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Effects of saline irrigated water on forage quality of globe artichoke (*Cynara carduncului* var. *scolymus* L.)

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ABSTRACT-Salinity is a major abiotic stress for crop production in many parts of the world. To evaluate the effects of irrigation with saline water on growth parameters and forage quality of globe artichoke (*Cynara cardunculus* var. *scolymus*), a field experiment was conducted using a randomized complete block design with three replications at Isfahan Agricultural and Natural Resources Research and Education Center, Iran during 2013-2015. The treatments were four irrigation levels with saline water (4, 8, 12 and 16 $dS.m^{-1}$). Plant fresh weight (FW), plant dry weight (DW), crude protein (CP), water-soluble carbohydrates (WSC), neutral detergent fiber (NDF), acid detergent fiber (ADF), dry matter digestibility (DMD), total tannins (TT) and ash content were measured in the second year of growth season. The results showed that the maximum fresh weight (51551 kg ha^{-1}) and dry weight (9000 kg ha^{-1}) were obtained at EC=4 $dS.m^{-1}$. Increasing salinity levels caused a significant reduction in NDF and ADF contents, while ash, CP, DMD and TT contents were increased. The treatments of EC=12 and EC=16 $dS.m^{-1}$ produced the highest amount of CP (178.3, 185.1 g/kg DM), DMD (613.2, 636.2g/kg DM) and the lowest content of NDF (598, 585.1g/kg DM) and ADF (393, 3778g/kg DM), respectively. The lowest tannin content (28.2g/kg DM) was observed in EC=4 $dS.m^{-1}$ and there was no significant difference between the treatments of EC=8 and EC=12 $dS.m^{-1}$. Generally, results showed that although increasing salinity decreased plant yield, it could increase forage quality characteristics.

INTRODUCTION

Globe artichoke (*Cynara cardunculus* var. *scolymus* L.) is a perennial plant that belongs to the Asteraceae family (Ceccarelli et al., 2010). It is described as a stout plant that can reach over two meters of height and often shows richly branched stems at maturity (Gominho et al., 2018).

This plant is cultivated all over the world especially in Italy, Spain, France, Greece, Argentina, and United States (Pandino et al., 2013). It is mainly grown for several uses such as human food, pharmaceutical compounds (Pandino et al., 2011; Rondanelli et al., 2011; Aksu and Altinterim, 2013) and green forage for ruminant feeding (Meneses et al., 2007; Sallam et al., 2008). Also, related studies have shown that the application of green forage from artichoke in animal feed as part of a balanced diet including cereals and other sources of fiber was beneficial (Mauromicale et al., 2019). Salman et al. (2014) indicated that artichoke by-products could be a good supplement incorporated in feed mixtures to replace conventional forages such as hay or silage in ruminant diets. In other research, the use of artichoke bracts in lamb diets increased the percentage of omega-3 fatty acids in fat deposits (Marsico et al., 1999).

Salinity is known as one of the major limitation to crop production in many regions of the world (Arzani and Ashraf, 2016). It occurs in the soil naturally or as a result of mismanaged irrigation water (Hakim et al., 2010). The use of saline water for irrigation is a common practice in arid and semi-arid areas, even though it may cause a loss in crop yield and progressive soil salinization (Domíngueza et al., 2011). It was shown that salinity had detrimental effects on plant growth and development in two phases of osmotic stress and ion toxicity (Arzani, 2008; Munns and Tester, 2008).

Artichoke has been rated as a moderately salt-tolerant plant. Graifenberg et al. (1993) reported that the threshold of tolerance to salinity for artichoke was 4.9 $dS.m^{-1}$ in a greenhouse experiment. Effects of salinity and responses of the plant are diverse and there are several reports in relation to the negative effects of salinity stress on forage crops (Li et al., 2010; Niu et al., 2012; Cornacchione and Suarez, 2017). On the other hand, forage quality of some plants such as *Paspalum vaginatum, Thinopyrum ponticum,* *Cynodon dactylon, Beardless wildrye* and *Medicago sativa* has been improved under salt stress (Suyama et al., 2007). In addition, Ferreira et al. (2015) found that salinity slightly improved forage parameters of alfalfa by significantly increasing crude protein, the net energy of lactation and the relative feed value.

