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Role of algae in alleviated salinity effect on *Jatropha curcas* plants

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Abstract

This study was carried out at green house on National Research Centre during two successive seasons of 2020-2021 in Giza governate. The aim objective of this work was to investigate the effect of spraying different levels of algae (0, 10 and 15%) on vegetative growth and chemical constituents of *Jatropha curcas* L. seedlings grown under various salinity concentrations (0, 2000, 4000 and 6000 ppm). Our results showed that, spraying algae at 15% increased both of (plant height, leaves number/plant, stem diameter, root length, branches number/plant, main flowers number/plant, sub-main flowers number/plant, fresh and dry weight of stem, leaves and roots, chlorophyll a, b, a+b and carotenoids, protein contents and total carbohydrates percentage), while a significant reduction in all the same parameters, were occurred by using high salinity level (6000 ppm). The combined proline and phenols contents decreased by using 10 or 15% algae, compares of treated as the control. The results suggested that *Jatropha curcas* L. seedlings benefited the application of algae especially under salinity concentrations grown in sandy soil.

Keywords: Growth stimulant; Algae; Salinity; Ornamental plants; *Jatropha*

1. Introduction

Jatropha curcas is a multipurpose shrub, growing naturally in the other tropical countries of the equatorial America. *Jatropha* seeds are rich in pure plant oil and when extracted it used directly as bio diesel in engines, Rejila and Vijayakumar, (2011). Overall, *J. curcas* biodiesel generally reduces the global warming potential and the nonrenewable energy demand as compared to fossil diesel, Singh, *et al*, (2012). The fertility regulatory effect of the fruit of *J. curcas* was investigated by oral administration of two pregnant rats for varying periods of time, Laxane, *et al*, (2013). Foetal resorption was observed with methanol, petroleum ether and dichloromethane indicating the abortifacient properties of the fruit, Shukla, *et al*, (2015). The aqueous leaf extracts of *J. curcas* showed inhibitory and stimulatory effects on seed germination, shoot length and root length in *Capsicum annum* L. (green chilli) and in *Sesamum indicum* L. (sesame), Iqbal, *et al*, (2015). *J. curcas* (Euphorbiaceae) is with many attributes and considerable potential, Islam, *et al*, (2011). Different parts of the *J. curcas* plant are employed in Indian traditional medicine effort he treatment of several disorders, Farag, *et al*, (2015).

Salinity may indirectly affect by reducing the quality of the natural environment (for example, where the numbers and variety of wildlife decrease in salinized wetlands), Baldock, *et al*, (2000). Salinity is one of the factors that has a critical inquence on the germination of halophyte seeds and plant establishment, Dehnavi, *et al*, (2020). However, NaCl exerts it's on vital processes through an osmotic effect or a species ion toxicity, is still not resolved, Miranda, *et al*, (2010). A split-root growth system was employed to evaluate the effect of NaCl on nodule formation by soybean (*Glycine max* L. Meff. cvs Davis), Singleton and Bohlool, (1984). The salinity stress and rhizobial in oculomotor only one. Half the root system, the effects of salinity on shoot growth were eliminated in the nodulation process, DuTeau, (1985). The Na-Ca-

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K-Cl brines are found in thermals rings and in fluid inclusions in one mineral by the available data for vapor-saturated NaCl-H_2O solutions, Isherwood, M. S., USA university, (1979). Salinity affects in production crops, pastures and trees by interfering with nitrogen uptake, reducing growth, stopping plant reproduction, imbibition and root elongation, Pirasteh-Anosheh, *et al*, (2016). Some ions (particularly chloride) are toxic to plants as the concentration increased, the plant is poisoned and dies. Salinity damage has also occurred to country roads and farm tracks and buildings, Acosta-Motos, *et al*, (2017).

