Research Article

Effect of Salinity and Seed Priming on Growth Characters of Wheat Varieties

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Abstract | The research study entitled "Effect of salinity and seed priming on growth characters of Wheat varieties" was carried out at Institute of Biotechnology and Genetic Engineering (IBGE), The University of Agriculture, Peshawar during winter 2013-2014. The experiment was conducted in completely randomized design (CRD) with three replications. The response of fourteen wheat varieties at two seed treatments (primed with 50 mM $CaCl_2$ and un-primed) with four salinity levels (0, 45, 90, 135 mM) was studied in sand as growth media. The results revealed that incremental increase of salinity stresses had decreasing effect on growth parameters compared with control. Highest germination (85.42% and 84.31%) was recorded from wheat varieties (Lalma-2013 and Pirsabak-2005). Minimum germination (64.40% and 73.89%), tillers plant^{-1}(2.83 and 3.49), leaves plant^{-1}(11.44 and 12.79), leaf area (21.47cm^2 and 25.20cm^2) and more days to emergence (9.92 and 8.98), was recorded from salinity levels of 135mM and 90mM, respectively compared with maximum germination (94.80%), tillers plant^{-1} (4.42), leaves plant^{-1} (17.45), leaf area (32.10cm^2) less number of days to emergence (7.54) from control. All growth parameters were significantly improved by seed priming with $CaCl_2$ except shoot length (cm). It is concluded that salinity stresses has adversely affected growth traits of wheat varieties however, seed priming with $CaCl_2$ has alleviated the adverse effects of salinity in wheat varieties.

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Introdcution

Among abiotic stresses salinity is the most important stress, which adversely affects growth and yield characters of crop (Bakht et al., 2012). Soil salinity is one of dominant barrier which minimize the yield of crops (Yokoi et al., 2003). Salinity stress is very serious threat to agricultural productivity in arid and semi-arid area (Babu et al., 2012). Soil salinity is the most severe problem of Pakistan, caused by human-induced soil erosion and long-term mismanagement of irrigation (Kausar et al., 2012). Pakistan is the 8th country in term of area (6174.5 thousand ha.) affected with salinity. In Pakistan, irrigated area is 16.795 million ha.out of which 10% of the area is slightly saline, 7% is strongly saline, 4% is moderately saline, 6% is miscellaneous, and 73% is categorized as non-saline (Haq et al., 2010). Salinity in the arid and semi-arid region reduces the yield of major crops up to 50% (Dugasa et al., 2016). Salts increase soil osmotic potential (decrease water potential), causing water to move from areas of lower salt concentration (plant tissue) in the soil where salt concentration is higher (Horneck et al., 2007). Crop physiology is disturbed at cellular and plant level (Shahid et al., 2011) initially through osmotic effect, later on plant growth is suffered by toxic effect (Collado et al., 2016). Poor emergence and reduced crop stand establishment are the main constraints in getting good yield, under high osmotic stress condition (Nawaz et al., 2013).

Seed priming with salinity alleviating agents has positive effect on performance of plants in saline growth medium (Afzal et al., 2008). Seed priming is a technique in which seeds are exposed to low water potential, which reduce the hydration of seed. Halopriming is one of those pre sowing seed treatment techniques which enhance germination and stand establishment. Seed priming is one of the simplest and low cost strategies to induce salinity tolerance in crops (Afzal et al., 2012). $CaSO_4$ and $CaCl_2$ proved to be the most effective priming treatments of wheat seed (Farooq et al., 2008). Wheat (*Triticum aestivium L.)* is the important staple cereal crop of Pakistan and grown throughout the country both on irrigated and rainfed areas. Total wheat production of Pakistan during the year 2014-15 was 25086 thousand tons. Wheat production of Khyber Pakhtunkhwa was 1260 thousand tons during 2014-15. Average yield of Khyber Pakhthunkhwa was 1720 kgha^{-1}and stand forth on provincial hierarchy. However, no remarkable increase in average yield of Khyber Pakhthunkhw aoccurs for the last two decades (MNFSR, 20014-15). With such a low average yield Pakistan in general and Khyber Pakhthunkhwa in specific would not be able meet the present and future food security of the nation. The production of wheat should be increased to meet the growing demands of growing population. Keeping in view the problem of salinity, the present experiment was designed to screen various wheat varieties for salinity tolerance, primed before sowing with salinity alleviating agent, when subsequently exposed to different salinity levels.

Materials and Methods

The experiment entitled: "Effect of salinity and seed priming on growth characters of Wheat varieties" was conducted at Institute of Biotechnology and Genetic Engineering (IBGE), The University of Agriculture Peshawar during winter season 2013-2014. The experiment was conducted in Completely Randomized Design (CRD) with three replications. The experiment was conducted in sand culture as growth media. Fourteen wheat varieties (viz. Lalma-2013; Shahkar-2013; Pirsabak-2013; Insaf-2015; Barsat-2010; Atta Habib-2010; Siran-2010; Bathoor-2008; Pirsabak-2008; Seher-2006; Pirsabak-2005; Saleem-2000; Uqab-2000; Inqilab-1991) were screened at two seed conditions (Primed with 50mM $CaCl_2$ and unprimed) with salinity (NaCl) levels of (0, 45, 90, 135 mM). In case of priming, seeds of the above mentioned wheat varieties were soaked in $CaCl_2$ (50 mM) solution for 12 hours at 25^{0}C, followed by surface drying, while dry seeds of same varieties were used as control. The sand was sterilized by thoroughly washing three times as a growth media. A standard pot of size (380.00 cm^2) with the capacity of 5kg sterilized sand was used for all treatments. Twenty seeds of various wheat varieties were sown in pots at uniform depth, salinized with desired level of NaCl (0, 45, 90, 135 mM). After completion of emergence thinning was done and 10 plants were maintained in each pot. The nutrients were applied intermittently to pots in the form of half strength Hoagland solution (Hoagland and Arnon, 1950). The composition of Hoagland solution in mg L^{-1} was KH_2PO_4, 24.8; K_2SO_4, 15.9; KNO_3, 18.5; $(NH_4)_2SO_4$, 48.2; $Ca(NO_3)_2$, 59.9; $MgSO_4$, 65.9; $MnCl_2.4H_2O$, 0.90; H_3BO_3, 2.90; $ZnSO_4.7H_2O$, 0.11; Fe citrate, 5.0; $CuSO_4.5H_2O$, 0.04; and H_2MoO_4, 0.01. The pH of solution was kept between 6.0-6.5. The salinity levels of the Hoagland solution was monitored regularly. Harvest of the plants was carried out after 50 days of sowing. Th edata was recorded on germination (%), days to emergence, tiller plant^{-1}, leaves plant^{-1}, leaf area (cm^2), shoot length (cm). Germination (%) was calculated by sowing 20 seeds of primed and unprimed treatment in pots, and germinations (%) was determined by dividing number of seed count emerged by total seed sown. The data on days to seedling emergences was recorded when seedling fully emerged in pots. The tillers of three plants were randomly chosen, counted and averaged to obtain the data for number of tillers plant^{-1} for each treatment. Leaves of three randomly selected plants in each treatment was counted and averaged to get number of leave splant^{-1}. Leaf area (cm^2) was determined manually with the help of ruler from top, middle and bottom of the plant, by multiplying the leaf blade length and averaged leaf width. The averaged leaf width was determined by taking leaf width from tips and center of the leaf. Shoot length (cm) of three randomly selected plants from each treatment was measured with the help of ruler and averaged.

