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# EFFECT OF VARIOUS ABIOTIC STRESSES ON THE GROWTH, SOLUBLE SUGARS AND WATER RELATIONS OF SORGHUM SEEDLINGS GROWN IN LIGHT AND DARKNESS.

***Prabhjot Kaur Gill, Arun Dev Sharma*, Prabhjeet Singh, Sukdev Singh Bhullar***

*Department of Biotechnology, Guru Nanak Dev University, Amritsar – 143005, Punjab, India*

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**Summary**. The effect of NaCl, PEG, heat and cold treatments on growth, water content, FW, DW and soluble sugar levels in 3 day old seedlings of *Sorghum bicolor* CSH-6 were studied. Under these stress conditions, RWC and water potential of seedlings decreased dramatically. Subsequently this reduction resulted in the markable decrease in FW of different parts of stress imposed seedlings. On the contrary, a substantial increase in DW was observed. Furthermore, a considerable increase in the sugar levels in different plant parts was detected. The fructose level was always higher than that of the glucose and sucrose in response to various treatments. The stressed light grown seedlings showed an elevated content of sugars in comparison with dark grown seedlings. Based on these studies, a possible relationships between seedling growth, water content and soluble sugar content in relation to various abiotic stresses were discussed.

***Keywords***: Abiotic Stresses, Dark, Light, sugar content, *Sorghum bicolor*

***Abbreviations***: DW – Dry weight, E – Endosperm, FW – Fresh Weight, PEG – Polyethylene glycol, R – Root, RWC – Relative Water Content, S – Shoot, T – Total

## Introduction

Plant resort to many adaptive strategies in response to different abiotic stresses such as high salt, dehydration, cold, heat and excessive osmotic pressure which ultimately

* Corresponding author, e-mail: goldi77700@yahoo.com

affect the plant growth and productivity (Epstein et al.,1980; Yancey et al.,1982). Against these stresses, plants adapt themselves by different mechanisms including change in morphological and developmental pattern as well as physiological and biochemical processes (Bohnert et al., 1990). Adaptation to all these stresses is associated with metabolic adjustments that leads to the accumulation of several organic solutes like sugars, polyols, betaines and proline (Flower et al.,1977; Greenway and Munns 1980; Yancey et al.,1982)). Among these accumulating solutes, sugars represent the major reserve in the seeds (Bewley and Black, 1994) which maximally synthesized during germination and mobilized to various tissues like stem and internods (Smith et al., 1967) in the form of sucrose, glucose and fructose, that are readily transportable to sites where they are required for growth (Mayer et al., 1975) and maintained the osmotic regulation of cells (Garham et al., 1981). There are earlier reports on carbohydrate accumulation during various abiotic stresses in the temperate grasses and cereals from the Gramineae family where long term carbohydrate storage occur during reproductive development (Archbald, 1940; Meier and Reid 1982). Accumulation of sugars in different parts of plants is enhanced in response to the variety of environmental stresses (Macleod et al., 1958; Escalada et al., 1976; Garham et al., 1981; Prado et al., 2000; Wang et al., 2000). In case of salt (Gill et al., 1985; Lin et al., 1995) and water stress (Prado et al., 2000; Siddique et al., 2000), adaptation to these stresses has been attributed to the stress induced increase in carbohydrate level. There are few studies on carbohydrate status in germinated seeds and its early developmental stages under stress conditions. The metabolism of these compounds can be affected by a number of environmental factors such as irridance, temperature, salinity and type of ion present (Bohnert et al., 1995). Thus the variation that occurs in carbohydrate level, during early developmental stages of seedling under different abiotic stresses is not well understood and information on physiological events involved in this process is scarce. In this report, we present details on growth and status of soluble carbohydrates in the developing seedlings of Sorghum under different abiotic conditions. Up to best of our knowledge it is the first report on Sorghum which try to compare the results obtained from different stresses in view to describe the common physiological tolerance of this important for arid and semiarid regions crop ( Aronson et al., 1985). Hence to see the effect of water level and ionic changes on growth and metabolic adjustments inside the plants, natively grown under dry and salty areas, we have selected four different kind of abiotic stresses like cold, heat, salt (NaCl) and drought (PEG) which affect the water status differentially with respect to each other (Levitt, 1980). As light and darkness are the two important factors that affect the growth through number of ways including tissue enlargement and differentiation, photosynthesis, synthesis of pigments etc. (for review see Sachs (1962) and Bhatia (1970)). In this study, we made an attempt to investigate the effect of these abiotic stresses under the dark and light on some important physiological processes of sorghum closely connected with the mechanisms of adaptability of this crop to the environmental factors.

