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A glasswort *Salicornia europaea*: agriculture, physiological responses to salinity stress and economic value: A Review

Mohamed M. Abd El-Maboud

Ecology and Range Management Department, Desert Research Center, Cairo, Egypt

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ABSTRACT

Samphires or glassworts are succulent true halophytes belong to Amaranthaceae, can grow naturally on the coastal areas. Thus, they can be grown on sea water or brackish water. Globally, climate changes have negatively affected the agricultural land areas which led to a decrease in the productivity of field crops. Hence it has become necessary to look for alternatives to traditional crops to fill the food gap. Due to continues lack in agricultural areas result from bad irrigation or lack of fresh water resources, *Salicornia* cultivation as one of the best non-conventional crops is recommended to display high biomass where traditional crops can not grow. *S. europaea* has multiple uses as food (freshly salad, pickle, cocked, its seeds contain high quality of edible oil), pharmaceutical and other uses. Furthermore, *Salicornia* is highly accumulated to salts so it can be used industrially in salts production. *S. europaea* can be invested in saline land reclamation of arid and semi-arid areas.

Keywords: *Salicornia europaea,* economic uses, Salinity, physiological brhavior

1. Introduction

Glassworts are succulent halophytes adapted naturally to saline environments. They can be called on *Sarcocornia* (Scott) and *Salicornia* (L.) genus belongs to the Amaranthaceae, subfamily Salicornioideae. In Egypt, they are widely distributed along the Mediterranean Sea coast (Boulos, 1999). *Salicornia* and *Sarcocornia* are closest to each other and can be differentiated by life form which is always perennials in *Sarcocornia* and annuals in *Salicornia* and flower feature devising a triangle shape with a greater central and two slighter lateral flowers in *Salicornia* opposed to being aligned in a horizontal row in *Sarcocornia* (Kadereit *et al*., 2007). Genetically, 62 accessions of *Salicornia* and *Sarcocornia* were investigated using the external transcribed spacer (ETS) sequence. Data revealed an obvious difference between the two genera and among different *Salicornia* taxa. Although the ETS was not adequate changeable to resolve morphologically distinct species in some cases (Singh *et al*., 2014). *Sarcocornia* includes 28 species over the world (Steffen *et al*., 2015), just two of them *S. fruticosa* and *S. perennis* are present in Egypt (Boulos, 1999). Regarding *Salicornia*, about 25-30 species distributed in Eurasia, North America and Africa (Kadereit *et al*., 2007). Only one species (*S. europaea*) is existing in Egypt growing at salt marshes and estuaries when the meeting of sea water and freshwater creates unique and dynamic habitats. *S. europaea* have synonyms names viz., *S. herbacea* L. and *S. patula* (Wilkoń-Michalska, 1985). It is the most broadly distributed species in the *Salicornia* genus across the Ireland and The UK. Marsh samphire are commonly distributed at different levels of sandy and/or muddy saltmarshes, in the transitional area of saltmarsh to sand dunes, in pans and channels, mudflats, sandflats, and in inland saline environments (Davy *et al*., 2001 and Gunning, 2016). This name is given on some plant species due to introduce their ashes in glass and soap industries. Glassworts can accumulate excess of sodium in their tissues, and then converts some of this sodium into sodium carbonate after ashing. Glasswort word has been born with a 16th century in English glassmaking (Kurinsky, 1991). Beside glassworts *Salicornia* has other names as sea asparagus, sea beans, pickle weed, samphire and drift seeds (Ozturk *et al*., 2018).

Corresponding Author: Mohamed M. Abd El-Maboud, Ecology and Range Management Department, Desert Research Center, Cairo, Egypt. E. mail: abdelmaboud2000@yahoo.com

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Salicornia and *Sarcosornia* genus have high nutritional value and high biomass in field conditions (Ventura and Sagi, 2013). Although many papers have screened the phytochemical profile of *Salicornia* and recommended as alternatives to common feedstuffs, there are some studies report that these plants have low protein content and require to be mixed with other feed (Gunning, 2016 and Mohammadi and Kardan, 2016).

