al*. (2014).

Table 10. Quality of alfalfa (%) as affected by the interaction irrigation regimes under saline calcareous soil conditions during 2016 /2017 and 2017/2018 growing year.

Treatments		K%			P%			Na%			N%			Protein %		
		1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st year	2nd year	Average	1st Year	2nd year	Average
I1	S1	1.54	1.84	1.69	0.21	0.24	0.23	0.13	0.11	0.12	2.28	3.01	2.65	13.47	17.14	15.31
	S2	1.56	1.87	1.71	0.19	0.18	0.19	0.22	0.18	0.20	2.38	3.08	2.73	14.28	18.23	16.28
	S3	1.36	1.72	1.54	0.14	0.16	0.15	0.29	0.25	0.27	2.63	3.17	2.90	16.45	19.95	18.20
I2	S1	2.11	2.33	2.22	0.27	0.26	0.26	0.05	0.05	0.05	2.28	3.05	2.67	14.30	18.48	16.39
	S2	2.10	2.20	2.15	0.20	0.19	0.19	0.11	0.10	0.11	2.38	3.03	2.71	14.89	18.42	16.66
	S3	1.91	2.16	2.03	0.14	0.17	0.16	0.17	0.14	0.15	2.69	3.18	2.93	17.61	19.89	18.75
I3	S1	2.67	2.65	2.67	0.23	0.24	0.24	0.04	0.04	0.04	2.41	3.03	2.72	15.07	18.76	16.92
	S2	2.45	2.59	2.52	0.26	0.24	0.25	0.08	0.06	0.07	2.44	3.15	2.79	15.27	19.45	17.36
	S3	2.36	2.38	2.37	0.18	0.19	0.18	0.14	0.12	0.13	2.71	3.22	2.96	17.34	20.19	18.76
I4	S1	2.48	2.60	2.54	0.27	0.26	0.27	0.02	0.34	0.03	2.43	3.14	2.78	15.18	19.63	17.40
	S2	2.34	2.67	2.50	0.26	0.25	0.25	0.07	0.06	0.06	2.45	3.21	2.83	15.35	20.07	17.71
	S3	2.29	2.47	2.38	0.18	0.19	0.18	0.11	0.10	0.11	2.66	3.23	2.95	16.68	20.92	18.80
LSD 0.05		0.05	0.03	0.04	0.003	0.006	0.004	0.001	0.002	0.002	0.05	0.08	0.03	0.36	0.53	0.24

Water requirements (WR):

The monthly and seasonally of water requirements (amount of applied irrigation water) for alfalfa crop according to the irrigation treatments during the two growing years are listed in Table 11. The highest monthly value of water requirements occurred during July in both years for all irrigation treatments. The total amount of water requirements for I_1, I_2, I_3, and I4 irrigation treatments were 126.0, 135.2, 144.3 and 153.9 cm. in the 1st year, and 128.8, 140.2, 152.0 and 163.8 cm. in the 2nd year, respectively. The obtained results are agreement with the results of Hanson *et al.* (2006), and Doorenbos and Kassam, (1986).

Table 11. Monthly and total water requirements in cm as affected alfalfa by irrigation treatments during 2016 /2017 and 2017/2018 growing years.

Season	Treatments	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Total
2016/2017	I_1	19.5	9.5	7.9	5.9	5.2	7.0	9.0	9.9	11.8	12.4	14.7	13.2	126.0
	I_2	19.5	10.3	8.5	6.5	5.7	7.7	9.7	10.7	12.8	13.4	16.0	14.4	135.0
	I_3	19.5	11.2	9.3	7.0	6.2	8.2	10.3	11.5	14.0	14.4	17.3	15.4	144.3
	I_4	19.5	11.9	10.0	7.6	6.6	8.8	11.4	12.4	15.1	15.6	18.4	16.6	153.9
2017/2018	I_1	12.9	11.8	8.9	6.4	5.1	6.7	8.1	11.2	12.9	14.3	15.4	15.1	128.8
	I_2	14.0	12.8	9.7	7.0	5.5	7.3	8.9	12.2	14.0	15.6	16.8	16.4	140.2
	I_3	15.2	13.9	10.5	7.5	6.0	7.9	9.6	13.3	15.2	16.9	18.2	17.8	152.0
	I_4	16.4	15.0	11.3	8.1	6.4	8.5	10.4	14.3	16.4	18.2	19.6	19.2	163.8

Convert the total requirements to m^3 multiply the value by 100

Productivity of irrigation water (PIW):

Results in Table 12 represented the productivity of irrigation water (PIW), expressed as kg of alfalfa yield per cubic meter of water requirements, for the two growing years. Comparing the values of PIW under the interaction between soil salinity and irrigation treatments for the summation cuts for two years, reveals that maximum values were 8.93 and 8.17 kg of alfalfa per cubic meter of water requirements, that obtaI1S1 interaction, in 1st and 2nd years, respectively. While the lowest values were 3.76 and 5.01 kg of alfalfa yield per cubic meter of water requirements that obtained by I_4S_2 interaction in the 1st and 2nd years, respectively. These results were agreement with those reported by Abid *et. al.* (2016), and Liu and Guo (2013).

Table 12. Productivity of irrigation water (PIW) for alfalfa yield in kg/m^3 water during 2016 /2017 and 2017/2018 growing years.

