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Seed Priming: Technology to improve Wheat Growth under Abiotic Stress Conditions

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Abstract

This study was conducted to check the role of seed priming in relation to wheat plant abiotic stress tolerance. Seeds of wheat cultivars NARC-2009 and NARC-2011 were surface sterilized and Halo, osmo and hydro priming methods were used, afterwards seed was allowed to germinate. Water stress was induced by with holding water for nine days, salinity induced by increasing salt in irrigation water for seven days and heat stress was induced by applying 40°C temperature treatment. Abiotic stresses influenced root length, shoot length, fresh weight and leaf area of wheat plant but seed priming ameloriated negative impacts of stress. The best treatment in drought and heat stress condition with 39% and 35% increased in root length was hydropriming. The most actual priming treatment under high salt condition was 5mM KNO_3 priming which increased root length up to 40%. Seed priming helped plant to alleviate determintal effect of different abiotic stresses.

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Introduction

Stress cause reduction in vital processes, accomplished by the plant for its growth and reproduction. Stress can be biotic and abiotic. Wheat (*Triticum aestivum* L.) is one of the significant crops grown as food source all over the world (Ashraf and Foolad, 2007). Drought stress can be defined as lack of required water for plant optimal growth and reproduction (Lichtfouse, 2010). Salt stress can be defined as increase in soluble salts from optimal level causing reduction in plant size and growth. A destructive effect caused by salt stress is not linked to any one aspect but it is combined influence of a number of many metabolic reactions that are being modified due to high salt concentration (Raza *et al.*, 2006; Ashraf and Ahsraf, 2012). Heat stress is defined as increase in temperature beyond an optimal level of plant. Permanent changes like reduction in growth and shortening of life cycle are introduced due to this stress. (Asseng *et al.*, 2011).

Seed priming is a pre-sowing seed treatment and partial hydration of seeds performed in controlled conditions while emergence of radical is avoided by drying before sowing (Basra *et al.*, 2006; Janick, 2010). Seed priming is proved to be cost effective strategy which is very helpful to increase growth attributes of cereal crops (Farooq *et al.*, 2009). Soaking of seeds before sowing can enhance rate of growth and seedling establishment (Farooq *et al.*, 2010). Hydro priming is immersing of seeds using distilled water. Halo priming is soaking of seeds using different salts solutions. Osmopriming is immersing of seeds in different solutions of osmotic concentrations.Therefore the present study was conducted to find out the role of priming in salt, drought and heat stress conditions.

Materials and methods

This study was carried out at PMAS Arid Agriculture University to study the role of wheat seed priming in relation to abiotic stress tolerance. Wheat selected variaties (NARC- 2009 and NARC- 2011) seed were surface sterilized by using with 0.1% mercuric chloride. For hydro priming, seeds was soaked in distilled water for 24 hours (Mabhaudhi and Modi, 2011). For osmo priming, seeds were soaked in potassium nitrate solution for 24 hours under lab conditions and two concentrations of KNO_3 i.e. 5mM and 10mM were used(Qadir *et al.*, 2012).

Halo priming was carried out by soaking seeds in sodium chloride (5mM and 10 mM NaCl) solution for 24 hours under lab conditions (Basra *et al.*, 2005). After seed priming seeds were sown in plastic pots and three seedlings were allowed to establish per pot. After 45 days of sowing stress was induced. Drought stress was induced by water holding water for 9 days,salt stress was induced by increasing salt (200mM) in irrigation water for 7 days and heat stress was applied by giving high temperature treatment (35 °C) to plants in incubator for 2 days. Soil samples were taken from depth of 15cm after harvesting the crop. Estimation of soil samples for different soil parameters including soil texture, pH, EC and soil moisture was done (Table 1).

Soil moisture content was calculated by using gravimetric analysis (Hesse, 1971). Soil solution was made by mixing 5g soil in 50ml water and well shaken for one hour by use of magnetic stirrer. pH meter (ino Lab – 720) was inserted in soil solution to measure soil pH. Conductivity meter was used to measure electrical conductivity of saturated soil solution (Rhoades, 1982). Samples from each treatment were assesd for root and shoot length. Fresh weight of roots and shoot of each treatment was measured. Leaf area meter (CID, CI-202) was used to measure leaf area. A two factor factorial experiment was designed with three replications. Analysis of variance was done by using Statistics 8.1 program.

