Asian Journal of Chemistry Vol. 19, No. 5 (2007), 4083-4092

Effect of Potassium Fertilization on Lettuce's (*Lactuca sativa* L.) under Different Sodium Media

YUSUF UÇAR*, ABDULLAH KADAYIFCI†, IBRAHIM ERDAL‡, GÖKHAN I. TUYLU†
and ULAS SENYIGIT
Department of Farm Structure and Irrigation, Faculty of Agriculture
University of Süleyman Demirel, 32260 Isparta, Turkey
Fax: (90)(246)2371693; Tel: (90)(246)2114654; E-mail: yucar@ziraat.sdu.edu.tr

The aim of this study was to determine the effect of potassium fertilization on the yield parameters and evapotranspiration of lettuce (*Lactuca sativa* L.) on the growing media contained different Na^+/K^+ rate. The study was carried out as pot experiments with three replicate under the greenhouse conditions. The growing media was constituted of perlit deprived on chemicals. At the beginning of the experiment, nutrients necessary for growing of the plants were applied to the media in order to obtain the optimum growing conditions in all treatments. Four different growing media were constituted of Na^+/K^+ rates with 0, 0.5, 1.0 and 2.0 value and the K^+ fertilization was applied as 10, 30, 50 and 70 mg kg^{-1}, respectively. During experiment, irrigation water was applied to prevent yield diminishing caused by water deficit and evapotranspiration were calculated by water-budget equation. Based on the results, there were found statistical significant differences at $p \leq 0.01$ confidence level throughout yields, lengths and surface diameters of lettuce (*Lactuca sativa* L.). For experiment conditions, lettuce's yields were decreased in significant level by increasing of Na contents in growing media. Therefore, fertilization especially in the level of K3 and K4 increased the yield in significant level in the growing media contained high rate of Na^+. On the other hand, K^+ fertilization was determined to tolerate Na^+ dosage. Although statistical significant difference were found at $p \leq 0.01$ confidence level in water consumption between treatments, there was statistical insignificant relation between Na^+ content and evapotranspiration. On the other hand, evapotranspiration was not influenced by excess Na^+ in growing media. Because, growing media were constituted from perlit and its structure was not spoiled by Na^+ effect as soil.

Key Words: Growing media, Sodium, Potassium fertilization, Lettuce, Water consumption.

†Department of Structure Education, Faculty of Technical Education, University of Süleyman Demirel 32260 Isparta, Turkey.

‡ Department of Soil Science, Faculty of Agriculture, University of Süleyman Demirel, 32260 Isparta, Turkey.

INTRODUCTION

The studies about soil salinity and salt distribution problems in the irrigated agriculture in arid and semi-arid area have increased in the world. One of the important subjects of salinity management in irrigation is to find answer to questions of which level of salinity could be allowed and which one of the necessary management precautions would be taken in the result of decreasing of water source quality.

In the agricultural areas where the uncontrolled irrigation exist, it can not be avoided to be formed some soil problems (salinity, sodium, saline-sodium, bore etc.). To continue agricultural practice in that areas *i.e.*, improving (or performing) of soils, establishing and/or improving field developing services, using high efficient irrigation methods and controlled irrigation, growing suitable plant varieties and some biologic and chemical precautions should be taken in order to eliminate problems.

Generally, plants grown under salinity meet two important problems. First, reducing of plant water potential because of increasing osmotic pressure depend on high salt content on the soil extract. Another is high concentration of injurious ions such as Cl^- and Na^+ and imbalance of ion concentrations. Na^+ and/or Cl^- toxicity can be appeared in the plant due to gathering of these factors. In spite of this, K^+ and Ca^{2-} deficiencies occur[1]. Under salt stress, excessive cumulated Na^+ in the plants prevents K^+ uptake[2] and Cl^- effects on NO_3^- uptake negatively and causes to change ion balance[3,4].

