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The effect of gypsum formation and content on barley growth and yield under drip irrigation system

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Field experiments were carried out in the selected three sites (BeniSuef, Fayoum; Minya, Egypt) that differs in formation conditions and content of gypsum during the two winter successive seasons of 2015 and 2016, to study the effect of gypsum content under two irrigation treatments (100 and 80 % from ETo) on barley drip irrigated growth characters and soil macro and micronutrients content. The obtained results cleared that all profiles contain on specific diagnostic horizons such as salic, calcic and gypsic horizon associated with the formation of gypsic soils. These horizons are dominated in all studied profiles. However the intensity of these horizons varied from one profile to another according to the concentration of soluble salts and thickness of the horizon. The selected three profiles, based on the climatologically conditions, physical, chemical analysis and morphological description, could be classified to TypicCalcigypsids. Barley plant height was enhanced under 100 %ETo than 80%. It could arrange the sites in descending orders as follows: BeniSuef>Fayoum>Minya. Decreasing irrigation treatments from 100 to 80 % decrease plant height by about 13, 12; 17 % for Minya, Fayoum and BeniSuef, respectively, while the reduction percentage relative to irrigation treatment was 13% in same sequence. Both of the no. of spikes and seed index strongly affected by irrigation treatments, where the highest values were attained under 100 %ETo irrigation treatment than 80 %. The percentage reduction of no of spikes and seed index was 7 and 11 % relative to irrigation treatments.Obtained data revealed that the highest grain and straw yield were obtained at BeniSuef (1154; 984 kg/fed) followed by Fayoum sites (612, 504 kg/fed) under 100 and 80 % ETo irrigation treatments. Also, data noticed that increasing irrigation water lead to alleviate salinity effect and increasing the yield of both straw and grains of barley. Irrigation treatment at 100% ETo has a positive effect on the straw and grain yield of the barley. The percentage of the increase of the straw and grain barley yield was about 13%. The highest water use efficiency (WUE) valuewas attained at BeniSuef (80%ETo) 0.74 kg/m^3 and the lowest one was 0.42 kg/m^3 attained at Minya (100 %ETo). Data noticed that decreasing irrigation treatment from 100 to 80% ETo led to increase WUE. The highest WUE percentage increase relative to stress treatment (80% ETo) was recorded at BeniSuef (21.1%) followed by Fayoum (14.5%) and Minya (2.4%).The values of macro N, P, K were highly under 100 % ETo than 80 %. Decreasing irrigation treatments from 100 to 80 %ETo associated with decrease the available studied nutrients.

Keywords:Gypsum, calcareous soils, soil properties, drip irrigation, WUE, growth characters and barley

INTRODUCTION

The gypsic soils are distributed over a considerable area all over the world under various environmental conditions. They may exist in several geological sediments, either recent or old ages' alluvium and consequently various litho logy. Gypsum accumulation may occur under Mediterranean deserted, tropical or subtropical and dry climate. Gypsiferous soils are very variable and their properties are influenced by many factors related to plant growth. Also, these types of soils can be productive and managed profitably if they are studied properly (Bakr et al.,2009), who reported that the chemical properties of gypsiferous and calcareous soils affect directly and/or in directly on the growth of plants, both natural vegetation and crops, and their mineral contents have been investigated.

Plant species growing responded differently to the excess of Ca and SO_4 present in the soils, depending upon their biogeochemical properties. The chemical composition of the plant's shoot is strongly influenced by the SO_4 %that could raise the SO_4 level in the gypsum tolerant plants.

It clear that the gypsum content of soils is only one of several factors, which affect plant growth and hence yield of crops. The other factors could be summarized by (Escudero et al., (2000) as follows: i) the depth of the topsoil over a gypsic layer, ii) the hardness and degree of crystallization of the gypsic layer after , iii) the total and active calcium carbonate contents, iv) the type of crops grown and their relative tolerance to gypsum, v) the drainage conditions and salinity of the soil after, and vi) the availability of plant nutrients and moisture content in the root zone (Abd El-Hady and Ebtisam, 2012),

The performance of plants grown on shallow soils mainly depends on their root system, the gypsum content, fertility, and water availability during the growth period. In particular the presence of a hard impervious gypsic layer has a strong effect on crop production under irrigation (Ballesteros et al., 2012),who reported that percolating water dissolves gypsum and salts and stagnates at the top of the gypsic layer creating a crouched water-table, often resulting in an accumulation of gypsum and salts**.** They reported also, that the performance of crops will be affected by both gypsum and salinity. The main features of the gypsum soils, plants encounter physical qualifications like unfavorable moisture distribution, high resistance to root penetration, or crust formation (Romao and Escudero, 2005). In spite of certain apparent chemical constraints of gypsum soils for plants, the way in which gypsum chemically effect the life cycle of plants isn't known enough (Palacio et al., 2007).

