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# Reflectants Application for Increasing Wheat Plant Tolerance Against Salt Stress

M.S. Gaballah and M. Moursy
Department of Water Relations and Field Irrigation, National Research Centre, Cairo, Egypt

**Abstract:** A pot trial was executed on two wheat varieties (Sakha 69 and Giza 168) grown in clay soil under saline conditions at the greenhouse of National Research Centre, for improving salinity tolerance of wheat plant and reducing moisture loss through transpiration by spraying plants twice with two types of reflectants (magnesium carbonate and kaolinite), during plant growth. Salinity stress had a drastic effect on plant growth and yield, however reflectant treatments improved growth and yield characters under salinity stress. The use of reflectants also reduced water loss and limited the potential for evaporative leaf cooling. Reflectants lowered Na/K ratio compared to untreated plants. On the other hand the use of reflectants did not show any significant accumulation or decrease in proline content compared to untreated plants. Also, reflectant application has no effect on carbohydrate reserves.

**Key words:** Air temperature, humidity, evapotranspiration, leaf temperature wheat varieties, salinity stress, reflectants, growth, yield, potassium, sodium, proline, carbohydrate

## INTRODUCTION

Water salinity poses serious limitation to agriculture in many areas around the world. Salinity can reduce plant growth by osmotic stress, ion toxicity and nutritional disturbances[1-3]. Growing wheat under saline conditions is of great importance due to secondary salinization which may be caused by extension of irrigation or by human activities. Many crop plants can withstand mild salinity stress by slowing their growth rate, closing stomata, has tend leaf senescence (ageing), exuding wax... etc). Inhibitory effect of salinity on seed germination, plant growth, nutrient uptake and metabolism was studied by Whitmore[4].

Improving salinity and tolerance of crop plants using reflectants has been an important but largely unfulfilled aim of modern agricultural technique.

Wheat plants may react against drought or salinity stress by increasing pubescence on the leaves. If the hairs are shiny and reflective they help to reduce the heat load on the leaves and hence the transpiration rate. So, natural plant defensive mechanism sprouted out the idea of using "reflectants". This approach to reduce water loss by transpiration aims to increase the reflection of sunlight by leaves, thereby reducing the amount of solar radiation they absorb and hence their temperature and the rate at which they transpire water. Dusting or spraying plants with reflectants might be advantageous to try to breed or select plants with a higher leaf albedo as a natural means of reducing transpiration. Also, the reflected light may penetrate the interior of the plant canopy where normally the leaves are too shaded for maximum photosynthesis.

Thus the aim of the present investigation is to improve salinity tolerance of wheat plant, curbing moisture loss by transpiration using reflectants and studying their effect on wheat growth and yield.

## MATERIALS AND METHODS

A pot experiment was executed twice during the two successive seasons of 2001-2002 and 2002-2003 at the greenhouse of the National Research Centre, Dokki, Cairo, Egypt.

Plastic pots of 30 cm diameter were filled with 10 kg clay soil for each of the following characteristics: Clay, 46.5%; silt, 33.11%; sand 18.7%; organic matter, 0.57%; total nitrogen, 0.024%; calcium carbonate, 1.12%; pH, 7.66; E.C., 1.30 $dSm^{-1}$. Wheat grains (*Triticum aestivum* L.) varieties Sakha 69 and Giza 168 were sown on early November at the rate of ten seeds $pot^{-1}$. All pots received recommended dose of NPK fertilizers (2.2 g of calcium superphosphate, 15.5% $P_2O_5$, 2.0 g potassium sulphate, 48% $K_2O$ and 4.0 g ammonium nitrate, 33.5% and irrigated according to plant need, approximately around field capacity. After two weeks plants were thinned to five seedlings $pot^{-1}$, seedlings were subjected to different salinity levels.

Each pot was replicated four times and arranged, in a complete randomized block design. Two types of reflectants were used Kaolinite 6% and Magnesium

**Corresponding Author:** Dr. Maybelle Gaballah, Department of Water Relations and Field Irrigation, National Research Center, (12622), Cairo, Egypt. E-mail: msgaballa54@yahoo.com

carbonate 10% they were mixed with water and sprayed twice during the plant life cycle, once at the vegetative stage and another before booting.

