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RESPONSE OF FODDER COWPEA TO DIFFERENT SALINITY LEVELS OF IRRIGATION WATER

A.S.M. Badawy[1], Shereen M. A. EL-Nahrawy[1] and M. A. Aiad[2]

1. Forage Crop Res. Sec. Field Crops Res. Inst., A. R. C. Giza, Egypt.
2. Soils water and Environ. Res. Inst., A. R. C., Giza, Egypt.

ABSTRACT

Salinity is a major threat to summer forage crops in Egypt. Thus, two experiments were performed at lysimeter experiment area at Soil Improvement and Conservation Res. Dep., during the two successive summer seasons 2018 and 2019 in Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt, to study the effect of irrigation water salinity on forage and seed yield of fodder cowpea and some soil properties. The experiments were designed as a split plot with three replicates. The main plots were occupied by three irrigation water salinity levels: normal salinity of irrigation water S_1 (EC=0.65; dS m^{-1} 416 ppm), S_2 (EC=2; dS m^{-1} 1280 ppm), S_3 (EC=3.5; dS m^{-1} 2240 ppm). Sub plots were occupied by three cowpea genotypes, namely Sakha 5 (V_1), Sakha 7 (V_2) and Balady (V_3). The data showed that the highest value for fresh yield (2.80-2.82 kg. $plot^{-1}$) and dry yield (0.602 - 0.610 kg. $plot^{-1}$) was obtained with applying irrigation water salinity level S_1. In addition, the genotype Sakha 5 gave the highest values for fresh and dry forage yields. The highest values for plant height, stem diameter, number of branches and leaf stem percent were recorded under S_1 comparing with the other two levels. With respect to genotype, Sakha 5, it gave the highest values for plant height, number of branches and leaf stem ratio. But, Balady gave the highest value of stem diameter in the two seasons. The data showed that the highest values for number of pods/plant, number of seeds/pod, 100- seed weight and seed yield were also recorded under normal water irrigation (S_1) comparing with the two salinity levels. The genotype Sakha 5 gave the highest value for number of pods plant, number of seeds pod, 100- seed weight and seed yield. It was observed that seed yield was decreased by 11.32 and 24.75% under water salinity levels of S_2 and S_3, respectively in relation to irrigation with fresh water (S_1).

Key words***: Forage cowpea, Vigna unguiculata, Irrigation water salinity, Soil properties.***

INTRODUCTION

Cowpea is a leguminous crop providing rich protein fodder for animals. This precious tropical and subtropical legume is especially important for the semi-arid regions of the tropics for forage, green pods and grains (Adeyanju *et al* 2007 and Ali *et al* 2004). In summer season of Egypt, there is a great shortage of fresh animal feed (Hathout 1987). So, cowpea becomes one of the available solutions to overcome the shortage in addition to summer forage (El-Nahrawy 2018). Salinity is one of the major threats to cowpea production, particularly in semi-arid regions of Africa. Salinity significantly affects seed germination and decreases pod yield in cowpea (Maas and Poss 1989 and Patel *et al* 2010). Cowpea has a higher tolerance to salinity than maize but lower than wheat, barley, sugar beet and cotton (Ravikovitch and porath 1967). According to the classification of crop tolerance to salinity, cowpea is a moderately sensitive crop (Maas and Hoffman 1977). Cowpea has exhibited no yield loss with salinity in the root zone exceeding an electrical conductivity of 4.9 dS m^{-1} (West and Francois

1982). For each increase of one dS m^{-1} above this threshold, yield was reduced by 21%. However, if the sources of water have different salinity levels, it is preferable to keep salinity low during germination and early vegetative growth, where, the crops are mostly sensitive. The poor quality water might be used during pod filling (Hall and Frate 1996).