Statistical analysis of the data for analysis of variance (ANOVA) was done by the method described by Gomez and Gomez (1984). All data are presented as mean values of three replicates. The significance of differences among means was compared by using the LSD test (Steel and Torrie, 1980).

Table 1: *Germination (%) and days to emergence, tillers plant^{-1}, leaves plant^{-1}, leaf area (cm^2) and shoot length of wheat varieties as affected by seed priming and salinity.*

Varieties	Germination (%)	Days to emergence	Tillers plant^{-1}	Leaves plant^{-1}	Leaf Area (cm^2)	Shoot Length (cm)
Lalma-2013	85.42a	8.13hi	3.99b	15.34b	29.80b	35.44a
Shahkar-2013	84.03b	8.25fgh	3.78cd	14.89c	28.33c	30.17cd
Pirsabaq-2013	81.11d	8.29fgh	3.77cd	14.87c	28.13c	30.20cd
Insaf-2015	82.64c	8.17ghi	3.83c	14.99c	29.76b	30.42c
Barsat-2010	78.06f	8.63e	3.55f	14.41d	24.76g	28.29g
Atta-Habib-2010	79.31e	8.33fg	3.72de	14.79c	27.28d	29.90de
Siran-2010	75.97g	8.92cd	3.56f	13.84e	26.14f	28.75g
Bathoor-2008	79.17ef	8.79de	3.65e	14.30d	26.66e	29.65ef
Pirsabaq-2008	79.03ef	8.38f	3.72de	14.84c	27.29d	29.25f
Seher-2006	74.86gh	9.13b	3.19i	13.00g	24.01h	25.54i
Pirsabaq-2005	84.31ab	8.04i	4.31a	15.91a	31.05a	32.57b
Saleem-2000	74.72h	9.00bc	3.41g	13.40f	24.20h	27.66h
Uqab-2000	72.50i	9.38a	3.00j	12.37h	22.57i	25.26h
Inqilab-1991	75.28gh	9.33a	3.28h	12.82g	24.40gh	27.29i
Salinity (mM)						
0	94.80a	7.54d	4.42a	17.45a	32.10	38.22
45	83.02b	8.07c	3.76b	15.39b	28.20	32.76
90	73.89c	8.98b	3.49c	12.79c	25.20	26.28
135	64.40d	9.92a	2.83d	11.44d	21.47	19.99
Seed priming						
Un-primed	75.97	9.05b	3.45b	13.76b	25.93b	29.21
Primed	82.08	8.20a	3.80a	14.78a	27.55a	29.41
Significance for P	S	s	s	s	s	ns
$LSD_{(0.05)}$ for v	1.184	0.184	0.074	0.206	0.456	0.477
$LSD_{(0.05)}$ for S	0.633	0.100	0.039	0.110	0.244	0.255
Interactions						
V x P	**	**	**	**	**	ns
P x S	**	**	ns	ns	ns	ns
V x S	**	**	**	**	**	**
P x S x V	**	**	**	**	**	ns

****:** *represent significance at P≤0.01 level of probability;* **ns:** *Non significant*; **s:** *Significant;* **V:** *Varieties;* **P:** *Seed priming;* **S:** *Salinity.*

Results and Discussion

Germination (%)

Table 1. Revealed germination (%) of wheat varieties as affected by seed priming and salinity levels. Germination (%) of wheat varieties was significantly affected by seed priming, and salinity levels. All possible interactions of seed priming x salinity, variety x seed priming, variety x salinity and seed priming x salinity x variety were significant. The germination (%) decreased with increasing salinity levels both in primed and non-primed seeds (Figure 1). However reduction in germination (%) was more in unprimed seed than primed seed with increasing salinity levels. Significant differences for germination (%) were observed across all the varieties at different salinity levels. The germination (%) decreased with increasing salinity levels apparently in all varieties except Lalma-2013; Insaf-2015 and Pirsabak-2005 where reduction in germination (%) was less than other varieties (Figure 2). The technique of seed priming had significantly enhanced the germination (%) in Lalma-2013 and Pirsabak-2005 over non-primed seed compared to all other varieties (Figure 3). The 3 way interaction (Figure 4) showed that germination (%) of wheat varieties decreased with increasing levels