The design of the experiment was as follows :

- Dilution of sea water for plant irrigation to 2000, 4000 and 6000 ppm.
- Two wheat varieties (Sakha 69 and Giza 168).
- Two types of reflectants ($MgCO_3$ 10% and Kaolinite 6%).
- Spraying with reflectants, at different phenological stages.

Reflectants are applied to two wheat varieties
Control
- Salinity level 2000 ppm.
- Salinity level 4000 ppm.
- Salinity level 6000 ppm.

Reflectants are not applied
Control
- Salinity level 2000 ppm.
- Salinity level 4000 ppm.
- Salinity level 6000 ppm.

Plant samples were collected at two phenological stages (vegetative and flowering) for estimating different growth and yield parameters. Leaf area $plant^{-1}$ was measured using Leaf Area Meter, while leaf temperature was estimated by using Steady State Promoter. Plant samples were dried for 48h at 70°C to determine dry weight and ion concentration of $Na^+$ and $K^+$ that determined spectrophotometrically following nitric-perchloric acid digestion. Proline and total carbohydrate were estimated according to Bates *et al.*[5] and Stewart[6].

Climatic data was recorded during the two successive seasons (2001-2003) to study the effect of climatic constraints on wheat plant grown under saline conditions. The combined data of the two successive seasons were statistically analyzed according to Snedecor and Cochran[7] where the means of studied treatments were compared using L.S.D. test at 0.05 significance level.

## RESULTS AND DISCUSSION

Some of the climatic features were recorded by means of Badrashin Climatic Station during experimentation. Obtained results of maximum relative humidity (Fig. 1 and 2) ranged between 83 and 89%, while the

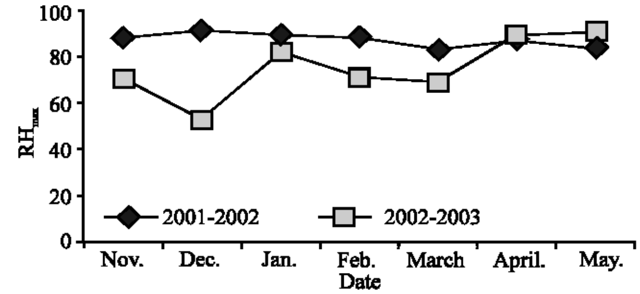


Fig. 1: Maximum relative humidity recorded during experimentation in Giza area (2001-2003)

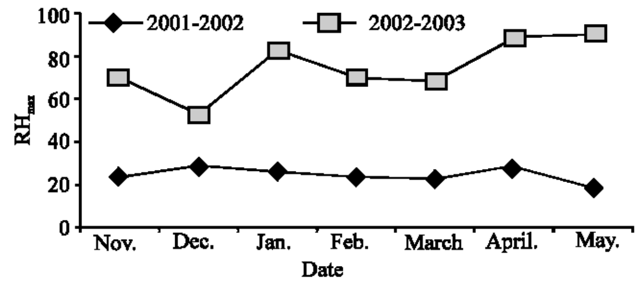


Fig. 2: Minimum relative humidity recorded during experimentation in Giza area (2001-2003)

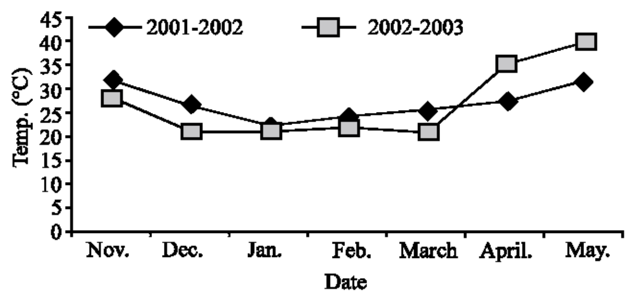


Fig. 3: Highest air temperature recorded in Giza area (2001-2003) during experimentation

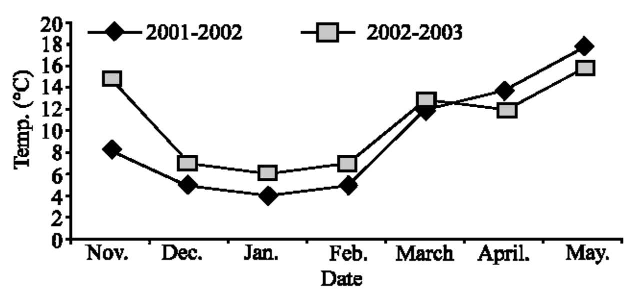


Fig. 4: Lowest air temperature recorded in Giza area (2001-2003) during experimentation