Algae known to affect membrane filtration directly or indirectly. During algae bloom, transmembrane pressure seriously increases or flux significantly decreases, Kwon, *et al*, (2005). Algae also produce taste and odor of a water supply causing compounds such as 2-methyl isoborneol (2-MIB) and geosmin as well as toxic materials, Abrha, *et al*, (2018). The effect of algae growth on aerobic granulation and nutrients removal in two identical sequencing batch reactors (SBRs). Sunlight exposure promoted the growth of algae in the SBR (Rs), forming an algal-bacterial symbiosis in granules. The growth of algae altered the microbial community in Rs, especially unfavorable for Nitrospiraceae and Nitrosomonadaceae, Huang, *et al*, (2015). Algae water is not suitable for drinking, recreation, or agricultural use. It can be cause skin irritation, mild respiratory, and hay fever-like symptoms. Ingesting toxins cause gastroenteritis, such as vomiting, diarrhoea, fever, and headaches Toole, (2013). Blue-green algae (cyanobacteria) is a type of bacteria with traits of both, Atia and Saad, (2014). It found in almost all water systems, and appear individually or in a group, Hanson, *et al*, (2011). In appropriate conditions, BGA grow rapidly and form visible blooms, or scums. Blooms are usually between dark green and yellowish brown and turn the surrounding water green during summer and autumn, when nutrient levels are high, temperatures are warm, and the water is relatively still. Weather conditions and water flow will affect how long a bloom last, or to inform the water management authorities of an outbreak, contact bodies located at councils, water corporations, Bradley, (2020).

The aim of the present work is evaluating the influence of different levels of algae on *Jatropha curcas* irrigated with different levels of salinity.

2. Material and methods

This study was carried out greenhouse on National Research Centre during two successive seasons of 2020-2021 in Giza governate. The aim objective of this study was to investigate the effect of spraying different levels of algae on vegetative growth and chemical constituents of *Jatropha curcas* seedlings grown under various salinity concentrations.

One year-old seedlings of *Jatropha curcas* L. were obtained from nursery of forestry Department Horticulture Research Institute, Agriculture Research Centre. The average height of seedling was (20 -25 cm). The seedlings were planted on 15th March of each season in plastic pots 30 cm filled with 10 kg of soil (clay + sand – 1:1 v/v). Three salinity levels were prepared (2000, 4000 and 6000 ppm) by addy sodium chloride (NaCl) + calcium chloride (CaCl) (1:1 v/v) for irrigation seedlings with previously prepared salinized. The untreated plants (control) were irrigated with tap water. One litre of water to each pot twice a week through the course of the study (8 months). On the 15th of April seedlings were sprayed three times (30, 60 and 90 days from planting) three concentrations of Bio-fertilizers of blue green algae namely (0, 10 and 15%) to cover completely the plant foliage. The statistical layout of the experiment with Completely Randomized Design of 2 factors (3 algae x 4 salinity concentrations) each treatment included 5 replicated. The available commercially fertilizer used through this experimental work was Kristalon (NPK 19:19:19) produced Phayzen company, Holland. The fertilizer rates were 20 gm/pot in four equal doses after 4, 8, 16 and 20 weeks from transplanting. Seedlings were irrigated four (4) months with tap water.

The following data were recorded for both seasons: plant height (cm), leaves number/plant, stem diameter (cm), root length (cm), branches number/plant, fresh and dry weight of leaves (g), stems and roots, main flowers number/plant (No.) and sub-main flowers number (No.). The obtained results were subjected to method statistical analysis of variance according to the LSD method described by Snedecor and Cochran, (1982) and the combined analysis of the two seasons was calculated according to the method of Steel and Torrie, (1980).

The following chemical constituents and mineral composition analysis was determined: pigments of chlorophyll a, b, a+b and carotenoids contents (mg / g f.w.) were determined according to Saric, *et al*., (1967) and Lichtenthaler, (1987). Total carbohydrates percentage (% d.w.) was determined according to Dubios, *et al*., (1956). Anthocyanin content (mg / g f.w.) was determined according to Cottenie, *et al*., (1982). The protein content (mg / g d.w.) was determined using dry material according to Gupta, *et al*., (2011). The proline content (micromole / g f.w.) was determined using fresh material according to Bates, *et al*., (1973). Total soluble phenols content (mg / g f.w.) were determined colorimetrically by using Follin Ciocalta reagent, A.O.A.C. (1985). Plant samples will be separated to leaves, stems, and roots then being grinded and digested for assayment of Nitrogen N%, Phosphorus P%, Potassium K%, Sodium Na% and protein% (N x 6.25) were determined according to A. O. A. C., (1985).

Physical and chemical analysis of the soil: the soil samples were collected from different locations in the plantation at many pots and analyzed for physical and chemical characters according to the standard procedures that mentioned by Wilde, *et al*., (1985) and Black, et al., (1965).