To grow a crop on saline soils and to irrigation with saline water, more information about salinity effects on both plant and soil are required (Oral *et al* 2009). FAO (2005) reported that in arid and semi-arid regions, soil sodicity is a common problem under these conditions. Moreover, in these soils, there are increasing potentials for hazardous accumulation of salts and the productivity of crops and plants is severely limited. Saline clay soils with low permeability are mostly found in the northern part of Nile Delta. Salinity affects agricultural production, water and nutrient uptake and metabolic activities in plant leading to drastic losses in term of reduced economic yield and deteriorate quality of agricultural products (Egamberdieva *et al* 2017 and Raphael *et al* 2018). Salinity is expected to increase in the future with serious implications for agriculture and food security (Fischer and Connor 2018). Egypt is one of the countries that had many salinity problems where 33% of the cultivated land area is already saline (Eissa *et al* 2016 and Masoud *et al* 2018). The Nile water is not available in most of Egyptian landS, thus the use of saline water for irrigation could be an alternative for irrigation (El-Desoky *et al* 2007 and Singh 2018). Salinity induces water deficiency even in well- watered soil by decreasing the osmotic potential of soil solutes (Mansour and Abd- El-Hady 2014). Salts-affected soil is about 30% of Delta area saline (Mohamed 2016). Saline- sodic soils are degraded due to the simultaneous effect of salinity and sodicity. This causes loss of soil physical structure by clay swelling, and dispersion (Young *et al.* 2016 and Yu *et al*. 2010). Salinization can cause yield decreases of 10-25% for many crops. Salinity affects plant growth by creating osmotic imbalances and specific ion toxicities (Parida and Das 2005). The soluble Ca^{+2}, Mg^{+2} and Na^{+} increase with increasing salinity level of irrigation water, while soluble K^{+} decreases with increasing salinity level. But soluble Ca^{+2} and Na^{+} increase with decreasing irrigation frequency, while increasing salinity levels and irrigation frequency decrease the hazardous effects (El-Boraie 1997).

The present study aimed to clarify the effect of irrigation by three levels of saline water on green forage and seed yields and its components of three forage cowpea genotypes.

MATERIALS AND METHODS

Experiment site and treatments

Two lysimeter experiments were carried out for fresh forage and seed yields to study the effect of irrigation saline water levels on green forage and seed yields of three cowpea genotypes. The experiments were done at Soil Improvement and Conservation Research Department, Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt, during the two successive summer seasons' 2018 and 2019. The studied genotypes were kindly provided by Forage Crops Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt. The site has an elevation of 6 meter above sea level with latitude of 31^{o} 7 E and longitude of 30^{o} 57^{--} N. The two experiments were designed as a split plot design with three replicates. The main plots were assigned to three levels of saline water, control (fresh water) S_1 (EC=0.65 dS m^{-1} equal 416 ppm), S_2 (EC=2 dS m^{-1} equal1280 ppm) and S_3 (EC=3.5 dS m^{-1} equal 2240 ppm). While the sub plot, were occupied by three genotypes of forage cowpea namely Sakha 5 (V_1), Sakha 7 (V_2) and Balady (V_3). Plot size was 1.0 m^2. Seeds were hand drilled at the seeding rate of 20 kg fed^{-1} and the rate of 150 kg super phosphate (15.5% P_2O_5) was applied at land preparation and 20 kg of nitrogen were added at every cut. Two cuts were taken in every season. Sowing dates were 1^{st} June and 2^{nd} May in 2018 and 2019 seasons, respectively. The 1^{st} cut was taken 65 days after sowing. The 2^{nd} cut was taken 37 days after the 1^{st} cut, at the first season. While 62 days from the sowing and 35 days after the 1^{st} cut were applied at the second season.

Data were recorded for the following traits:

Fresh forage yield (kg/ plot), dry forage yield (kg/ plot), plant height (cm), stem diameter (cm), number of branches/plant, leaves/stem percent (dry basis), number of pods/plant, number of seeds/pod, weight of 100- seed (g) and seed yield g/plot.