Another reason of observed growing recession of plants under salt condition is prevention of nutrient uptake, transfer and use. In addition, leaf water potential and leaf area of plant change and stable yield decrease occurs after a point of salt level[5]. As an example, it has been determined that the growing recession, observed for barley growed in a media with salt and low Mn concentration was caused by Mn deficiency related to salt[6]. Increased salt concentration in cotton grown in a soil contained poor phosphate decreased P uptake and its activity[7]. It is revealed that use-rate of P in the tomato's leaves decreases to half when salt amount in media increases from 10 mmol to 50 and 100 mmol[8]. Another similar studies determined that spinach planted under salt stress required two times more K^+ amount according to normal conditions[9], despite soil salinity increases Mn and Zn amount, decreases Fe and Cu amount in stem and leave of maize and barley[10,11] Ca, P and Fe amount increased with increased salt concentration and Mn amount is not changed in stem and leave of groundnut[12]. Nevertheless, plant tolerate to salt is related to limitation in Na^+ uptake and K^+ takes an important role in this limitation. Plants which have toleration of salinity take more K^+ than sensitive plants and tolerate to salt of plants are increased with increased K^+/Na^+ rate in plant[13,14].

It is claimed that, plant growth metabolism could be increased by K^+ in the plant under salinity[15]. In the several studies, the role of K^+ is clearly emphasized to stable turgid pressure[16-18].

In the study, effects of K^+ fertilization applied to growing media under different Na^+/K^+ rate on lettuce's growth, yield and evapotranpiration were aimed to determine.

EXPERIMENTAL

The study was carried out as pot experiments with three replications under greenhouse conditions in Suleyman Demirel University. First, lettuce seeds were rooted in viols, then, transferred to the plastic pots which have 45 cm diameter, 48 cm deep and lettuce plants are grown there. Experiment pots were placed on the tables in dimension of 0.75 × 3.00 × 0.42 m. In order to obtain drained water amount, another pots were put under experiment flowerpots which have 36.5 cm deep and 35.5 cm diameter. The same perlites amount, deprived of chemicals was placed into the experiment pots. High Na^+ concentration in the soil has both effects to plants toxically and soil conditions negatively. Soils with high Na^+ amount existent in its texture, show oily appearance. Soil colloid is expanded, soil pore is plugged, air and water permeability of soil are reduced, pH value of soil extract are increased by injurious Na^+ level in soil. Thus, it blocks plant water uptake from soil and reduces plant water consumption (ET). In this experiment, using perlites in the growing media was anticipated both possible negative effects in the media and effects source from water could not be taken by plant in determination of crop yield would be removed.

Beginning of the study, optimal conditions necessary for plant cultivation were provided. For this reason, required nutrient amounts of lettuce were calculated and applied to all pots before planting[19]. Required temperature and humidity for plants in the greenhouse were provided.

First irrigation was done available water reach till to field capacity in all trial pots, then, in following irrigations, measured irrigation amount that was more than needed (taking care no excessive leaching) were applied in order to determine irrigated and drained water amount. Evapotranspiration between preceeding irrigation date and that day irrigation date were calculated from water budget eqn. 1.

$$ET_{i-(i-1)} = (I_i - Dp_i)/(\rho_w A) \qquad (1)$$

In equation, $ET_{i-(i-1)}$ is evapotranspiration between i and i-1 th days (mm), I_i and Dp_i are applied irrigation water and drained water amount in i th day (L), ρ_w is intensity of irrigation water and A is surface area of flowerpot (m^2).

Drained water was added into irrigation water not to change plant nutrient matter and/or salt content in trial pot. Furthermore, base and acid level in growing media were always observed with pH meter and growing media were kept under control as well as done.

Variance analysis for obtained yield parameters of treatments, Duncan test for classification of treatments, regression equality for the relations between applied water, measured evapotranspiration and yield parameters were used statistically[20].

In the study, 16 experiment treatments were constituted of 4 different growing media belong to different Na^+ content and 4 different K^+ fertilizing. These are:

Growing media

Several researchers determined that, for a good cultivation, Na^+/K^+ rate mg kg^{-1} in growing media should be < 1 except specific requirement of plants. Therefore, growing media were arranged as different Na^+/K^+ rate. These are:

-Na0 : Na^+/K^+ rate: 0.0 (Na^+ = 0 mg kg^{-1}, reference treatment for growing media)

-Na1 : Na^+/K^+ rate: 0.5 (Na^+ = 15 mg kg^{-1})

-Na2 : Na^+/K^+ rate: 1.0 (Na^+ = 30 mg kg^{-1})

-Na3 : Na^+/K^+ rate: 2.0 (Na^+ = 60 mg kg^{-1})

However, in all of the growing media, required nutrients by plants were supplied.