Table 1 Analysis of soil (Average of two seasons)

Appreciation Sample	
pH (1:2.5)	7.66
EC (dSm^{-1}) (1:5)	0.72
OM	0%
Soluble cations (ml, milliliter equivalent / liter) mEq/L^{-1}	
($CaCO_2$) Ca^{++}	1.0
Mg^{++}	0.8
Na^{+}	5.6
K^{+}	0.05
Dissolved soluble anions (mEq/L^{-1})	
$CO_3^{=}$	-
HCO_3^{-}	1.5
Cl^{-}	2.5
$SO_4^{=}$	3.45
Pb	-
Soil types	
Sand	50%
Silt	0%
Clay	50%

Table 2 Laboratory Analysis of Blue-Green Algae

Blue-Green Algae (BGA), detected Microcystin-LR (µg/L)	
Thomas Pond, May, No BGA cells detected	0.61
Cochrane Pond, May, No BGA cells detected	0.27
Paddy's Pond, May, No BGA cells detected	0.30
Three Arm Pond, May, No BGA cells detected	0.30
Three Island Pond, May, No BGA cells detected	0.38
Topsail Pond, May, No BGA cells detected	0.28
Chicken Farm, September, Not analyzed	less than detect
Site #5, September, Anabaena	less than detect
HCO_3-	1.5

Cl-	2.5
SO_4=	3.45
Pb	-
Soil types	
Sand	50%
Silt	0%
Clay	50%

3. Results and discussion

3.1. Vegetative growth

The growth parameters as affected by saline water irrigation treatments are showed in Table (3). However, all growth parameters (plant height, leave number/plant, stem diameter, root length, branches number/plant, main flowers number/plant, sub-main flowers number/plant, fresh and dry weight of stem, leaves, and roots) were reduced by irrigation with different levels of saline water as compared with the control plants. Concerning the effect of Algae in growth parameters, data in all previous Table (4) revealed that using different algae had a significant positive effect on all growth parameters of *Jatropha curcas* seedlings during the two growing seasons. Regarding interaction between salt concentrations and different algae concentrations, data presented in Table (5) pointed out that all different salinity levels + all concentration of algae had a more significant impact compared to salinity treatments only.

Table 3 Effect of salinity concentrations on growth parameters of *Jatropha curcas* plants (Means of two seasons)

	Parameters												
Salinity ppm	**Plant height (cm)**	**Leaves number**	**Stem diameter (mm)**	**Root length (cm)**	**Branches number**	**Main flowers number**	**Sub-Main flowers number**	**Fresh weight of leaves (gm)**	**Fresh weight of stems (gm)**	**Fresh weight of roots (gm)**	**Dry weight of leaves (gm)**	**Dry weight of stems (gm)**	**Dry weight of roots (gm)**
0	125.20	55.3	3.88	44.40	3.73	4.80	14.44	215.10	375.99	131.36	61.28	124.35	51.68
2000	108.23	43.7	3.50	42.63	3.23	4.17	14.11	177.34	341.81	112.88	48.70	110.87	43.17
4000	95.33	34.9	2.99	32.63	2.70	3.50	13.95	139.02	307.36	94.66	36.77	97.71	35.02
6000	81.57	28.1	2.38	28.20	2.35	3.00	13.78	96.16	193.96	81.63	24.26	57.64	29.46
L.S.D. 0.05:	3.16	1.96	0.25	5.96	0.27	0.16	1.28	3.29	24.1	15.5	1.69	3.10	2.05

Data in Table (3) on *Jatropha curcas* recorded that increasing salinity concentration, up to decreased significantly and the concentration of salinity at 6000 ppm significantly decreased plant height, leaves number and stem diameter compared with control plants. The decrements were (34.8%, 49.2% and 38.7%), respectively, compared with control plants in both seasons. Similar results were also reported on other timber, ornamental and other plants by Mona, *et al*., (2017) on *Tecoma capensis*, Nahed, *et al*., (2020) on *Doranta erecta*, Nahed, *et al*., (2011) on *Amaranthus tricolor* plants, Azza, *et al*., (2012) on *Chrysanthemum indicum* plants, Nahed, *et al*., (2011) on *Mathiola incana* plants and Wlodzimierz, *et al*., (2022) on *Lactuca sutiral* plants. They reported that increasing the concentrations of salinity led to decrease these parameters. The depressive effect on plant height by salinity might be mainly attributed to reduction in cell division and enlargement, water stress induced by salinity, also causes of stomata which reduced the supply of carbon dioxide of photosynthesis, Paganova, *et al*., (2022). The reduction in plant height might be due to salinity which decreased each of cell division, cell elongation and meristemic activity Ruf, *et al*., (1963) also, under salinity conditions, reduction of leaves number/plant might cause a disturbance in natural hormones leading to unbalanced growth of the plant.