## Materials and Methods

**Plant material**. All the studies were carried out at seedling stage in *Sorghum bicolor* cv CSH-6. Different stress treatments were imposed to these seedlings in the presence of light and dark separately.

**Growth conditions and Stress induction.** *Sorghum* seeds were sterilized with 1% (w/v) mercuric chloride and 70% ethanol as described by Singh et al., (2000). The six imbibed seeds were spread on wet filter sheets in the petriplates and were placed in seed germinater at 37 °C in the dark. After 24 h of germination some petri plates containing 24 germinated seeds were transferred to another seed germinater at 37 °C in the light/ dark (14 h/10 h) photoperiod for further growth. The rest of petriplates containing 24 germinated seeds remained in the seed germinater under complete dark conditions. The different stress treatments were imposed to 3-day-old seedlings in complete dark and light/dark separately as follows:

- Seedlings were moistened with NaCl (0.41 M) having osmotic potential –1.86 MPa for 24 h at 37 °C.
- Seedlings were moistened with 31% PEG 8000 (-1.86 MPa) at 37 °C for 24 h.
- Cold treatment was imposed by placing the seedlings at 4 °C for 24 h.
- Heat shock was imposed to seedlings at 42 °C for 24 h.

**Determination of water potential and relative water content**. Water potential of each part (shoot, root and endosperm) from freshly harvested whole seedling was measured separately after each treatment. Measurements were made with a Themocoupler Dew point microvoltmeter (Model HR 33T,Wascor, USA). Relative water content of shoot, root and endosperm tissues of whole seedling after different stress treatments was determined as:

$$RWC = (\text{fresh weight} - \text{dry weight})/(\text{turgid weight} - \text{dry weight}) \times 100$$

Fresh weights were determined with in 2 h after excision. The dry weight was obtained after drying the plant tissues for 48 h at 72 °C. Turgid weight was obtained after soaking the tissues in distilled water for different time intervals depending upon the type of tissue. For light treated seedlings, time of reaching the full turgor weight for shoot, root and endosperm tissues was 3 h, 1 h and 0.5 h after soaking. Time for seedlings grown under dark was 4 h, 3 h and almost 0.5 h after soaking.

**Extraction and estimation of sugar**. The different tissues (shoot, root and endosperm) were extracted twice with 80% ethanol at 90 °C followed by 4 times extraction with 70% ethanol (Singh et al.,1994). The ethanol extracts of different tissues were pooled separately and concentrated in rotatory water bath at 70 °C under vacuum and their qualitative make up was ascertained by paper chromatography (PC) on 3 MM

Whatmann chromatography paper using *n*-Butanol : Acetic acid : Water (4 : 1 : 5, v/v/v) as an developing solvent and $AgNO_3$ in acetone as stain (Trevelyan et al.,1950). From the extract obtained, the reducing sugars were quantitatively estimated by Nelson's method (1944). Total sugars were estimated by Dubois et al. (1956) and free sugars were estimated by the method of Singh et al. (1994).

## Results

### Changes observed during various abiotic stresses in the presence of light

*RWC, Water potential changes in stress imposed seedlings*

Compare to treated seedlings parts (shoot, root and endosperm), control seedlings maintained higher mean RWC under PEG, NaCl, heat and cold treatments. Maximum decrease in mean RWC was observed in shoot and root parts of treated seedling in response to salt stress (Table1). On the contrary, under all these treatments mean RWC of endosperm remained unaffected. Water potential decreased dramatically under NaCl and PEG treatments (Table 1). Maximum decrease in water potential in root and shoot parts of 3 day old seedlings under NaCl and PEG treatments was observed. Relatively no significant change in water potential was observed in different tissue parts under cold treatment.