On the other hand, Rahman (2013) attention has been observed to the various forms of calcium sulphate crystallized from an aqueous solution as affected by pH, temperature and an equal ratio analyzer of retinal ions, and the level of impurities such as Al^{3+}, Mg^{2+} and Fe^{3+}.Another factor effect on gypsum formation such as pH soil**.** Kaiwei et al.,(2015) reported that the pH value is a key factor in the formation of gypsum at given sulfate concentrations in solution. A decrease of pH value is beneficial for gypsum formation and promotes the growth of gypsum crystals. For the amorphous materials such as iron and aluminum which effect of gypsum formation, Lina et al., (2017) concluded that, those impurities inhibited the gypsum crystals formation, and Fe^{3+} ions caused the strongest inhibition, followed by Mg^{2+} and Al^{3+}.

Barley (*Hordeum vulgare*) the fourth most important cereal crop for human food and animal feed, and is one of the most drought sensitive species (FAO, 1990). Also, it is an important crop well adapted on gypsiferous soils under drought conditions, and is widely used in semiarid region. A two-course rotation is practiced. Fallow is extensively used after wheat or barley, in localities where the average annual rainfall is 200-300 mm. All the evidence suggests that barley like wheat is tolerant to gypsum. Yields of 1.5 to 3 tons per hectare were obtained under rainfed agriculture depending upon total seasonal rainfall and distribution. However, some fraction of these salts could not move further, i.e. below 15–30 cm zone during the leaching. Bakr et al., (2009)reported that sandy loam soils are prone to more dispersion and illuviation of clay particles; which could block pores in the deeper layers. There is a great debate concerning the physical and chemical constraints of the flora inhabiting these areas, as well as about whether gypsophiles are refugees or specialists of gypsum substrates (Palacio et al., 2007).

This work was carried out on three new reclaimed areas (Minya, BeniSuif and Fayoum, Egypt) to study the effect of gypsum formation and content under two irrigation requirements (100 and 80 % from ETo) on barley growth characters and yield and macro, micronutrients content.

MATERIALS AND METHODS

Location experimental:

Field experiments were carried out during the two winter successive seasons of 2015 and 2016, in three in new reclaimed areas (Map 1): Minya, BeniSuef and Fayoum, Egypt, to study the effect of gypsum content under two irrigation treatments (100 and 80 % from ETo) on barley growth characters such as (plant height, no. of spikes/m^2,

Map (1) Location of the examined experimental sites.

1000 kernel weight (seed index), grain and straw yield kg/fed and some macro and micronutrients status.

Agriculture practices:

Barley (Hordeum vulgare L., hyprid 100) was sowing at 20 November by rate 50 kg /fed) and lasted 124 days. Barley plants were irrigated by drip irrigation system with lateral line 20 m (JR) and dripper space 30 cm and discharge 4 L/h). Surface canal water with pH and EC : 0.41, 0.44; 0.38- 7.32, 7.44, 7.36, for three studied sites Fayoum, Beni-Suef and Minya, respectively. 100 kg mono-superphosphate (15 %P_2O_5) was added to the experimental soil during preparing to planting. Ammonium nitrate (33.5 N%) was applied at rate 120 kg/fed the first dose (20%) after planting, 2nd after 21 days from planting (40%) and the last one after 60 days. Also, 50 kg potassium sulphate (50 % K_2O) was added in two equal doses, with the last doses of N fertilizer.

Twenty cubic meter of irrigation water was applied to the experimental sites before planting to leach excess salts away root zone. Water applied relative to the available metrological data in site as a rate of evapotranspiration (ETo) in mm. Irrigation scheduling (twice a week) was done according to evaporation and as per growth stage, due to sensitive some growth stages to stress especially during jointing, booting and heading. To maximize yield, we maintain soil moisture levels above 50 % of available moisture in the active root zone from seeding to the soft dough stage.