Plants Description:

Salicornia L. is a common annual hygro-halophytic, leafless herb that have articulated and succulent stems. *Salicornia* species are small, erect till 35 cm tall, branches are opposite on the main stem and consisted of short, cylindrical or clavate internodes, each with a succulent, photosynthetic covering, conferring the articulated appearance (Davy *et al*., 2001 and Kadereiat *et al*., 2007). Flowers are hermaphrodite, wind pollinated, and the fruit is small, succulent and joins a single seed (Ball, 2004). *S. europaea* has a geographical distribution across 4 continents such as Africa, North America, Europe and Asia. The stems are spongy with minute scale-like leaves, indistinct flowers and fruits (Photo 1). The green plant changes orange, pink to reddish by ending its life cycle (Kadereiat *et al*., 2007 and Patel 2016). In nature, short day length in summer enhances *Salicornia* to give short segments that finally format terminal fruiting spikes in which the seeds are yielded (York *et al*., 2000). The flowering response within *Salicornia* species from different geographical areas could be controlled through day and night period extension (Ventura *et al*. 2011). The shoot length around three folds longer than the root length. The pH of *S. europaea* shoot ranged from7.6 to 8.8 and the osmotic pressure in stem increased from 650 mOsm.Kg^{-1} in early growth stage to 2600 mOsm.Kg^{-1} at the end of growth (Momonoki and Kamimura, 1994).

Photo 1: *S. europaea* as dominant in nature (June, 2019) including few numbers of *Sarcocornia fruticosa* (on the left hand) along Port Said- Damietta coastal road, Egypt. The GPS reading is N: 31 17.618, E: 32 09.680

Cultivation

To obtain successful germination, start with exposing the seeds to a period of cold stratification. The cold stratification method to break seed dormancy. The cold stratification period should be accomplished for 30 days in dark at approximately 5°C. Around 25 seeds were put on moist filter paper (with fresh water) in a sealed petri dish and check daily. After 30 days, seedling will be ready to transfer to suitable medium such as aeroponics (added nutrients in water without soil) and pots (Gunning, 2016). *Salicornia* can be invested for reclamation of deserted lands, salt flats, and sea shores. Shortly, they can be recommended for seawater agriculture. It is proposed that as climate changes threatens to flood more areas closest to sea shores, and freshwater is decreasing, a shift to saline crop may be a valid choice (Katschnig *et al*., 2013). In nature, *S. europaea* germinates in rainfall seasons where the salt concentration is the lowest (Williams and Ungar, 1972). Soil reaction ranges from slightly acidic to slightly alkaline (Abd El-Maboud, 2021). Additionally, Orlovsky *et al*. (2016) studied the germination response to salinity in *S. europaea* dimorphic seeds and demonstrated that large seeds keep a 90% germination up to 2% NaCl concentration (342 mM), with a sharp decline to 20% at 3% NaCl (513 mM) and no germination at 5% and 7% NaCl concentration. Small seeds, contrarily, showed germination below 10% at 2% NaCl concentration. Moreover, Philipupilli and Ungar (1984) declared that lateral seeds are more tolerant than central seeds in *S. europaea*. *Salicornia* spp. can be grown in segregated wet land systems and irrigated with nutrient-rich saline sewer water or discharges from aquaculture to increase sustainability or hydroponics (Brown *et al*., 1999; Buhmann and Papenbrock, 2013 and Singh *et al*., 2014). Few publications discussed germination and growth items in *S. europaea* as shown in Table 1. *S. europaea* has been successfully cultivated in native sand dunes irrigated with drip system. Also, it was cultivated either under simple nets or inside greenhouses (Ventura and Sagi, 2013). Ma *et al*. (2020) observed growth of *S. europaea* is better at 200 mM NaCl than at 0 mM NaCl. The 0.2 M NaCl enhanced increase in numbers of branches, height, water content of shoots and dry weight in presence of $CdCl_2$ (0, 25, 50, or 100 µMCdCl2) as compared with control (Zhu *et al*., 2022). Furthermore, Lv *et al*. (2012) declared *S. europaea* can tolerate more than 1 M NaCl.

