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Effect of Salt Stress on Some Agronomical Characteristics and Essential Oil Content of Coriander (*Coriandrum sativum* L.) Cultivars

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Abstract
This study was carried out to investigate the effect of five different salt levels (0, 25, 50, 75, 100 mMol) on some agronomical traits and essential oil content of three coriander cultivars (Gürbüz, Kudret-K, Pel-Mus) in 3 greenhouse conditions in Adana, Turkey. In this research; plant height, number of umbrella/plant, number of seeds/umbrella, number of branches/ plant, seed weight/plant and essential oil rate were determined. The results indicated that growth and yield parameters and technological properties of coriander cultivars were affected by salt stress. Highest essential oil rate was obtained from Kudret-K cultivar with 75 mMol salt level.

Keywords: Coriander, salinity, esssential oil.

INTRODUCTION

Medicinal and aromatic plants are cultivated because of their active constituents which are used for different purposes [1]. Coriander which is an annual plant belonging to the family Umbelliferae and used as an aromatic and medicinal plant is cultivated mainly for its fruits and seeds. The medicinal plant is used as carminative, stimulant, diuretic, dyspeptic, antipyretic and antioxidant [2]. Coriander is believed to be a native plant of Egypt, Turkey, and East Mediterranean region. The major producers are India, Morocco, Canada, Pakistan, Romania and the former Soviet Union while Iran, Turkey, Egypt, Israel, China, Burma and Thailand are minor producers [3]. Coriander's fruits are also used for food ingredients (preperation of sausages, alcoholic beverages), cosmetics and parfumery [4]. The seeds are rich in polyphenols and essential oil [5].

Salinity is the most effective problem for crop production. Approximately 6 % world's land surface area suffers from salinity [6]. Furthermore, saline soils are major problems for cultivated lands in semi arid and arid areas. About 23% of the worlds ($1.5x10^9$ ha of cultivated) land is saline and 37% is sodic [7]. Depending on the increasing world population, it has become necessary to develop crops that can adapt to saline conditions. Some of the plants show significant tolerance or sensibility to the salinity. Coriander plants are moderately tolerant to salinity. Coriander can be grown in the soils up to 6 EC (dSm^{-1}) and 10 ESP (exchangeable sodium percentage). For ideal conditions, soils should have EC and ESP less than 2 dSm^{-1} and 5 dSm^{-1}, respectively [3]. The aim of this study was to investigate the effects of five salt levels (0, 25, 50, 75, 100 mMol) on three coriander cultivars (Gürbüz, Kudret-K and Pel-Mus).

MATERIAL AND METHOD

The experiment was conducted with 3 replications in greenhouse of Karaisalı Vocational School of Cukurova University in 06.03. 2014. Pots were filled up with peat and pearlite. The all cultivars germinated on 18.03.2014. During the seedling formation the all pots were irrigated with stock solution once a week. Stock solution was prepared at pH: 5.5-5.7 EC: 1.5-1.8 N= 172 ppm, P= 53 ppm, K= 330 ppm, Ca= 120 ppm, Mg= 50 ppm .
Ingredients of nutrient solution were as follows; macro elements: $Ca(NO_3)_2$: 614g, KNO_3:421, NH_4NO_3:69, Fe-EDDHA(Sequestrin) micro elements: $ZnSO_47H_2O$:5.6, Borik acid:5.16, $MnSO_4$:5.50, $CuSO_47H_2O$:1, $(NH_4)6Mo_7O_{24}$:2.4/10liter. 30 days after sowing 25, 50, 75 and 100 mM NaCl were added to the nutrient solution. The other days plants were regularly irrigated with distilled water. Plants of height were measured all the replicates. Number of branches/plant, number of umbrella/plant, number of seeds/ umbrella were counted each treatments all 3 replicates. The plants were harvested on 30.05.2014. The all data regarding the characteristics studied were obtained before harvest. Seeds were weighed per/plant.

Extraction of the essential oils

Seeds of the plants were separated and dried at 35°C after harvest. Dry seeds materials (10 g) were subjected to a 3-h water-distillation by using a Neo-Clevenger apparatus. The extracted essential oils were stored at 4°C until GC analysis. Essential oil rates in plants were determined by using volumetric (ml/100 g) [8].

Data were subjected to analysis of variance for each parameter. All data were analyzed by computer software (Standard ANOVA analysis). The means were compared by using the LSD test described by Steel and Torrie [9].

RESULTS AND DISCUSSION

Plant Height

Plant height was affected from salinity levels x cultivars interaction ($p<0.01$) significantly. The maximum plant height was obtained from Kudret-K cultivar with 77cm in control plants. Data in Table 1 showed that, plant height decreased significantly with increasing salinity levels. Salinity is a limiting factor in plant production [10]. Our results were higher than that of other researchers [11-12], this difference is thought to result from salt application in different plant growth period.

Table 1. Effects of salt stress on plant height, number of branches/ plant, number of umbrella/plant, number of seeds/ umbrella and seed weight/plant of Coriander (*Coriandrum sativum* L.) Cultivars