K^+ Fertilization

Amount of required K^+ by lettuce[17] is 10 mg kg^{-1}. Treatments planned that taking base of that value (10 mg kg^{-1}) to determine the amount of K^+ applied to the growing medium with different Na^+ content are such as the following;

-K1 : 1 × K1 (K^+ = 10 mg kg^{-1}, reference treatment for fertilizing)

-K2 : 3 × K1 (K^+ = 30 mg kg^{-1})

-K3 : 5 × K1 (K^+ = 50 mg kg^{-1})

-K4 : 7 × K1 (K^+ = 70 mg kg^{-1})

RESULTS AND DISCUSSION

Treatments, lettuce yields, effects of K^+ fertilizing on yield in similar growing media and effects of Na^+ content on different growing media and Duncan classifications were given in Table-1. As seen in Table-1, significant differences were found statistically throughout the treatments for lettuce's yields at $p \leq 0.01$ level. Maximum and minimum yields were obtained in Na0K2 (average 319.6 g/pot) and Na3K1 (average 187.3 g/pot), respectively.

TABLE-1
TREATMENTS, LETTUCE YIELDS, EFFECT OF K^+ FERTILIZING TO RATE OF YIELD INCREASE IN SIMILAR GROWING MEDIA AND EFFECT OF Na^+ CONTENT TO RATE OF YIELD INCREASE IN DIFFERENT GROWING MEDIA

Treatments	Lettuce yields (g/pot)					Effect of K^+ to rate of yield increase on similar growing media (%)		Effect of Na^+ content to rate of yield decrease on different growing media (%)	
	A	B	C	Average					
Na0K1	281.3	275.7	235.7	264.2	abcd**	-	ns	-	a**
Na0K2	292.6	367.4	298.8	319.6	a	21.0	ns	-	a**
Na0K3	309.3	313.5	294.0	305.6	ab	15.7	ns	-	a*
Na0K4	310.1	303.8	332.1	315.3	a	19.3	ns	-	a*
Na1K1	255.4	270.9	232.8	253.0	bcde	-	ns	4.2	a**
Na1K2	306.2	258.7	276.9	280.6	abc	10.9	ns	12.2	a**
Na1K3	281.7	299.6	271.5	284.2	abc	12.3	ns	7.0	ab*
Na1K4	276.6	287.0	250.4	271.3	abc	7.2	ns	14.0	b*
Na2K1	201.9	193.0	228.9	207.9	ef	-	b*	21.3	ab**
Na2K2	221.6	205.3	197.4	208.1	def	0.1	b	34.9	b**
Na2K3	232.7	282.0	315.5	276.7	abc	33.1	a	9.5	ab*
Na2K4	284.3	281.8	255.2	273.8	abc	31.7	a	13.2	b*
Na3K1	208.6	196.5	156.8	187.3	f	-	b**	29.1	b**
Na3K2	201.7	203.8	203.1	202.9	ef	8.3	b	36.5	b**
Na3K3	242.4	251.5	215.6	236.5	cdef	26.3	b	22.6	b*
Na3K4	299.7	302.1	273.5	291.8	abc	55.8	a	7.5	ab*

$^{**}p \leq 0.01$, $^{*}p \leq 0.05$

Relations between lettuce yield and K^+ fertilizing in treatments with similar Na^+ content are shown in Fig. 1. A linear relation was obtained between yield and K^+ fertilizing in all treatments. In other words, increasing of K^+ fertilizing increased the lettuce's yield in all growing media. But, this increasing slope occurred quite lower in Na0 and Na1 (13.93 and 5.85%) than Na2 and especially Na3 (26.63 and 34.71 %). In spite of K^+ fertilizing increased yield in rate of 15.7-21.00 % (average 18.7 %) in Na0 and 7.2-12.3 % (average 10.1 %) in Na1, this increasing was not found significant statistically. Although significant yield increasing was observed in K2 level, increasing of the level of potassium more than this level did not caused significant change in yield. Therefore, it can be stated that in the growing media where Na^+ content is relatively lower, increasing of K^+ fertilizing more than required does not provide increasing on the yield significantly. However, it was determined that the effect of K^+ to increase the yield was important on the level of $p < 0.05$ and $p \leq 0.01$ statistically in the treatments of Na2 and Na3, respectively, where the Na^+ is more effected negatively. This increasing level mentioned were 0.1-33.1 % (average 21.6%) and 8.3-55.8 % (average 30.1 %) for Na2 and Na3, respectively. Therefore, for experiment conditions, it can be said that fertilization especially on the level of K3 and K4 in the growing medium with high Na^+ content increased yield significantly, in other words K^+ fertilizing tolerated negatively effect of Na^+.