Table 1: Growth parameters in *S. europaea* as response to different salinity levels

SI. No	Salinity teatments	Parameters studied	Inference	Reference
1	0, 150, 300, 600 mM NaCl	Germination%, shoot length, root length	The highest germination ~ 85% was observed from 0 to 300 mM then sharply decreased to 50% at 600 mM. The highest shoot and root length were recorded at 150 and 300 mM, while the lowest values at 0 mM.	Muscolo *et al.* (2014)
2	0,100, 200,300,400 and 500 mM NaCl	Root and shoot length, fresh weight /plant, stem diameter and number of branches	A gradual increase to salinity has observed in root and shoot length and branching till 200 mM, then declined until reached the lowest at 500 mM. The highest fresh weight per plant was at 100 mM and the highest stem diameter and the tallest node were at 100 and 200 mM.	Algharib *et al.* (2016)
3	0, 100, 200, 300, 400, 600 mM NaCl	Germination%	The optimum value ~ 72% at 0, then declined to ~ 45% between 100 and 400 mM and further decreased to 28% at 600 mM.	Calone *et al.* (2020)
4	0, 200, 400, 800 and 1000 mM NaCl	Biomas	The moderate salinities; 200 and 400 mM gave the highest biomass, while 0 and 1000 mM gave the lowest.	Cárdenas-Pérez *et al.* (2020)
5	0, 100, 200, 400, 600 mM NaCl	Shoot fresh and dry weight, and root fresh and dry weight	No significant change has observed in shoot fresh and dry weights and root dry weight from 0 to 400 mM but they decreased by 600 mM. On the other	Ghanem *et al.* (2021)

			side, root fresh weight has decreased by all salinity levels.	
6	0, 200, 400, 800, 1000 mM NaCl	Plant height, branches number, plant surface area, and shoot diameter, shoot, root, and total fresh and dry weight	At 1000 mM plants were the smallest surface area, shortest thinnest diameter and the lowest number of branches as compared to the others. No significant change has occurred in plant height and shoot diameter between 0, 200, 400, and 800 mM. Plant surface area and branches number were higher in both 400 and 800 mM. The highest values for fresh and dry weight were recorded at 400 mM while the lowest were at 1000 mM.	Cárdenas-Pérez *et al.* (2022)

Physiological Studies

In general, true halophytes have three main mechanisms to resist salinity; salt excretion, compartmentalization and reduction of Na^+. Regarding *Salicornia*, trichomes or modified trichomes has not ocuured, so the first one is not used. Compartmentalization can be proceeded via tonoplast inside vacuoles and the Na^+ reduction can be proceeded via apoplast in cell membrane (Yadav *et al*., 2012). NHX1 antiporters are occured in tonoplasts to reduce cytosolic Na^+ by pushing into the vacuole, while SOS1 effluxes Na^+ in apoplasts and is present in the plasma membrane (Shi *et al*., 2002). Compartmentalization mechanism is the most common in *Salicornia* that synergist with succulence to dilute ion toxicity (Abd El-Maboud, 2021). Succulence is a manner of the increased size of individual cells result in increased ion intake (Black, 1958). The constitution of phenolic acids and flavonoids, like rutin, conceivably linked with adaptation mechanisms in saline environments (Sánchez-Gavilán *et al*., 2021). Some fatty acids *viz*., Lauric, myristic, and palmitoleic were only found in *S. patula* shoots growing at coastal salt marshes in lower proportions (Sánchez-Gavilán *et al*., 2021).

The photosynthetic pigments had no significant change by salinity till 800 mM NaCl as compared with control (Durdu *et al*., 2021). In contrary, they were decreased gradually by raising NaCl levels (0, 200, 400, 800, 1000 mM) and the lowest values were at 1000 mM (Cárdenas-Pérez *et al*., 2020). In this line, Muscolo *et al*. (2014). found Photosynthetic pigments were reduced while anthocyanins were increased significantly. Chl a was fluctuated by low and moderate salinity then sharply decreased at 600 mM NaCl while chl b increased by moderate salinity then sharply decreased by 600 mM NaCl. Carotenoids decreased gradually with salinity (Ghanem *et al*., 2021). Optimal photosynthetic rate were observed with the plant treated with 200-400 mM NaCl (Lv *et al*., 2012). Calone *et al*. (2022) found a significant reduction in chl a only among photosynthetic pigments by salinity and no significant difference after recovery. In contrary, water deficit created a significant reduction in all photosynthetic pigments and turned to increase the values after the recovery treatment, with no significant difference from the control. Tikhomirova *et al*. (2016) found that the increase in salinitycauded reduction in chl a and chl b.