Soil sampling and analysis

Soil samples were collected from all plots before starting the experiment and after the first and second seasons in three consecutive depths of 0-20; 20-40 and 40-60 cm, to monitor some physical and chemical characteristics. The texture class of soil was determined according to the pipette method as described by Dewis and Fartias (1970). Some chemical properties of the studied site such as total soluble salts (soil EC), soil reaction (pH), both soluble cations and anions were determined according to method described by Jackson (1973). Results of soil analysis are shown in Tables (l and 2).

Table 1. Mean values of some soil chemical properties of the experimental site before cultivation.

Soil depth (cm)	pH	EC dS m^{-1}	SAR	ESP %	Soluble Cations ($megl^{-1}$)				Soluble Anions ($megl^{-1}$)			
					Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3	CL^{-}	SO_4^{-2}
0-20	7.93	2.76	9.06	10.80	5.82	2.51	18.50	0.60	__	1.50	14.10	11.83
20-40	8.11	3.57	9.82	11.69	7.48	4.26	23.80	0.71	___	2.00	17.50	16.75
40-60	8.36	4.63	11.50	13.58	9.75	5.54	31.80	0.81	___	3.00	23.40	21.50
Mean	___	3.65	10.13	12.02	7.68	4.10	24.70	0.70	___	2.17	18.33	16.69

Table 2. Mean values of some physical properties of the experimental site before cultivation.

Soil depth (cm)	Particle size distribution %			Texture class	Bulk density (g cm^{-3})	$CaCO_3$ (%)
	Sand	Silt	Clay			
0-20	19.60	26.85	53.55	Clay	1.17	1.65
20-40	17.90	25.15	56.95	Clay	1.26	2.35
40-60	16.80	24.54	58.66	Clay	1.32	2.86
Mean	18.10	25.51	56.39	Clay	1.25	2.29

pH: was determined in soil water suspension (1: 2.5), EC: was determined in a saturated soil paste extract, SAR (sodium adsorption ratio) and ESP (Exchangeable sodium percentage). All soil chemical properties in Table (1) increased with increment of soil depth.

The impact of irrigation using sea water mixed with fresh water to obtain the irrigation water electrical conductivity. Concentration of sea water to the different required volume (L) was mixed with 20 L fresh water to obtain the required EC for irrigation sea water. After that, it was diluted to EC_W= 2 and 3.5 dS m^{-1}. Fresh water as a control equivalent to 0.65 dS m^{-1} was used for irrigation as presented in Table (3).

Table 3. The average values to calculate the volume of sea water for specific irrigation volume and ECW according to its salt content during the two seasons:

Ec sea dS m^{-1}	Co sea g/L	EC_W dS m^{-1}	Required irrigation	Required VOL/L	Vol. of sea water L/ required volume in L
56.5	45.20	0.65	0.65	20	0.00
56.5	45.20	0.65	2.00	20	0.386
56.5	45.20	0.65	3.50	20	0.815

Also, the data in Table (4) showed the average values of chemical analysis of irrigation water increased with increment of salt concentration of irrigation water from S_1 to S_3.

Table 4. The average values of chemical analysis for irrigation water used in the experiments during the two growing seasons.

Treatment	EC dS m^{-1}	SAR	pH	Cations (meg L^{-1})				Anions (meg L^{-1})			
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
S_1	0.65	4.26	7.56	1.42	0.81	4.50	0.30	__	1.50	3.15	2.38
S_2	2.00	7.55	7.89	4.25	2.43	13.80	0.60	__	2.00	9.84	9.24
S_3	3.50	9.25	7.96	6.33	3.60	20.60	0.80	__	3.50	14.31	13.52

Statistical analysis:

The results were analyzed statistically by analysis of variance (ANOVA) using computer program according to the method of Gomes and Gomes (1984). According to analysis of variance assumption. The differences between the means were tested by the least significant difference (L.S.D.) values at 0.05 and 0.01 levels of probability determined for various genotypes as explained by Steel *et al* (1997).