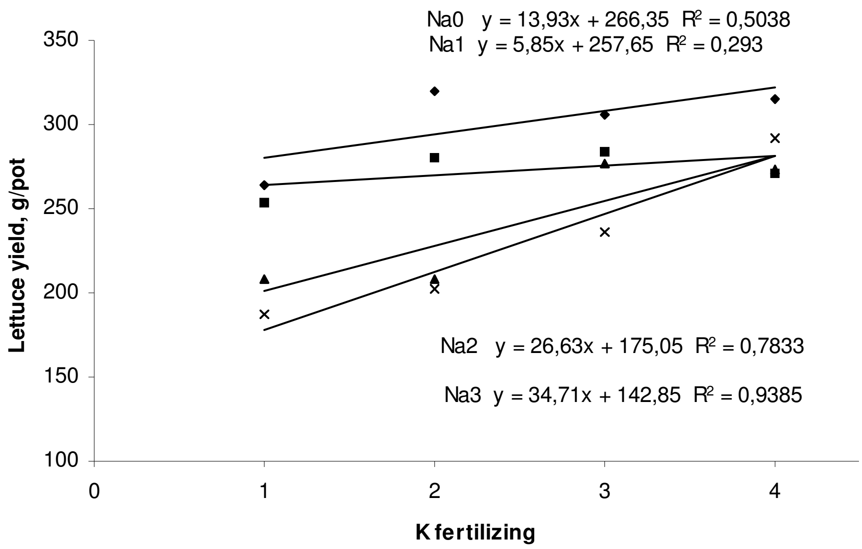

Fig. 1. Effect of K^+ fertilizing on lettuce's yield in similar growing media

Effect of change in Na^+ level in growing media on the lettuce's yield was shown in Fig. 2. As seen in Fig. 2, a linear relation was determined between increasing of Na^+ level and yield reducing in all treatments. Slopes of this relation in K1, K2 and K3 treatments were obtained as -27.58, -42.26 and -21.48, respectively. But, this value in K4 treatment were determined as -6.8.

Significant differences obtained between Na^+ level and lettuce's yield at $p \leq 0.01$ level for K1 and K2, at $p \leq 0.05$ for K3 and K4 and Duncan classifications were shown in Table-1. As seen in Table-1, lettuce's yield in K1, K2, K3 and K4 were decreased in rate of 4.2-29.1 % (average 18.2 %), 12.2-36.5 % (average 27.9 %), 7.0-22.6 % (average 13.0 %) and 7.5-14.0% (average 11.6 %), respectively. Nonetheless, reducing for obtained yield in increment level of Na^+ in the growing media was similar as well in K1, K2 and K3 treatments, but quite low in K4 treatment.