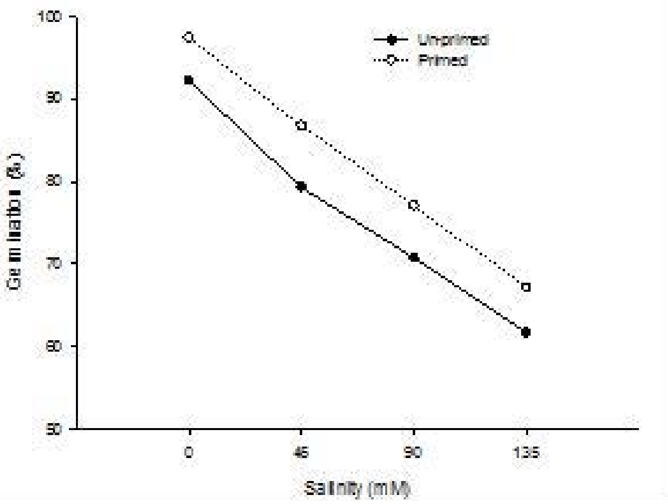

Figure 1: *Interaction of seed priming and salinity for germination (%).*

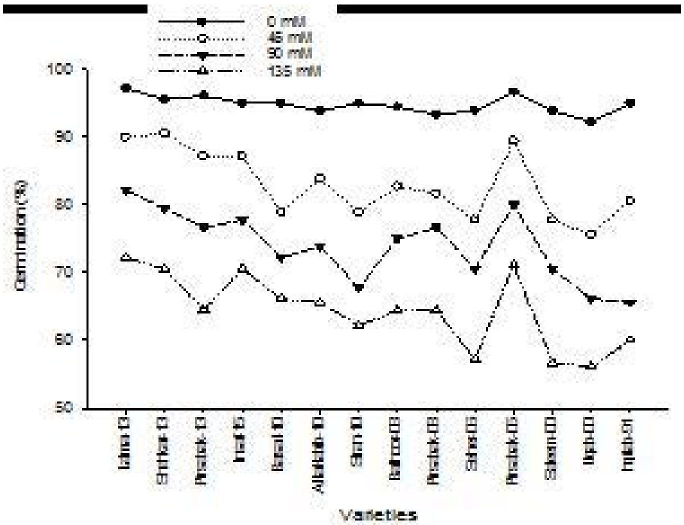

Figure 2: *Interaction of varieties and salinity for germination (%).*

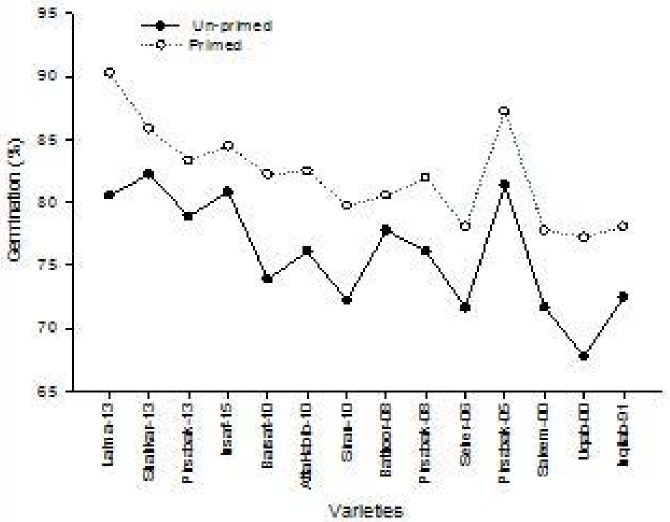

Figure 3: *Interaction of varieties and seed priming for germination (%).*

of salinity in both primed and un-primed seeds (Figure 4). Minimum reduction in germination (%) was observed in primed seeds of wheat varieties (Lalma-2013; Shakar-2013; Insaf-2015) compared to other varieties, when planted in saline environment compared with plantation of unprimed seed of wheat varieties with application of salinity. Wheat varieties showed variable effect on germination (%). Highest germination (%) was recorded from Lalma-2013 (85.42%) followed by Pirsabaq-2005 (84.31%) and Shahkar-2013 (84.03%). The lowest germination was observedin Uqab-2000 (72.50%) followed by Seher-2006 (74.86%) and Saleem-2000 (74.72%) respectively. The variation in germination might be because of difference in sensitivity range of different wheat varieties, which depends on growth stage of wheat varieties. Plants were more sensitive to salt stress at germination (Phang et al., 2008). Seed priming technique has enhanced germination by 8.04% than un-primed seed as control (82.08% and 75.97% respectively). The incremental increase of salinity stress has decreasing effect on germination (%).The germination (%) of wheat varieties decreased with application of additional increments of salinity. The application of salinity stress of 45, 90 and 135 mM has

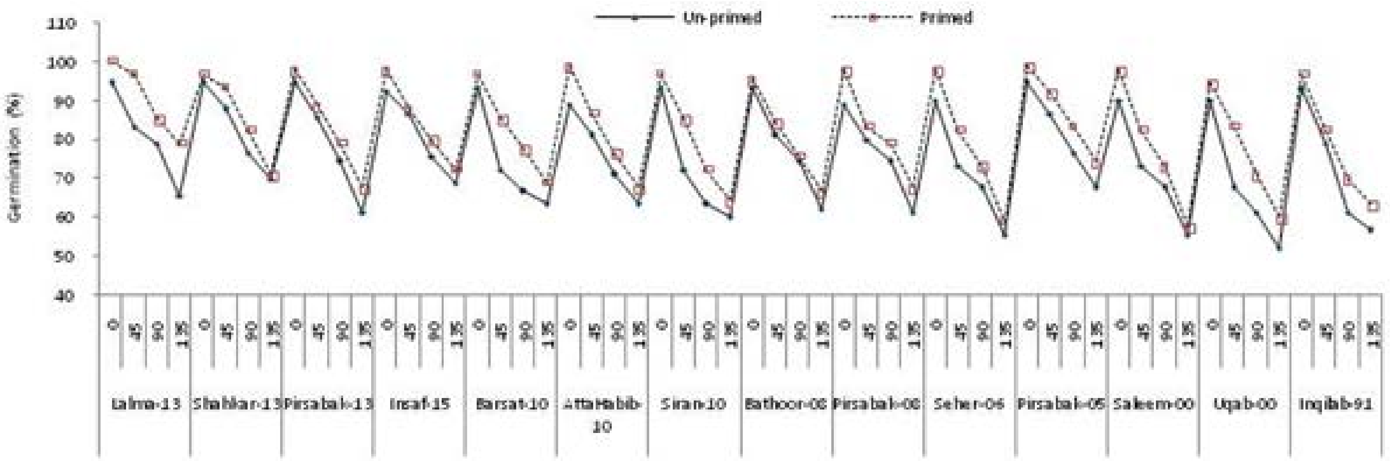

Figure 4: *Interaction of seed priming, salinity and varieties for germination (%).*