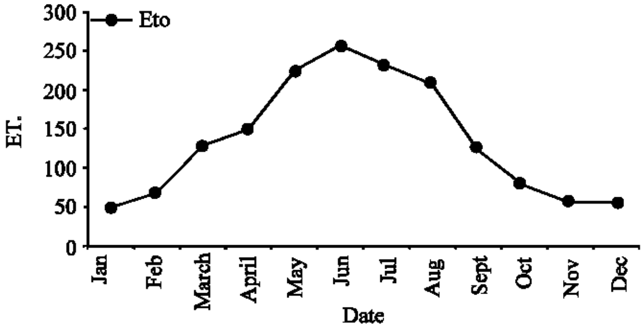


Fig. 5: Mean values of evaporation $Et_o$ (2001-2003) at Giza area

minimum between 47 and 20%. While the air temperature ranged between 31.6 and 21.0°C for the highest air temperature and between 4.0 and 18°C for the lowest air temperature (Fig. 3 and 4).

The mean values of evapotranspiration recorded during (2001-2003). (Fig. 5) revealed that the lowest record was in January (48.1) and the maximum was recorded in June (256.7). Evapotranspiration was low during the early stages of plant growth and increased by 62.5% at the critical plant growth stages booting and ripening (March, April and May).

The application of reflectants whether kaolinite or Magnesium carbonate on wheat plants reduced water loss and limited the potential for ecaporative leaf cooling which resulted in high leaf temperatures.

Exposure of plants to salinity stress increased leaf temperature in wheat varieties (Table 1) where the increases ranged between 10.7 to 14.3% in variety Sakha 69 under different salinity levels, while in Giza 168 the range was between 15.1 and 23.3%. Spraying with kaolinite reflectant was not so effective in Sakha 69 variety which reduced leaf temperature only by 1% than the untreated plants under the same saline conditions, while an obvious decrease was observed in Giza 168 leaf temperature as it was reduced by 12.6% than the untreated plants with kaolinite. Wheat varieties sprayed with Magnesium carbonate reflectant showed the same trend as Kaolinite for Sakha variety the reduction in leaf temperature was 0.5% and in Giza 168 was 8.6% compared untreated plants under salinity stress.

Laurie *et al.*[8] found that desert plants sprayed with antitranspirants showed a threshold leaf temperature above which photosynthesis was severely impaired. Also, Rao and Bhatt [9] found that Kaolinite at 5% was so effective in reducing water stress which resulted in significantly higher leaf relative water contents than control, which may be due to reduction in stomatal aperture or stomatal closure.

On the contrary Nakano *et al.* [10] found that spraying tomato plants with kaolin antitranspirant enhanced water loss from leaves. They suggested that Kaolin enhanced cuticle transpiration but not transpiration via stomata.

In general, salinity decreased plant leaf area (Table 2) by 45.6% in Sakha variety and by 50.9% in Giza 168 at 6000 ppm salinity level. Spraying with kaolinite on wheat varieties increased leaf area by 20.9% in Shakha 69 and 11.1% in Giza 168, while spraying with Magnesium carbonate increased leaf area by 11.1% in Sakha 69 and 10.2% in Giza 168 than untreated plants under 6000 ppm salinity level at leaf boot. Other growth parameters such as shoot length was recorded at the vegetative and jointing stages (Table 3 and 4). It was clear that salinity

Table 1: Effect of reflectants on mean leaf temperature (°C) of wheat varieties grown under different salinity levels at booting stage

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 32.15 | 31.65 | 29.13 | 28.78 | 33.12 | 31.11 | 30.83 | 29.99 |
| 2000 | 33.63 | 30.50 | 32.30 | 30.15 | 35.30 | 33.91 | 31.68 | 30.11 |
| 4000 | 34.29 | 32.70 | 34.11 | 31.33 | 36.40 | 34.51 | 33.44 | 30.88 |
| 6000 | 35.60 | 34.78 | 35.93 | 31.88 | 37.88 | 35.43 | 35.50 | 31.93 |
| L.S.D at 5% level | 0.08 | 0.08 | 1.0 | 0.19 | 0.91 | 0.86 | 0.91 | 0.07 |