Neither saliniy or water stress caused increase in MDA or H_2O_2 levels in *S. europaea* shoot. MDA contents decreased under salt stress in *S. europaea* and increased after recovery to be still less than control but without significant change **(**Calone *et al*., 2022). MDA was significant decreased by salinity at all concentration till 600 mM NaCl except the 100 mM which produced non-significant change (Ghanem *et al*., 2021). The reactive oxygen species H_2O_2 kept stability up to 800 mM NaCl and increased at 1000 mM that reflexes the high tolerance of *S. europaea* to salinity stress (Cárdenas-Pérez *et al*. (2022). Antioxidant enzyme activities via Peroxidase (POD), catalase (CAT) and superoxide dismutase (SOD in *S. europaea* were increased gradually as NaCl levels increased up to 500 mM (Algharib *et al*., 2016). In this connection, (Aghaleh *et al*., 2011 and Algharib *et al*., 2016) reported POD, and SOD activities play a pivotal role in the scavenging reactive oxygen species (ROS) in *S. europaea*. Indeed, (Cárdenas-Pérez *et al*. (2022) reported that POD increased gradually by salinity while CAT was more sensitive to NaCl levels. The highest intensities of esterase and peroxidase isozymes was at 200 mM NaCl Ghanem *et al*. (2021). The glutamine synthetase (GS) activity was inhanced by 50 mM NH_4Cl specially in root and at higher NaCl levels (50 and 200 mM). Root GS activity was also moderately stimulated by NaCl. At 0 mM NaCl, the glutamate dehydrogenase (GDH) activity was enhanced by NH_4^+ only in the shoots, with a remarkable effect of the 50 mM treatment, that increased it by 4-fold compared to 1 mM NH_4Cl. At 200 mM NaCl in the growth medium significantly stopped the GDH enzymatic activity in the shoot, while motivated it in the root (Ma *et al*., 2020).