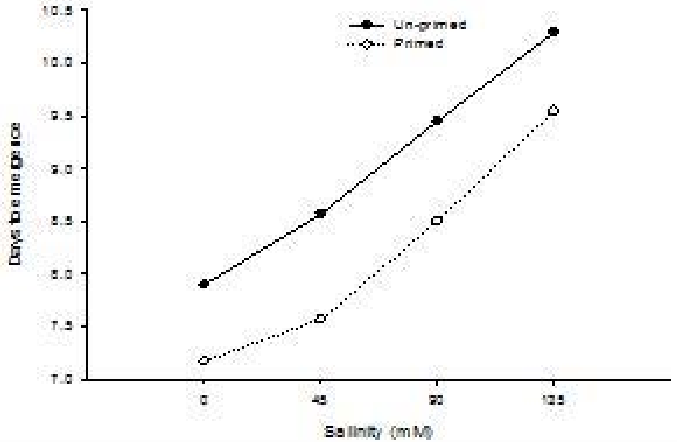

Figure 5: *Interaction of seed priming and salinity for days to emergence.*

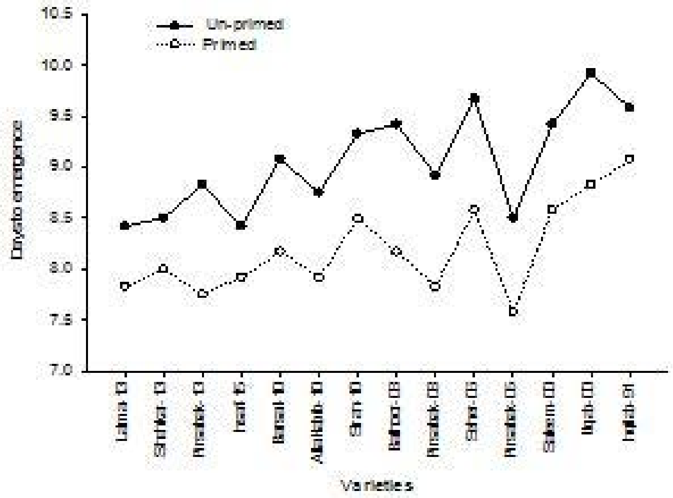

Figure 6: *Interaction of varieties and seed days priming for days to emergence.*

reduced germination by 12.43 %, 22.06%, and 31.98% respectively compared with control. Moghanibashi et al. (2012) and Ahmadvand et al. (2012) reported adverse effect of salinity on germination (%).

Days to emergence

Days to emergence of wheat varieties was significantly affected by salinity levels and seed priming (Table 1). The interactions of seed priming x salinity, variety x seed priming, variety x salinity and seed priming x salinity x variety were significant. The treatment of seed priming has reduced number of days of emergence compared with no seed priming at different levels of salinity (Figure 5). The treatment of seed priming has reduced number of days to emergence, however, the positive effect of seed priming was more pronounced in tolerant wheat varieties (i.e. Lalma-2013 and Shahkar-2013) compared with sensitive varieties such as Inqilab-1991 and Uqab-2000 (Figure 6). The number of days to emergence enhanced with increasing levels of salinity compared with less number of days to emergence from control in wheat varieties (Figure 7). Minimum number of days to emergence was observed in tolerant wheat variety (Pirsabak-2005) with seed priming compared with other wheat varieties with no seed priming in saline environment (Figure 8). Maximum number of days to emergence was observed in Uqab-2000 (9.38) followed by Inqalib-1991 (9.33) and Seher-2006 (9.13). Minimum number of days to emergence was recorded from Pirsabaq-2005 (8.04), followed by Lalma-2013 (8.13), and Insaf-2015 (8.17) respectively. Several species have exhibited sensitivity to salinity at germination stage as reported by Howat (2000). The seed priming showed early germination of wheat seeds. Seed priming proved superior over un-primed seeds by reducing number of days to emergence by (9.47%) (9.05 vs. 8.20 days to emergence). Yasmeen et al. (2013) reported that emergence index and seedling vigor attributes were raised by seed priming technique with $CaCl_2$. Such improvement in germination could be accredited to increased rate of metabolism in primed seed with $CaCl_2$. The elevation of salinity stress has caused increasing effect on days to emergence of wheat. The number of days to emergence was delayed by 07.11%, 19.12% and 31.60% with the imposition of 45, 90 and 135 mM salinity levels as compared with control.

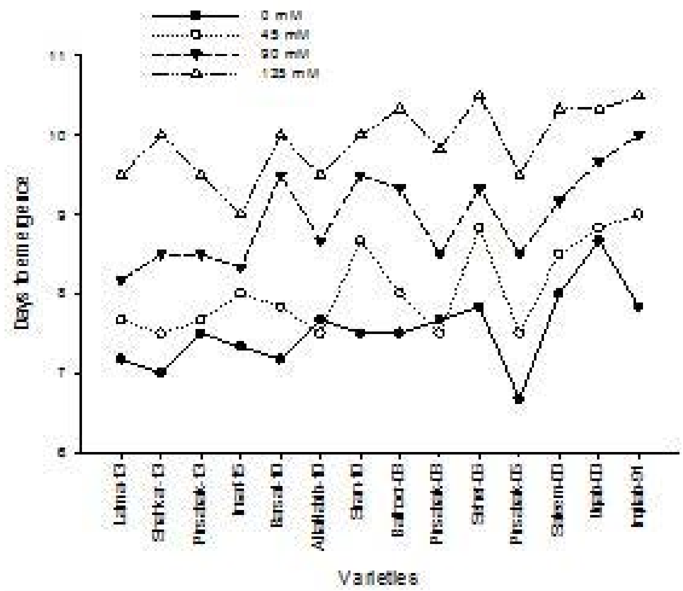

Figure 7: *Interaction of varieties and salinity for days to emergence.*

Tillers plant^{-1}

The effects of salinity levels, and seed priming on tillers plant $^{-1}$ of wheat varieties in presented in Table 1. The interaction of variety x salinity, seed priming x variety and seed priming x salinity x variety was significant. The tillers plant^{-1} decreased with increasing salinity levels in all varieties except Lalma-2013) and