Variety 1: Sakha 69 Variety 2: Giza 168 Refl.: Reflectant No. Refl. No Reflectant

Table 2: Effect of reflectants on leaf area $plant^{-1}$ $cm^2$ of wheat varieties grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 128.51 | 121.76 | 130.11 | 130.17 | 123.73 | 123.33 | 130.72 | 130.13 |
| 2000 | 92.33 | 109.80 | 119.82 | 123.56 | 122.88 | 120.12 | 107.11 | 108.51 |
| 4000 | 83.69 | 92.98 | 84.97 | 92.24 | 89.43 | 92.47 | 86.32 | 98.28 |
| 6000 | 71.16 | 92.80 | 66.20 | 80.16 | 67.28 | 80.66 | 64.16 | 77.11 |
| L.S.D at 5% level | 5.12 | 4.91 | 4.16 | 3.11 | 4.11 | 3.55 | 3.12 | 2.89 |

Variety 1 : Sakha 69 Variety 2 : Giza 168 Refl. : Reflectant No. Refl. No Reflectant

Table 3: Effect of reflectants on shoot length (cm) of wheat variety Sakha 69 grown under different salinity levels at two phenological stages

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Phenological stages | Stage 1 | | Stage 2 | | Stage 1 | | Stage 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 79 | 81 | 84 | 86 | 76 | 76 | 79 | 77 |
| 2000 | 78 | 79 | 83 | 79 | 77 | 82 | 80 | 83 |
| 4000 | 70 | 71 | 74 | 76 | 79 | 77 | 67 | 77 |
| 6000 | 61 | 71 | 67 | 78 | 69 | 70 | 64 | 71 |
| L.S.D at 5% level | 3.3 | 4.0 | 4.4 | 6.1 | 8.2 | 8.9 | 5.5 | 5.6 |

Stage 1:Vegetative Stage 2: Jointing Refl.: Reflectant No Refl. : No reflectant

Table 4: Effect of reflectants on shoot length of wheat variety Giza 168 grown under different salinity levels at two phenological stages

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Phenological stages | Stage 1 | | Stage 2 | | Stage 1 | | Stage 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 75 | 79 | 81 | 80 | 68 | 71 | 73 | 73 |
| 2000 | 77 | 81 | 79 | 85 | 76 | 77 | 75 | 79 |
| 4000 | 70 | 74 | 73 | 74 | 71 | 78 | 70 | 71 |
| 6000 | 70 | 70 | 71 | 70 | 63 | 66 | 68 | 69 |
| L.S.D at 5% level | 3.6 | 2.5 | 4.2 | 4.4 | 2.7 | 3.3 | 3.5 | 4.1 |

Stage 1: Vegetative Stage 2: Jointing Refl. : Reflectant No. Refl. No Reflectant

Table 5: Effect of reflectants on Harvest index (%) of wheat varieties grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 35.24 | 34.05 | 35.62 | 33.22 | 37.21 | 37.33 | 34.24 | 35.11 |
| 2000 | 27.66 | 28.30 | 36.11 | 33.86 | 27.90 | 29.24 | 34.92 | 35.05 |
| 4000 | 24.86 | 26.51 | 28.42 | 29.10 | 25.80 | 25.94 | 27.82 | 31.23 |
| 6000 | 22.92 | 22.36 | 22.97 | 26.30 | 24.61 | 23.54 | 20.13 | 24.69 |
| L.S.D at 5% level | 4.41 | 2.74 | 3.91 | 4.64 | 5.1 | 3.88 | 3.81 | 2.55 |

Variety 1: Sakha 69 Variety 2: Giza 168 Refl. Reflectant No Refl. No reflectant

Table 6: Effect of reflectants on biological yield/plant (g) of wheat varieties grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 24.69 | 24.60 | 27.91 | 27.86 | 24.19 | 24.11 | 26.50 | 27.21 |
| 2000 | 22.92 | 23.11 | 16.51 | 18.97 | 18.10 | 17.72 | 21.71 | 19.32 |
| 4000 | 19.44 | 21.17 | 13.33 | 14.69 | 11.65 | 13.57 | 9.36 | 13.55 |
| 6000 | 13.32 | 18.71 | 9.31 | 13.11 | 7.94 | 11.53 | 8.01 | 12.66 |
| L.S.D at 5% level | 3.62 | 3.31 | 2.83 | 2.44 | 2.11 | 2.61 | 2.56 | 2.85 |