Results and discussion

When root length data subjected to ANOVA, it was found that effect of seed priming remained significant ($p \leq 0.05$) (Fig. 1). Hydro priming was proved to be best treatment in drought condition with 35 % increase in root length. The most effective treatment in high salt was 5mM KNO_3 priming which increased root length up to 61%.

Table 1. Soil characteristics under different abiotic stresses.

Soil parameters	Control	Drought exposed	Salt exposed	Heat exposed
Moisture content(%)	18.96	4.16	14.28	14.68
pH	7	7.1	7.3	7.01
EC (µS/cm)	184	149	641	152

Hydro priming was also proved to most effective treatment in high temperature with 23 % increase in root length. When subjected to ANOVA results show significant difference ($p \leq 0.05$) (Fig 2). In shoot length 33% increase was observed in drought stress by hydro priming and 5mM KNO_3 was also most effective for high salts with 20 % increase in shoot length followed by Hydro priming with 11 % and 5mM NaCl with 6% increase respectively (Fig. 3). Root fresh weight of hydro primed plants was highest and increased up to 35% followed by 5mM KNO_3 with 29% increase.

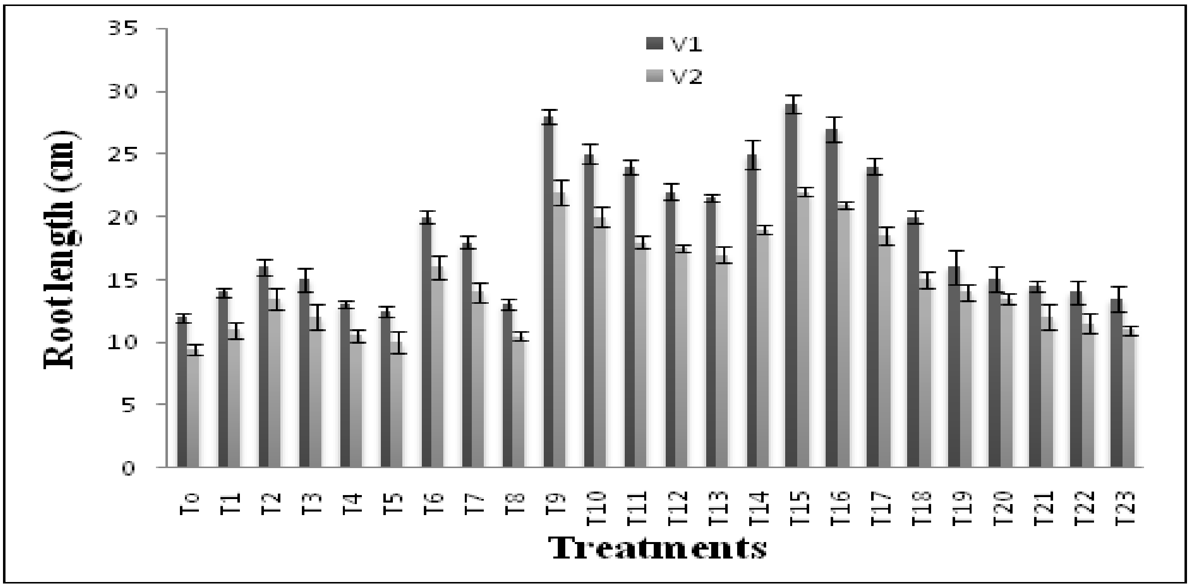

Fig. 1. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO$_3$) and halo priming (5mM, 10mM NaCl) on root length of two wheat varieties under drought, salt and heat stress. To= well watered and un primed, T1= hydro primed and well watered, T2= Osmo primed (5mM KNO_3) and well watered, T3= Osmo primed (10mM KNO_3) and well watered, T4= halo primed (5mM NaCl)and well watered, T5= Halo primed (10mMNaCl) and well watered, T6= drought stressed, T7= salt stressed, T8= heat stressed, T9= hydro primed and drought exposed, T10= Osmo primed (5mM KNO_3) and drought exposed, T11= Osmo primed 10mM KNO_3 and drought exposed, T12= halo primed (5mMNaCl)and drought exposed, T13= Halo primed (10mMNaCl) and drought exposed, , T14= hydro primed and salt exposed, T15= Osmo primed (5mM KNO_3) and salt exposed, T16= Osmo primed 10mM KNO_3 and salt exposed, T17= halo primed (5mM NaCl)and salt exposed, T18= Halo primed (10mM NaCl) and salt exposed, , T19= hydro primed and heat exposed, T20= Osmo primed (5mM KNO_3) and heat exposed, T21= Osmo primed 10mM KNO_3 and heat exposed, T22= halo primed (5mMNaCl)and heat exposed, T23= Halo primed (10 mM NaCl) and heat exposed. V1= NARC-2009 and V2= NARC-2011.

