Indian Journal of Agricultural Sciences **89** (1): 41–5, January 2019/Article
https://doi.org/10.56093/ijas.v89i1.86102

Effect of saline stress on growth and biochemical indices of chrysanthemum (*Chrysanthemum morifolium*) germplasm

VANLALRUATI[1], PRATIVA ANAND[2], GUNJEET KUMAR[3] and A K TIWARI[4]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 27 March 2018; Accepted: 16 July 2018

ABSTRACT

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is one of the most popular cut flowers in the world and occupies important position in the world flower industry. An experiment was conducted to study the effect of saline stress on growth and biochemical indices on 10 chrysanthemum germplasm. It was determined by performance comparisons against control tests (without NaCl treatment) which acts as an indicator. Germplasm selected for the experiment were Garden Beauty, Shanti, Red Stone, Basanti, Yellow Reflex, Arka Ravikiran, Anmol, Mother Teresa, Sweta Singar and Jaya. Salt stress had significant effects on plant growth, assimilator pigment content and proline concentration. With application of 150 mM NaCl, there is reduction of shoot growth, root growth, leaf area, leaf number, shoot dry weight and chlorophyll content, whereas level of proline increased with increase salinity. Shoot elongation was less sensitive to salinity than root growth, with significant reductions in root growth at high salinity levels (150 mM). The genotype- Garden Beauty (5.03%) recorded minimum shoot length reduction, whereas minimum shoot dry weight reduction was observed in Anmol (23.97%) with increasing salinity. The genotype Basanti (2.35%) recorded minimum reduction in root growth. Minimum reduction in photosynthetic pigments was observed in Mother Teresa (51.55%) and high accumulation of proline content was recorded in Sweta Singar (162.50%). The genotypes Mother Teresa, Anmol, Basanti and Sweta Singar were found to be tolerant due to enhanced photosynthetic pigments, proline concentration and better shoot and root growth with higher salinity.

Key words: Chrysanthemum, Germplasm, Salt tolerance, Screening

Salinity is known to affect one-third of the world's arable land. It is the major abiotic stress reducing the yield of wide variety of crops all over the world (Tester and Davenport 2003). Salt affect osmotic stress and ionic toxicity of plants, affecting all major plant processes (Yadav *et al*. 2011). Growth and yield performance reduced through a decrease in ability of plants to take up water from the soil solution and the destruction of soil structure (Barrett-Lennard 2003). Salinity tolerance of flowers crops is of increasing importance due to decreasing availability of high-quality irrigation water. Increasing the salt tolerance of crops-will allow the effective use of poor quality irrigation water. Currently, only few major determinant genetic traits of salt tolerance have been identified owing to low success in releasing of salt-tolerant crops for optimal use of salt-contaminated water resources (Flowers 2004, Munns 2005). Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is the leading ornamental species of economic importance, and the environmental conditions especially salinity and drought highly define its yield and quality. Several approaches have been developed for abiotic stress tolerance but important ornamental crops like chrysanthemum were rarely tapped. Therefore, an attempt has been made to study the effect of saline stress on growth and biochemical indices of chrysanthemum germplasm.

MATERIALS AND METHODS

The present investigation was conducted at National Phytotron Unit, IARI, New Delhi during 2015-16. The effect of saline stress on the chrysanthemum germplasm was determined by performance comparisons against control tests (without Nacl treatment) which acts as an indicator. Ten chrysanthemum germplasms were selected for the experiment, viz. Garden Beauty, Shanti, Red Stone, Basanti, Yellow Reflex, Ravi Kiran, Anmol, Mother Teresa, Sweta Singar and Jaya. Suckers of chrysanthemum germplasm were kept in plug trays for rooting in shade net and transferred after sufficient root establishment. Nutrient solution was used in hydroponics system and rooted cuttings were kept in Hoagland solution for a week initially for acclimatisation. Treatments were given after a week using 0 mM NaCl (control) and 150 mM NaCl. Interaction effect of salinity and

[1]Scientist (e mail: maruathmar@gmail.com). [2]Scientist (e mail : prativa.iari@gmail.com). [3]Principal scientist (e mail: gunjeet234@gmail.com). [4]Principal scientist (e mail: drajaitiwari@gmail.com), Division of Floriculture and Landscaping.

germplasm was significant for the parameters studied. For each parameter measured, analysis were performed on raw data for three mean replicate tank values per treatment. All data were analyzed with SAS release 8.2 using proc GLM (SAS Institute 2001). A completely randomized design was used, each treatment was replicated three times. Observations for plant growth, viz. shoot length (cm), root length (cm), leaf area (cm^2), leaf numbers and shoot dry weight was recorded at the end of the experiment. Chlorophyll and chlorophyll b content assays were performed according to Lichtenthaler (1987). The proline concentration was determined using fresh material according to Bates *et al*. (1973).