It is realized from Table (3) that all tested concentrations of salinity in irrigation water induced decrements in root length, branches number, main flower number and sub-main flowers number in both seasons. The significant decrease was recorded at salinity concentration at 6000 ppm. Worthy to mention that increasing the concentration of salinity significantly retarded these parameters and reached its maximum at salinity concentration in both seasons being (36.5%, 41.0% and 37.5%), respectively compared with the normal untreated plants in both seasons. Our results are in accordance with those recorded on other plants by Nassar, *et al*., (2016) on *Leucaena* plants, El-Khateeb, *et al*., (2010), El-Dabh, *et al*., (2011) and Azza, *et al*., (2011). In this respect, Lewis, *et al*., (1980) reported that natural hormones might be affected due to saline conditions leading to unbalanced growth of the plant, consequently, the decrease in number of branches / plant. Bernstien, *et al*., (1973) found that, the effect of high salt concentration in rooting media on growth might be due to an osmotic inhibition of water absorption, specific ion concentration in saline media, or a combination of both.

The obtained data in Table (3) cleared that, leaves, stems and roots fresh and dry weight were significantly depressed gradually by increasing salinity concentrations. This effect was pronounced in plant grown under higher salinity (6000 ppm). Leaves, stems, and roots fresh weight were decrements by (55.3%, 48.4% and 37.9%), respectively, compared with control plants. Leaves, stems, and roots dry weight were decrements by (60.4%, 53.7% and 43.0%), respectively, compared with control plants. The control of salt uptake by the roots and the regulation of salt distribution to the aboveground organs are important mechanisms in preventing the concentration of salt ions in plant leaves. It is significant characteristic of the plant tolerance to salinity Boursier and Lauchli, (1990) – Murillo-Amador, *et al*., (2006). Similar findings were also registered by Nahed, *et al*., (2011) on *Matthiola incana* and Azza, *et al*., (2011) on *Schefflera arboricola*. Plant growth is the result of cell division, enlargement, and differentiation, all these factors are affected by water status of the plant Mckersi and Leshen, (1994). Moreover, the decrease in fresh and dry weight of all plant organs due to the Cl or Na accumulation in leaves might cause injury by interfering with normal stomatal closure causing excessive water loss and leaf injury symptoms like those of drought and CO_2 fixation might reduce under high level of salinity which led to lower metabolism. Similar results were obtained by Azza, *et al*., (2006) and Nahed, *et al*., (2006).

Table 4 Effect of algae concentrations on growth parameters of *Jatropha curcas* plants (Means of two seasons)

	Parameters											
Algae%	**Plant height (cm)**	**Leaves number**	**Stem diameter (mm)**	**Root length (cm)**	**Branches number**	**Main flowers number**	**Sub-Main flowers number**	**Fresh weight of leaves (gm)**	**Fresh weight of stems (gm)**	**Fresh weight of roots (gm)**	**Dry weight of leaves (gm)**	**Dry weight of stems (gm)**	**Dry weight of roots (gm)**
0%	90.90	49.3	3.51	40.08	3.43	4.25	15.63	179.09	342.68	124.38	49.76	112.94	48.45
10%	99.15	38.9	3.16	37.13	2.94	3.83	14.59	155.84	304.46	101.05	42.35	97.28	37.81
15%	117.70	33.3	2.89	33.50	2.65	3.53	12.00	135.79	267.20	89.97	36.15	82.71	33.23
L.S.D. 0.05:	0.31	1.69	2.74	5.16	0.34	0.14	1.17	3.12	28.1	13.4	2.04	2.23	1.57