Abd El-Maboud (2021) concluded Na^+ and Cl^- are the major ions in plant shoot and associated soil. Araus *et al*. (2021) studied impact of three different irrigation water; fresh water (0.3 dS m^{-1}), brackish (25 dS m^{-1}) and sea water (40 dS m^{-1}) on ion content in two ecotypes; RAK and UAQ of *S. europaea*. Higher salinity irrigation increased the level of Na^+, K^+ and Mg^{2+} and decreased P in the shoots, while Ca^{2+} level was maximal with brackish water irrigation. Regarding the seeds, sea water irrigation increased the level of Na^+, and to a lesser extent K^+, and decreased the P level, while no impact on Ca^{2+} and Mg^{2+} levels. The UAQ ecotype revealed higher levels of Na^+ and K^+ in the shoots and lower levels of Ca^{2+} and P than in the RAK ecotype, while no change observed between ecotypes in Mg^{2+}. Regarding seeds, K^+ level was regularly higher while Mg^{2+} and P were lower in UAQ than RAK and no change existed for Na^+ and Ca^{2+}. Ghanem *et al*. (2021) used different salinity concentration (0, 100, 200, 400 and 600 mM NaCl) on *S. europaea* and found at 200 mM Na and Ca attained the highest concentration in shoots while K was at 100 mM. In roots, Na increased gradually by salinity while K decreased. Both Na and Cl were increased gradually by salinity while K and P were decreased and Mg did not change (Muscolo *et al*., 2014). The Na^+ content in the shoots was considerably higher than that in the roots of *S. europaea* (Lv *et al*., 2012). The Na^+ in *S. europaea* cells may act as an effective osmotic adjuster to maintain cell turgor, promoting photosynthetic competence and plant growth. In this respect, Moghaieb *et al*. (2004) interpreted the higher accumulation of salts in shoots than those in roots as stimulating high osmotic pressure of vacuolar sap and promoting water intake. Calone *et al*. (2022) studied the impact of salinity, water stress and recovery treatments on ionic composion of *S. europaea* and found root and shoot Na^+, Ca^{+2} and Cl^- levels increased significantly in response to salinity treatment, whereas water deficit did not produce change in the ions levels except Ca^{+2} increased by water stress. The recovery treatment caused reduction of the three ions in root of salt-stressed plants down to control levels. In contrast, no differences were observed in shoot Na^+ and Ca^{+2} before and after recovery, while Cl^- increased significantly in the control. The stress treatments did not cause changes in the root K^+ concentration, At the shoot level, mean K^+ concentrations decreased upon salt treatment, although the difference with the control was non-significant while it increased by water stress. After recovery, K^+ concentrations were lower in the root and higher in the shoot than control values either of salt-stressed or water stressed plants. Tikhomirova *et al*. (2016) found that the increase in salinity of nutrient solutions from 171 to 342 mM NaCl had no effect on the relative content of Na, S, K, P, and N in the shoot of *S. europaea* grown at photosynthetic active radiation (PAR) intensity of 690 µmol/(m^2 s) but reduced the Ca and Mg content. The further increase in salinity to 513 mM NaCl elevated the Na content in shoot and lowered the content of Ca and P as compared to lower salinity. At PAR intensity of 1150 µmol/(m^2 s), Na and K were increased as salinity increased, whereas Ca, Mg and P content were decreased. In shoot, water content,Ca and Mg were decreased in summer, whereas K, Na and Cl were increased (Abd El-Maboud, 2021). Compared with the control, 0.2 M NaCl treatment significantly raised Na^+ accumulation in shoots and roots of *S. europaea*, even though it was significantly higher in the shoots than in the roots. When *Salicornia* grown in 0.2 M NaCl treated with Cd^{2+}, the Na^+ content of shoots and roots increased significantly. In Comparison with the control, 0.2 M NaCl treatment had negative effect on K^+ content of shoots and roots. Also, Cd^{2+} had negative effect on K^+ content in shoots inside control. When grown in 0.2 M NaCl, Cd^{2+} had no significant change on K^+ concentration in shoots but decreased the concentration in roots (Zhu *et al*., 2022). Ushakova *et al*. (2006) used two factors; salinity treatments (0.3, 171, and 342 mM NaCl), and photosynthetically active radiation (PAR) of 600 or 1150 µmol/(m^2 s) to study their effects on productivity, minerals concentration and ammino acids in *S. europaea*. At PAR of 600 µmol/(m^2 s), plant productivity increased as salinity increased while at 1150 µmol/(m^2 s), the highest productivity was noticed in the plants grown at 171 mM of NaCl. The content Na in shoots, regardless of PAR, increased gradually with salinity concentrations. Using different levels of NaCl in presence of 1 mM NH_4Cl, kept stability on NH_4 content. At 0 mM NaCl, 50 mM NH_4Cl significantly raised NH_4^+ content by 5-fold in root and shoot. Although NH_4^+ content decreased in root as NaCl increased, they increased moderately in shoot. Na^+ accumulation increased around 3-fold at 200 mM NaCl in shoot and only increased by 36% in root. Addition of 50 mM NH_4^+ inadequately frustrate the Na^+ concentration in shoot at 50 and 200 mM NaCl; contrarily same perform was noted in root at 10 and 50 mM NaCl (Ma *et al*., 2020).

Free proline content was more accumulated by increasing salinity (Aghaleh *et al*., 2011; Algharib *et al*., 2019 and Abd El-Maboud, 2021). It increased around 4-fold at 600 mM NaCl (Ghanem *et al*., 2021). However, Cárdenas-Pérez *et al*. (2022) found no significant change in proline in *S. europaea* up to 1000 mM NaCl. In this line, Calone *et al*. (2022) reported proline content did not influence by salinity stress but increased by water stress in *S. europaea* shoot 5-fold to control and sharply decreased to control value after recovery. *S. europaea* adapted to salinity by increasing in proline, reducing saccharide, oligosaccharide and soluble saccharide and decreasing in polysaccharides, and proteins (Aghaleh *et al*., 2009). Glutamic acid, rather than proline, was the main organic osmolyte in this plant species (Ushakova *et al*., 2006). It responded to water stress by increased accumulation of total soluble sugars (Calone *et al*., 2022). In shoot, water content, op and soluble sugars, were decreased in summer, whereas proline was increased (Abd El-Maboud, 2021). The content of free amino acids in shoots, regardless of photosynthetic active radiation of 600 or 1150 µmol/(m^2 s) decreased gradually with salinity concentrations (Ushakova *et al*., 2006). Neither salt stress nor water deficit caused any variation in glycinebetaine contents in *S. europaea* shoot (Calone *et al*. 2022). Glycine betaine is perhaps the major organic compound take part in osmoregulation for *Salicornia* spp (Gorham *et al*., 1980). *Salicornia* under fresh water cultivation yields higher flavonoid and phenolic content than those under saline water cultivation (Kang *et al*., 2015). In contrary, Muscolo *et al*. (2014) demonstrated high accumulation of total phenols as high salinity. Neither water stress nor salinity stress enhanced significant change in total phenolic and total flavonoides in shoot on *S. europaea* before and after recovery (Calone *et al*., 2022).