RESULTS AND DISCUSSION

Effect of salt on plant growth

Increment in salinity level cause decline in shoot growth, root development, leaf area and leaf number among the chrysanthemum germplasm (Table 1) (Fig 1). Shoot growth was significantly decreased by increase salinity level compared to control. Maximum reduction in shoot growth was observed in Sweeta Singar (26.67%) followed by Anmol (25.49%) when plants were treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease for the parameter was observed in Garden Beauty (5.03%) followed by Mother Teresa (6.92%). Hasanuzzaman *et al*. (2013) reported that plants are susceptible to salinity during the seedling and early vegetative growth stage. Natural hormones might be affected due to the saline conditions leading to unbalanced growth of the plant (Lewis *et al*. 1980). Effects of salinity in reducing growth of different ornamental plants have also been reported in gladiolus (Ahir and Singh 2017), in marigold (ValdezAguilar *et al*. 2009), in zinnia (Zivder *et al*. 2011) and in rosemary (Kiarostami *et al*. 2010). Salinty has significant effects on root growth of Chrysanthemum germplasms. Maximum reduction in root length was observed in Mother Teresa (42.86%) followed by Red Stone (26.88%) when plants were treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease for the parameter was observed in Basanti (2.35%) followed by Yellow Reflex (9.09%). High external salt concentrations can also inhibit root growth, with a reduction in length and mass of roots. Cassaniti *et al.* (2009) also reported on decreasing plant height and root growth with increase salinity in ornamental shrubs. The overall negative effect of salt on growth attributes in the present study also conforms to the findings of Ashraf and Ahmad (2000) in cotton. Significant reduction in leaf area was observed at high salinity level in all the chrysanthemum germplasms. The genotype Shanti (24.11%) recorded maximum reduction in leaf area followed by Red Stone (17.09%) when plants were treated with 150 mM NaCl compared to their performance in non saline condition whereas minimum decrease in leaf area was observed in Garden Beauty (8.11%) followed by Mother Teresa (7.32%). At high NaCl concentration (150 mM), the germplasm shows chlorotic leaves whereas the leaves of controlled plants were comparatively green and fully expanded. Reduction in leaf number was also observed at high salinity level in all the germplasm and maximum reduction was observed in Jaya (70.00%) followed by Shanti (60.00%) when plants were