Although artichoke is placed in the moderately salt-tolerant category during the vegetative stage (Francois, 1995; Saleh et al., 2005), but bud yield and quality of this plant highly negatively affected by salinity (Francois et al., 1991; Graifenberg et al., 1993 and 1995; Vincenzo et al., 2000; Saleh et al., 2005). Bahreininejad (2016) indicated that increasing salinity levels caused a significant reduction in vegetative growth characters and days to blooming, flowering and maturity of artichoke plants.

Several researchers have evaluated the effects of salinity on germination and seedling growth of artichoke at laboratory conditions (Mauromicale and Licandro, 2002; Kian, 2009; RezvaniMoghaddam et al., 2011 ,Gholizadeh et al., 2016), but little information is available on the effects of salinity on the forage quality indices of this plant under field conditions. Hence, the aim of the present experiment was to evaluate the effect of saline irrigated water on forage quality and quantity of artichoke.

MATERIALS AND METHODS

Experimental Site

This field experiment was conducted at Roodasht Salinity Research Station, Isfahan Agricultural and Natural Resources Research and Education Center (65 km east of Isfahan, 32°29'N, 52°11'E, 1560 m asl), Iran during 2013-2015. The soil and water characteristicsat the experimental site are presented in Table 1 and Table 2, respectively.

Design and Treatments

The salinity treatments comprised four concentrations (4, 8, 12 and 16 $dS.m^{-1}$) of saline water. These irrigation water treatments were obtained by mixing two sources of waters shown in Table2, river and surface well water. A randomized complete block design (RCBD) with three replications was used. Although soil salinity was very high (Table 1), it was alleviated by three consecutive heavy irrigation with river water just after planting in the first year of growth.

Soil Preparation and Sowing of Seed

A cultivar of artichoke (*Cynara cardunculus* var. *scolymus* Hayek), from Isfahan Agricultural and |Natural resources Research and Education Center, Isfahan, Iran, was used in this study. Plot size was 5×3 m. Each plot consisted of five rows, five m long with 60 cm spaced between rows and 30 cm distance between artichoke plants on the rows. Plant density was four plants/m^2. Fertilizers were applied prior to planting at a rate of 100 kg N ha^{-1} from urea and 80 kg P_2O_5 ha^{-1} from triple superphosphate sources. Sowing was performed in late March 2013. In order to prevent any loss in plant establishment, saline water was applied only with low stress (4 $dS.m^{-1}$) in the first year of cultivation. Salinity treatments began at 6 leaf stage in the second year and continued until harvest. Weeds were controlled by hand at the 3-8 leaf stage. Plants used for the forage quality measurements were harvested at the heading stage in the second year (June, 2014).

Measured Quantity and Quality Traits

Plant fresh weight (FW), plant dry weight (DW), crude protein (CP), water-soluble carbohydrates (WSC), neutral detergent fiber (NDF), acid detergent fiber (ADF), dry matter digestibility (DMD), total tannins (TT) and ash content were determined.

After harvesting, plant fresh weights were taken immediately and due to the large volume of the samples they were dried at room temperature at first, then to reach a constant dry weight they were put in oven at 65 °C for 48 h until. Dried samples were ground to pass a 1 mm screen for chemical analysis. Nitrogen content was analyzed by the micro-kjeldahl method and protein content was determined as N content multiplied by 6.25 (Horwitz, and Latimer, 2007). ADF and NDF were determined by Fibertec (Fibertec System Tecator) (Van Soest, 1994). The calibration of NIR was done for analyses and the calibration equation was developed using multiple linear regression with the high coefficient of determination and the lowest standard error of prediction (Jafari et al., 2003). Ash content, dry matter digestibility (DMD) and water-soluble carbohydrate (WSC) were measured by near-infrared spectroscopy (NIR Inframatic 8620). Total tannin (TT) was measured according to the methodology described by Makkar (2003).