Treatments	Productivity of irrigation water (PIW)	
	2016/2017	2017/2018
I_1S_1	8.93	8.17
I_2S_1	7.91	7.59
I_3S_1	7.32	6.84
I_4S_1	6.79	6.64
I_1S_2	5.22	7.01
I_2S_2	5.13	6.48
I_3S_2	4.61	5.73
I_4S_2	3.76	5.01
I_1S_3	6.90	7.68
I_2S_3	6.65	7.17
I_3S_3	6.85	6.43
I_4S_3	5.66	6.13

CONCLUSION

From the obtained results, it could be concluded that:

1- Maximum fresh and dray alfalfa yields were obtained by irrigation with amount of irrigation equals ET_p + 10 ET_p and with soil salinity treatment of 2 dS/m^{-1}. (I_1S_1).
2- Fresh and dry alfalfa yields were decreased by 28.4 and 18.13% at I_1S_2 and by 14.6 and 13.19% at I_1S_3, respectively, as compared with I_1S_1 interaction.
3- Seasonal range of water requirements for alfalfa crop was 126.0 – 153.9 cm in the first year and it was 128.8 – 163.8 cm in the second year.
4- The highest value of the productivity of irrigation water for alfalfa crop was obtained by irrigation with amount of water equals ET_p + 10% ET_p (as leaching requirements) and with soil salinity treatment of 2 ds/m (I_1S_1).
5- The highest values of nitrogen and protein percentage were obtained by the interaction of I_3S_3 (2.969) and I_4S_3 (18.803)

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تأثير معدلات الرى على انتاجية محصول البرسيم الحجازى تحت ظروف الأراضى الجيرية الملحية

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تم اجراء تجربة حقلية بالمزرعة البحثية لمحطة البحوث الزراعية بالنوبارية خلال موسمى ٢٠١٦/٢٠١٧ & ٢٠١٧/٢٠١٨ لدراسة تأثير مستويات الرى تحت ظروف الأراضى الجيرية الملحية على محصول البرسيم الحجازى ونوعيتة والاحتياجات المائية للمحصول وإنتاجية مياه الرى. وكانت معاملات الرى هى I_1= الرى بكمية مياه تعادل جهد البخرنتح (ET_p) مضاف اليها ١٠% من جهد البخرنتح (كاحتياجات غسيلية), I_2 = الرى بكمية مياه تعادل جهد البخرنتح (ET_p) مضاف اليها ٢٠% من ال ET_p, I_3 = الرى بكمية مياه تعادل جهد البخرنتح (ET_p) مضاف اليها ٣٠% من ال ET_p, I_4 = الري بكمية مياه تعادل جهد البخرنتح (ET_p) مضاف اليها ٤٠% من الET_p. وتم اختيار ثلاث مستويات من التربة الجيرية الملحية وهى: S_1 = متوسط الملوحة 2 dS/m^{-1}, S_2= متوسط الملوحة 6 dS/m^{-1}, S_3= متوسط الملوحة 10 dS/m^{-1}وأوضحت النتائج الأتى: وجود تأثير معنوى لمعاملات الملوحة على الوزن الرطب و الجفاف لمحصول البرسيم الحجازى من مجموع السنتين حيث أعطت المعاملة S_1 أعلى محصول رطب وهو ٢١٣,٥١٠ طن/هكتار و أعلى محصول جاف وهو ٤٩,٨٦ طن /هكتارلا يوجد تأثير معنوى لمعاملات الرى على وزن محصول البرسيم الحجازى الرطب والجاف من خلال مجموع السنتين. يوجد تأثير معنوى للتفاعل بين المعاملات على محصول البرسيم الحجازى الرطب والجاف من خلال مجموع السنتين , فقد أعطى التفاعل I_1S_1 أعلى محصول رطب وهو ٢١٧,٧٤ طن/هكتار وأعطى التفاعل I_4S_2 أقل محصول وهو ١٣٩,٩٩٥ طن/هكتار. أم بالنسبة لمحصول البرسيم الحجازى الجاف فقد أعطى التفاعل I_1S_1 أعلى محصول وهو ٤٩,٨٦١ طن/هكتار وأعطى التفاعل I_3S_2 أقل محصول جاف وهو ٣٥,٩١ طن/هكتار. انخفض محصول البرسيم الحجازى الرطب والجاف بمقدار ٢٨,٤, ١٨,١٣% للتفاعل I_1S_2 وكذلك بمقدار ١٤,٦, ١٣,١٩% للتفاعل I_1S_3 الترتيب وذلك بالقارنة بالتفاعل I_1S_1 . يوجد تأثير معنوى للتفاعل بين المعاملات على تركيز الأملاح المعدنية لنباتات البرسيم الحجازى وقد وجد أن المعاملة I_3S_3 , I_4S_3 أعطت أعلى محتوى لنسبة النيتروجين والبروتين داخل انسجة النبات. الاحتياجات المائية لمحصول البرسيم الحجازى كانت ١٢٦,٠ , ١٣٥,٠ , ١٤٤,٣ , ١٥٣,٩ سم خلال السنة الأولى وكانت ١٢٨,٨, ١٤٠,٢, ١٥٢,٠, ١٦٣,٨سم فى السنة الثانية وذلك لمعاملات الرى I_1, I_2, I_3, I_4 على التوالى. أعلى انتاجية لمياه الرى كانت ٨,٩٣, ٨,١٧ كيلوجرام أخضر/متر مكعب مياه رى وذلك خلال السنة الأولى والثانية على التوالى.