RESULTS AND DISCUSSION

Forage yield and its components

The mean values of the vegetative growth traits of the three forage cowpea genotypes as affected with saline irrigation water treatments during the two seasons are presented in Tables (5 and 6).

Plant height and stem diameter

The mean values of plant height and stem diameter of three forage cowpea genotypes as affected by irrigation saline water treatments are presented in Table (5) for the two seasons. Data showed highly significant differences among the three saline water treatments in the two cuts, where control treatment (fresh water) recorded the highest values of plant height (82.4 and 78.7 cm) and the lowest values of stem diameter (0.70 and 0.67 cm) as an average of two cuts in both seasons, respectively. While S_3 recorded the lowest values of plant height (55.2 and 57.5 cm) and the highest stem diameter (0.82 and 0.84 cm) as an average of two cuts in both seasons, respectively. These results are in agreement with EL-Hefny (2010), Patel *et al* (2010), Salih and Kia (2013), who reported that increasing salinity decreased plant height of cowpea crop. The initial phase of growth reduction for plant height and stem diameter was noticed with the highest level of irrigation water salinity (S_3), might be due to a reductions in cell division and elongation Atta Ullah (1981). Concerning forage cowpea genotypes, data indicated highly significant differences among them in both seasons in the two cuts, where V_1 gave the highest means in plant height (76.7 and 74.2 cm.) for the first and the second seasons, respectively. But V_3 was the shortest means of plant height (61.3 and 59.9 cm).

Table 5. Means of plant height (cm) and stem diameter (cm) of three fodder cowpea genotypes as affected by irrigation water salinity level during 2018 and 2019 seasons.

Treat	Plant height (cm)						Stem diameter (cm)					
	2018			2019			2018			2019		
	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$
S_1	91.0	73.7	82.4	85.0	72.3	78.7	0.703	0.703	0.70	0.697	0.650	0.67
S_2	78.7	62.7	70.7	72.0	62.3	67.2	0.710	0.730	0.72	0.743	0.723	0.73
S_3	61.0	49.3	55.2	61.3	53.7	57.5	0.820	0.818	0.82	0.863	0.817	0.84
F test	**	**		**	**		**	**		**	**	
LSD 0.05	3.73	0.87		3.06	0.44		0.041	0.041		0.013	0.059	
V_1	84.7	68.7	76.7	79.3	69.0	74.2	0.697	0.694	0.69	0.703	0.697	0.70
V_2	77.7	62.7	70.2	74.3	64.3	69.3	0.750	0.717	0.73	0.733	0.700	0.72
V_3	68.3	54.3	61.3	64.7	55.0	59.9	0.787	0.840	0.81	0.897	0.793	0.84
F test	**	**		**	**		**	**		**	**	
LSD 0.05	5.69	4.41		4.09	3.58		0.065	0.073		0.065	0.056	
S×V	N.S	N.S		N.S	N.S		N.S	N.S		N.S	N.S	-

Treat = Treatment, * and **, indicates significance at 0.05 and 0.01 probability levels, respectively, N.S: Not Significant.

While V_1 had the lowest average for stem diameter (0.69 and 0.70 cm), but V_3 recorded the highest average for stem diameter (0.81 and 0.84 cm) in the two seasons as an average of the two cuts, respectively.

It seems that irrigation water salinity levels were proportional to plant height of forage cowpea. That reduction in height varied among genotypes. This result is in agreement with Omara and El-Gaafarey (2018) who reported that addition of saline irrigation water significantly decreased plant height of cowpea when compared to normal irrigation water with saline water. The result revealed that the average were (66.2 to 54.3 cm) and (66.6 to 55.0 cm) at the two cuts in both seasons, respectively. On the other hand, Omara and El-Gaafarey (2018) indicated that increased saline irrigation water significantly decreased stem diameter of cowpea when compared to normal irrigation with saline water (9.24 to 7.55 mm) and (11.30 to 7.97 mm) at the two cuts as an average in both seasons, respectively. The interactions between water salinity and cowpea genotypes were insignificant in the two cuts in the two seasons for plant height and stem diameter.