**Table 1**. Effect of NaCl, PEG, heat and cold treatments on RWC, water potential, DW and FW of different parts of 3 days old seedlings. Data are mean values ±SE of ten seedlings.

| Parts of seedlings | Type of stress imposed | Relative water content, (%) | Water potential, (bars) | Dry weight (mg) | Fresh weight, ( mg) |
|---|---|---|---|---|---|
| Shoot | NaCl | 81±0.57 | -46±1.00 | 4.0±0.57 | 30.0±0.56 |
| Root | – | 62±0.57 | -88±1.50 | 2.3±0.56 | 9.0±0.57 |
| Endosperm | – | 50±0.70 | -12±1.00 | 19.0±0.56 | 20.0±1.00 |
| Shoot | PEG | 93±0.57 | -50±1.00 | 5.0±0.28 | 32.0±1.00 |
| Root | – | 71±0.70 | -75±2.10 | 3.0±0.05 | 8.0±0.56 |
| Endosperm | – | 66±0.69 | -10±0.70 | 20.0±0.57 | 22.0±1.00 |
| Shoot | Heat | 89±0.70 | -40±1.00 | 3.5±0.20 | 30.0±0.57 |
| Root | – | 79±1.50 | -50±0.60 | 1.4±0.10 | 9.0±0.57 |
| Endosperm | – | 50±0.57 | -10±0.61 | 19.0±1.00 | 21.0±1.00 |
| Shoot | Cold | 93±1.00 | -24±1.20 | 3.3±0.07 | 31.0±1.00 |
| Root | – | 88±0.70 | -30±1.40 | 2.5±0.20 | 10.0±1.00 |
| Endosperm | – | 50±0.57 | -10±1.00 | 21.0±1.00 | 22.0±0.56 |
| Shoot | Control | 97±0.70 | -33±1.00 | 2.8±0.56 | 35.0±1.00 |
| Root | – | 89±0.70 | -29±0.50 | 1.8±0.15 | 10.0±1.00 |
| Endosperm | – | 50±1.00 | -8±1.02 | 19.0±0.57 | 20.0±0.70 |

*Changes in FW, DW and seedlings part lengths*

The relationship between FW and DW in control and stress imposed seedlings is summarized in Table 1. A remarkable reduction in FW under NaCl, PEG, heat and cold treatments was observed. Maximum reduction in FW was obtained in shoot part in response to NaCl and heat treatments (Table 1), whereas root and endosperm were least affected under different treatments.

On the contrary, a dramatic gain in biomass was observed under 4 different treatments, A significant increase in dry weight (relative to control) was observed in different tissues of treated seedlings in response to NaCl and PEG treatments (Table 1). Maximum increase was observed under PEG treatment where almost two fold increase in DW of shoot was observed, however endosperm was relatively unaffected under various treatments (Table 1).

Further we investigated the growth of seedlings under different abiotic stresses and growth was expressed by means of change in shoot and root lengths. A significant decrease in shoot and root lengths was observed in response to PEG, NaCl and heat treatments (Fig. 1). However cold treatment resulted in about 33% increase in root length relative to control which may be an adaptation against the cold environment.

*Change in Carbohydrate contents*

Imposition of different treatments to sorghum seedlings significantly increased total sugar content. As compare to control, a drastic increase was observed in shoot, root

**Table 2**. Effect of NaCl, PEG, heat and cold treatments on RWC, water potential, DW and FW of different parts of 3 days old seedling grown in the dark. Data are means ±SE of ten seedlings.