Variety 1: Sakha 69 Variety 2 : Giza 168 Refl. Reflectant No Refl. No reflectant

Table 7: The effect of reflectants Na/K ratio in Grains wheat varieties grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 0.06 | 0.08 | 0.07 | 0.07 | 0.06 | 0.07 | 0.06 | 0.06 |
| 2000 | 0.08 | 0.05 | 0.09 | 0.05 | 0.07 | 0.05 | 0.09 | 0.08 |
| 4000 | 0.08 | 0.06 | 0.12 | 0.07 | 0.09 | 0.06 | 0.10 | 0.08 |
| 6000 | 0.09 | 0.07 | 0.14 | 0.07 | 0.10 | 0.08 | 0.15 | 0.09 |

Variety 1: Sakha 69 Variety 2: Giza 168 Refl. :Reflectant No Refl. : No Reflectant

Table 8: The effect of reflectants on proline concentration mg/g dw in leaves of wheat varieties grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 4.20 | 4.35 | 4.15 | 4.40 | 4.15 | 4.15 | 4.25 | 4.40 |
| 2000 | 4.58 | 4.40 | 4.15 | 4.35 | 5.30 | 4.20 | 4.50 | 4.35 |
| 4000 | 5.95 | 4.20 | 5.90 | 4.35 | 5.66 | 4.18 | 5.15 | 4.30 |
| 6000 | 6.35 | 4.05 | 6.20 | 4.40 | 6.22 | 4.20 | 6.10 | 4.35 |
| L.S.D at 5% level | 0.09 | N.S | 0.08 | N.S | 1.1 | N.S | 1.3 | N.S |

Variety 1: Sakha 69 Variety 2 : Giza 168 Refl.: Reflectant No Refl.: No Reflectant

Table 9: Effect of reflectants on total carbohydrate (mg/100g dw) content in wheat varieties leaves grown under different salinity levels

| Reflectants | Kaolinite | | | | Magnesium carbonate | | | |
|---|---|---|---|---|---|---|---|---|
| Varieties | Variety 1 | | Variety 2 | | Variety 1 | | Variety 2 | |
| Salinity (ppm) | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. | No. Refl. | Refl. |
| 0 | 39.28 | 39.28 | 37.75 | 38.11 | 37.45 | 36.11 | 38.11 | 37.85 |
| 2000 | 28.20 | 28.20 | 30.00 | 37.91 | 36.14 | 35.85 | 37.25 | 36.95 |
| 4000 | 30.11 | 34.10 | 27.50 | 35.63 | 29.30 | 34.75 | 31.14 | 34.22 |
| 6000 | 27.22 | 32.25 | 23.50 | 34.25 | 22.10 | 33.21 | 25.10 | 33.10 |
| L.S.D at 5% level | 1.10 | 0.33 | 1.11 | 0.75 | 0.80 | 0.76 | 0.98 | 0.36 |

Variety 1: Sakha 69 Variety 2: Giza 168 Refl.: Reflectant No Refl.:No Reflectant

stress reduced shoot length significantly the reduction ranged between 9.2 and 25.3% at both stages in Sakha 69 at 6000 ppm salinity level, while in Giza 168 the percentage of reduction was less than Sakha which ranged between 6.6 and 12.3%.

Using reflectants seemed to be effective only in variety Sakha 69, Kaolinite increased shoot length by 10.4% at the vegetative stage and 16.2% at jointing, while Magnesium carbonate increased shoot length by 1.4% at vegetative stage and 11.2% at jointing stage at 6000 ppm salinity level.

Moftah[11] and Aldesuquy *et al.*[12] supported previous results, as they found that antitranspirant treatments improved growth characters particularly at stress but this does not include all plant varieties. Salinity stress had a drastic effect on yield characters (Table 5 and 6).

Harvest index reduction percentage ranged between 35.4 and 33.8% in Sakha 69 and between 41.2 and 35.4% in Giza 168 at 6000 ppm salinity level. Spraying plants with Magnesium carbonate increased harvest index by 20% in both varieties, while kaolinite by 14.7% in Giza 168 and wasn't effective in Sakha 69.

