Pak.J.Bot., 28(1): 97-102, 1996.

EFFECT OF HUMIDITY ON GROWTH OF LETTUCE (*LACTUCA SATIVA*, VAR. GREAT LAKES) UNDER SALINE CONDITION

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Abstract

Lettuce (*Lactuca sativa* var. Great Lakes) grown in soil irrigated with water of different salinities maintained with 0-72mM NaCl showed greater leaf area, shoot/root ratio and dry weight when kept at 92/100% night and day R.H., as compared to 62/82% R.H. No significant difference in the rate of assimilation or stomatal conductance was found in plants grown at high and low R.H.

Introduction

Approximately one half of the arid or semi-arid regions of the world are affected by soil salinity which adversely affects agricultural productivity (Croughan & Rains, 1982). If good quality water is available, the salts may be leached out of the soil by irrigation (Meiri & Plaut, 1985) or saline and non-saline water may be mixed to irrigate plants of different salt sensitivities (Bradford & Letey, 1992). Soil salinity is becoming a serious problem along the coastline of Oman in the Arabian Peninsula. The extraction of scarce ground water for irrigation allows the infiltration of sea water into the water table leading to an increase in soil salinity. Some coastal regions receive considerable occult precipitation in the form of mists brought inland by winds from the sea. A good amount of dewfall has also been noticed during winter months in these areas. Plant species whose growth is retarded by saline soils are known to benefit from high atmospheric humidity (O'Leary, 1975; Hoffman & Jobes, 1978). The physiological drought caused by salinity of rooting medium is offset by obtaining good quality water through foliage under humid environment. The introduction of short lived species of crop plant such as lettuce, whose period of growth is timed to coincide with episodes of occult precipitation may be advantageous, where soil salinity would otherwise limit growth. Experiments were therefore carried out to study the interactive effects of humidity and salinity on assimilate partitioning, photosynthesis and stomatal conductance in relation to growth of lettuce.

Materials and Methods

Lettuce seeds (*Lactuca sativa* var. Great Lakes) were germinated and grown to 5 leaf stage in seed trays containing river washed sand and peat moss (9:1), mixed with 0.1% w/w of commercial NPK fertilizer (Nitrophoska, BSAF, Ludwigshafen, Germany in a ratio of 15:15:15. Three seedlings were transplanted in 1 Kg of sand and peat

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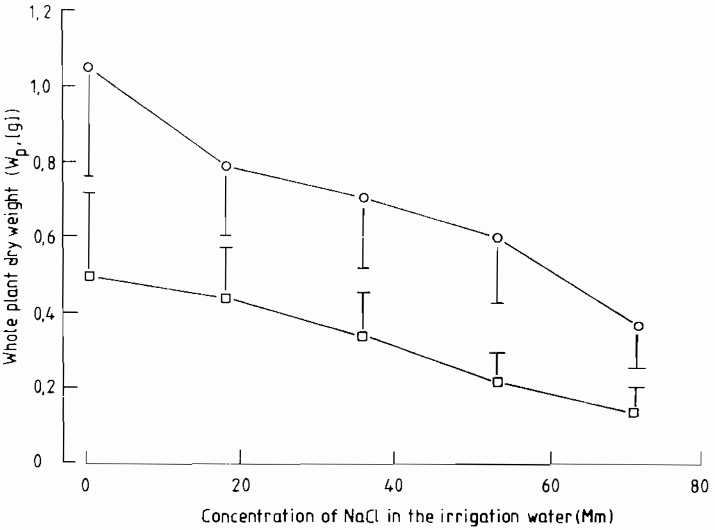

Fig. 1. Salinity response curve of lettuce grown at high (O) and Low (| |) R.H.

mixture in each of two plastic containers for each salinity treatment. The plants were grown in 2 separate growth cabinets (Fi-Totron 600H, Fisons Environmental Equipment, Loughborough, England) set at different relative humidity (low at 62/81% R.H. and high at 92/100% R.H. during the night/day). Day and night temperatures were set at 23°C and 17°C, respectively, with 11 h photoperiod illuminated with phosphorescent tubes and tungsten light producing 0.15 mol photons M^{-2} PAR. The plants were irrigated daily with water for one week followed by daily irrigation with the following concentration of sodium chloride solution, 0 mM (EC: ca. 0.8 $dS.m^{-1}$), 18 mM (EC: ca. 1.7 $dS.m^{-1}$), 36 mM (EC: ca. 3.3 $dS.m^{-1}$), 54 mM (EC: ca 5.0 $dS.m^{-1}$) and 72 mM (EC: ca. 6.6 $dS.m^{-1}$). Excess solution was allowed to drain out from the soil to prevent build up of excess salts in the soil. Necessary care was also taken not to splash the foliage of the plants with the salt solution.