Concerning the effect of algae on the growth parameters, data in Tables (4) showed that all plant growth criteria studied were significantly increased under the high level of algae at (15%) comparing with other levels in both seasons. However, the most effective treatments which had the highest plant, leaves number, stem diameter, root length, branches number, main flower number, fresh and dry weight of leaves, stems and roots, when application of algae at 15%. The increment was 30% for plant height, 48.0% for leaves number, 22% for stem diameter, respectively, over the control plant of *Jatropha* plants. The ameliorating role of algae may be due to the high level of cytokinin's, auxins, other growth hormones and other nutrients Crouch, *et al*., (1992). Cytokinin's can act to inhibit senescence in leaves by counteracting the effect of ethylene or abscisic acid. They also maintain membrane integrity by reducing lipase and lipoxygenase activity processes which are involved in membrane breakdown Bachanun, *et al*., (2000). The blue green algae addition significantly increased plant height, Bassal and Zahran, (2002), recorded that increasing salinity concentration up to 6000 ppm significantly and gradually decreased the growth parameters, compared to control plants.

Table 5 Effect of interaction on growth parameters of *Jatropha curcas* plants (Means of two seasons)

Salinity ppm + Algae%	Parameters												
	Plant height (cm)	Leaves number	Stem diameter (mm)	Root length (cm)	Branches number	Main flowers number	Sub-Main flowers number	Fresh weight of leaves (gm)	Fresh weight of stems (gm)	Fresh weight of roots (gm)	Dry weight of leaves (gm)	Dry weight of stems (gm)	Dry weight of roots (gm)
0 ppm + 0%	113.6	44.9	3.53	41.50	3.34	4.60	15.67	189.57	339.12	115.99	52.51	107.84	44.89
0 ppm + 10%	121.3	53.7	3.91	45.10	3.65	4.70	12.67	210.41	376.21	122.13	60.18	124.90	47.75
0 ppm + 15%	140.7	67.3	4.21	46.60	4.21	5.10	15.00	245.31	412.63	155.95	71.14	140.30	62.38
2000 ppm + 0%	97.3	36.9	3.12	38.80	2.81	3.80	11.67	151.11	302.11	93.17	40.50	93.96	34.38
2000 ppm + 10%	103.5	41.7	3.42	43.10	3.12	4.10	18.67	182.11	341.61	110.31	49.72	110.00	41.59
2000 ppm + 15%	123.9	52.5	3.95	46.00	3.76	4.60	12.00	198.81	381.71	135.15	55.87	128.64	53.52
4000 ppm + 0%	83.7	29.6	2.79	30.00	2.41	3.10	10.67	120.31	261.25	81.35	31.28	80.47	29.29
4000 ppm + 10%	91.3	33.5	2.97	32.20	2.67	3.50	16.67	139.63	316.41	91.71	36.58	99.67	33.39
4000 ppm + 15%	111.0	41.5	3.21	35.70	3.03	3.90	14.50	157.13	344.41	110.91	42.43	112.97	42.37
6000 ppm + 0%	69.0	21.7	2.11	24.50	2.02	2.60	10.00	82.15	166.31	69.35	20.29	48.56	24.34
6000 ppm + 10%	80.5	26.6	2.35	28.10	2.33	3.00	10.33	91.21	183.61	80.03	22.89	54.54	28.49
6000 ppm + 15%	95.2	35.9	2.67	32.00	2.71	3.40	21.00	115.11	231.95	95.51	29.58	69.82	35.53
L.S.D. 0.05:	5.47	3.39	0.59	2.34	0.38	0.60	10.32	26.8	50.2	6.24	5.19	5.28	3.16

Regarding the effect of interaction between irrigation saline water and foliar application of algae, the presented data in Tables (3-5) showed that the combined between application of algae at 15% and non-irrigation saline water followed by algae at 15% with salinity at 2000 ppm significantly increased all growth parameters of *Jatropha* plants in both seasons. Several research were done in the use of algae on alleviation of abiotic stresses Ibrahim, (2016) and Rinez, *et al*., (2016), Hussein, *et al*., (2020), El-Sayed, *et al*., (2015) and Nahed, *et al*., (2011), they reported that seaweed extracts application enhance plant tolerance against salinity and favorable effect on vegetative growth.

3.2. Chemical constituents

Effect of salinity, foliar application of algae and their interaction on chemical constituents of *Jatropha* plants.