Number of branches/plant and leaf stem percent (dry weight)

The effect of irrigation with saline irrigation water and its interactions with genotypes on branches/plant and leaf stem percent (dry weight) of three forage cowpea genotypes in 2018 and 2019 seasons are presented in Table (6).

Table 6. Mean number of branches and leaf stem percent (dry weight) of three fodder cowpea genotypes as affected by irrigation water salinity level during 2018 and 2019 seasons.

Treat	Number of branches/plant						Leaf stem percent (Dry weight)					
	2018			2019			2018			2019		
	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$	1st cut	2nd cut	$\bar{X}$
S_1	4.10	4.10	4.10	4.07	4.00	4.04	49.33	52.67	51.00	50.33	52.67	51.50
S_2	3.67	3.73	3.70	3.59	3.73	3.66	48.67	50.33	49.50	49.00	49.33	49.16
S_3	2.97	3.07	3.02	2.82	2.90	2.86	44.33	45.44	44.88	43.33	44.33	43.83
F test	**	**		**	**		**	**		**	**	
LSD 0.05	0.15	0.08		0.47	0.27		2.43	1.84		2.62	2.89	
V_1	3.80	3.93	3.87	3.69	3.89	3.79	52.00	51.33	51.66	51.67	51.67	51.67
V_2	3.70	3.70	3.70	3.64	3.70	3.67	46.00	50.33	48.16	47.33	48.67	48.00
V_3	3.23	3.27	3.25	3.14	3.11	3.12	44.33	45.44	44.88	43.67	46.00	44.83
F test	**	**		**	**		**	*		**	*	
LSD 0.05	0.33	0.36		0.25	0.33		3.86	3.30		3.61	5.54	
S×V	N.S	N.S		N.S	N.S	-	N.S	N.S	-	N.S	N.S	-

Treat = Treatment,* and ** indicates significance at 0.05 and 0.01 probability levels, respectively, N.S: Not Significant.

Data indicated highly significant differences among irrigation water treatments. The control treatment (S_1) (fresh water) recorded the highest value for branches (4.10 -4.04) and dry leaf stem percent (51- 51.5) in both seasons as an average of the two cuts, respectively. Concerning forage cowpea genotypes, data revealed highly significant differences in both seasons. V_1 recorded the highest number of branches (3.87 -3.79) and leaf stem percent (dry weight) (51.66 -51.67) in both seasons, respectively. While V_3 gave the lowest number of branches (3.25 -3.12) and leaf stem percent (dry weight) (44.88-44.83) in both seasons respectively. These results are in agreement with El-Hefny (2010) and West and Francois (1982), who recorded that increasing salinity, decreased No. of branches. Also, results for leaf stem percent (dry weight) are in agreement with Salih and Kia (2013). Both of them mentioned a reduction in No. of branches/plant and leaf stem percent with increasing the level of salinity water irrigation on cowpea crop. The interaction between water salinity level and cowpea genotype was nonsignificant in the two cuts and the two seasons for No. of branches/plant and leaf stem percent.

Fresh and dry forage yields (kg plot^{-1})