The plants were harvested after 70 days from the commencement of the NaCl treatments. Leaves and roots were carefully separated. The roots were gently washed in water to remove the adhering soil and broken roots were collected on a sieve. Leaf area was measured with a leaf area meter (Delta T Devices, Cambridge, U.K). Leaves and roots of the plants were dried at 80°C for three days for dry weight determination. Photosynthesis was measured on plants growing in 0 mM and 2 mM NaCl kept at low and high R.H., one week prior to harvest. Rate of photosynthesis and stomatal conductance was measured with a portable infra red gas analyser [IRGA] (LCA2, Analytical Development. Corporation, Hoddesdon, Hertfordshire, England). Fully expanded leaves were measured at the low R.H. growth cabinet at 23°C with an illuminance of 0.15 mmol $m^{-2}s^{-1}$. The pots of plants growing at high R.H were placed in the low R.H. growth chamber for four hours prior to measurements. Measurements were made within one minute of the leaf being placed in the chamber of IRGA and were taken 4 h after the commencement of photoperiod. Six leaves were measured for each salinity and humidity treatments.

Results

Dry weight (W_p) of lettuce plants decreased significantly with increase in soil salinity at both high and low R.H. (Fig.1). Where plants were grown at high R.H. the whole plant dry weight (W_p) was more than double to that recorded for plants grown in low R.H except that of 18 mM NaCl treatment (Fig.1). Leaf area was also greatly affected at both the R.H. in all the salinity treatments. Plants grown in high R.H had mean leaf area between three and six times greater than the plants grown in low R.H. (Fig.2).

The partitioning of dry material between the shoots and roots was not greatly affected by soil salinity in both R.H. environments, since the shoot/root ratio did not significantly differ between the salinity treatments (Table 1). However, for each soil salinity, the mean shoot/root ratio of plants was higher in the plants grown under high compared to low R.H. (Table 1). Lettuce plants grown under high R.H had a significantly greater LAR than the plants grown in low R.H. at all levels of soil salinity. The LWR and SLA was significantly greater at all soil salinities in plants grown in high R.H., compared to plants grown in low R.H. conditions (Table 1).

In plants grown at both high and low R.H., there were little differences in LWR in the range of soil salinities used (Table 1). Greater LAR for the high R.H. plants resulted from a larger increase in SLA than in LWR. This differential effect of R.H. on the LWR and SLA increased with increasing salinity whereas at 54 mM NaCl, the LWR was 17.2% and the SLA 46.9% greater in plants grown at high compared to low R.H. (Table 1).

Differences in mean whole plant dry weight between the high and low R.H. treatments and at soil salinities of 0 and 72 mM NaCl was not the result of different rates of photosynthesis per unit leaf area, since carbon assimilation did not significantly different between the treatments (Table 2). Stomatal conductance was also similar in the plants grown at high and low R.H or at soil salinities of 0 and 72 mM NaCl (Table 1).

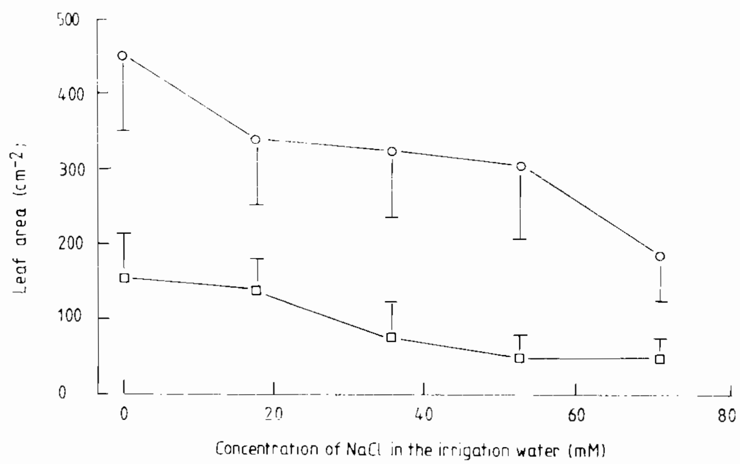

Fig.2. Changes in leaf area of lettuce plants grown at high (O) and low (□) R.H. in response to changes in soil salinity.

Table 1. Growth of lettuce plants on range of NaCl concentrations and at high and low humdity.

	Concentrations of NaCl (mM)				
	0	18	36	54	72
Shoot/root ratio					
High R.H.	6.6±2.5	6.4±5.9	5.3±4.1	7.1±2.4	4.9±4.8
Low R.H.	3.9±2.7	4.3±2.3	2.8±3.3	2.4±3.6	4.1±2.8
Ratio (%)	40.90	32.8	47.2	66.2	16.3
Leaf area ratio (LAR)					
High R.H.	4.33±0.16	4.33±0.17	4.55±0.14	4.91±0.70	4.94±0.13
Low R.H.	3.23±0.22	3.09±0.60	2.27±0.11	2.15±0.50	2.96±0.10
LAR (%)	25.4	28.6	50.1	56.1	40.1
Leaf weight ratio (LWR)					
High R.H.	0.86±0.01	0.86±0.02	0.84±0.01	0.87±0.01	0.82±0.02
Low R.H.	0.79±0.01	0.81±0.01	0.74±0.01	0.72±0.02	0.79±0.01
LWR (%)	8.1	5.8	11.9	17.2	3.6
Specific leaf area (SLA)					
High R.H.	5.04±0.16	5.03±0.23	5.41±0.18	5.64±0.70	6.02±0.14
Low R.H.	4.09±0.26	3.82±0.80	3.07±0.15	2.99±0.30	3.75±0.11
SLA (%)	18.8	24.1	43.2	46.9	37.7