Plant height						
	Salt dozes (mMol)					
Cultivars(C)	**0**	**25**	**50**	**75**	**100**	**Mean**
Gürbüz	68.00	63.00	57.00	53.00	44.00	57.00
Kudret-K	77.00	57.67	55.00	51.67	40.00	56.26
Pel-Mus	65.00	57.00	55.67	53.67	50.67	56.40
Mean	70.00	59.22	55.89	52.78	44.89	
LSD (%1)	C:ns		S:2.316**		CxS:4.011**	
number of branches/ plant						
Gürbüz	9.67	9.00	6.67	6.33	5.00	7.33
Kudret-K	8.67	6.67	6.33	6.00	5.67	6,67
Pel-Mus	12.33	7.67	7.67	6.67	5.67	8.00
Mean	10.22	7.78	6.89	6.33	5.44	
LSD(%1)	C:0.520**		S:0.671**		CxS:1.162**	
number of umbrella/plant						
Gürbüz	17.00	12.33	8.67	5.67	5.33	9.80
Kudret-K	18.67	14.00	11.33	8.67	6.00	11.73
Pel-Mus	17.67	15.33	14.67	11.33	10.67	13.93
Mean	17.78	13.88	11.55	8.55	7.33	
LSD (%1)	C:1.039**		S:1.342**		CxS:2.324**	
number of seeds/ umbrella						
Gürbüz	14.00	11.66	12.33	7.00	2.67	9.53
Kudret-K	12.00	11.00	8.66	8.33	6.67	9.33
Pel-Mus	16.00	11.66	10.66	9.33	7.67	11.06
Mean	14.00	11.44	10.55	8.22	5.67	
LSD (%1)	C:0.900**		S:1.162**		CxS:2.013**	
seed weight/plant						
Gürbüz	2.26	2.23	1.68	0.56	0.01	1.35
Kudret-K	3.62	3.55	3.07	2.54	2.04	2.96
Pel-Mus	5.03	4.35	3.68	2.64	2.33	3.61
Mean	3.63	3.37	2.81	1.91	1.46	
LSD (%1)	C:0.257**		S:0.332**		CxS:0.576**	

*: $p<0.05$ **:$p<0.01$ ns:nonsignificant

Table 2. Effects of salt stress on essential oil rate/plant of coriander (*Coriandrum sativum* L.) cultivars.

Cultivars (C)	Salt dozes (mMol)				
	0	**25**	**50**	**75**	**100**
Gürbüz	0.50	0.45	0.39	0.33	-
Kudret-K	0.45	0.75	0.55	0.85	0.32
Pel-Mus	0.40	0.42	0.49	0.32	0.77

Number of branches/plant: The salinity x cultivar interaction affected the number of branches /plant significantly ($p<0,01$). The data showed that the number of branches/plant decreased in all cultivars except for Pel-Mus with increasing salinity levels. Our results are in agreement with the other researcher's results who studied with coriander [13-14]. Gürbüz cultivar's salt tolerance decreased after 50 m Mol NaCl. Otherwise, Kudret-K and Pel-Mus cultivars had different tolerance mechanisms amongst them. These cultivars were divaricated lateral growth in salinity condition

Number of umbrella/plant: There were significant differences among the cultivars in terms of number of umbrella/plant (Table 1). The maksimum umbrella /plant was obtained by Kudret-K in control plants (18.67/plant). Also, Abd el Wahab [15] (fennel) and Nabizadeh et al [16] (cumin) mentioned that increasing salt concentrations caused a significant reduction in the number of umbrella/plant. Our results decreased too, but especially Pel-Mus cultivar demonstrated great performance at 100 mMol salinity levels for number of umbrella/plant

Number of seeds/ umbrella: Number of seeds/umbrella is very important character for Umbelliferae family plants such as in coriander. Number of seed/umbrella was affected from salinity level x cultivar interaction ($p<0,01$) significantly (Table 1). Number of seeds per umbrella ranged between 16 and 2.67 seeds per plant. Morphological parameters such as number of seeds/umbrella varied up to 100 mMol salinity levels for Kudret-K and Pel-Mus cultivars. In other words, coriander cultivars except Gürbüz can tolerate NaCl salinity up to the concentration of 100 mMol. Data showed that salinity had significantly affected vegetative growth increasing level of salt caused severe decrease in all parameters like number of seeds per umbrella. Our findings were similar to the results studied by cumin [17

Seed Weight/plant: The salinity x cultivars interaction affected the seed weight/plant significantly ($p<0,01$). According to the seed weight/plant data, the maximum seed weight was obtained from the control plants of Pel-Mus cultivar (5.03g/plant). Salinity is one of the most important limiting factor for production. The seed yield parameter is a important criteria for coriander cultivation. cultivars can be classified as salt sensitive, salt resistant or having great performence to salinity. All cultivars were affected from the salt levels, seed weight significantly decreased. It was found that Pel- Mus cv. was less affected from salt levels as compared with other cultivars (Table 1) Similar results reported by the researchers Semiz et al. [18] (fennel); Ewase et al.[11] (Coriander).

Essentiol oil rate/plant: Essentiol oils are important secondary metabolities in medicinal plants. Some researchers [1] reported that essential oil concentration production and main constituents of medicinal plants can be increased. Olle and Bender [19] reported that coriander fruit contained 0,2-1.5% of volatile oil and its characteristic aroma was due to linalool (60-70 %). Neffatti and Marzouk [20] mentioned that essential oil yield of coriander increased significantly up to 18 and 43 % at 25 and 50 mMol NaCl treatment respectively, under high salinity conditionals it decreased. Essential oil rates varied from 0.32 to 0.85 % all cultivars. The highest essential oil content was obtained from Kudret- K cultivars with 75 mMol NaCl concentration (Table 2). Our results were similar to the findings studied by Matricaria recutita [21]. Although, Jouyban [22] mentioned that the content of some secondary plant products is significantly higher in plants grown under salt stress than in those cultivated in normal conditions.

In conclusion, plant growth parameters and seed weight decreased while the salinity levels increased. The essential oil rates of cultivars differed according to the salt concentrations. For an example, essential oil rate of Gürbüz cv. regularly decreased according to the increasing NaCl levels. Especially under stress conditions medicinal and aromatic plants have been produced higher secondary metabolities such as essential oil. As shown our results, the essential oil rates in Kudret-K and Pel-Mus cultivars increased while the salt levels increased.

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