Five mili molar potassium nitrate priming resulted in maximum root fresh weight with 25% increase followed by hydro priming with 24% and 5mM NaCl with 18%, increase in plant grown under high salts. Hydro priming on root fresh weight remained highest with 28% increase. Root dry weight of hydro primed plants was highest and increased up to 25%. ANOVA analysis showed considerably difference in results ($p \leq 0.05$) (Fig. 4).

Shoot fresh weight of plants were decreased in drought, heat and salt stress as compared to control plants. Seed priming increased shoot fresh weight in control and stress conditions (Fig 5). Shoot fresh weight of hydro primed plants was highest and increased up to 36% in water stress and hydro priming remained effective for heat with 30.4% increase.

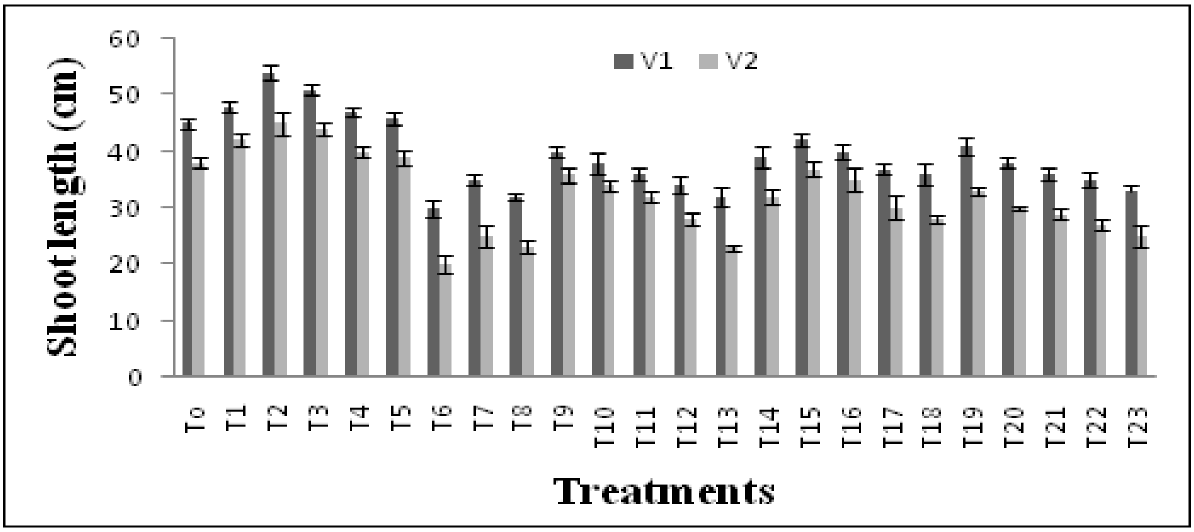

Fig. 2. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO_3) and halo priming (5mM, 10mM NaCl) on shoot length of two wheat varieties under drought, salt and heat stress.