Economic value

1. As food

The *Salicornia* species have been brought into the European market as a vegetable like green asparagus, exactly in Italy and France, they have been used in vinegar manufacture. Also, Korean people consumed them as a seasoned vegetable, fermented food and salad (Kim *et al*., 2011). The lipid profile of *S. patula* manifested the presence of oleic, palmitic, stearic, and linoleic as the major fatty acids (Sánchez-Gavilán *et al*., 2021). In some communities, the shoots are commercially processed into drinks as makgeolli (a Korean rice wine), nuruk (a type of fermentation starter), or vinegar (Song *et al*., 2013 and Kim *et al*., 2013). *Salicornia* is valuable source of bioactive compounds make them as one among important candidates for future use in food processing due to their health properties (Loconsole *et al*., 2019 and Sánchez-Gavilán *et al*., 2021). Selenium has been detected in *S. brachiata* shoots (Mishra *et al*., 2015). That is a vital micro nutrient for growth and vigorous antioxidant effects, shortage of which has been acknowledged to hurt the immune system (Finley, 2005). The seeds of *S. europaea* contained 28% oil content, 30.2% protein content under sea water irrigation (Ơ Leary *et al*., 1985). Total lipid content ranges from 32-36%, n6c linoleic acid (accounting for around 60 %), followed by n9c oleic acid ~ 20 %, palmitic acid <10 %, alpha linolenic acid cosest to 5% and stearic acid ~ 2% (Araus *et al*., 2021). Indeed, (Austenfeld, 1986) declared the seeds contain from 26% to 30 % lipid, and linoleic acid was the main component among fatty acid content, approximately 70 %. Also, Liu *et al*. (2005) found linoleic acid as the major compound in oil seeds 75.6%, and oleic acids 13.0% besides stearic and palmitic acids. *S. herbacea* seed oil has been studied to be stable to oxidation and eligible to be used in food processing. The oil composed of linoleic acid, palmitic acid, oleic acid, arachidic acid, tocopherol (α, γ, δ type), and phenol (Choi *et al*., 2014). *S. herbacea* has significant concentrations of essential amino acids like aspartic, glutamic and isoleucine in their shoots and roots (Min *et al*., 2002).

2. In medicine

Some of the *Salicornia* species have been used in folk medicine (for treatment of hepatitis, bronchitis and diarrhea) and displayed significant biological properties such as anti-inflammatory, antioxidant, cytotoxic and hypoglycemic activities. The phytochemical studies on *Salicornia* showed abundance of fatty acids, saponins, flavonoids, alkaloids, sterols, chlorogenic acid derivatives, and different kind of phenolic compounds (Isca *et al*., 2004). Due to presence of active material, such as, tannins, flavonoids, alkaloids, essential oils in *S. europaea* land parts permit to use this plant in pharmacology (Sïlybaeva *et al*., 2016). Moreover, it is wealthy with tungsten acids, quercetin, and isorhamnetin, which have anti-inflammatory and antioxidant effects. Also, it involves polysaccharides that take part in the treatment of diabetes, obesity, constipation and cancer (Gunning, 2016 and Patel, 2016). Primary and secondary compounds have been identified in *S. europaea* (Kim *et al*., 2009 and Cho *et al*., 2016). It has antioxidative, antiinflammatory, antihypertensive, antidiabetic, antilipidemic, hepatoprotective, immune-modulatory, antimicrobial, anticancer and antiobesity activities (Kim *et al*., 2009; Cho *et al*., 2016 and Kim *et al*., 2021). The oral administration of fresh *Salicornia europaea*, in Edremit Gulf folk medicine, to treat goiter (Polat and Satyl, 2012). It has been used in traditional Chinese Medicine to treat cephalalgia, hypertension and scurvy (Wang *et al*., 2012 and Isca et., 2014). Moreover, it has antioxidant, antimicrobial, anti-inflammatory, and anti-tumor properties (Ksouri *et al*., 2012). In South Korea, low-sodium salt has been extracted from *S. europaea* tissues by Phyto Corporation. The company claims the naturally-derived plant salt is helpful in handling fatty liver and high blood pressure disease by lowering sodium intake (Panth *et al*., 2016). Desalted *Salicornia* powder has been recommended for use as a food supplement to be effective in reducing obesity through its antiobesity and antiadministration properties (Rahman *et al*., 2018). Aqueous extract of *S. europaea* succeeded to improve the texture of human skin who affected by the sun-exposed areas of the facial skin. Also, it is not only can suppress the UVB-induced changes in the morphology of basal keratinocytes but also keep on the normal balance between the symmetric divisions and asymmetric divisions of basal keratinocytes from UVB-induced perturbations (Doi *et al*., 2020). *S. europaea* extract may maintain an antidepressant impact, that became visible to control Nrf2-ARE pathway and increased levels of dopamine and corticosterone CORT in the hippocampus and cortex (Sun *et al*., 2022). Crude in addition to purified polysaccharides from *S. herbacea* (at 0.5–4 mg/ml) exhibited anti-proliferation of human colon cancer HT-29 cells when incubated for 24-48 h (Ryu *et al*., 2009). *S. herbacea* -derived chlorogenic acid, 3-caffeoyl, 4-dicaffeoylquinic acid employed running on metastasis of human fibrosarcoma HT-1080 cell line (Hwang *et al*., 2010). Pentadecyl ferulate kept apart from *S. herbacea* ethyl acetate extract has antioxidant event and expends anticancer effect against human hepatocellular liver carcinoma HepG2 and human lung adenocarcinoma epithelial A549 cells, as well as phytol and γ-linolenic acid (Wang *et al*., 2013).