3.2.1. Total carbohydrates, photosynthetic pigments, anthocyanin, protein, proline, and phenol contents

According to the data in Table (6), it is noticed that irrigation of saline water caused significantly decreased total carbohydrates in leaves especially 6000 ppm and photosynthetic pigments (chl. a, b, total chls. and carotenoids). The decrements were 18.28% for total carbohydrates in leaves, 26.4% for chl. a, 20.0% for chl. b, 25.0% for total chls. and 27.6% for carotenoids, respectively, compared with control plants in both seasons. The present finding is generally in accordance with other researchers by Eid, *et al*., (2011) on *Tagetes erecta*, Mazher, *et al*., (2012) on *Chrysanthemum indicum* and Farahat, *et al*., (2013) on *Gerevillea robusta* plants, they reported that, the highest concentration of salinity significantly decrease total carbohydrates. The accumulated salts in the leaves may inhibit enzymes involved in carbohydrates metabolism or exert a direct toxic effect on photosynthetic processes Munns and Tester, (2008).

Our results agree with the finding of Farahat, *et al*., (2013) on *Gerevillea robusta* plants, Ibrahem, *et al*., (2013) on *Khaya senegalensis*, Sayed, *et al*., (2014) on *Tagetes erecta*, Nisha, (2015) on *Dalbergia sissoo*, Nahed, *et al*., (2020) on *Duranta erecta* L. plants, and Paganova, *et al*., (2022) on *Pyrus pyraster* and *Tilia cordata* Mill seedlings, they found that pigments content was decrease. They found that, pigments content was decrease with increasing salinity levels. Chlorophyll content in leaves is the biochemical indicator of the plant's tolerance to salinity Rahneshan, *et al*., (2018). The degradation of photosynthetic pigments lower as the photo-reception efficiency of photo systems, which reduces the overall level of photosynthesis Geissler, *et al.*, (2009) and Zhang, *et al.*, (2012).

Table 6 Effect of salinity concentrations on chemical constituents of *Jatropha curcas* plants (Means of two seasons)

	Parameters								
Salinity ppm	**Total carbohydrate (%)**	**Chlorophyll A (mg/g f.w.)**	**Chlorophyll B (mg/g f.w.)**	**Total chlorophyll (A + B) (mg/g f.w.)**	**Carotenoids (mg/g f.w.)**	**Anthocyanin content (mg/g f.w.)**	**Protein content (mg/ml d.w.)**	**Phenol (mg/g d.w.)**	**Proline (m.mol/ml d.w.)**
0	44.19	1.163	0.350	1.512	0.652	0.08	0.48	8.15	42.22
2000	42.01	1.104	0.320	1.423	0.606	0.07	0.46	9.39	48.61
4000	38.14	0.986	0.295	1.281	0.518	0.07	0.43	10.82	45.61
6000	36.11	0.856	0.280	1.134	0.472	0.06	0.34	11.88	56.71
L.S.D. 0.05:	1.60	0.08	0.03	0.115	0.06	0.01	0.05	1.35	1.78

Results in Table (6) indicated that increasing salinity levels decreased chlorophyll a, b, a+b and carotenoids content compared to control treatment. The lowest photosynthetic ability under salt stress condition was due to stomata closure, inhibition of chlorophylls activity as reported by Patil and Waghmare, (1982). These results agree with those obtained by Mazhar, et al., (2008) on *Taxadium disitaum* and EL-Khateeb, *et al*., (2010) on *Cebia pentandora* L. and Ramarajain, et al., (2013) on Soybean.

Data presented in Table (6) showed that increasing the saline water concentration especially 6000 ppm significantly decreased anthocyanin and protein contents. The decrement was (25% and 30%), respectively, above the control plants in both seasons. In this regard, Larsen, (1982) mentioned that salinity depressed protein hydrolysis which might cause accumulation of toxic products. The same trend observed concerning protein when treated plant with saline water significant reductions the protein content, which might occur through a faint in corporation of acid / or protein Azza, *et al*., (2012) on *Chrysanthemum indicum* L. plants.

Salt stress significantly increased proline and phenol contents Table (6) the increments were (35% and 46%), respectively, over pass the control plant. Similar increase in proline content was found by Watanabe, *et al*., (2000), Nahed, *et al*., (2011), Magdalene and Barbara, (2022), Azza, *et al*., (2011) and Azza, *et al*., (2012). Ackerson, (1984) stated that osmotic adjustment within the cytoplasm is maintained by synthesis of comparable solutes, some of which such as proline have deleterious effects on metabolism and growth at high concentration. Bellinger, *et al*., (1991) reported that the increase of free proline in salt-stressed plant tissues could be interpreted as a tolerance mechanism of osmotic regulation and / or accumulation of the excess of ammonium produced by salt stress. Al-Bahrany, (1994), indicated that salt stress enhanced the production of proline, which causes osmotic adjustment.