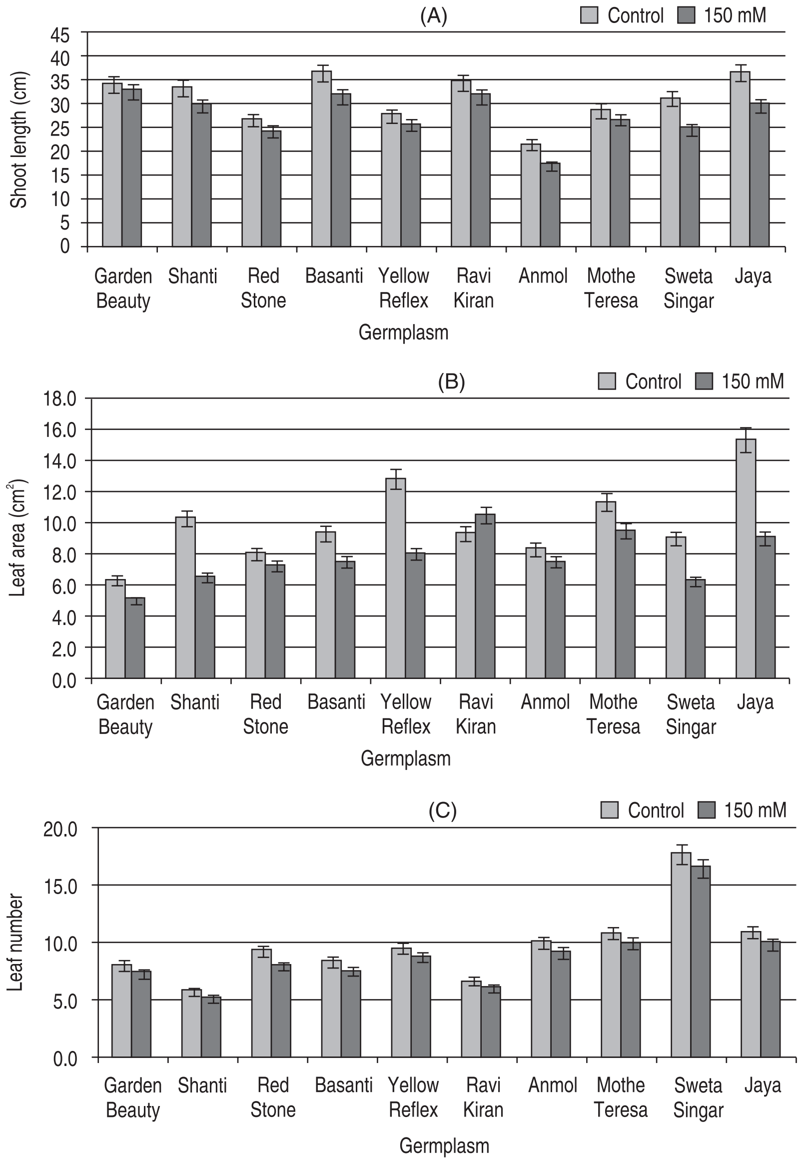

Fig 1 Effect of salt stress (0 and 150 mM NaCl) on plant growth of 10 Chrysanthemum germplasm : Shoot length (A), Leaf area (B), and Leaf number (C). Each value represents the mean of three replicates ± SE. Two-way analysis of variance for the interaction of germplasm x treatment and main effects of germplasm and treatment were significant at $P < 0.05$.

Table 1 Root length and proline concentrations (mean±SE) in chrysanthemum germplasms subjected to salinity stress at different concentrations of NaCl

Germplasm	Root length (cm)		Proline (µmol/g FW)	
	NaCl (150 mM)	Control	NaCl (150 mM)	Control
Garden Beauty	12.0 ± 1.16	14.3 ± 0.79	4.5 ± 0.90	1.6 ± 0.01
Shanti	11.5 ± 0.54	13.0 ± 1.25	18.3 ± 3.32	1.2 ± 0.02
Red sone	9.3 ± 0.99	11.8 ± 0.96	11.0 ± 2.85	1.3 ± 0.29
Basanti	8.5 ± 0.68	8.7 ± 0.47	13.4 ± 2.16	0.9 ± 0.01
Yellow Reflex	11.0 ± 1.12	12.0 ± 1.16	8.3 ± 1.16	2.1 ± 0.05
Arka Ravikiran	10.0 ± 1.03	11.2 ± 0.59	11.5 ± 0.95	2.2 ± 0.01
Anmol	6.0 ± 0.66	7.3 ± 0.64	18.2 ± 2.98	1.2 ± 0.69
Mother Teresa	6.3±1.02	9.0 ± 1.31	13.1 ± 0.94	1.5 ± 0.04
Sweta Singar	8.3 ± 0.14	9.8 ± 0.75	14.0 ± 0.90	2.6 ± 0.46
Jaya	8.0 ± 0.50	10.3 ± 0.47	9.3 ± 1.00	0.4 ± 0.35

treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease for the parameter was observed in Arka Ravikiran (3.20%) followed by Red Stone (10.34%). When plants are exposed to salinity at an early stage of seedling development, there are linear reductions in both leaf area expansion and total plant biomass. Leaf area reduction could be caused by a decrease in turgor in the leaves, as a consequence of changes in cell wall properties or a reduction in photosynthetic rate. Cassaniti *et al.* (2009) also reported that salinity reduced cell elongation and division in plant cell, thereby decreasing number of leaves and leaf area in ornamental shrubs.