Discussion

Lettuce plants grown at low R.H. can be considered as moderately salt sensitive according to the categories of Maas (1985). The present study demonstrates that high R.H. shifts the salt sensitivity of lettuce to moderately salt tolerant. The ability of humidity to relieve salinity stress appears to be related to the salt sensitivity of the species used. High atmospheric R.H. has been responsible of reducing salt stress in the salt sensitive red kidney bean (*Phaseolus vulgaris* L.), onion (*Allium cepa* L.) and raddish (*Raphanus sativus* L.) (O'Leary, 1975; Hoffman & Jobes, 1978) while the salt tolerant cotton (*Gossypium hirsutum*) showed no interaction between R.H. and salinity (Hoffman *et al.*, 1971).

Leaf area is particularly a good indicator of water and salinity stress, since leaf expansion generally requires a high turgor pressure for cell enlargement (Krieg, 1983). In the present study leaf area ratio and the specific leaf area appeared to be more adversely affected by salinity and atmospheric humidity than the leaf weight ratio (leaf dry weight/whole plant dry weight). Leaf area ratio was 25.4-56.1% greater in lettuce grown at high, compared to low R.H. This shows that the plants grown at high R.H. were able to produce considerably more dry material per unit leaf area than the plants grown at low R.H., irrespective of soil salinity treatments. At all the salinity levels, there was greater increase in SLA than in LWR for plants growing in high R.H., compared to low R.H., since the changes in SLA were greater than those for LWR, It would suggest that SLA has more influence in determining the efficiency with which a plant uses its leaves to produce the whole plant dry weight through photosynthetic process i.e., LAR than LWR.

Table 2. Rate of photosynthesis (μmol $m^{-2}s^{-1}$) and stomatal conductance ($mol\ m^{-2}s^{-1}$) per unit leaf area of plants irrigated with 0 and 72 mM NaCl and grown at low or high R.H.

NaCl Concen. (mM)	High humidity Photosynthetic Rate	Stomatal Conductance	Low humidity Photosynthetic Rate	Stomatal Conductance
0	1.69±0.09	0.07±0.01	1.93±0.36	0.07±0.01
72	1.55±0.27	0.10±0.03	1.79±0.25	0.07±0.01

Although the whole plant dry weight decreased with the increasing soil salinity in plants grown at high R.H., the SLA increased by 16% between the lowest and the highest salinity treatments. However, the SLA decreased by 9% in low R.H. plants irrigated with the same range of salinities. This demonstrates that at high R.H., larger and thinner leaves were produced in response to increasing soil salinity, while smaller and thicker leaves were produced at low R.H., as the level of soil salinity increased. It is an advantage for plants growing in humid conditions to produce a larger leaf area to increase assimilates on leaf area basis. Plants growing at low humidites have thicker leaves with low area in order to conserve water even at the expense of less growth.

Large leaf area of lettuce plants grown at high R.H., was able to produce considerably more assimilate which was then portioned in favour of shoots rather than roots compared to plants grown at low R.H. This resulted in a higher shoot/root ratio in plants grown at high R.H., than those grown at low R.H., at all soil salinities used. This is a useful information when considering growth of agricultural crops in high soil salinity and atmospheric R.H., as greater yields would result from a leaf crop than a species cultivated for roots. This ability of leaf crops to grow rapidly in saline conditions during periods of atmospheric mists or dewfall could contribute to agricultural productivity in regions where low annual rainfall and saline soils reduce agricultural development. Similarly in absence of good quality water, broad leaved vegetables could also be grown at sandy strata through brackish water irrigation under above mentioned humid conditions.

The inability of the photosynthesis and stomatal conductance measurements to detect significant differences between treatments may have resulted from the low light intensity used or the acclimation procedure used for the plants grown at high R.H. prior to the measurements being made. There are reports where decrease in photosynthesis (Gale *et al.*, 1967) and stomatal conductance (Meiri *et al.*, 1970) occur in plants growing in saline conditions. Greater whole plant dry weight of lettuce grown at high compared to low R.H., appear to reflect the larger leaf surface area of these plants rather than an increased assimilatory power per unit leaf area. The higher mean value of photosynthesis of the plants grown at low R.H., may be the result of a greater leaf thickness and hence the number of photosynthetic cells in a given leaf area. The similarity in mean stomatal conductance between the treatments suggests that transpiration was not a limiting factor in these experiments.

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(Received for Publication 2 February, 1995)