Soil and plant analysis:

Samples studied taken from three profiles (Minya, BeniSuef and Fayoum governorate) Egypt. Table 1 shows some physical and chemical properties of the selected soil samples determined by using standard methods (Black et al., 1982). Soil texture is determined after Gee and Bauder (1986).Calcium carbonate ($CaCO_3$) after Soil Survey Division Staff (1993). Cation Exchange Capacity (CEC) was determined after (Malcolm and Miller, 1986). Gypsum determined by acetone (Sayegh et al., 1978).

Surface soil samples were taken after harvest and air dried to determine pH and EC, total nitrogen and extractable P (21 ppm), potassium, Fe and Znin plant by nitric acid and pirochloric acid digestion and then analyzed by inductivity coupled plasma optical emission spectrometry after (Rebecca, 2004).

Plants were harvest the plant growth characters such as and grain and straw yield were determined by weighting.

The total irrigation water amounted applied to the plots were 1793,1435- 1730, 1384 and 1756, 1404 m3/fed/season at 100 and 80 % ETo for Minya, Fayoum and Beni-Sueflocations, respectively. Water use efficiency was estimated as the follows:

$WUE kg/m^3$= Grain yield (kg)/total irrigation water(m^3)

Statistical analysis:

The treatments were assigned to plots using randomized complete block design (RCBD) and each treatment was replicated three times. The plots were 10 x 4 m with 1m guard rows between plots. Data were subjected to analysis of variance (ANOVA) to determine the effect of the treatments on the measured parameters. The treatment means were separated using Fisher's Least Significance Difference test (LSD) (Dospekhov, 1984)

RESULTS

The obtained results reveal that gypsum content fluctuates between 15.2 to 31.1%. These gypsum contents in the whole locations or some of its layers satisfy the gypsic horizon requirements according to USDA (2014).The gypsic soils under investigation are mostly highly or extremely saline.

Soil Taxonomy was used to classify different soil profiles under this study into taxonomic units starting from soil order level down to the soil family level according to soil taxonomy manual of the United States Department of Agriculture (USDA, 2014). All soils classified to Typic calcigypsids. This classification is based on field survey, morphological description, chemical and physical analyses.

Profile No.: 1	**Soil classification: TypicCalcigypsids**
Location: Minya, Sharona	**Drainage conditions:** Freely drained
Topography: Nearly level	**Profile depth:** Very deep
Natural vegetation: None	**Remarks:** calcic and Gypsic deposits

Depth(cm)	Description
0 – 60	Brown(10YR 4/6 moist); dull yellow orange (10YR 7/3 dry) Loamy; fine and medium, weak, platy; soft; many, fine and medium yellowish brown, mottles; common, fine, crystalline, gypsum precipitations; strong effervescence with HCl; diffuse, irregular boundary.
60-140	Yellowish brown (10YR 5/6 moist); dull yellow orange (10YR 5/3 dry); Loamy; compound medium, moderate, angular blocky and medium, moderate, platy; slightly hard; medium, yellowish and dark mottles of Fe and Mn; common, fine, crystalline, gypsum and lime precipitations and many irregular gypsum precipitations cover the ped faces; strong effervescence with HCl.

Profile No.: 2	**Soil classification:** TypicCalcigypsids
Location: Fayoum, HewaraElmaktaa	**Drainage conditions:** Freely drained
Topography: Nearly level	**Profile depth:** Very deep
Natural vegetation: None	**Remarks:** calcic and Gypsic deposits

Depth(cm)	Description
0 – 30	yellow orange (10YR 7/8, moist), bright yellowish brown (10YR,7/6 dry); sandy; structure-less, single grains; loose; very thin, regular, smooth stratification coarse and fine sand sheets; moderate effervescence with HCl; abrupt smooth boundary.
30 - 120	Dull yellow orange (10YR 7/3 moist), dull yellow orange (10YR7/2 dry); sandy; structure-less, single grains; loose; (similar stratification); common, medium, soft irregular, weak cemented sand with gypsum and salts; many, fine and medium, decayed plant roots; slight effervescence with HCl; abrupt, smooth boundary.
+ 120	Dull yellow orange (10YR 6/3 moist), dull yellow orange (10YR7/2 dry); fine sand, structure-less, single grains; loose; many, soft, fine, irregular, aggregates of sand cemented with lime or gypsum; moderate effervescence with HCl.