Effect of salt on shoot dry weight

Increment in salinity level significantly reduced shoot dry weight in the moderately sensitive chrysanthemum germplasm (Fig 2). Maximum reduction in shoot dry weight was observed in Garden Beauty (97.80%) followed by Basanti (93.55%) when plants were treated with 150 mM NaCl compared to their performance in non saline condition whereas minimum decrease was observed in Anmol (23.97%) followed by Mother Teresa (35.14%). High reduction for the parameters was also observed in Red Stone (92.42%) and Shanti (92.31%) and was statistically at par. Salt tolerance is marked by percent biomass production as growth takes place in saline condition when compared with non saline condition. Metabolic processes like enzyme activities, protein and nucleic acid synthesis might induced inhibitory effects on dry and fresh weight of shoots and roots with increased salinity. The results regarding plant biomass reported in the current study is in accordance with the findings Ltaief et *al.* (2007). Cassaniti *et al*. (2009) added in his findings that the decrease in shoot dry weight and leaf area were the first visible effects of salinity both in sensitive and tolerant species such as *Cotoneaster lacteus* and *Eugenia myrtifolia* respectively.

Effect of salt on photosynthetic pigments

Increment in salinity level significantly reduced photosynthetic pigments in the moderately sensitive chrysanthemum germplasm (Fig 2). Maximum reduction in chlorophyll a content was observed in Arka Ravikiran (96.77%) followed by Anmol (93.65%) when plants were treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease was observed in Garden Beauty (10.75%) followed by Sweta Singar (16.39%). Maximum reduction of chlorophyll b content was observed in Shanti (99.16%) followed by Garden Beauty (80.00%) when plants were treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease was observed in Mother Teresa (51.55%) followed by Red Stone (52.36%). A decrease in the chlorophyll content with high salt concentration might be associated with disruption in cellular functions and damage to photosynthetic electron transport chain or membrane deterioration (Djanaguiraman *et al*. 2016). Zhong (1997) also reported that leaf chlorophyll contents of Nanjing *Chrysanthemum indicum* and *Chrysanthemum chanetii* increased with low salt concentration, but decrease with increment in salt concentration. Reducing effect of salinity on photosynthesis and water use efficiency was also reported by Nahed *et al*. (2011) on *Matthiola incana* and Azza *et al*. (2011) on *Schefflera arboricola*. The increased enzyme activity in salt stress is associated with decreased photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) content as reported in *Picea* sp (Croser *et al.* 2001), and *Rosmarinus officinalis* (Kiarostami *et al*. 2010). In sweet cherry rootstock Gisela 5 (*Prunus cerasus* × *Prunus canescens*), a decrease in chlorophyll content was alao observed as a result of sodium chloride exposure (0, 50, 100, and 150 mM) (Erturk *et al*. 2007).

Effect of salt on proline content

Increase salinity level significantly reduced the level of proline in the moderately sensitive chrysanthemum germplasm (Table 1). Maximum increase in proline concentration was observed in Sweta Singar (162.50%) followed by Basanti (98.57%) when plants were treated with 150 mM NaCl compared to their performance in non-saline condition, whereas minimum decrease of proline level was observed in Garden Beauty (16.96%) followed by Red Stone (23.35%). Proline accumulation in tissues of plants exposed to saline stress can be attributed to an increase in proline synthesis and a reduction in its degradation. Their deposition induced by salt stress leads to clearing of free radicals in cells which act as a tolerance mechanism of osmotic regulation (Bellinger *et al*. 1991). Oprica Lacramioara *et al.* (2015) reported that accumulation of proline in the marigold seedling treated with 100 mM NaCl was by 2.8 times higher than control. Similar result of enhanced proline