Table 1. Some physicochemical parameters of the experimental site of this study

Soil texture	Clay	Silt	Sand	Total N (%)	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	Organic carbon (%)	pH	EC ($dS.m^{-1}$)
Silt clay	43	41	16	0.07	11.6	260	0.7	7.4	18.6

Table 2. Chemical analysis of irrigation water resources used in the experiment of this study

Irrigation water resources	pH	EC ($dS.m^{-1}$)	HCO_3^-	SO_4^{--} meq/l	Cl^-	Ca^{+2}+Mg^{+2}	Na^+	SAR
River water	7.5	1.8	1.8	4	4	9	11	1.56
Surface well	7.9	17.9	5.2	217.8	142	56	162.8	2.4

Statistical Analysis

Analysis of variance was conducted usingthe GLM procedure of SAS software ver. 8.2 and the means compared by Fisher's LSD test at $P \leq 0.05$ unless mentioned otherwise.

RESULTS AND DISCUSSION

Plant Fresh Weight (FW)

Statistical analysis showed that irrigation with saline water significantly reduced plant fresh weight (Table 3). The maximum fresh weight (51551kg ha^{-1}) was achieved by using the minimum salinity level (EC=4 $dS.m^{-1}$). This trait decreased by 34, 34 and 54 % when water salinity increased from 4 to 8 $dS.m^{-1}$, 4 to 12 $dS.m^{-1}$, and 4 to 16 $dS.m^{-1}$, respectively (Table 4).

Plant Dry Weight (DW)

Results showed that there was a negative effect of salt stress on artichoke dry weight (Table 3). The minimum salinity level had the highest plant dry weight with 9000 kg ha^{-1}. The dry weight reduced by 31, 33 and 44 % in the treatments of 8, 12 and 16 $dS.m^{-1}$, respectively, compared to treatment of EC=4 $dS.m^{-1}$. The DW of treatments of 12 and 16 $dS.m^{-1}$ had no statistically significant difference and were in the same statistical group (Table 4).

Irrigation with saline water significantly reduced plant fresh weight and plant dry weight in artichoke. These findings are in agreement with those of other researchers who reported that salinity stress caused significant reduction in plant biomass (Munns and Tester, 2003; Rezaei et al. 2017; Akrami et al. 2018; Ebrahim et al. 2019). It was also shown that several factors, such as leaf area loss, increased respiration, turgor reduction, rising osmotic adjustment costs and salt uptake and excretion at higher salinity levels led to a reduction in plant weight (Ramos et al., 2012). Tunçtürk et al. (2011) noted that when the osmotic potential occurred by salt, the root cells did not obtain the required water and the uptakes of some mineral nutrients dissolved in water were also limited. Thus, plant growth was inhibited due to the occurring defect in metabolism. Many authors have pointed out that salinity could affect negatively growth and plant yield. Bahreininejad (2016) reported that irrigation water salinity significantly reduced the plant height, fresh and dried aerial part yield and dry to fresh weight ratio in artichoke plant. In other research, salinity stress decreased significantly root dry weight and shoot dry weight of artichoke in laboratory conditions (Jorenush and Rajabi, 2015). Cornacchione and Suarez (2015) evaluated the effect of salinity continually from emergence to mature plant growth in Alfalfa (*Medicago sativa* L.) at successive harvests. They noted that the dry weight per plant decreased in the first harvest as salinity increased. Salinity level from 1.5 to 7 $dS.m^{-1}$ increased the plant dry weight of *Kochia scoparia* slightly but with salinity over 7 $dS.m^{-1}$ and up to 35 $dS.m^{-1}$, plant dry weight decreased significantly (Salehi et al., 2009).