Results of fresh forage yield and dry forage yield in Table (7) showed highly significant differences among irrigation treatments with saline water, where the highest values of fresh and dry forage yields were recorded when fresh water treatment (S_1) was used (2.8 -2.82 kg plot^{-1}) and dry forage yield (0.603 -0.610 kg plot^{-1}) in both seasons, while S_3 showed the lowest performance of fresh forage yield (2.32 - 2.18 kg plot^{-1}) and dry forage yield (0.411-0.400 kg plot^{-1}), respectively. Concerning forage cowpea genotypes, data indicated highly significant differences among genotypes in both seasons. In that respect, V_1 genotype was the highest yielding of fresh forage yield (2.84 -2.83 kg plot^{-1}), but V_3 genotype had the lowest (2.36 -1.96 kg plot^{-1}) for total fresh forage yield and (0.417 -0.450 kg plot^{-1}) for total dry yield in both seasons, respectively. The obtained results are in agreement with those reported by El-Hefny (2010), Omara and El-Gaafarey (2018), who observed significant reduction in fresh and dry forage yields with increasing salinity water irrigation in cowpea genotypes. Fresh and dry forage yields were related to plant height and number of branches per plant (Tables 5 and 6) for salinity levels and cowpea genotypes. Also, the highest effect traits of S_3 on fresh, dry yields, plant height and No. of branches is due to the high salinity of water and soil. The interaction between water salinity and cowpea genotype was nonsignificant in the two cuts and two seasons for fresh forage yield and dry forage yield.

Table 7. Means of fresh and dry forage yields (kg/plot) of three fodder cowpea genotypes as affected by irrigation water salinity level during 2018 and 2019 seasons.

Treatment	Fresh forage yield (kg $plot^{-1}$)						Dry forage yield (kg $plot^{-1}$)					
	2018			2019			2018			2019		
	1st cut	2nd cut	Total	1st cut	2nd cut	Total	1st cut	2nd cut	Total	1st cut	2nd cut	Total
S_1	2.05	0.75	2.8	1.93	0.89	2.82	0.299	0.304	0.603	0.300	0.310	0.610
S_2	1.94	0.75	2.69	1.57	0.78	2.35	0.258	0.257	0.515	0.267	0.263	0.530
S_3	1.7	0.62	2.32	1.5	0.68	2.18	0.224	0.187	0.411	0.187	0.213	0.400
F test	**	**	**	*	*	*	**	**	**	**	**	**
LSD 0.05	0.04	0.01	0.06	0.35	0.15	0.47	0.149	0.021	0.029	0.029	0.308	0.041
V_1	2.06	0.78	2.84	1.98	0.85	2.83	0.299	0.287	0.586	0.293	0.290	0.583
V_2	1.88	0.73	2.61	1.73	0.82	2.55	0.269	0.257	0.526	0.237	0.270	0.507
V_3	1.75	0.61	2.36	1.28	0.68	1.96	0.213	0.204	0.417	0.223	0.227	0.450
F test	**	**	**	**	*	**	**	**	**	**	**	**
LSD 0.05	0.11	0.09	0.13	0.26	0.11	0.31	0.134	0.021	0.032	0.018	0.023	0.023
SXV	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

*** and ** indicates significance at 0.05 and 0.01 probability levels, respectively., N.S: Not Significant.**

Seed yield and its components

Number of pods/ plant and number of seeds/pod

Data of number of pods $plant^{-1}$ and number of seeds pod^{-1} in Table (8) indicated highly significant difference existed among the three treatment of irrigation, where control treatment (S_1) showed the highest values (10.67 -10.37) and (8.33 -8.28) in both seasons. By contrast, S_3 gave the lowest values (6.83 -6.23) and (6.07 -5.33) in both seasons. This means that increasing EC_W significantly decreased number of pods $plant^{-1}$ and number of seeds pod^{-1} in both seasons. Concerning the differences among the three forage cowpea genotypes, data showed highly significant differences among them in both seasons, where V_1 revealed the highest (9.63 -9.33) and (7.67 - 7.48) in both seasons for number of pods/plant and number of seeds/pod. By contrast, cowpea genotype V_3 had the lowest values (7.60 -7.13) and (6.60 - 6.13) in the two seasons for pods/plant and No. of seeds/pod, respectively. These results of number of pods/plant are similar to those reported by West and Francois (1982), Maas and Poss (1989) and El-Hefny (2010), who revealed that increased salinity of irrigation water decreased the number of pods/plant and the number of seeds/pod in cowpea genotypes.