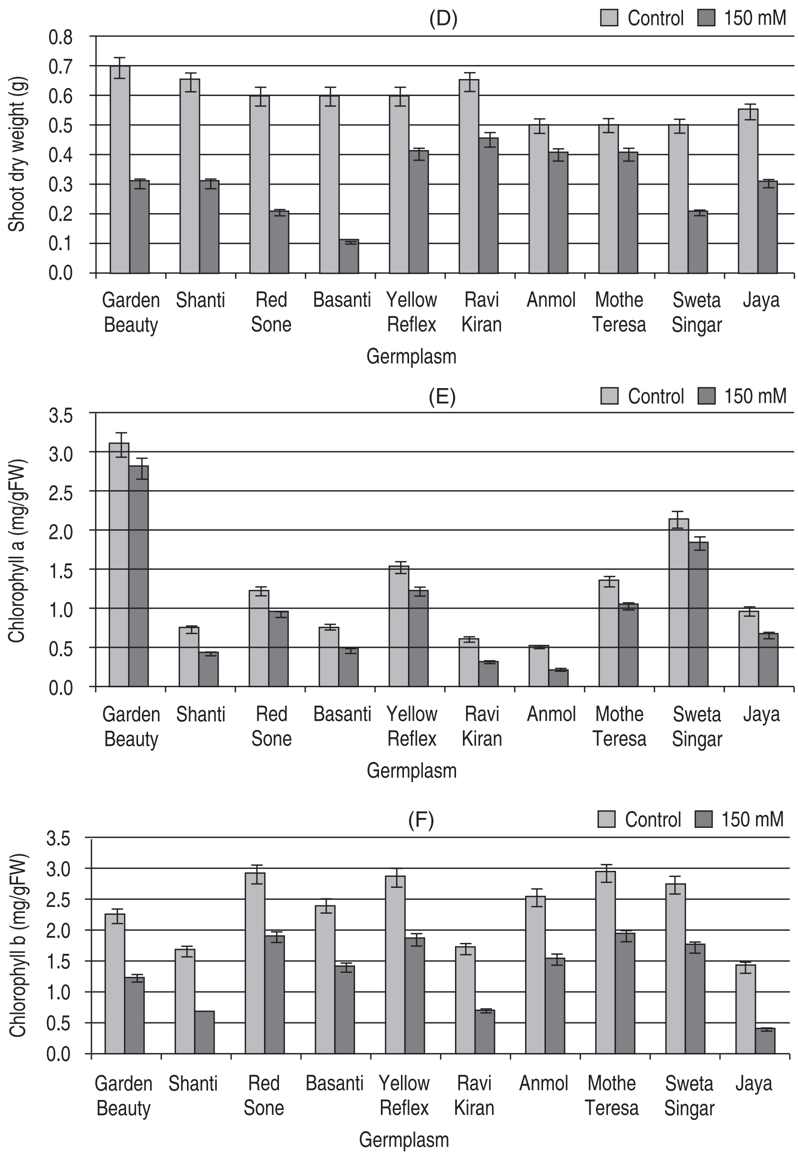

Fig 2 Effect of salt stress (0 and 150 mM NaCl) on shoot biomass and chlorophyll content 10 chrysanthemum germplasms : Shoot dry weight (D), Chlorophyll a (E), and Chlorophyll b (F). Each value represents the mean of three replicates ± SE. Two-way analysis of variance for the interaction of germplasm × treatment and main effects of germplasm and treatment were significant at $P < 0.05$.

concentration with increasing salinity was also reported by Azza *et al*. (2011) on *Schefflera arboricola* plant and Nahed *et al*. (2011) on *Matthiola incana* plants. Lutts *et al*. (1996) also reported on the significant relationship between proline accumulation and plant salt tolerance in rice.

ACKNOWLEDGEMENT

I would like to extend my gratitude to National Phytotron Unit, ICAR-IARI for their valuable assistance and providing facilities for my data collection.

REFERENCES

Ahir M P and Singh Alka. 2017. Effect of different levels of irrigation water on growth and yield of gladiolus cv. American Beauty. *Trends in Biology* **10** (43) : 9011- 3.

Ashraf M and Ahmad S. 2000. Influence of sodium chloride on ion accumulation, yield components and fibre characteristics in salt tolerant and salt-sensitive lines of cotton (*Gossypium hirsutum* L.). *Field Crops Research* **66**:115–27.

Azza A M, Mazhar Mon, Mahgoub H and Abd El-Aziz G. 2011. Response of *Schefflera arboricola* L. to gypsum and sulphur application irrigated with different levels of saline water. *Australian Journal of Basic and Applied Sciences* **5**(10): 121-9.

Barrett-Lennard E G. 2003. The interaction between waterlogging and salinity in higher plants: Causes, consequences and implications. *Plant Soil* **253**: 35–54.

Bates L S, Waldren R P and Teare I D. 1973. Rapid determination of proline for water stress studies. *Plant and Soil* **39**: 305-7.

Bellinger Y, Bensaoud A and Larher F. 1991. Physiological significance of proline accumulation, a trait of use to breeding for stress tolerance. (In) *Physiology – Breeding of Winter Cereals for Stressed Mediterranean Environment*, pp: 449-58. Acevedo *et al*. (Eds). INRA, Paris.