Profile No.: 3	**Soil classification:** TypicCalcigypsids
Location: BeniSuef, KomAborady	**Profile depth:** Deep
Topography: Nearly level	**Remarks:** Many very fine plates of shales.
Natural vegetation: Many, thin, dry, scattered shrubs	**Drainage conditions:** Well

Depth(cm)	**Description**
0 - 35	Bright yellowish brown (10YR 7/6 moist), dull yellow orange (10YR 7/3 dry) sandy; structure-less, single grains; loose; few, very fine, decayed residues of plant; slight effervescence with HCl; diffuse, smooth boundary.
35 - 100	Bright yellowish brown (10YR 7/6 moist), dull yellow orange (10YR 7/3 dry); fine sandy; structure-less, single grains; loose; few, medium and fine, decomposed residues of roots; moderate effervescence with HCl; abrupt, smooth boundary.

All the investigated locations were poor in organic matter, which does not exceed 1.6%, especially BeniSuef (0.2%). Values of the cation exchange capacity (CEC) were around 17.4, 22.4 and 17.6 meq/100 g soil for Fayoum, BeniSuef and Minya, respectively.

Data in table (1) showed some physical and chemical characteristics of the investigated sites. It is clear to mention that all investigated locations were shallow, except BeniSuef (70 cm). Also, these sites were selected as represented new reclaimed soils form side and from other one to their content from gypsum content. Beni Suef were highly one to their content in Gypsum (31.1%) and Minya is the lowest one (7.1%).

The obtained results indicated that pH values were moderately to slightly alkaline. The highest and lowest values were attained at Fayoum and BeniSuef, respectively. Whereas Fayoum recorded the highest EC value (24.1dSm^{-1}) and the lowest ones was recorded at Minya. Macro nutrients N, P and K, which appeared the soils, were poor in most examined nutrients.

Regarding the gypsum and calcium carbonate content values, Table (1) provides a detailed description of the field and some physical and chemical analysis in the laboratory. The gypsum accumulation in the profiles under study is found in the following forms:

Gypsum phase is none crystallized in some layers. Consequently this form can be accumulated from sudden evaporation saline water in micro-pores.

Formations from gypsum crystals when calcium carbonate is high reveal that, in this case many crystals of gypsum under such conditions were cemented together or cemented with fine crystals of calcite.

Many needles of anhydrous gypsum noticed in the subsurface and deep layers, crystals of single small needle cemented forming large nodules.

Nodules of Sali–gypsic formation, this form were easily distinguished in field as small stones, and mostly extend to form continuous to gypsic horizon.These features have direct effect on percolating water, which accumulate above these layers with low permeability, where salts precipitation occurs in most cases. Then water table rises and evaporates leaving the salts on the soil surface consequently inhibit plant growth (Wahba et al., 2004).

The amount of water used by a barley is affected by a number of factors including the availability of soil water, stages of crop growth, crop rooting depths and environmental factors including amount of solar radiation, humidity, and temperature. A prolonged water deficit will have a significant adverse effect on a crop

Data manifested in table (2) illustrated the Ec values of the experimental sites after barley harvest. No doubt that the water applied before sowing barley has agreat effect on the EC reduction, especially at Minya (-30%) than others. Table (2) showed the macro nutrients N, P and K, which appeared the the soils were poor in most examined nutrients. Also the values were highly under 100 % ETo than 80 %. With respect to the effect of irrigation treatments, one can notice that decrease irrigation treatments from 100 to 80 %ETo associated with decrease the available studied nutrients.Data of the barley growth were recorded in Table (3). Barley plant height was enhanced fewer than 100 %ETo than 80

Table (1); Some chemical of the investigated samples studied.

Location	Depth of the sample cm		Gyp	$CaCO_3$	OM	CEC	EC	Particle size distribution %			
		pH	%			meq/100g soil	dSm^{-1}	Sand	Silt	Clay	Texture
Fayoum	-30	8.0	20.7	14.7	1.6	17.4	24.1	27.8	18.4	3.8	Loamy sand
BeniSuef	-70	7.3	31.1	17.9	0.2	22.4	15.0	56.0	20.4	23.6	Silt loam
Minya	-50	7.9	15.2	20.3	1.4	17.6	8.8	63.2	23.2	3.6	Loamy sand
LSD 5%		0.2	1.3	2.1	0.1	3.1	2.3	3.8	1.5	2.4	-

Table (2) Soil salinity, Macro and micronutrients of the experimental sites as affected by location and irrigation treatments (mean of the two seasons)