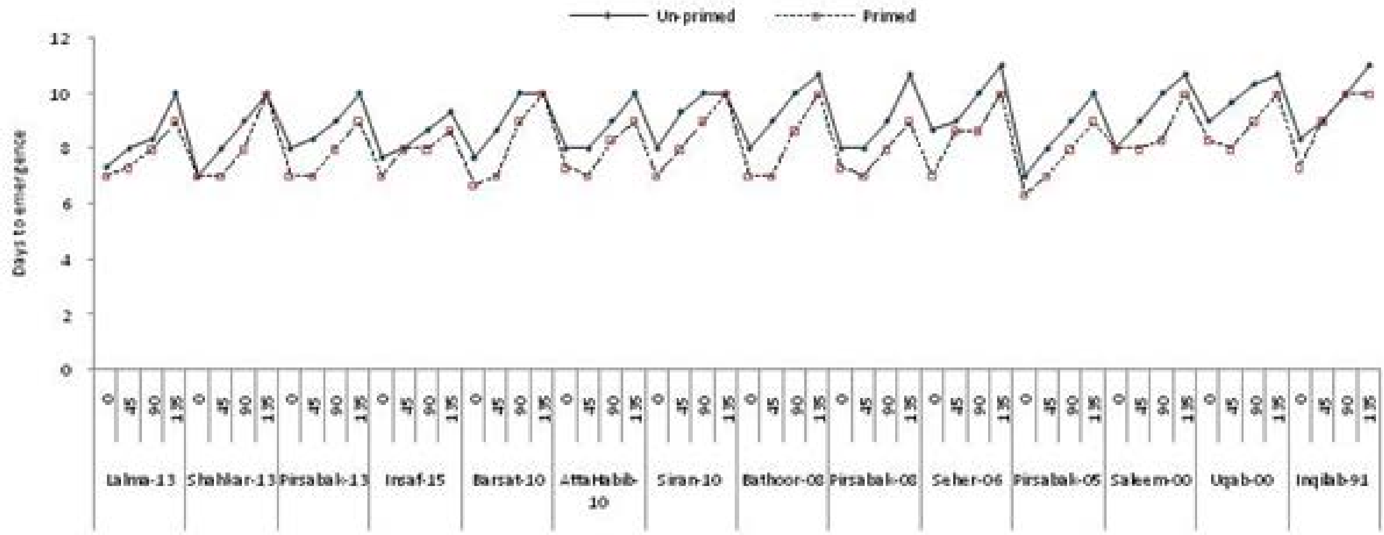

Figure 8: *Interaction of seed priming, salinity and varieties for days to emergence.*

Pirsabak-2005) where reduction in tillers plant^{-1} was minimum compared with other wheat varieties (Figure 9) The seed priming had significantly enhanced tillers plant^{-1} in Lalma-2013; Shahkar-2013 and Pirsabak-2005 than no seed priming of wheat varieties (Figure 10). The interaction of seed priming, salinity levels and varieties revealed that tillers plant^{-1} of wheat varieties decreased with application of salinity in primed and un-primed seeds (Figure 11). However, less decrease in tillers plant^{-1} was recorded from treatment of seed priming of wheat varieties than no seed priming of wheat varieties, when grown in saline condition. Highest number of tiller plant^{-1} (4.31) was recorded from Pirsabaq-2005) followed by Lalma-2013) (3.99 tiller plant^{-1}) and Insaaf-2015 (3.78tiller plant^{-1}). Lowest number of tiller plant^{-1} (3.00) was produced by Uqab-2000 followed by Seher-2006 (3.19 tillers plant^{-1}) and Inqilab-1991 with (3.28 tiller plant^{-1}) respectively. Tillering capacity is one of the important contributing factors for grain yield. Jamal et al. (2011a) and Akram et al. (2011a) reported highest number of tillers plant^{-1} from salt tolerant wheat variety. Shafi et al. (2009) concluded that varieties respond variably to salinity in term of tillers plant^{-1}. They reported tallest plants, more no of tillers plant^{-1} and longest roots were observed in control environment while reverse is true for combined effect of salinity and cadmium stresses. Seed priming with $CaCl_2$ showed enhanced number of tiller plant^{-1}. The treatment of seed priming produced 10.05% more tillers plant^{-1} due to seed priming (3.80), compared with control (3.45). Jamal et al. (2011b) and Farooq et al. (2008) reported positive effect of seed priming on tillers plant^{-1}. The increase in salinity stress reduces the tillering capacity of wheat varieties. The steady increase in salinity stress by 45, 90, 135 mM NaCl has reduced the capacity of tillers plant^{-1} by 14.95%, 20.94% and 36.01% respectively compared with control. The tiller plant^{-1}of wheat varieties reduced