| Parts of seedlings | Type of stress imposed | Relative water content, (%) | Water potential, (bars) | Dry weight (mg) | Fresh weight, ( mg) |
|---|---|---|---|---|---|
| Shoot | NaCl | 85±0.56 | -45±1.0 | 4.8±0.10 | 34.0±0.56 |
| Root | – | 58±0.56 | -75±1.30 | 2.4±0.11 | 8.0±0.57 |
| Endosperm | – | 50±0.70 | -10±1.00 | 25.0±0.13 | 26.0±0.58 |
| Shoot | PEG | 88±0.76 | -46±0.75 | 5.3±0.75 | 35.0±0.59 |
| Root | – | 66±0.69 | -55±0.57 | 2.0±0.56 | 8.0±0.60 |
| Endosperm | – | 50±0.70 | -11±0.56 | 22.0±0.55 | 23.0±0.75 |
| Shoot | Heat | 93±0.15 | -30±0.53 | 3.3±0.56 | 37.0±0.85 |
| Root | – | 53±0.55 | -35±0.43 | 2.2±0.56 | 8.0±0.79 |
| Endosperm | – | 50±0.50 | -12±1.00 | 21.0±0.75 | 23.0±0.57 |
| Shoot | Cold | 96±0.60 | -24±1.11 | 5.6±0.85 | 33.0±0.55 |
| Root | – | 79±0.51 | -24±0.35 | 2.2±0.33 | 10.0±1.00 |
| Endosperm | – | 66±0.53 | -11±0.56 | 21.0±0.55 | 22.0±1.11 |
| Shoot | Control | 97±0.54 | -25±0.57 | 4.7±0.33 | 38.0±1.61 |
| Root | – | 88±0.56 | -23±0.57 | 2.1±0.56 | 10.0±1.73 |
| Endosperm | – | 50±0.34 | -10±0.58 | 23.0±0.71 | 24.0±1.00 |

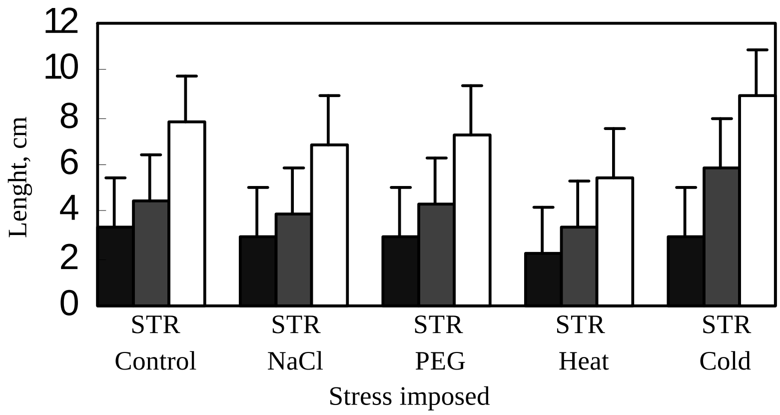


**Fig**. 1. Effect of various abiotic stresses on the shoot, root and total length of 3 days old light-grown seedlings. Vertical bars represent standard deviation of means.

and endosperm.: 4-fold increase in total sugar content in shoot part in response to NaCl treatment (Table 3). Six-fold increase in root tissue in response to PEG treatment. Similarly, a dramatic change was observed in endosperm in response to heat. Furthermore, the levels of reducing sugar were also much higher in the stress-imposed seedlings than that of control ones. PEG and NaCl treatments caused markable in-

**Table 3**. Effect of NaCl, PEG, heat and cold treatments on sugar content in different parts of 3 days old light-grown seedlings. Data are means ±SE of ten seedlings.

| Plant parts | Type of stress imposed | Sugar content (mg $g^{-1}FW^{-1}$) | | | | |
|---|---|---|---|---|---|---|
| | | Reducing | Total | Fructose | Glucose | Sucrose |
| Shoot | NaCl | 486±1.00 | 500±1.00 | 310±0.31 | 110±0.10 | 90±0.10 |
| Root | – | 39±1.11 | 138±1.11 | 10±0.57 | 8±1.11 | 9±1.31 |
| Endosperm | – | 295±0.75 | 332±0.75 | 213±0.55 | 73±0.75 | 12±1.00 |
| Shoot | PEG | 173±0.57 | 247±0.85 | 150±0.53 | 35±0.57 | 12±0.57 |
| Root | – | 224±0.55 | 247±0.57 | 170±0.57 | 25±0.55 | 10±0.58 |
| Endosperm | – | 357±0.56 | 385±0.56 | 310±1.00 | 35±0.43 | 11±0.61 |
| Shoot | Heat | 176±0.55 | 250±0.55 | 130±1.11 | 25±0.41 | 12±0.59 |
| Root | – | 54±0.71 | 96±1.00 | 31±1.12 | 10±0.56 | 5±0.61 |
| Endosperm | – | 184±0.81 | 420±1.11 | 120±0.57 | 30±1.00 | 15±0.59 |
| Shoot | Cold | 121±1.00 | 185±1.21 | 90±0.55 | 10±1.00 | 5±0.71 |
| Root | – | 46±1.11 | 118±0.85 | 25±0.31 | 11±0.57 | 5±0.73 |
| Endosperm | – | 146±1.00 | 288±0.86 | 98±0.41 | 21±0.58 | 9±1.00 |
| Shoot | Control | 114±0.75 | 171±0.76 | 98±0.57 | 9±0.59 | 5±0.73 |
| Root | – | 32±0.85 | 41±0.75 | 20±0.55 | 10±0.61 | 5±0.83 |
| Endosperm | – | 168±0.85 | 297±0.57 | 100±0.51 | 23±0.63 | 10±0.91 |