Locations	Irrigation % ETo	EC	N	P	K	Fe	Zn
		dS/m	ppm				
Minya	100	6.2	450.8	59.7	161.3	8196	500
	80	7.7	445.1	56.3	162.4	7895	468
	Mean	6.95	447.95	58.0	161.9	8045	484
Fayoum	100	18.3	529.6	66.5	180.6	11523	698
	80	18.7	514.3	65.2	180.1	10234	612
	Mean	18.5	521.95	65.85	180.4	10878	655
BeniSuef	100	11.4	752.7	90.1	274.3	18918	969
	80	12.8	688.5	86.4	265.4	16252	874
	Mean	12.1	720.6	88.25	269.9	17585	921
LSD 5%	location	1.1	45.3	7.4	24.6	234	112

Table (3) Plant growth characters and yield and water use efficiency as affected by location and irrigation treatments (mean of the two seasons)

Location	Irrigation % ETo	plant height	no. of spikes/m2	seed index	Yield kg/fed		Water applied	kg/m^3
					Grain	Straw	m^3/season	WUE
Minya	100	62.4	254	21.3	754	551	1793	0.42
	80	55.4	233	18.4	612	504	1435	0.43
		58.9	244	19.85	683	528	1614	0.42
Fayoum	100	71.4	374	26.7	1066	868	1730	0.62
	80	63.7	356	24.3	984	712	1384	0.71
		67.55	365	25.5	1025	790	1557	0.66
BeniSuef	100	98.6	421	34.5	1154	984	1756	0.66
	80	84.2	386	31.1	1035	908	1404	0.74
		91.4	404	32.8	1095	946	1580	0.69
LSD 5%	location	10.2	76	2.3	12	143	17	0.04

%. It could arrange the sites in descending orders as follows: BeniSuef>fayoum>Minya. And decrease irrigation treatments from 100 to 80 % decrease plant height by about 13, 12; 17 % for Monya, fayoum and BeniSuef, respectively, while the reduction percentage relative to irrigation treatment only was 13% in same sequence.

Both of the no of spikes and seed index strongly affected by irrigation treatments, where the highest values were attained under 100 %ETo

irrigation treatment than 80 %. Also, these plant characters strongly reflected in yield and yield components.

The highest values of those characters were recorded at BenisSuef. And coul be arrange the sites as follows: BeniSuef>Fayoum>Minya. Also the percentage reduction of no of spikes and seed index was 7 and 11 % relative to irrigation treatments.

Regarding to the grain and straw yield as affected by investigated sites and irrigation treatments, data on hand revealed that the highest grain and straw yield were obtained at BeniSuef (1154, 984 kg/fed) followed by Fayoumsites (612, 504 kg/fed) under 100 and 80 % ETo irrigation treatments. Also, data noticed that increasing irrigation water lead to alleviate salinity effect and increasing the yield of both straw and grains of barley.

Regardless the sites, irrigation treatment at 100%ETo has a positive effect on the straw and grain yield of the barley. The percentage of the increase of the straw and grain barley yield were 13%.

Data noticed that the water use efficiency (WUE), that represent the total yield divided on the consumed irrigation water. The total irrigation water consumed during barley growing season were 427, 341.6- 412, 329.6 and 418, 334.4 mm/season, which represented in cubic meter as follows 1793, 1435-173, 1384 and 1756, 1404 for Minya, Fayum and Beni-Suef sites, respectively. The highest WUE value was attained at BeniSuef (80%ETo) 0.74 kg/m3 and the lowest one was 0.42 kg/m^3 attained at Niya (100 %ETo). Data noticed that decreasing irrigation treatment from 100 to 80 %ETo led to increase WUE. The highest percentage increase relative to stress treatment (80%ETo) was recorded at BeniSuef 21.1% followed by Fayoum (14.5%) and Minya (2.4%).

Also, data found that there are a highly significant correlations between gypsum content and barley plant growth characters (table 4). Whereas, the opposite was true in case of the calcium carbonate content negative significant correlation between calcium carbonate with some barley plant growth characters, that could arranged in descending order: Grain> no. of spikes> Straw. In addition, there is a positive significant correlations between gypsum and water use efficiency of the grain yield, and the opposite was true in calcium carbonate content.