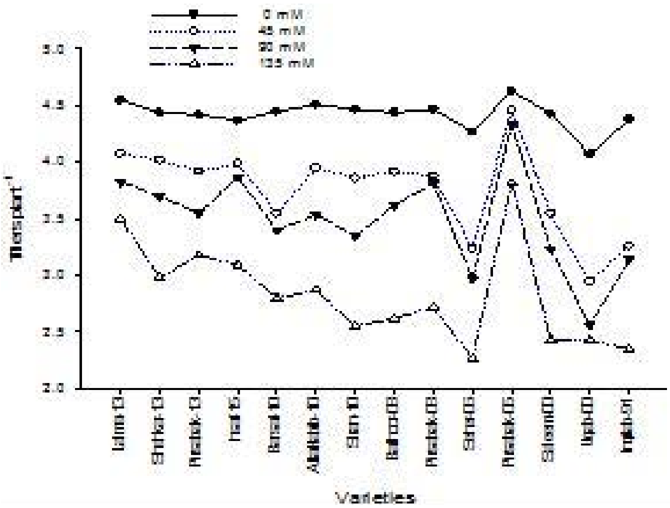

Figure 9: *Interaction of varieties and salinity for tillers plant^{-1}.*

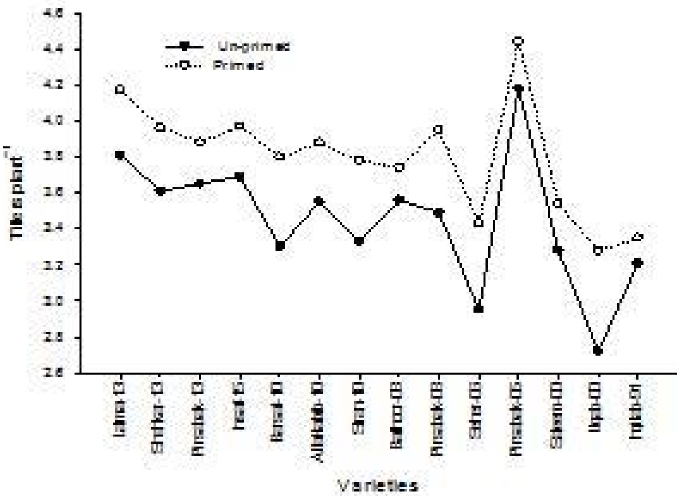

Figure 10: *Interaction of varieties and seed priming for tillers plant^{-1}.*

Links Researchers

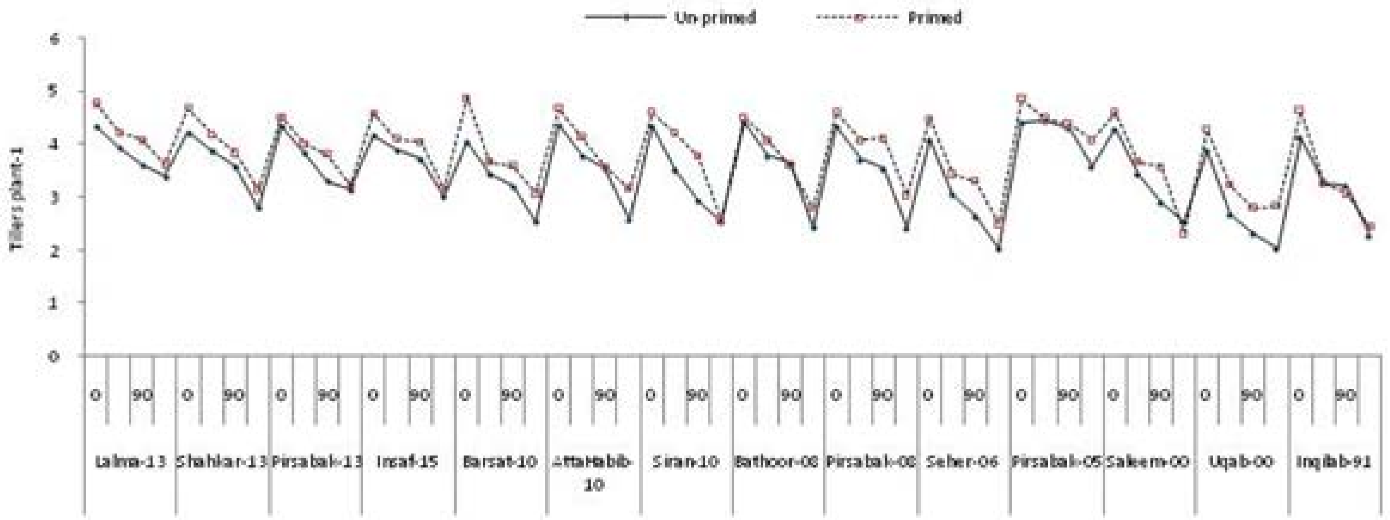

Figure 11: *Interaction of seed priming, salinity and varieties for tillers plant^{-1}.*

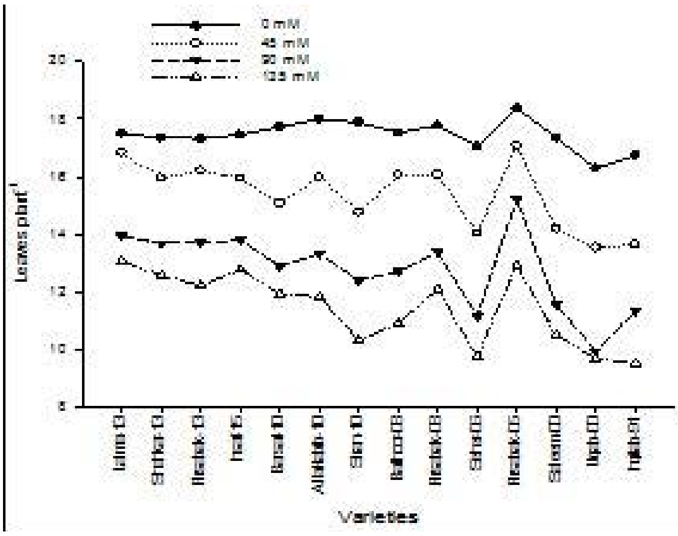

Figure 12: *Interaction of varieties and salinity for leaves plant^{-1}.*

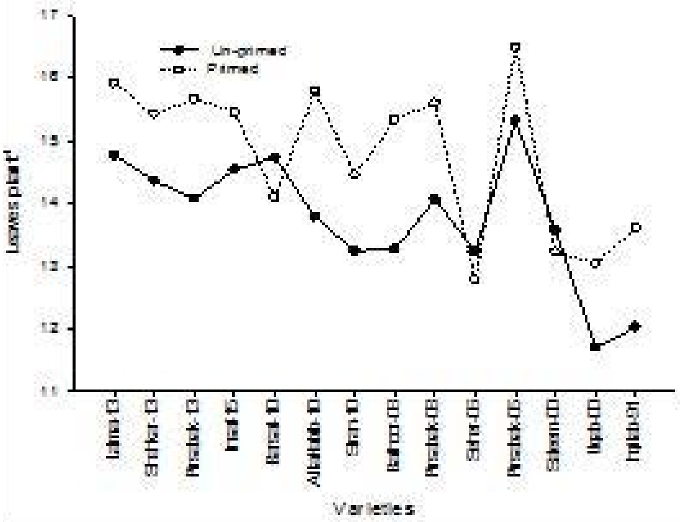

Figure 13: *Interaction of varieties and seed priming for leaves plant^{-1}.*

with gradual increase of salinity application. Tillering capacity decreased with increasing salinity levels due to deleterious effect of salinity on plant growth as reported by Amin et al. (2012).

Leaves plant^{-1}

The effect of salinity, and seed priming was significant on leaves plant^{-1} of wheat varieties (Table 1). The interaction of variety x salinity, seed priming x variety and seed priming x salinity x variety was significant. The application of different salinity levels has reduced leaves plant^{-1} across all varieties (Figure 12). The leaves plant^{-1} was decreased with application of enhancing salinity levels in all varieties except Lalma-2013) and Pirsabak-2005) where reduction in leaves plant^{-1} was minimum than other varieties. The technique of seed priming had significantly enhanced the leaves plant^{-1} of wheat varieties (Lalma-2013; Shahkar-2013 and Pirsabak-2005) compared with no seed priming of wheat varieties (Figure 13). The interaction of varieties, seed priming and salinity levels indicated that leaves plant^{-1} of wheat varieties was reduced with application of high levels of salinity in primed and un-primed seeds (Figure 14). Minimum number of leaves plant^{-1} was observed in primed seeds of wheat varieties (Lalma, 2013; Shakar, 2013; Pirsabak, 2005) compared with other varieties in saline environment with no seed priming and application of salinity. The varieties have inconsistently affected leave plant^{-1}. Maximum number of leave plant^{-1} (15.91) was produced by Pirsabaq-2005, followed by Lalma-2013 (15.34) and Shahkar-2013 (14.99) leaves plant^{-1} respectively. Minimum number of leaves plant^{-1} (12.37) was recorded from Uqab-2000 followed by Inqilab-1991 (12.82) leaves plant^{-1} and Seher-2006 (13.00) respectively. Seed priming technique was efficient method in term of enhanced number of leaves plant^{-1}. The seed priming has in