Table 3. Analysis of variance for growth parameters and forage quality indices of artichoke

Source of variable	df	Mean squares (MS)								
		FW	DW	CP	DMD	WSC	NDF	ADF	Ash	TT
Replication	2	39794585	847106.87	7.941	78.2	29.23	1644	499.01	50.85	27.04
Salinity	3	404560379**	8644522.23**	782.53 **	1534.759 *	6.07 ns	1201.78*	1834.3 **	464.01 **	7.60 **
Error	6	6334960	227353	54.76	156.27	20.56	112.71	47.96	25.87	0.72

**significant at 1%,* significant at 5%, ns: not significant, FW: Plant fresh weight, DW: Plant dry weight, CP: Crude protein, DMD: Dry matter digestibility, WSC: Water soluble carbohydrates, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, TT: Total tannins.

Table 4. Means (±SD) of growth parameters and forage quality traits of artichoke as affected by irrigation with saline water

Salinitylevels ($dS.m^{-1}$)	FW (kg ha^{-1})	DW (g/kg DM)	CP (g/kg DM)	DMD (g/kg DM)	NDF (g/kg DM)	ADF (g/kg DM)	Ash (g/kg DM)	TT	FW (kg ha^{-1})
4	51551^a ±5028.6	9000^a±952.63	151.7^b± 6.04	584.5^c± 10.2	630.8^a± 8.66	435.7^a± 5.65	183.7^c± 4.15	28.2^c± 0.69	4
8	34154^b±5028.6	6240.7^b±952.63	158.2^b± 6.04	595.2^{bc}± 10.2	615.8^{ab}± 8.66	408.6^b± 5.65	190.5^{bc} ± 4.15	30.1^b± 0.69	8
12	34072^b±5028.6	5988.9^{bc}±952.63	178.3^a± 6.04	613.2^{ab}± 10.2	598^{bc}± 8.66	393^{bc}± 5.65	198.5^b ± 4.15	30.4^b± 0.69	12
16	23521^c±5028.6	5055.6^c±952.63	185.1^a± 6.04	636.2^a± 10.2	585.1^c± 8.66	377.8^c± 5.65	212.6^a± 4.15	32.1^a± 0.69	16

Data expressed as the mean ± SD and means in the same column followed by different letter(s) are significantly different using LSD test (p≤0.05), FW: Plant fresh weight, DW: Plant dry weight, CP: Crude protein, DMD: Dry matter digestibility, WSC: Water soluble carbohydrates, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, TT: Total tannins.

Crude Protein (CP)

Salinity stress increased the crude protein of artichoke plant (Table 3). The highest CP content was obtained at 16 $dS.m^{-1}$ with the value of 18.51 %. The treatments of 12 and 16 $dS.m^{-1}$ were grouped in the same statistical category. Also, there was no statistically significant difference between 4 and 8 $dS.m^{-1}$ treatments (Table 4).

According to results of this study, as salinity levels increased, CP content significantly decreased. It was reported that saline conditions had a marked effect on nitrogen metabolism in plants, producing direct effects on the synthesis rate of nucleic acids and proteins (Ashraf et al., 2018). Synthesis of alternative proteins and polypeptides might increase as a result of changes in gene expression due to salt stress response (Yang and Yen, 2002; Tester and Davenport, 2003). In agreement with the results of this study, different studies also reported that salinity stress increased the crude protein content of tested plant species. Nabati et al. (2015) studied the effect of different salinity levels (0, 10, 20, 30, 40, 50 and 60 $dS.m^{-1}$) on kochia (*Kochia scoparia*) at different growth stages (planting and early seedling) and gradually application salinity at the end of growth stage of this plant. They stated that applying saline water caused an increase in the crude protein content of Kochia forage. In another study, El Shaer (2010) noted that most of the salt-tolerant fodders attained reasonable CP under salinity conditions. Despite the results of many studies indicating a positive effect of salt stress on protein content, there were studies that presented a negative effect of salt stress. For example, Khosravinejad et al. (2009) applied salinity with 50, 100, 200, 300 and 400 mM NaCl on barley (*Hordeum vulgare* L.) and observed that sodium chloride reduced protein content in the plant seedlings. Decreasing of CP content of pearl millet fodder with an increased level of salinity from 0.6 $dS.m^{-1}$to 9 $dS.m^{-1}$ has also been reported by Makarana et al. (2017). In general, the protein content of forage crops can be affected negatively or positively by salt stress. The positive effects of salinity stress on other seed quality components such as oil content and fatty acid compositions have also been reported in crop plants (Yeilaghi et al., 2012).