Regarding to algae spraying, the effect of various treatments on photosynthetic pigments content in presented in Table (7). The increase in algae is gradually increased chlorophyll a, b, a+b and carotenoids content.

Regarding the effect of foliar application of algae on total carbohydrates in leaves and photosynthetic pigments of *Jatropha* plants, data presented in Table (7) show foliar application of algae at 15% significantly increased total carbohydrates in leaves and photosynthetic pigments of *Jatropha* plants in both seasons. The increments were 16.04% for total carbohydrates, 19.1% for chl. A, 23.0% for chl. B, 20.0% for total chls. and 17.0% for carotenoids, respectively, compared with control plants of *Jatropha* plants in both seasons. Sridhar and Rengasamy, (2010) indicated that plants treated with the higher seaweed dosage, the carbohydrates content were increased, these results may be related with the seaweed contained higher amounts of cytokines, auxins, macro, and micronutrients. Also, Nahed, *et al*., (2011) found that foliar application of seaweed at higher concentration led to increase the total carbohydrates and pigments of *Amaranthus tricolar* plants. Lozano, *et al*., (1999) suggested that the application of algae extracts on *Potatos* plants increased carbohydrates. Thangam, *et al*., (2003) on *Syamopsis tetragonoloba* L. and Whapham, *et al*., (1993) on *Cucumber cotyledons* plants, they observed that the application of seaweed increased pigments content of plants.

Table 7 Effect of algae concentrations on chemical constituents of *Jatropha curcas* plants (Means of two seasons)

	Parameters								
Algae%	**Total carbohydrate (%)**	**Chlorophyll A (mg/g f.w.)**	**Chlorophyll B (mg/g f.w.)**	**Total chlorophyll (A + B) (mg/g f.w.)**	**Carotenoids (mg/g f.w.)**	**Anthocyanin content (mg/g f.w.)**	**Protein content (mg/ml d.w.)**	**Phenol (mg/g d.w.)**	**Proline (m.mol/ml d.w.)**
0%	37.29	0.935	0.282	1.218	0.519	0.06	0.34	11.40	62.10
10%	39.78	1.031	0.303	1.334	0.562	0.08	0.46	10.07	51.20
15%	43.27	1.114	0.347	1.461	0.607	0.08	0.49	8.71	44.97
L.S.D. 0.05:	1.45	0.10	0.02	0.143	0.04	0.01	0.03	1.26	1.41

Regarding the effect of algae on anthocyanin and protein content, data presented in Table (7) showed that increasing the concentration of algae at 15% significantly increased the anthocyanin and protein content compared with control plant. The increments were (34% and 45%), respectively, exceed the control plants. But there were no significant between the two concentrations of algae application on anthocyanin and protein content. These results agreement with Lozano, *et al*., (1999), Abd El-Baky, *et al*., (2009), Hussein, *et al*., (2020), El-Sayed, *et al*., (2015).

Algae are known to produce essentially all the known phytohormones of higher plants and they carry out similar. Physiological functions in algae as they do in plants, Tarakhovskaya, *et al*., (2007). Changes in the level of exogenous cytokinin's alter the regulation of physiological plant processes Stirk and Staden, (2010).

Concerning the effect of algae on proline and phenol content reveled that, increasing the concentrations of algae significantly decrease of proline content. The decrement was (28% and 24%), respectively, above the control plants. These results agreement with Nahed, *et al*., (2011) on *Amaranthus tricolar* plants.

Concerning the interaction between irrigation of saline water and foliar application of algae on *Jatropha* plants, showed that in Table (8) indicated that, the combined with foliar application of algae at 15% and zero salinity significantly increased total carbohydrates and photosynthetic pigments, followed by algae at 15% combined with 2000 ppm salinity compared with control plants in both seasons of *Jatropha* plants. The same results agreement with Nahed, *et al*., (2011) on *Amaranthus tricolar* plants, they found that application of seaweed at higher concentration and saline water at 1000 ppm had a favourable effect on carbohydrate percentage.