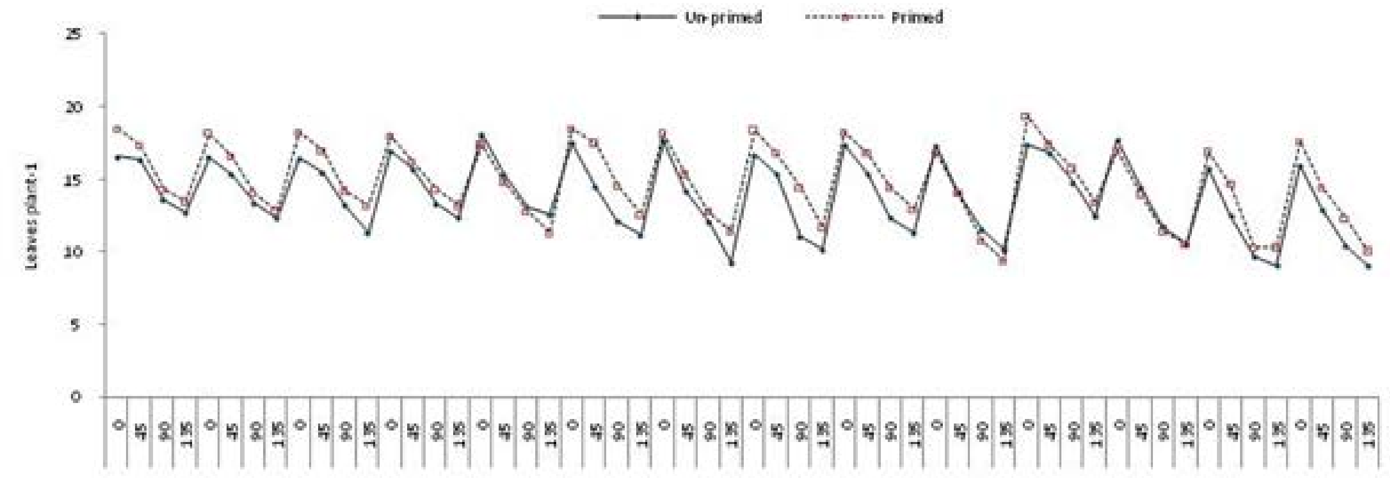

Figure 14: *Interaction of seed priming, salinity and varieties for leaves plant^{-1}.*

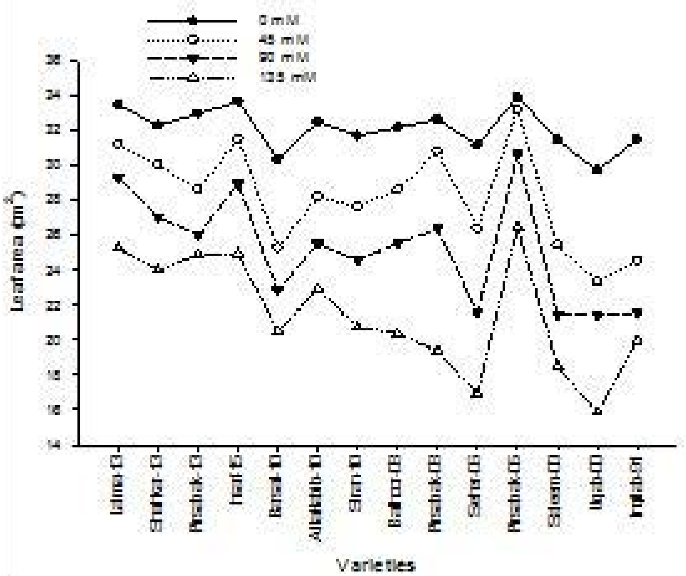

Figure 15: *Interaction of varieties and salinity for leaf area (cm^2).*

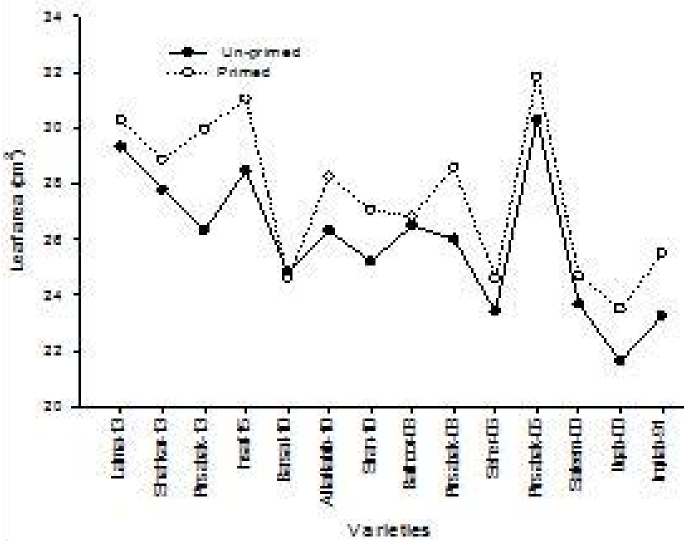

Figure 16: *Interaction of varieties and seed priming for leaf area (cm^2).*

creased leaves plant^{-1} (14.78) by 8.74% compared with control (13.76). The increase in number of leaves plant^{-1} by seed priming may be because of its effect on development hormones such GA3, which is the most critical development controller, which breaks seed priming, and advances germination, internodal length, hypocotyl development and cell division in cambial zone and builds the measure of leaves (Rahmatullah et al., 2012). Therefore number of leaves has contributed to final biomass as described by (Anwar et al., 2011). The incremental elevation in salinity doses has reduced leaves plant^{-1} gradually in wheat varieties. The gradual increase in salinity by 45, 90, 135 mM NaCl has reduced leaves plant^{-1} gradually by 11.83%, 26.70% and 34.44% respectively. Francois (1996) and Naz et al. (2009; 2010) revealed that number of leaves plant^{-1} was significantly reduced due to enhancing levels of salinity. The possible reason could be impaired growth by reduced nitrate reductase activity, which influence nitrogen metabolism (Kausar et al., 2014).