100- Seed weight

Results in Table (8) showed that highly significant differences existed among irrigation with saline water treatments for 100-seed weight trait in both seasons, where the control treatment gave the highest values of 100- seed weight (22.67-22.65 g), but the values in S_3 were decreased (18.33 - 15.83 g) in both seasons. Also forage cowpea genotype V_1 gave the highest value of 100- seed weight (22 - 21.5 g), while cowpea genotype V_3 had the lowest (18.67 - 17.33 g) in both seasons, respectively. These results are in agreement with West and Francois (1982), who observed that 100-seed weight decreased with increasing salinity of water irrigation.

Table 8. Means of number of pods/plant, number of seeds/pod, 100 seed weight and seed yield (g/plot) of three fodder cowpea genotypes as affected by irrigation water salinity level during 2018 and 2019 seasons.

Treatment	Number of pods/plant		Number of seeds/pod		100- seed weight (g)		Seed yield (g/plot)	
	2018	2019	2018	2019	2018	2019	2018	2019
S_1	10.67	10.37	8.33	8.28	22.67	22.65	170.33	166.33
S_2	8.87	8.03	7.23	6.97	20.67	20.00	155.22	143.33
S_3	6.83	6.23	6.07	5.33	18.33	15.83	141.67	111.67
F test	**	**	**	**	**	**	**	**
LSD 0.05	0.12	0.24	0.12	0.07	0.12	0.44	2.31	5.95
V_1	9.63	9.33	7.67	7.48	22.00	21.50	173.00	15833
V_2	8.83	8.47	7.37	6.97	21.00	19.67	160.89	146.33
V_3	7.60	7.13	6.60	6.13	18.67	17.33	129.33	120.67
F test	**	**	**	**	**	*	**	**
LSD 0.05	0.56	0.45	0.38	0.39	0.93	2.30	9.36	8.94
SXG	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

*** and ** indicates significance at 0.05 and 0.01 probability levels, respectively, N.S: Not Significant.**

Seed yield (g/plot)

The effect of irrigation with saline water treatments on seed yield of three forage cowpea genotypes in 2018 and 2019 seasons is presented in Table (8). Data indicated that highly significant differences existed among irrigation with saline water treatments. The control treatment (S_1 fresh water) recorded the highest range (170.33 -166.33 g/plot^{-1}) while S_3 gave the lowest value (141.67-111.67 g/plot^{-1}) in both seasons, respectively. Concerning the differences among the three genotypes, data showed that highly significant differences existed among genotypes in both seasons, where V_1 gave the highest range (173.00-158.33 g/plot) in both seasons for seed yield. By contrast, V_3 showed the lowest range (129.33–120.67 kg plot^{-1}) in both seasons. The obtained results are in harmony with those found by West and Fracois (1982), Ali *et al* (2004) and Young *et al* (2016) on cowpea where seeds were significantly decreased by increasing irrigation water salinity. The interactions between water salinity and cowpea genotypes were nonsignificant in the two cuts and the two seasons for No. of pods/plant, No. of seeds/pod, 100- seed weight and seed yield.

Salt accumulation and distribution in soil profile

Data presented in Table (9) illustrated that the irrigation water salinity of 3.5 dS m^{-1} caused the greatest soil salinity at the end of season and irrigation water salinity level 0.65, 2.00 and 3.5 dS m^{-1} increased soil salinity by 8.22, 16.16 and 28.22% after the first season and 13.97, 24.10 and 35.07%, respectively after the second season. The salinity of top layer (0-20 cm) with all treatments was lower than salinity of subsoil layer (20-40 cm) and deepest layer (40-60 cm). The highest difference between salinity of top soil layer and deeper soil layer occurred at irrigation water salinity of 3.5 dS m^{-1}. Data in Table (9) indicated that the use of irrigation water salinity of 0.65, 2.00 and 3.5 dSm^{-1} increased the sodium adsorption ratio (SAR) to 2.57, 5.92 and 10.56% after the first season and 4.84, 9.58 and 15.30%, respectively after the second season. The SAR values in the top soil layer were lower than the deepest soil layer. These results are in agreement with those obtained by Aiad *et al* (2017), Amer *et al* (2017), Tsague, *et al* (2017), Omara and EL-Gaafarey (2018), Mozahidul Islam *et al* (2019).