Dry Matter Digestibility (DMD)

There was a significant difference in dry matter digestibility of artichoke plant among different levels of salinity (Table 3). DMD values varied from 584.5 (4 $dS.m^{-1}$) to 636.2 g/kg DM (16 $dS.m^{-1}$) and there was an increasing trend with increasing salinity levels from 4 to 16 $dS.m^{-1}$. The treatments of 12 and 16 $dS.m^{-1}$were at the same statistical group by 613.2 and 636.2 g/kg DM, respectively, while there was no statistically significant difference between 8 and 12 $dS.m^{-1}$ treatments (Table 4).

Increasing DMD values with increasing salinity levels from 4 to 16 $dS.m^{-1}$could be due to the increasing CP content and decreasing NDF and ADF contents of artichoke over increasing salinity levels. Nabati et al. (2015) showed that increasing salinity at planting and early seedling stages increased the dry matter digestibility of kochia (*Kochia scoparia*). Ben-Ghedalia et al. (2001) reported that dry matter digestibility of ryegrass (*Lolium multiflorum*) improved with increasing salinity. Also, in another research, Boyd and Rogers (2004) stated that dry matter digestibility of chicory (*Cichorium intybus* cv. *Puna*) increased with increasing salinity levels.

Water-Soluble Carbohydrates (WSC)

Salinity treatments had no significant effect on water-soluble carbohydrates in plants (Table 3). The trend in WSC content was not consistent and varied from 147.7 to 151.1 g/kg DM. It was reported that water-soluble carbohydrates including monosaccharaides and oligosaccharides constituted a ready source of carbon skeletons and energy for microbial protein synthesis in animals (Fulkerson and Donaghy, 2001). Although previous studies reported that soluble sugars acted as alleviating factor for salt stress in plants (Bhattacharjee and Mukherjee, 2002) but it seems that these solutes do not play an essential role in the response to salt stress in artichoke plants. Several studies have been published on the effect of salinity on water-soluble carbohydrates in forage crops. Teimouri et al. (2009) and Chaparzade (1996) showed that soluble carbohydrates decreased under salinity stress in three *Salsola* species and in alfalfa, respectively. Bavei et al. (2011) noted that the salt-tolerant cultivar of sorghum showed an increase in WSC content under salt stress. Khodary (1992) stated that carbohydrate content increased in wheat and sorghum plantlets by the increase of NaCl. Salinity resulted in higher accumulation of carbohydrate in pearl millet (Makarana et al.,2017).

Neutral Detergent Fiber (NDF)

Increasing salinity levels significantly (*P*≤0.01) decreased NDF content of artichoke plant (Table 3). The treatment of 8 $dS.m^{-1}$ had no significant difference with 4 and 12 $dS.m^{-1}$ treatments. Also, the treatment of 12 $dS.m^{-1}$ was at the same statistical group with 8 and 16 $dS.m^{-1}$(Table 4).