crease in reducing sugar content in all the tissue parts of stress imposed seedlings (Table 3). Difference in glucose, fructose and sucrose content changes were observed under various treatments. More substantial difference was establisshed in fructose and sucrose levels. Fructose content was always higher than the glucose and sucrose under NaCl, PEG and heat treatments. Four fold increase in shoot part under NaCl treatment, 8-fold increase in root and 3-fold increase in endosperm was observed in response to PEG treatment respectively.

**Changes observed in response to various abiotic stresses under dark conditions**

*Change in water status under stress conditions*

A substantial decrease in RWC was observed in the seedlings in response to all these four treatments. NaCl treatment resulted in significant decrease in RWC in shoot part of the treated seedlings. Similarly, a dramatic reduction in RWC was established in root tissue under heat treatment (Table 2). However, there was no significant difference in RWC between control and cold treated seedlings. Parallel to RWC, a conciderable decrease in water potential and an effective decrease was observed under NaCl treatment. On the other hand, no significant difference was established under cold treatment in all different parts of seedlings (Table 2). Tissuewise, maximum decrease in water potential was found in root under NaCl and PEG treatments whereas endosperm maintained equal water potential as that of control.

*Change in FW, DW and length of parts of seedlings*

Relative to control, a markable decrease in FW was observed in different parts of treated seedlings. NaCl and cold treatment caused significant decrease in FW in shoot part of seedling in response to stress (Table 2). Relatively no significant difference was observed in root and endosperm under different treatments.

The highest DW was established in shoot part of seedling in response to cold and PEG treatment. Minor increase in DW was observed in endosperm under NaCl treatment, whereas the differences caused by PEG, heat and cold treatments were insignificant (Table 2). Relative to control, all the treatments caused a substantial decrease in shoot and root lengths (Fig. 2).

*Carbohydrate changes*

Total sugar content was much higher in the treated seedlings under NaCl treatment as compare to the control. Tissuewise, maximum accumulation of total sugar was observed in endosperm tissue under cold treatment (Table 4). Root tissue showed maximum total sugar accumulation in response to PEG treatment. On the contrary, in shoot, no significant increase was observed under NaCl, PEG, heat and cold treatments. Level of reducing sugar content was much higher in shoot tissue of the treated seedling in response to salt stress as compare to other stresses. In root tissue, PEG treatment caused markable increase in the reducing sugar content. Significant increase in reducing

**Table** 4. Effect of NaCl, PEG, heat and cold treatments on sugar content in different parts of 3 days old dark-grown seedlings. Data are means±SE of ten seedlings.

Plant parts Type of stress imposed Sugar content (mg g$^{-1}$FW$^{-1}$)
Reducing Total Fructose Glucose Sucrose