Also, the biological yield plant$^{-1}$ was seriously affected under high salinity stress 6000 ppm, reduction reached 70% in Giza 168 and 67% in Sakha 69, Kaolinite treatment increased by biological yield by 22.2% in Sakha 69 and 13.1 in Giza 168 at 6000 ppm salinity level, while Magnesium carbonate increased it by 15% in Sakha 69 and 16.4% in Giza 168 at 6000 ppm salinity level compared to untreated plants.

The findings of Abdel Nasser [13], Khanvilkar *et al.*[14], El Kobbia *et al.*[15], Suryanarana *et al.*[16], Makus[17] and Aldesuquy *et al.*[12] supported previous results and proved that application of antitranspirant generally improved yield components of stressed plants.

Salinity stress induced an increase in Na/K ratio in both wheat varieties (Table 7). Using reflectants lowered Na/K ratio compared to untreated plants. Rajpar [18] and Grieve and Poss [19]. Came to the same results where they concluded that salinity stress increased $Na^+$ and lowered $K^+$ content. According to Grattan and Grieve[20] the reduction of K concentration in plant tissue observed with increasing salinity could be due to the interaction of Na x K at the uptake and transport level. Reduction of K uptake in plants by Na is a competitive process.

Proline content significantly increased with increasing salinity stress (Table 8) in both wheat varieties. However, the use of reflectants did not show any significant accumulation or decrease in proline content compared to the untreated plants. The results were in compatible with Rao and Bhatt[9], Cayuela *et al.*[21], Demir and Kocacaliskan[22], the other hand Sarma *et al.*[23] found that spraying with KCl and Paraquat at the boot leaf stage significantly increased plant moisture content and reduced proline content in seeds. However, Tang *et al.*[24] and Hamada[25] found that using antitranspirants increased proline level in leaves compared to their controls.

Demir and Kocacaliskan[22], Jain *et al.*[26] suggested that proline may play a role as an enzyme-stabilizing agent under NaCl salinity and reduces peroxidative damage to the lipid membranes due to salt dependent oxidative stress.

It was clear that salinity stress reduced carbohydrate content in wheat leaves (Table 9), the reduction percentage reached 40.98 in Sakha 69 and 37.34 in Giza 168 at 6000 ppm salinity level. The reflectants application improved the carbohydrate reserves under saline conditions Magnesium carbonate treatment helped in lowering the percentage of carbohydrate reduction compared to untreated plants, in Sakha 69 was only 8 and in Giza 168 12.5 at 6000 ppm, but for kaolinite application the reduction percentage was 17.8 in Sakha 69 and 10.12 in Giza 168 at 6000 ppm salinity level.

Hu-Yuncai *et al*.[7] found the main effect of salinity is on the water soluble carbohydrate and its accumulation is in the photosynthetically active zone during photoperiod. On the other hand, Marimuthu *et al*.[28] found that antitranspirant use had no effect on carbohydrate reserves.