The reduction in NDF content of the artichoke plant under salinity stress may be due to a decrease in plant growth. It was reported that NDF consisted of cellulose, hemicellulose and lignin which are affecting the rate of digestion of feeds (Attia-Ismail, 2016). Dado and Allen (1995) mentioned that the higher value of NDF (more than 30-35 %) could restrict dry matter intake in livestock, while Russel et al. (1992) stated that its lower values (lower than 20-25 %) could decrease bacterial yield. Various results were reported in other plants under salinity stress. Neutral detergent fiber of Russian thistle (*Salsla iberica* Sennen and Pau) plants decreased linearly with increasing salinity (Fowler et al., 1992). Al-Dakheel et al. (2015) assessed the effect of three irrigation water salinity levels (5, 10, 15 $dS.m^{-1}$) on the nutrient composition of selected Buffel grass (*Cenchrus ciliaris* L.) accessions. They reported that NDF increased as salinity in irrigation water increased from lower to medium level (5–10 $dS.m^{-1}$) while, the NDF content might be reduced or increased in response to a salinity of more than 10 $dS.m^{-1}$. Ben-Ghedalia et al. (2001) reported that neutral detergent fiber of ryegrass (*Lolium multiflorum*) increased with increasing salinity. In general, different species showed a variable response to the salinity, though in this study artichoke showed an appropriate response to the increasing water salinity regarding forage quality.

Acid Detergent Fiber (ADF)

ADF showed similar trends with NDF in response to salinity stress. This parameter was also decreased with increasing salinity levels. The highest amount of ADF content (435.7 g/kg DM) obtained at 4 $dS.m^{-1}$. The treatment of 12 $dS.m^{-1}$ had no significant difference with 8 and 16 $dS.m^{-1}$ treatments (Table 4).

It seems that the reduction in ADF content of artichoke plant might be due to decrease in plant growth under salinity conditions. It was reported that ADF contained mainly cellulose and lignin but lacked hemicellulose (Van Soest, 1994). NDF and ADF represent the fiber in plant cell walls and ultimately determine forage quality. It was shown that low fiber content indicated higher feed digestibility for animal consumption (Grant et al., 2014). In a similar study, Bahreininejad (2016) stated that irrigation with saline water with an EC of > 12 dS.m^{-1} reduced artichoke growth. The obtained results of this study agreed with what some researchers had presented. Fowler et al. (1992) reported that the ADF concentration of Russian thistle (*Salsla iberica* Sennen and Pau) decreased with increasing salinity stress. Ferreira et al. (2015) who studied the response of alfalfa (*Medicago sativa* L.) to saline irrigation water noted that ADF % decreased under salinity stress.

Ash

Based on the obtained results of this study, total ash increased significantly ($P \leq 0.01$) with increasing salinity levels (Table 3). The highest amount of ash (212.6 g/kg DM) observed in the treatment of 16 dS.m^{-1} while the treatment of 8 dS.m^{-1} had no significant difference with 4 and 12 dS.m^{-1} treatments (Table 4).

Significant increasing of the total ash with increasing salinity levels could be due to excessive absorption of salt under stress conditions. Some researchers have noted that the absorption of a large amount of salt under stress conditions in the above ground of the plant led to an increase in ash content. Pare et al. (2011) stated that the ash content of *Echinochloa pyramidalis* significantly increased with increasing level of salinity (2 to 9 dS.m^{-1}). Increasing the amount of ash in lucerne (*Medicago sativa* L.) and melilotus (*Melilotus albus* Medik.) have been reported under saline conditions (Guerrero-Rodriguez, 2006). In general, it was shown that salinity affected nutrient availability, competitive uptake, transport or partitioning within the plant (Grattan and Grieve, 1999).