| Plant parts | Type of stress imposed | Sugar content (mg g$^{-1}$FW$^{-1}$) | | | | |
|---|---|---|---|---|---|---|
| | | Reducing | Total | Fructose | Glucose | Sucrose |
| Shoot | NaCl | 190±2.86 | 295±0.50 | 100±0.55 | 70±0.43 | 13±1.11 |
| Root | – | 101±0.57 | 121±0.56 | 85±0.56 | 25±0.53 | 5±1.15 |
| Endosperm | – | 284±0.56 | 362±0.43 | 190±0.57 | 21±0.36 | 13±0.75 |
| Shoot | PEG | 183±1.00 | 189±0.53 | 99±0.10 | 55±0.37 | 14±0.81 |
| Root | – | 219±0.46 | 226±0.23 | 150±0.35 | 50±0.55 | 10±0.43 |
| Endosperm | – | 314±1.15 | 351±0.56 | 210±0.36 | 90±0.57 | 55±0.44 |
| Shoot | Heat | 181±0.57 | 212±1.00 | 110±0.37 | 60±0.56 | 20±0.57 |
| Root | – | 141±0.51 | 170±0.34 | 121±0.43 | 31±0.55 | 12±0.61 |
| Endosperm | – | 157±0.51 | 314±0.56 | 99±0.57 | 31±0.53 | 11±0.65 |
| Shoot | Cold | 161±1.00 | 191±0.55 | 98±0.56 | 40±0.52 | 24±0.47 |
| Root | – | 138±0.57 | 162±0.56 | 88±0.55 | 28±0.51 | 15±0.48 |
| Endosperm | – | 288±1.52 | 426±0.10 | 176±0.10 | 85±0.49 | 35±0.33 |
| Shoot | Control | 175±1.52 | 233±0.43 | 98±1.00 | 55±0.34 | 13±1.00 |
| Root | – | 102±1.00 | 107±0.05 | 75±1.11 | 25±0.75 | 10±1.11 |
| Endosperm | – | 219±0.56 | 272±0.07 | 175±0.73 | 35±0.10 | 10±0.75 |

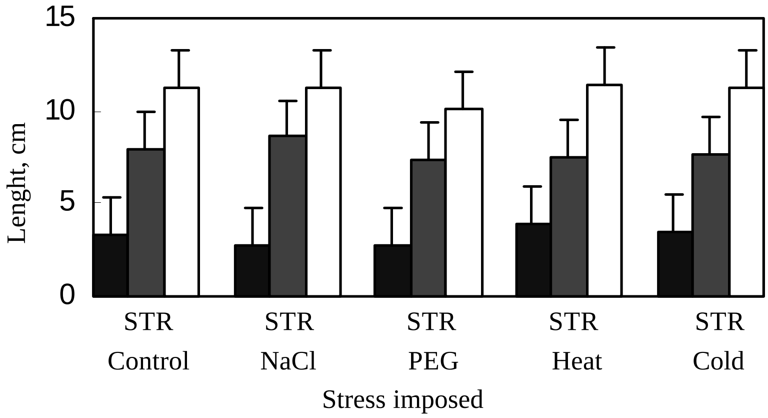


**Fig. 2**. Effect of various abiotic stresses on the shoot, root and total length of 3 days old dark-grown seedlings. Vertical bars represent standard deviation of means

sugar content was observed in endosperm in response to PEG treatment (Table 4). Similarly among the free sugars, fructose was found to be maximally accumulated in stress imposed seedlings under heat and NaCl treatments. Relatively no change in free sugar content in all the parts of the treated seedlings was observed under cold and PEG treatments. Similar type of pattern was observed for glucose and fructose contents (Table 4).

## Discussion

The effect of various abiotic stresses on S*orghum bicolor cv-CSH-6.* was studied. Imposition of all these stresses at the seedling stage resulted in the significant reduction in RWC of the shoot and root tissues of the treated seedlings indicating that plants were under stress at the time of sampling. Siddique et al. (2000), in wheat, Prado et al. (2000), in *Chenopodium quinona,* (Rascio et al., 1988) and Pennypacker et al. (1990) in alfalfa have reported the similar findings where drought stress and salt stress resulted in significant decrease in RWC. Among all the treatments studied, imposition of NaCl and PEG treatments resulted in a significant decrease in RWC and water potential of those seedlings which were grown under light (Table1). No significant difference in RWC and water potential was observed under heat and cold treatments as compare to the other two stresses with respect to the control. A similar type of trend was noticed in those seedlings which were grown in the dark. On the contrary, all the stresses had no significant effect on water potential in endosperm of seedlings grown under light or dark conditions. These observations support the earlier findings that water potential of wheat grain is relative insensitive to water stress (Aspinall et al., 1983; Barlow et al., 1983; Brooks et al., 1982). All these changes in water potential might be attributed to the change in osmotic pressure – the osmotic component of water potential (Siddique et al., 2000).