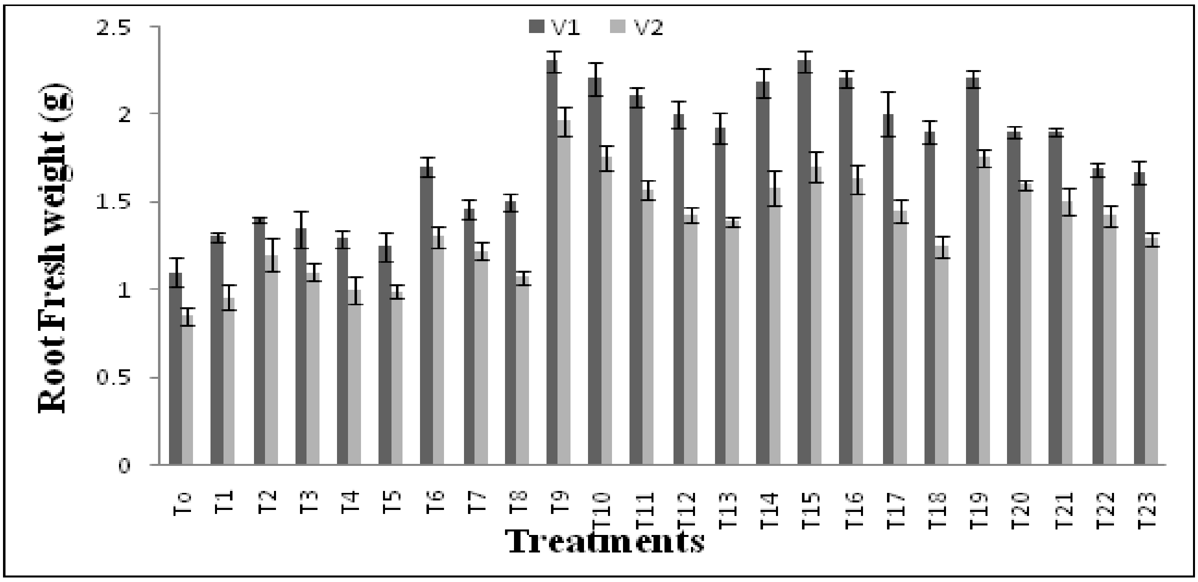

Fig. 3. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO_3) and halo priming (5mM, 10mM NaCl) on root fresh weight of two wheat varieties under drought, salt and heat stress.

In salt stress condition 5mM KNO_3 priming resulted in shoot fresh weight with 19.3% increase. ANOVA analysis of shoot dry weight showed significant results ($p \leq 0.05$) (Fig. 6). In drought stress hydro primed plants was shown highest shoot dry weight and increased up to 32%. Hydroprimed plants shown large leaf area under all stresses. Under drought stress, leaf area hydro primed plants was showed increase up to 19% and in salt stress, 5mM KNO_3 priming resulted in maximum leaf area with 20% increase followed by heat stress, effect of hydro priming on leaf area remained highest with 15% increase as compared to stressed unprimed plants (Fig. 7).

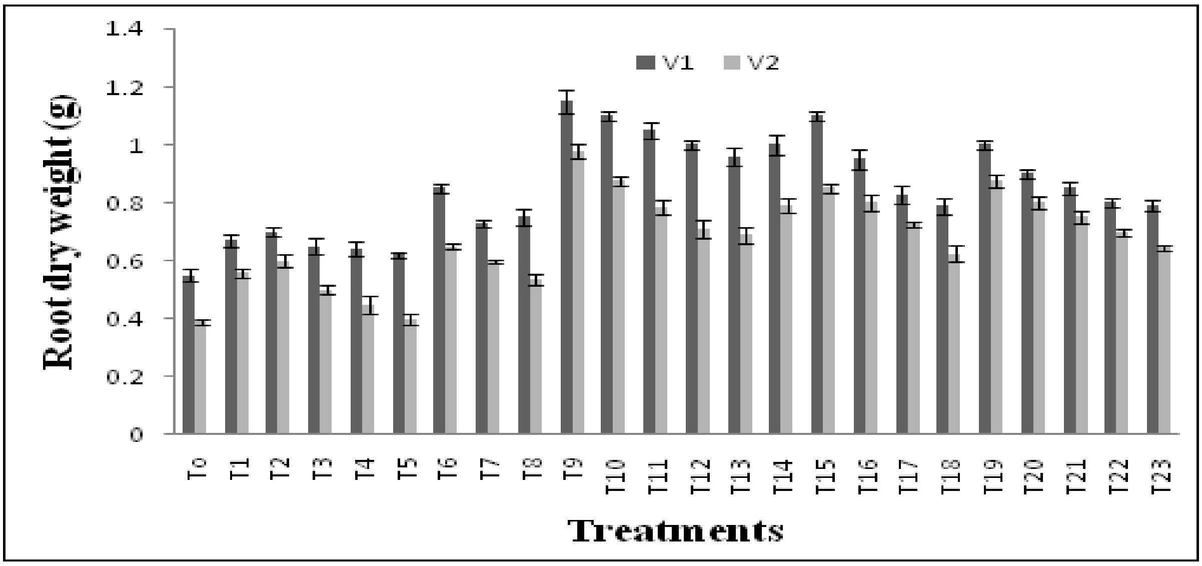

Fig. 4. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO$_3$) and halo priming (5mM, 10mM NaCl) on root dry weight of two wheat varieties under drought, salt and heat stress.