Total Tannin (TT)

The results of this study showed that salinity increased the total tannin content ($P \leq 0.01$) of artichoke plant. The treatments of 16 dS.m^{-1} had the highest amount of tannin with the value of 32.1 g/kg DM, while no significant difference was observed between the treatments of 8 and 12 dS.m^{-1} (Table 4). Tannins are the anti-nutritional factor in forage crops and the high levels of these compounds might have a negative effect on forage quality (Makkar, 2003). Salinity increased the total tannin content of artichoke plant. These results agreed with what some researchers had presented. Nabati et al. (2013) in kochia ecotypes and Elfeel and Bakhashwain (2012) in *Acacia saligna* showed that the tannin content was increased with increasing irrigation water salinity.

CONCLUSIONS

This study showed that the growth and nutritive values of artichoke plant can be affected by different levels of water salinity. Plant growth traits, fresh and dry weights were greatly reduced at higher salinities. Increasing salinity levels caused significant reductions in NDF and ADF of this plant, while ash, CP, DMD and TT increased. Generally, forage quality increased as CP and DMD were increased, while NDF, ADF and tannin content were decreased. Despite with increasing in tannin content, salinity could enhance forage quality in artichoke. The highest amount of CP and DMD (as the advantages of forage quality) and the lowest amount of NDF and ADF (as the disadvantages of forage quality) were obtained at 12 and 16 dS.m^{-1}, which did not differ significantly in these two treatments. Overall, although increasing salinity decreased aerial part plant production, it could increase forage quality characteristics.

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تأثیر آب آبیاری شور بر کیفیت علوفه کنگرفرنگی (*Cynara cardunculus* var. *scolymus* L.)

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آب شور

تانن کل

چکیده-شوری تنش مهم غیرزیستی برای تولید محصولات زراعی در بسیاری از نقاط جهان است. برای ارزیابی تاثیر آبیاری با آب شور بر پارامترهای رشد و کیفیت علوفه کنگرفرنگی، آزمایش مزرعه‌ای در قالب طرح بلوک‌های کاملاً تصادفی با سه تکرار در مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی اصفهان، ایران طی سال‌های ۹۳-۱۳۹۱ انجام شد. تیمارهای مورد بررسی شامل چهار سطح شوری با آب آبیاری با هدایت الکتریکی ۴، ۸، ۱۲ و ۱۶ دسی زیمنس بر متر بود. وزن تر و خشک گیاه، پروتئین خام، کربوهیدراتهای محلول در آب، الیاف نامحلول در شوینده خنثی، الیاف نامحلول در شوینده اسیدی، قابلیت هضم ماده خشک، تانن کل و خاکستر درسال دوم رشد اندازه‌گیری شدند. نتایج نشان داد که حداکثر وزن تر (۵۱۵۵۱ کیلوگرم در هکتار) و وزن خشک (۹۰۰۰ کیلوگرم در هکتار) در تیمار شوری با آب آبیاری با هدایت الکتریکی ۴ $dS.m^{-1}$بدست آمد. افزایش سطح شوری باعث کاهش معنی‌دار میزان الیاف نامحلول در شوینده خنثی و الیاف نامحلول در شوینده اسیدی گیاه شد، درحالی‌که میزان خاکستر، پروتئین خام، قابلیت هضم ماده خشک و تانن کل افزایش یافت. تیمارهای شوری با آب آبیاری با هدایت الکتریکی ۱۲ $dS.m^{-1}$ و ۱۶ بیشترین میزان پروتئین خام و قابلیت هضم ماده خشک و کمترین میزان الیاف نامحلول در شوینده خنثی و الیاف نامحلول در شوینده اسیدی را داشتند. کمترین میزان تانن (۲/۲۸ g/kg DM)در تیمار شوری با آب آبیاری با هدایت الکتریکی ۴ $dS.m^{-1}$ مشاهده شد و بین تیمارهای شوری با آب آبیاری با هدایت الکتریکی ۸ $dS.m^{-1}$ و ۱۲ اختلاف معنی‌داری وجود نداشت. به طور کلی، نتایج نشان داد اگرچه با افزایش شوری عملکرد گیاه کاهش یافت لیکن توانست باعث افزایش خصوصیات کیفی علوفه شود.