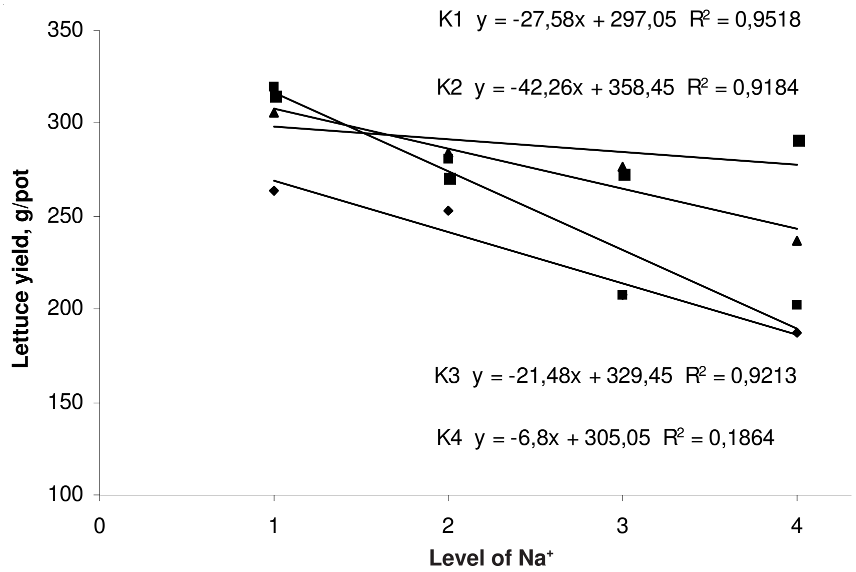

Fig. 2. Effect of Na^+ level in growing media on lettuce's yield

In nourishment media with Na^+, plant growth was effected positively by adding K^+ with increment doses. This situation was seen with increasing of plant K^+ concentration with increment K^+ doses and decreasing of Na^+ concentration (Table-2). As understood from this, K^+ application with increment doses prevented Na^+ damage for plant until a level. This event could be related with plant metabolism which is planted in salinity condition increased by K^+ and salt toleration of plant was increased with increment of K^+/Na^+ rate[15]. A reason of observed[6] growth regression in salinity conditions could be indicated that impede uptake, remove and use of another nutrient matters together with K^+.

Height and surface diameter values belong to lettuce and Duncan classifications found from variance analyses were shown in Table-3. A significant differences were determined between the treatments for plant heights and surface diameters at $p \leq 0.01$ level statistically. Maximum plant height (average 16.9 cm) was obtained from Na0K2 and Na0K3 treatments and, also, minimum plant height (average 8.8 cm) was obtained from Na3K1. Maximum and minimum width of plant surface diameter were observed from Na2K3 (average 27.3 cm) and Na1K1 (average 11.3 cm) treatments, respectively. From these values, it can be concluded that plant heights and surface diameters increased with increment of K^+ fertilization, also, plant heights were relatively shorter in the treatments contained high Na^+ level. But, there was no linear relation between changing of Na^+ content and plant surface diameter.

TABLE-2
UPTAKING K AND NA FROM GROWING MEDIA, K AND Na IN LETTUCE'S PLANTS AND DRY MATTERS

Treat-ments	K^+ in lettuce's plants (%)					Na^+ in lettuce's plants (%)				
	K1	K2	K3	K4	Average	K1	K2	K3	K4	Average
Na0	5.97	6.65	7.94	8.24	7.20b*	6.90	7.00	6.90	6.10	6.70c
Na1	7.74	9.10	6.77	8.58	8.04a	6.50	7.00	8.30	8.30	7.50b
Na2	7.00	7.46	6.90	6.68	7.01b	7.70	8.30	7.60	7.60	7.80b
Na3	6.25	8.70	5.83	6.58	6.84b	7.60	8.20	8.80	8.70	8.30a
Average	6.74c	7.97a	6.86c	7.52b		7.10b	7.60ab	7.90a	7.70a	
	Uptaking Na^+ (mg kg^{-1})					Uptaking K^+ (mg kg^{-1})				
Na0	0.38	0.44	0.41	0.46	0.42b	0.33	0.42	0.48	0.63	0.47b
Na1	0.47	0.57	0.46	0.46	0.49a	0.55	0.73	0.38	0.51	0.54a
Na2	0.40	0.45	0.43	0.44	0.43b	0.36	0.41	0.39	0.39	0.39c
Na3	0.38	0.42	0.63	0.51	0.49a	0.31	0.44	0.40	0.40	0.39c
Average	0.41b	0.47a	0.48a	0.46a		0.38b	0.50a	0.42b	0.48a	
	Dry matters (%)									
Na0	5.53	6.31	6.00	7.59	6.34ab					
Na1	7.19	8.10	5.60	5.70	6.65a					
Na2	5.20	5.47	5.72	5.82	5.55c					
Na3	4.96	5.10	7.18	6.00	5.81bc					
Average	5.72a	6.25a	6.13a	6.28a						