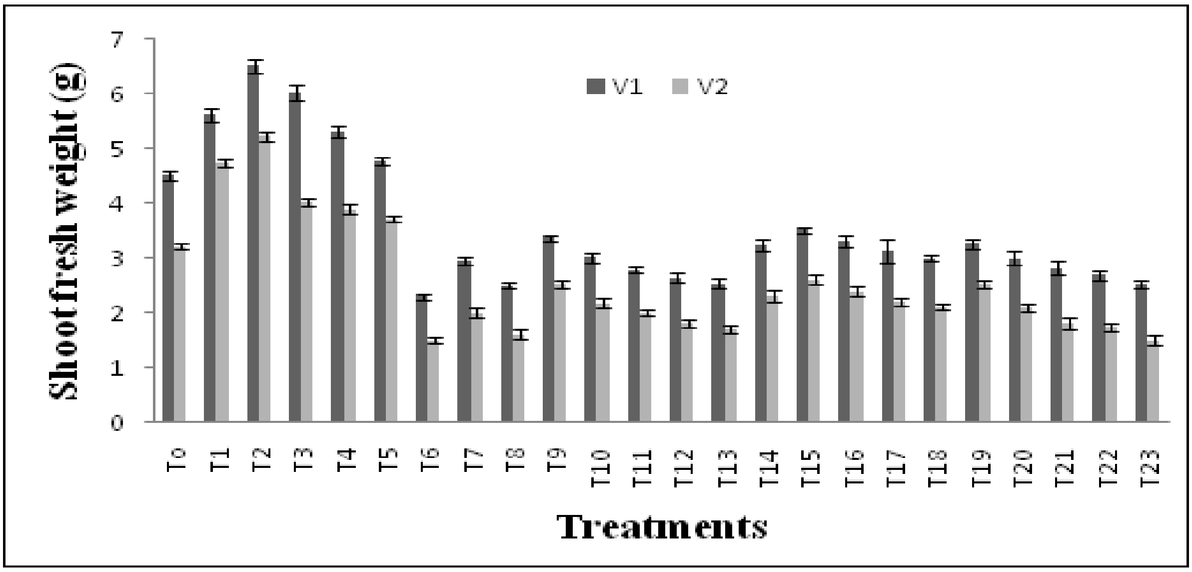

Fig. 5. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO$_3$) and halo priming (5mM, 10mM NaCl) on shoot fresh weight of two wheat varieties under drought, salt and heat stress.

On account of global environmental changes, drought, salinity and high temperature are important stresses that cause a limitation in crop establishment, growth and productivity. Different priming strategies were used in order to screen the most effective seed priming under different abiotic stress conditions (Powell *et al.*, 2000; Afzal *et al.*, 2008). Primed seeds can better imbibe water than stressed seeds thus enhancing tolerance under stress conditions. Negative effects of salinity on shoot length and root length were observed due t disturbance in the physiology and disturbance in metabolism and eventually reduced plant expansion. Shafi *et al.* (2009) findings depict that drought stress effects cell division which eventually decreases cell elongation process. Present study finding depicted that hydro priming increased root length and shoot length under drought and heat stress followed by KNO_3 priming which improved these parameters under saline conditions as compared to stressed unprimed plants. Moreover; priming has a positive effect on cell division by synchorization of the G_2 cycle processing. These results are in accordance with findings of Sivritepe *et al.* (2003); Abbasi *et al.* (2012); Ahmadvand *et al.* (2012) ; Kaur *et al.* (2012). Shoot fresh and dry weight decreased under in unprimed plant grown in saline environment and this decrease is remobilization of reseviors from cotyledons to embryo axis affecting growth rate (Nazem Bekaee and Fahimi, 1999).