DISCUSSION

The obtained figures of the soil constituents that recorded in table 1 and 2, revealed that the investigated location represent the three categories. This finding agreed with Labib et al., (1999)who reported that there are three categories of soils according togypsum content as: low gypsum content soils(< 5%); moderate gypsum content soils (5-10%) and high gypsum content soils (>10%). They also, reported that the effective factors induced gypsum accumulation, under local conditions are: soil texture, type and quantity of soluble salts, the level and quality of ground water table and eventually calcium carbonate content (Gamil et al., 2008).The negative effect of gypsum content mainly due to induced salinity which reflected in highly dS/m on seed germination and plant growth that has been attributed mainly to both osmotic stress and ion toxicity (Song et al., 2005). However, the lack of a negative response to gypsum under studied soils is consistent with the results obtained by Herrero and Porta (2000), mentioned that gypsum could cause negligible osmotic stress and ion toxicity in plant growth stages. Specifically, sulfates are less toxic than chlorides, probably because sulfate is a macronutrient involved in the synthesis of cell-detoxification molecules (Tobe et al., 2003), who added that calcium could mitigate the toxic effects of other salt components not only on seed germination but also the early vegetative growth.

Soil reclamation with high water-requirement crops benefits from the additional leaching that occurs because of the greater volume of applied irrigation water (Tayel et al.,2010; Abd El-Hady and Ebtisam, 2012 and Ebtisam et al., 2013) particularly on soils with good permeability. Also, it was detected a negative response to gypsum content for some studied plant growth among the investigated soils under different irrigation treatments. In contrast, salts more soluble than gypsum have been shown in many studies to exert an inhibitory effect not only on germination, but also many of the growth characters (Song et al., 2005) who added that gypsum concentrations could enhance germination percentage of two gypsophile species, because the soil would reserve chemical properties for the emergence of certain gypsophiles (Song et al., 2005).

Nevertheless, the chemical features of gypsum do notseem to have a determinant effect on the germination for the overall tested soils. The presence or absence of certain plants in gypsum outcrops may be determined by other life Figure.

Palacio et al.(2007) and Ageeb et al., (2015), studying leaf chemical composition, suggested that regionally dominant gypsophiles might fit the ‘specialist’ model, being specifically adapted to gypsum. This finding is in harmony with the obtained results on germination: while it is found positive effects of gypsum on regionally dominant gypsophiles. Also, it is found negative or neutral effects of gypsum solution on narrow gypsophile endemics.

To overcome adverse environments, Sekmen et al., (2012) reported that on gypsophily profile, it is closely related to physical in addition to chemical characteristics. Specifically, it was found that dissolved gypsum has no effect on germination for many species and exist of gypsum could represent and feature of the germination growth stage.

Table (4) Simple correlations among $CaCO_3$, gypsum content and growth and yield characters of barley.

	$CaCO_3$	Gypsum	Plant height	No. of Spikes	Seed index	Grain yield	Straw yield
Gypsum	-0.187	1					
Plant height	-0.165	0.908**	1				
No. of Spikes	-0.657*	0.821**	0.847**	1			
Seed index	-0.347	0.918**	0.977**	0.934**	1		
Grain Yield	-0.686*	0.738*	0.821**	0.987**	0.911**	1	
Straw yield	-0.531	0.864**	0.906**	0.974**	0.966**	0.959**	1
Grain WUE	-0.721*	0.757*	0.620*	0.895**	0.761*	0.850**	0.815**

The role of soils and surficial formations containing gypsum is rarely considered in the global environmental studies in spite of the gypsum/calcium carbonate/CO interactions outlined by (FAO, 1990).

Also, positive effect of the gypsum on the barley growth and yield characters could attributed mainly to plant ability to overcome gypsum induced salinity in excess Ca^{++} in media that plant highly needed, whereas, $CaCO_3$ content had a negative effect on some barley growth and yield characters, where the calcium carbonate increased soil pH in direct and decrease availability of the most plant nutrients under high pH. These results were in harmony with those obtained by (Lee and Kenneth, 2011 and Palacio et al., 2007).

CONCLUSION

Our results suggest that chemical features of gypsum could offer an advantage at the germination stage, rather than posing a constraint for seed germination to maximize plants number per area. Drip is most preferable than sprinkling irrigation to increased leaching salts in specific rootzone that help in good plant growth where good distribute of irrigation water and to retard evaporation. Gypsum lands often support specific ecosystems which merit conservation and careful management.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Abd El-Hady analyzed and discussed the obtained results, carried out the land evaluation assessment and wrote the manuscript. Aziz and Ebtisam carried out the field work as well as the laboratory analyses and contributed in discussing the results. All authors read and approved the final version.

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