*$p \leq 0.01$

TABLE-3
LETTUCE PLANT'S HEIGHT AND SURFACE DIAMETERS

Treatment subjects	Plant heights (cm)					Plant surface diameters (cm)				
	A	B	C	Average		A	B	C	Average	
Na0 K1	13.5	16.4	14.9	14.9	ab**	16.0	15.2	13.9	15.0	fg**
Na0 K2	18.2	16.6	16.0	16.9	a	18.5	17.2	16.4	17.4	def
Na0 K3	18.0	17.0	15.7	16.9	a	19.2	17.2	16.8	17.7	cdef
Na0 K4	15.3	14.7	15.5	15.1	ab	14.8	14.2	13.3	14.1	fg
Na1 K1	10.9	10.9	11.6	11.1	efg	11.7	10.6	11.5	11.3	g
Na1 K2	12.3	11.5	11.3	11.7	def	12.6	20.8	20.3	17.9	cdef
Na1 K3	13.4	12.9	11.9	12.7	bcde	21.5	20.5	21.4	21.1	bcd
Na1 K4	12.1	12.1	11.4	11.7	cdef	23.5	21.0	22.9	22.5	abc
Na2 K1	8.8	10.8	11.9	10.5	efgh	17.1	21.0	23.1	20.4	cde
Na2 K2	11.5	10.6	10.0	10.7	efgh	21.7	21.0	20.1	20.9	bcd
Na2 K3	13.6	14.2	14.7	14.2	bc	29.1	25.5	27.2	27.3	a
Na2 K4	13.1	13.3	12.1	12.8	bcde	25.9	25.3	25.2	25.5	ab
Na3 K1	9.3	7.7	9.3	8.8	h	16.2	13.9	17.5	15.9	ef
Na3 K2	9.5	9.2	8.4	9.0	gh	18.0	17.2	17.1	17.4	def
Na3 K3	9.8	10.0	10.5	10.1	fgh	18.0	18.2	18.4	18.2	cdef
Na3 K4	12.3	15.1	14.5	13.4	bcd	22.2	26.8	27.3	25.4	ab

**$p \leq 0.01$

Applied irrigation water, measured drained water and plant water consumption values in experiment pots were shown in Table-4. As seen in Table-4, irrigation water was applied 23-27 L per each pot along the growing season and a part of applied water amount (1.1-1.9 L/pot) was drained. Significant differences were determined between the treatments for plant water consumption at $p \leq 0.05$ level as statistically. Maximum plant water consumption (199.6 mm) was observed from Na1K1 and minimum plant water consumption (167.6 mm) was observed from Na2K2. There was no statistically significant difference between Na^+ content in growing media and plant water consumption. In other words, excess Na^+ amount in growing media had not influenced plant water consumption negatively. High Na^+ concentrations in soil either have toxic effect on plant or negative effect on soil condition[21]. The soil with high Na^+ content seems oily. Soil colloid is get swollen, the soil pores are plugged, air and water permeability of soil are reduced and pH degrees of soil solution are gone up to

TABLE-4
TREATMENTS, APPLIED AVERAGE IRRIGATION WATER AMOUNTS, DRAINED AVERAGE WATER AMOUNTS, AVERAGE EVAPOTRANSPIRATION AND EFFECT OF Na^+ ON RATE OF PLANT WATER CONSUMPTION DECREASE IN DIFFERENT GROWING MEDIA

Treatments	Applied average irrigation water amounts (L/pot)	Drained average water amounts (L/pot)	Average evapotranspiration (mm)		Effect of Na^+ on rate of ET decrease in different growing media (%)	
Na0 K1	27.0	1.5	196.0	a*	-	ns
Na0 K2	26.0	1.3	190.7	ab	-	ns
Na0 K3	26.0	1.4	190.1	ab	-	ns
Na0 K4	26.0	1.4	189.4	ab	-	ns
Na1 K1	27.0	1.1	199.6	a	-1.8	ns
Na1 K2	27.0	1.5	196.4	a	-3.0	ns
Na1 K3	26.0	1.6	187.5	abcd	1.4	ns
Na1 K4	24.0	1.5	173.8	bcd	15.6	ns
Na2 K1	25.0	1.7	179.0	abcd	8.7	ns
Na2 K2	23.0	1.3	167.6	d	12.1	ns
Na2 K3	25.0	1.9	177.8	abcd	6.5	ns
Na2 K4	26.0	1.5	188.9	abc	0.3	ns
Na3 K1	26.0	1.5	189.2	ab	3.5	ns
Na3 K2	23.0	1.2	168.4	cd	11.7	ns
Na3 K3	24.0	1.9	169.8	bcd	10.7	ns
Na3 K4	25.0	1.2	183.2	abcd	3.3	ns