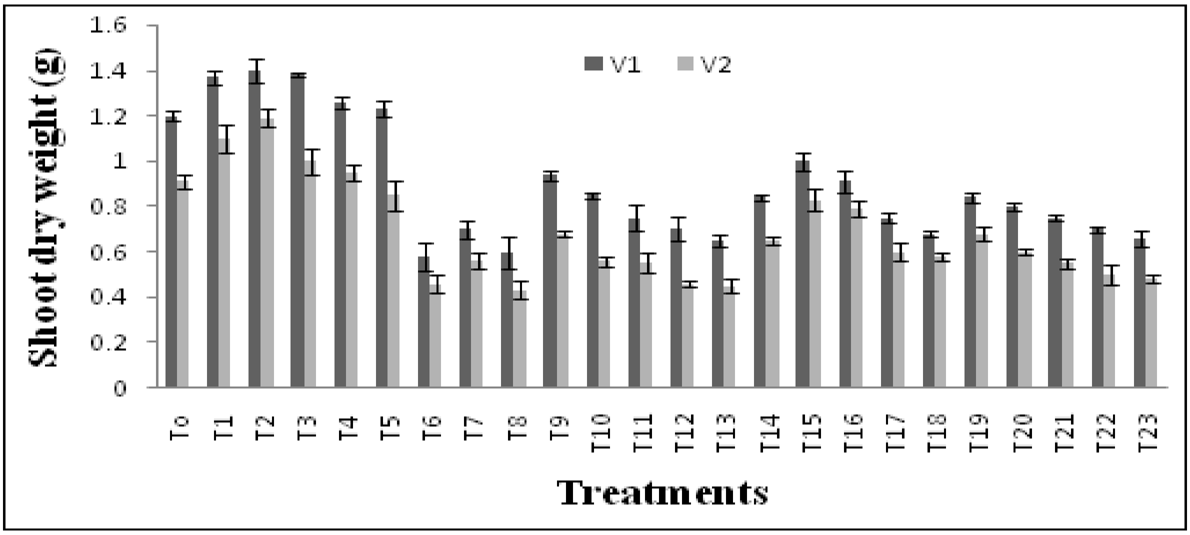

Fig. 6. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO_3) and halo priming (5mM, 10mM NaCl) on shoot dry weight of two wheat varieties under drought, salt and heat stress.

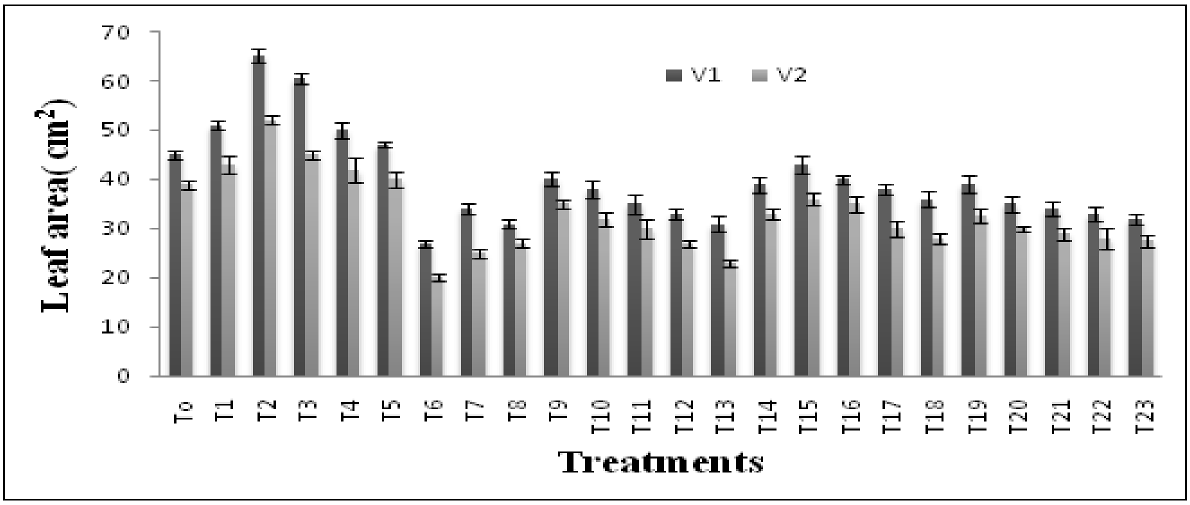

Fig. 7. Effect of Hydro priming, Osmo priming (5mM, 10mMKNO3) and halo priming (5mM,10mM NaCl) on leaf area of two wheat varieties under drought, salt and heat stress.

Presently it was found that plant weight was increased hydro priming and KNO_3 priming under drought and salt stress was observed, which is in accordance with results of Moghanibashi *et al.* (2012); Ahmadvand *et al.* (2012). Leaf area increase by KNO_3 priming under salt stress conditions was observed and supported by Ahmadvand *et al.* (2012).

Present study also depicted that hydroprimed plants had leaves with maximum leaf area under drought stress as found by Eniseh and Khourshid (2010).

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