Cassaniti C, Leonardi C and Flower T J. 2009. The effect of sodium chloride on ornamental shrubs. *Scientia Horticulturae* **122**:586- 93.

Croser C, Renault S, Franklin J and Zwiazek J. 2001. The effect of salinity on the emergence and seedling growth of *Picea mariana*, *Picea glauca* and *Pinus banksiana*. *Environmental Pollution.* **115** : 9-16.

Djanaguiraman M, Sheeba J A, Shanker A K, Durgadevi D, Bangarusamy U. 2006. Rice can acclimate to lethal level of salinity by pre-treatment with sub lethal level of salinity through osmotic adjustment. *Plant Soil* **284** : 363-73.

Erturk U, Sivritepe N, Yerlikaya C, Bor M, Ozdemir F and Turkan I. 2007. Response of the cherry rootstock to salinity *in vitro*. *Biologia Plantarum* **51**(3): 597-600.

Flowers T J. 2004. Improving salt tolerance. *Journal of Experimental Botany*. **55**:307–19.

Hasanuzzaman M, Nahar K and Fujita M. 2013. Plant response to salt stress and role of exogenous protectants to mitigate salt-induced damages. (*In*) : *Ecophysiology and Responses of Plants under Salt Stress,* pp 25-87. Ahmad P, Azooz M M, Prasad M N V, (Eds). Springer, New York Heidelberg Dordrecht London.

Lichtenthaler H K. 1987. Chlorophylls and carotenoids: pigments of photosynthetic membranes. *Method in Enzymol*ogy **148** : 350- 82.

Munns R. 2005. Genes and salt-tolerance: bringing them together. *New Phytologist* **3**: 645–63.

Lutts S, Kinet J M and Bouharmont. 1996. Effects of salt stress on growth, mineral nutrition and proline accumulation in relation to osmotic adjustment in rice (*Oryza sativa* L.) cultivars differing in salinity resistance. *J. Plant Growth Regulators* 19: 207.

Nahed Abdel, Aziz G, Azza Mazhar A M and Mona Mahgoub H. 2011. Influence of using organic fertilizer on vegetative growth, flowering and chemical constituents of *Matthiola incana* plant grown under saline water irrigation. *World Journal of Agricultural Sciences* **7**(1) : 47-54.

Oprica Lacramioara, Marius Nicusor Grigore and Gabriela Vochita. 2015. Impact of saline stress on growth and biochemical indices of *Calendula officinalis* seedlings. *Romanian Biotechnological Letters* **20**(6) : 11007-17.

Kiarostami K H, Mohseni R and Saboora A. 2010. Biochemical changes of *Rosmarinus officinalis* under salt stress. *Journal of Stress physiology and Biochemical* **6** (3): 114-22.

Ltaief B, Sifi B, Zaman-Allah M, Drevon J and Lachaal M. 2007. Effect of salinity on root– nodule conductance to the oxygen diffusion in the *Cicer arietinum–Mesorhizobium ciceri* symbiosis. *Journal of Plant Physiology* **164**:1028–36.

Lewis O A M., Leldi E O and Lips S H. 1980. Effect of irrigation source on growth response to salinity stress in maize and wheat. *New Phytologist* **411(2)** : 155-62.

Tester M and Davenport R. 2003. Na+ tolerance and Na+ transport in higher plants. *Annals of Botany* **91**:503–27.

Wolverton B C, Rebecca C McDonald and Watkins Jr E A. 2013. Foliage plants for removing indoor air pollutants from energy-efficient homes. *Economic Botany* **38**(2): 224-8.

Yadav S, Irfan M, Ahmad A and Hayat S. 2011 Causes of salinity and plant manifestations to salt stress: A review. *Journal of Environmental Biology* **32:** 667-85.

Valdez-Aguilar L A, Grieve C M and Poss J A 2009. Salinity and alkaline pH of irrigation water affect marigold plants. I. Growth and shoot dry mass partitioning. *Hort Science* **44** : 1719-25.

Zhong G and Wang J. 1997. Protective effect of exogenous betalain on Chinese cabbage leaves under NaCl stress. *Plant Physiology Communication* **33**: 333-5.

Zivder S, Khaleghi E and Dehkordi F S. 2011. Effect of salinity and temperature on seed germination indices of *Zinnia elegans* L. *Journal of Applied Horticulture* **13** (1):48-51.