*$p \leq 0.05$

harmful level by Na^+. Therefore, it hinders the water uptake from the soil by plant and causes decreasing of plant water consumption. In the experiment, it can be said that the reason of plant water consumption values not affected by Na^+, because of the growing media were constituted from perlite and it's structure is not spoiled by Na^+ effect as soil.

As in the beginning of research, perlite was used to investigate the possibilities of plant toleration with K^+ fertilizing against Na^+ uptake or Na^+ damaging and to be necessary yield decreasing not source from water deficit. For this reason, experiment was carried out successfully.

Conclusion

Excess Na^+ in growing media had negative effects on lettuce's yield and plant heights such as other plants. But, this negative effect can be tolerated partly by K^+ fertilizing. Specially, in growing media with quite high Na^+ content, amount of applied K^+ fertilizing should be much more. Beside of this, high amount of K^+ fertilizing should be compared from the point of view of economical input and output where applied on the growing media with excess Na^+. However, it can be indicated that this application has quite effective on plants which have relatively higher economic values.

REFERENCES

1. H. Greenway and R. Munns, *Annu. Rev. Plant Physiol.*, **31**, 149 (1980).
2. S.M. Siegel, B.Z. Siegel, J. Massey, P. Lahne and J. Chen, *Physiol. Plant*, **50**, 71 (1980).
3. E.A. Kirkby and A.H. Knight, *Plant Physiol.*, **60**, 349 (1977).
4. A. Günes, W.H.K. Post, E.A. Kirgby and M. Aktas, *J. Plant Nutr.*, **17**, 1929 (1994).
5. E.V. Maas and G.J. Hoffman, *Irrig. Drain. Div. ASCE*, **103**, 115 (1977).
6. G.R. Cramer and R.S. Nowak, *Physiol. Plant.*, **84**, 600 (1992).
7. J.K.M. Roberts, C.S. Linker, A.G. Benoit, O. Jardetzky and R.H. Nieman, *Plant Physiol.*, **75**, 947 (1984).
8. V. Martinez and A. Lachli, *Physiol. Plant.*, **83**, 627 (1991).
9. W.S. Chow, M.C. Ball and J.M. Naderson, *Aust. J. Plant Physiol.*, **46**, 53 (1990).
10. N.A.K. Hasan, J.W. Drew, D. Knudsen and R.A. Olson, *Agron J.*, **62**, 43 (1970).
11. N.A.K. Hasan, J.W. Drew, D. Knudsen and R.A. Olson, *Agron J.*, **62**, 46 (1970).
12. P.D. Chavan and B.A. Karadge, *Plant Soil*, **54**, 5 (1980).
13. M.M. Sayed and S.A. El-Swaify, The Journal of the Faculty of Agriculture, University of West Indies, pp. 45-51 (1973).
14. M. Ashraf, Z.U. Zafar and Z.A. Cheema, *Phyton Horn.*, **34**, 219 (1994).
15. M. Helal, K. Koch and K. Mengel, *Physiol. Plant.*, **35**, 310 (1975).
16. M.D. Guardia and M. Benlloch, *Physiol. Plant.*, **49**, 443 (1980).
17. K. Mengel and W.W. Arneke, *Physiol. Plant*, **54**, 402 (1982).
18. T.C. Hsiao and A. Lachli, *Preager Scientific*, **2**, 281 (1986).
19. C. Sonneveld, Proefstation Voor Tuinbour Under Glass, No. 8, Naolwijk, The Netherlands (1992).
20. N. Yurtsever, Toprak ve Gübre Aras. Ens. Md. Yayinlari, No. 91, Eskisehir, Turkey (1982) (in Turkish).
21. M. Ayyildiz, Ankara Üniversitesi, Ziraat Fakültesi Yayinlari, 1196, Ankara, Turkey (1990) (in Turkish).

(*Received*: 13 December 2006; *Accepted*: 12 March 2007) AJC-5520