Concerning the effect of interaction between saline water irrigation and algae application on anthocyanin, the data in Table (8) illustrated that irrigated *Jatropha* plants with zero salinity combined with 10% algae followed by irrigated plants with 2000 ppm salinity with application at 15% algae, significantly increased anthocyanin content compared with control, while irrigation of zero saline water combined with 15% of algae followed by saline water at 2000 ppm combined with 10% of algae significantly increased protein content compared with control plants. Several research were done in the use of algae extraction alleviation of abiotic stress, Ibrahim, (2016) and Rinez, *et al*., (2016).

The results of total carbohydrates percentage and protein content presented in Table (8) show that growing seedlings under salinity conditions led to a reduction in total carbohydrates and protein content compares as comparison to the control at two seasons. As regarding the effect of algae application on total carbohydrates% and protein content in the two growing seasons, were increased by using algae application, especially by using the higher rate of algae 15%.

Concerning the effect of interaction, algae applications were also effective on total carbohydrates percentage and protein content of salinized water irrigated plant, total carbohydrate and protein were greatly induced.

Table 8 Effect of salinity and algae concentrations on chemical constituents of *Jatropha curcas* plants (Means of two seasons)

	Parameters								
Salinity ppm + Algae%	**Total carbohydrate (%)**	**Chlorophyll A (mg/g f.w.)**	**Chlorophyll B (mg/g f.w.)**	**Total chlorophyll (A + B) (mg/g f.w.)**	**Carotenoids (mg/g f.w.)**	**Anthocyanin content (mg/g f.w.)**	**Protein content (mg/ml d.w.)**	**Phenol (mg/g d.w.)**	**Proline (m.mol/ml d.w.)**
0 ppm + 0%	41.25	1.113	0.309	1.422	0.601	0.07	0.27	9.17	48.13
0 ppm + 10%	43.08	1.165	0.328	1.493	0.643	0.10	0.52	8.54	42.17
0 ppm + 15%	48.23	1.210	0.411	1.621	0.711	0.08	0.66	6.75	36.35
2000 ppm + 0%	39.11	1.004	0.285	1.289	0.571	0.06	0.39	10.12	56.31
2000 ppm + 10%	41.31	1.131	0.312	1.443	0.614	0.06	0.65	9.71	48.31
2000 ppm + 15%	45.61	1.176	0.361	1.537	0.633	0.09	0.34	8.35	41.21
4000 ppm + 0%	35.09	0.891	0.271	1.162	0.483	0.05	0.33	12.61	65.71
4000 ppm + 10%	38.61	0.961	0.293	1.254	0.511	0.08	0.37	10.13	51.71
4000 ppm + 15%	40.71	1.105	0.321	1.426	0.561	0.08	0.59	9.71	45.61
6000 ppm + 0%	33.70	0.733	0.264	0.997	0.412	0.06	0.35	13.71	78.25
6000 ppm + 10%	36.12	0.869	0.280	1.145	0.481	0.06	0.29	11.91	62.61
6000 ppm + 15%	38.51	0.965	0.296	1.261	0.522	0.06	0.38	10.01	56.71
L.S.D. 0.05:	2.82	0.19	0.06	0.250	0.09	0.02	0.08	2.50	3.80

Regarding the effect of interaction between saline water and algae on proline and phenol, the data in Table (8) found that irrigation saline water at 6000 ppm combined with zero application of algae significantly increased proline and phenol content. The increments were (63% and 50%), respectively, compared with control plant of *Jatropha* plants in both seasons. These results agreement with Nahed, *et al.*, (2011) on *Amaranthus tricolar* plants.

Data in Table (8) recorded that the contents of proline and phenols contents were decreased by using 10 or 15% algae. However, the highest values of phenols and proline content resulted from the highest salinity level (6000).

Concerning the interaction between algae levels and salinity levels data in Table (8) indicated that spraying algae at 15% under non-saline treatment increased all photosynthetic pigments content compared to other treatments.

4. Conclusion

Algae known to affect membrane filtration directly or indirectly. However, the most effective treatments which had the highest root length, branches number, main flower number, sub-main flower number, fresh and dry weight of leaves, stems and roots, when application of algae at 15%. The results suggested that *Jatropha curcas* L. seedlings benefited the application of algae especially under salinity concentrations grown in sandy soil, especially could be used high salinity level (6000 ppm) with 15% algae.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no competing interests.

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