## REFERENCES


1. Greenway, H. and R. Munns, 1980. Mechanism of salt tolerance in nonhalophytes. Ann. Rev. Plant Physiol., 31: 149-190.
2. Läuchli, A., 1986. Responses and adaptations of crops to salinity. Acta Horticulturae, 190: 243-246.
3. Cheeseman, J.M., 1988. Mechanisms of salinity tolerance in plants. Plant physiol., 87: 547-550.
4. Whitmore, J.S., 2000. Drought Management of Farmland. Kluwer academic publishers/Boston/ London, pp: 49-63.
5. Bates, L.S., R.P. Waldren and L.D. Teare, 1973. Rapid determination of free proline of water-stress studies. Plant and Soil, 39: 205-207.
6. Stewart, E.A., 1995. Chemical Analysis of Ecological Materials. 2nd Edn. chapter 8. Blackwell Sc. Publication. Oxford. London.
7. Snedecor, C.W. and J. Cochran, 1982. Statistical Methods. 7th Edn. Iowa State Univ. Press. Iowa, USA.
8. Laurie, S., M. Bradbury, G.R. Stewart, 1994. Relationship between leaf temperature, compatible solutes and antitranspirant treatment in some desert plant. Plant Science Limerick. 100 : 147-156.
9. Rao, N.K.S. and R.M. Bhatt, 1990. Responses of onion to antitranspirants, plant water balance. Plant Physiol. Biochem., New Delhi, 17: 69-74.
10. Nakano, A., Y. Uehara, K. Tozai, Ed., C. Kubota, Ed., K. Fujiwara, Ed., Y. Ibaraki, Ed. and S. Sase, 1997. The effects of kaolin clay on cuticle transpiration in tomato. Acta horticulturae, 440: 233-238.
11. Moftah, A.E., 1997. The response of soybean plants, grown under different water regimes, to antitranspirants application. Ann. Agril. Sci., Moshtohor, 35: 263-292.
12. Aldesuquy, H.S., A.T. Makarios and H.A. Awad, 1998. Effect of two antitranspirants on growth and productivity of salt treated wheat plants. Egyptian J. Physiol. Sci., 22:189-211.
13. Abdel-Nasser, G., 1993. Effect of some antitranspirants on growth, yield, water contents and water use of squash plant. Assiut. J. Agril. Sci., 24: 193-210.
14. Khanvilkar, S.A., N.P. Singh and S.D. Hukkeri, 1987. Response of spring sunflower to irrigation, mulch and antitranspirants. J. Maharashtra Agril. Uni., 12: 322.
15. El Kobbia, T. and A. Ibrahim,1986. Effect of Antitranspirants on salt accumulation in plant root zone under saline condition. Acta Horticulturae, 190: 291-298.
16. Suryanarana, V. and A. Venkateswarlu, 1981. Effect of irrigation frequency, antitranspirant and mulching on growth and yield of tomato. Orissa J. Horti., 9: 2, 17.
17. Makus, D.J., 1997. Effect of an anti-transpirant on cotton grown under conventional and conservation tillage systems. Proceedings Beltwide Cotton Conferences, New Orleans, LA, USA, January 6-10, 1: 642-644.
18. Rajpar and N.B Sial, 2002. Effect of hydroponic salinity 120 molm$^{-3}$-NaCl on the ion uptake and growth of different wheat varieties. Pak. J. Appl. Sci., 2: 541-543.
19. Grieve, C.M. and J.A. Poss, 2000. Wheat response to interactive effects of boron and salinity. J. Plant Nut., 23: 1217-1226.
20. Grattan, S.R. and C.M. Grieve, 1999. Salinity-mineral nutritional relations in horticultural crops. Sci. Hort., 78: 127-157.
21. Cayuela, E., A.F. Perez, M. Caro and M.C. Bolarin, 1996. Priming seeds with NaCl induces physiological changes in tomato plants grown under salt stress. Physiol. Plant, 96: 231-236.
22. Demir, Y. and I. Kocaliskan, 2001. Effect of NaCl and proline on polyphenol oxidase activity in bean seedlings. Boil. Plant, 44: 607-609.
23. Sarma, S., S.C. Dey and A.K. Choudhury, 1995. Effect of seed hardening, potassium levels and antitranspirant on proline content and NR-activity in rice *Oryza sativa* L.. J. Potassium Res., 11: 373-376.

24. Tang, R., J.H. Shen, H. Tong, Y.X. Guan, Qiu-Zensen, R.S. Tang, J.H. Shen, H.Y. Tong, Yx. Guan and Z.S. Qiu, 1999. Effect of FA Handilong on increasing drought resistance of rice seedling and its physiological basis. Jiangsu J. Agril. Sci., 15: 131-135.
25. Hamada, A.M., 2000. Amelioration of drought stress by ascorbic acid, thiamin or aspirin in wheat plants. Indian J. Plant Physiol, 5: 358-364.
26. Jain, M., G. Mathur, S. Koul and N.O. Sarin, 2001. Ameliorative effects of proline on salt stress-induced lipid peroxidation in cell lines of groundnut (*Arachis hypogaea* L.) Plant Cell Rep., 20: 463-468.
27. Hu-Yuncai, H. Schnyder, U. Schmidhalta and Hu-Yc, 2000. Carbohydrate deposition and partioning in elongating leaves of wheat under saline soil conditions. Australian. J. Plant Physiol., 27: 363-370.
28. Marimuthus, S., L. Manivel and R.R. Kumar, 1996. Carbohydrate reserve in tea roots. Planters-Chronicle, 91: 43-45.