In relation to seedling growth, shoot and root length of the treated seedlings was suppressed by all abiotic stresses. As compare to shoot and root length of the control seedlings (3.4 cm, 4.4 cm) grown under light, a significant decrease in their lengths was observed. Among all the four treatments, a markable decrease was established in shoot under heat treatment (2.2 cm) as compare to the other stresses, whereas root length was markedly affected under NaCl and heat treatment) (Fig.1). Similarly, in comparison to shoot and root lengths of the control seedlings grown under dark, a substantial decrease in shoot length was observed in NaCl and PEG treatments. Root length was significantly affected by PEG treatment only (Fig. 2). They were smaller than those seedlings which were soaked with distilled water because of reduced FW resulting from reduced water absorption (Prado et al., 1995; 2000). The FW increase of seedlings in distilled water was mainly due to an increase in tissue water content which is clearly reflected on water potential and RWC (Table 1, 2). Under all the four stresses, a significant decrease in FW of shoot tissue was observed. Similar changes were noticed for root tissue also under NaCl, PEG and heat treatments, whereas no change was observed under cold tretament in the light or dark grown seedlings. On the other hand, no substantial difference was established in endosperm tissue under both conditions (Table 1,2). In contrast to significant decrease in FW, all the stresses resulted in significantly higher gain in biomass as it is clear from the increase of DW after stress imposition (Table 1, 2). This DW increase is associated with cell division and new material synthesis (Sunderland et al., 1960). Hence, this gain in biomass might be attributed to the increased synthetic activity which is visible from the DW values. The established increase after stress imposition probably reflects an increase in carbohydrate metabolism (Table 3, 4). Furthermore, we observed a significant increase in shoot DW after NaCl and PEG treatments in light as compare to dark (Table 1). Relatively minor increase was observed under heat and cold treatments . This enhancement might be attributed to the light enhanced synthesis of anthocyanins and other flavonoid pigments which are involved in the sugar metabolism in the chlorophyll containing cells under stress conditions (for details see, Salisbury et al., 1995). Similarly an substantial increase in root DW was observed under NaCl, PEG and cold treatments. After stress impositions to the dark grown seedlings DW in shoots was more under PEG and cold treatments (Table 2). Root tissue was maximally affected under NaCl treatment. No significant change was observed in endosperm tissue under all the stresses in light or dark. Further to go insight into the physiological changes occurred during stress conditions, we studied the sugar content changes in the different tissue parts of the stress imposed seedlings. In the earlier research, Gill and Singh (1985) has reported that germination, growth, respiration and other related processes can be affected in seeds that are subjected to environmental stresses. Changes in anyone of these processes can affect other metabolic activities, particularly the carbohydrate metabolism that plays an important role in germination and seed development. In this context, our results showing these variations that occurred in total soluble sugar content during various abiotic treatments in sorghum seedling could be very useful to understand the physiological events associated with seed germination and its development. In the early research Schubert et al., (1995), has reported a linear correlation between salt stress and dry matter accumulation in *Medicago sativa*. Our findings coinsided with results of *Medicago. S*ignificant increase in total soluble sugar, reducing sugar content in response to various abiotic stresses in different parts of treated seedlings was observed (Table 3, 4). In light grown seedlings total sugar and reducing sugar content in the shoot and root tissue was maximum under NaCl and PEG treatment as compare to the heat and cold treatments (Table 3). Nearly the same trend was observed in the dark grown seedlings under these two osmotic stresses (Table 4). Among the free soluble sugars, fructose was accumulated to the higher extent than that of glucose and sucrose which have been associated with an adaptation to different environmental conditions (Quick et al., 1989; Wang et al., 1996). This could be attributed to the fact that seed carbohydrate metabolism under stress conditions can be considered as a dynamic process involving concomitantly occurring processes of polysaccharide degradation and synthesis of new compounds and nevertheless, some researcher agree that salinity and water stress induce soluble sugar accumulation (Binzel et al., 1989; Wang and Stutte. 1992; Kameli and Losel. 1995). All these studies indicates that the changes observed under stress conditions are totally associated with adaptation of plants to various stresses which leads to gain in synthetic activity, carbohydrate content and other changes associated with them. Consequently, our study is the first contribution to understanding the physiological events occuring during the early developmental period of Sorghum seedlings. Sorghum is a major crop of temperate areas with high tolerance against drought. Further investigations are needed to impove our understanding of the effect of different abiotic stresses during early seed development.

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