Table 9. Effect of irrigation water salinity on soil salinity, soil sodacity and the rate of change (%) under cowpea with different soil depths at harvest for the two seasons.

Treatments	Soil salinity (ECe)					Soil sodacity (SARe)				
	Soil depth cm				Rate of change%	Soil depth cm				Rate of change%
	0-20	20-40	40-60	mean		0-20	20-40	40-60	mean	
	After the first season									
S_1	3.70	3.85	4.30	3.95	8.22	10.18	10.39	10.52	10.37	4.84
S_2	3.92	4.18	4.63	4.24	16.16	10.48	10.82	10.90	11.10	9.58
S_3	4.22	4.53	5.30	4.68	28.22	10.87	11.27	11.45	11.68	15.30
	After the second season									
S_1	3.85	4.06	4.57	4.16	13.97	10.39	10.67	10.80	10.62	4.84
S_2	4.21	4.46	4.92	4.53	24.10	10.85	11.18	11.27	11.10	9.58
S_3	4.75	4.92	5.12	4.93	35.07	11.54	11.74	11.75	11.68	15.30

CONCLUSION

In generally, increasing salinity in irrigation water caused a significant reduction in yield and yield components of cowpea genotypes. There were significant correlations among levels of high salinity in irrigation water and yield and its components of cowpea. Using saline water in irrigation needs to add suitable leaching fraction to prevent salt accumulation in soil profile. In addition, the genotype Sakha 5 that was ranked the first in yield and yield components, seeds of this genotype could be used as a base population for breeding program to produce a highly tolerant genotype to high level of salinity in irrigation water or soil.

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استجابة لوبيا العلف لمستويات مختلفه من ملوحة مياه الرى

عبدالكريم سليمان محمد بدوى[١]، شيرين محمد النحراوى[١] و محمود ابوالفتوح عياد[٢]

١– قسم بحوث محاصيل العلف– معهد بحوث المحاصيل الحقلية–مركز البحوث الزراعية–الجيزة– مصر

٢– قسم بحوث تحسين وصيانة الاراضى – معهد بحوث الاراضى والمياه والبيئه – مركز البحوث الزراعية–الجيزة– مصر

[illegible]

الزتهيئ ة لكهح ب ليئ ىلك نىئ لآخ نو. ليملئ زجكلكة نقي الكهفتو لكلخ و ئعكو لكقيلك زلقلك زقف (٧٠٪. ˇ٧٣٪.
زل) خلإك لهز لولكخفزب. زجك ةئعكو لكقيلك لف لم عخخلكق نه مكلف مائ ة ˇ هعخخلكاهذكلف فذم ˇ هرم
ىلك ˚ ˚ ٠ حا ن ه لح شهك لكاهذ لظ لعئلكب لكهح ب ليئ لكنو S_1 لئ ئنفب لك لزتهيئ ةئلآخنو. هفخ زجكلكة نقي ا
لكهفتو زخئ ٤ئعكو لكقيلكك فسئ ةلك زئق ن. حخ تى ئمفعئصك لح شهك لكادن الفخئذ ٢١.٠٠ ˇ ١٣.٦٤٪ ةح ة
لزتهيئ ةلك لكهح ب S_2 ˇS_3 عكو لكتلكو لكمزانك لكهح ب ليئ لكنو لكعغين ˇ ههئ يخك عكوئم لح شهك لكاهنقئم
ئقتذ ةتئفلك لكهح ن ع مك لح شهكىلإخصذ.

لك لجكبلك لـ شفي بلكة نلي بلكمائ ة ١٥(٠): ٧٦- ٢ ˚ ٠ (١١ ˚ ١)