3. Others

However high salt content, animals fed moderate amounts of *Salicornia* gained as much weight as those whose diet contained hay or other terrestrial weeds (Swingle *et al*., 1996). *Salicornia* is allowable as the fodder component of diets fed to goats (Glenn *et al*., 1992) and as an additive in broiler chicken diets (Attia *et al*., 1997). S. *europaea* is a forage, and can be used for saline land reclamation and biofuel precursor production on marginal lands (Feng *et al*., 2015). It is a good candidate as a biofilter to recycle water and nutrients included in drain water from marine aquaculture and as a phytoremediator of saline soils attenuated with heavy metals (Cárdenas-Pérez *et al*., 2021). It can be introduced in the manufacture of soap owing to its high ash content, a practice which dates back over centuries (Davy *et al*., 2001). Some studies have demonstrated their suitability for the regreening of marginal areas to increase carbon sequestration and alleviate soil erosion (Carrasco Barea, 2020 and Gispert *et al*., 2021).

Accompanied risks of *Salicornia* diet

However valuable effects of *Salicornia*, it has some risks too. It is necessary to bear in mind of possible harmful reactions before utilization. Some awful truth have been summed. Accumulation of heavy metals in plant parts is a danger to user health (Lei *et al*., 2015). Recently, Milic *et al*. (2012) reported that roots of *Salicornia europaea* accumulate much more heavy metals than the above-ground organs. This succulent is responsive to metal and oil spill stressors. A study carried out on a marsh of California revealed that *Salicornia virginica* suffers stress from heavy metals (Rosso *et al*., 2005). *S. brachiata* is able to imbibe cadmium, nickel and arsenic salts (Sharma *et al*., 2010). Also, some *Salicornia* spp have been used as biomonitors of copper and zinc, accelerating its applicability in metal remediation from water (Smillie, 2015). Wetlands are rich in biodiversity and are critical for ecological stability, but these unique ecosystems over the world are delicate now, despite increased human interference (industrial effluent release, sewage treatment etc.) (Gutzwiller and Flather, 2011 and Anza *et al*., 2014).

Conclusion

S. europaea are highly tolerant to salt stress and sensitive to water stress. Glassworts as true halophytes need to be maximized and invested by expanding in their cultivation on marginal salt lands due to their use in many purposes. Expansion in cultivating glassworts on seashores and estuaries keep ecosystem balance represented by carbon sequestration, soil fixation and land reclamation. To fill the gap in food requirements, result from reduction in fertile soil (salinization) and lack of fresh water we must return to halophyte crop cultivation especially those have high economic value like *Salicornia*.

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