Leaf area (cm^2)

Leaf area (cm^2) of wheat varieties was significantly affected by seed priming and salinity levels (Table 1). All possible interactions i.e. variety x seed priming, variety x salinity and seed priming x salinity x variety except seed priming x salinity were significant. The interaction of wheat varieties and salinity showed that all wheat varieties produced more leaf area (cm^2) in control conditions compared with less leaf area (cm^2) with application of enhancing salinity levels (Figure 15). Wheat varieties Pirsabak-2005, Lalma-2013 and Shahkar-2013 with seed priming showed improvement in leaf area of wheat varieties compared with no seed priming (Figure 16). The leaf area of wheat varieties decreased with application of each additional increment of salinity in treatments of both primed

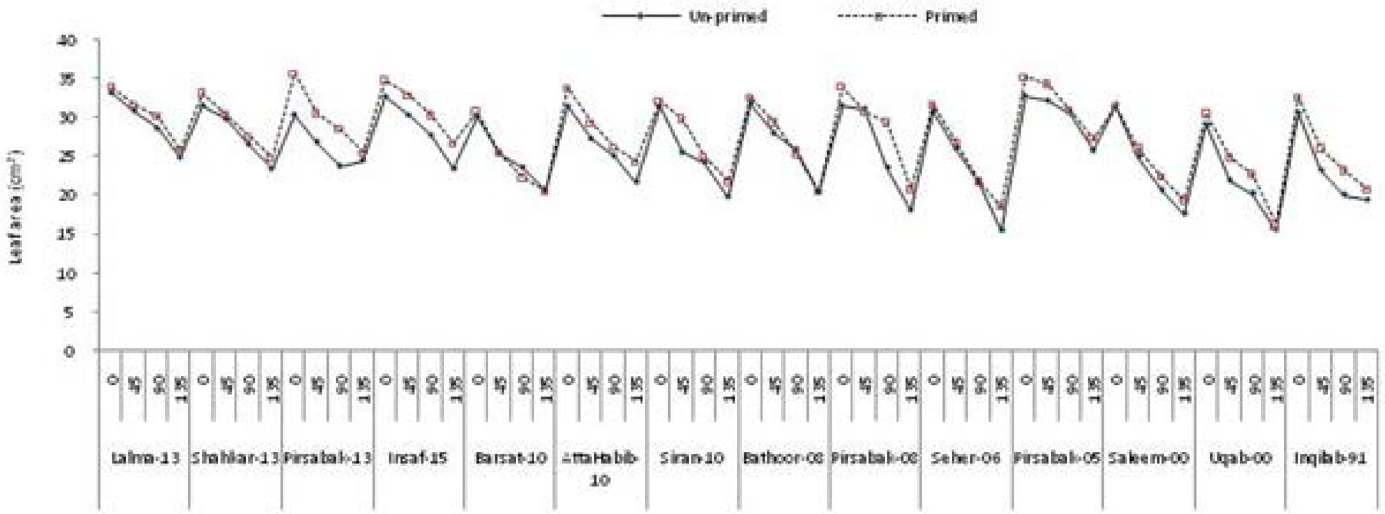

Figure 17: *Interaction of seed priming, salinity and varieties for leaf area (cm²).*

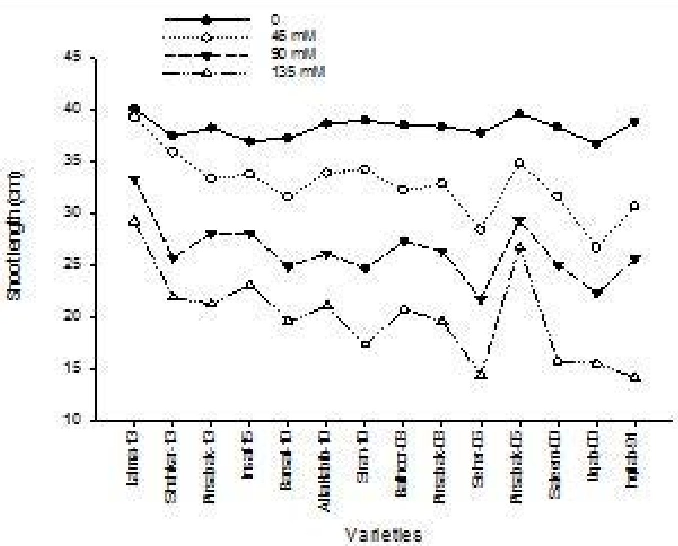

Figure 18: *Interaction of varieties and salinity for shoot length (cm).*

and un-primed seed, however, the decreasing trend was least in primed seeds of tolerant varieties in saline environment (Figure 17). The leaf area of different wheat varieties showed variable trend. Highest leaf area (31.05 cm²) was recorded from (Pirsabaq-2005), followed by Lalma-2013 (29.80cm²) and (29.76cm²) from Insaf-2015 respectively. The wheat variety (Uqab-2000) produced significantly ($P<0.05$) lowest leaf area (22.57 cm²), followed by Seher-2006 (24.01cm²), and Saleem-2000 (24.20 cm²) respectively. Reduction of leaf area was more pronounced in salt sensitive wheat varieties. Salt stressed plants have low leaf area, with low rate of photosynthesis and minimum accumulation of dry matter as reported by (Khan et al., 2010). Seed priming has proved its performance compared to unprimed wheat seed. The seed priming has improved the leaf area by 6.23%, compared with non-primed seed (27.55cm² vs 25.93 cm²). Jamal et al. (2011b) concluded that leaf area plant^{-1}was enhanced significantly due to seed priming with NaCl in wheat cultivars. The leaf area was drastically falls down by imposition of various salinity stress levels. The imposition of elevating salinity levels of 45, 90, 135 mM NaCl has reduced the leaf area by 12.16%, 21.49%, 33.01% respectively. Cereal crops are generally sensitive to high salt concentration during vegetative and early reproductive stage, while less sensitive to salinity in late reproductive stage (Khaled et al., 2012).

Shoot length (cm)

Table 1 reveals shoot length (cm) of wheat as affected by seed priming and salinity. The salinity levels and wheat varieties has significantly affected shoot length (cm). The interactions of seed priming x varieties, seed priming x salinity and seed priming x salinity x varieties except varieties x salinity were non-significant. The shoot length of wheat varieties was significantly affected by different levels of salinity (Figure 18). The study revealed maximum reduction in shoot length of sensitive wheat varieties (Inqilab-1991; Uqab-2000; Saleem-2000) with application of enhancing levels of salinity. However, tolerant varieties (Lalma-2013; Shahkar-2013; Pirsabak-2013) has suffered minimum reduction in shoot length. The effect of seed priming on shoot length (cm) was non-significant. Mean values of the data indicates largest shoot length (35.44 cm) from wheat variety Lalma-2013, followed by Pirsabaq-2005 with shoot length (32.57 cm), which was followed by shoot length (30.42 cm) of Insaf-2015. The wheat variety Uqab-2000 produced shortest shoot length (25.26 cm), followed by Seher-2006 with shoot length (25.54 cm) and Inqilab-1991 shoot length (27.29 cm). Reduction in shoot length under saline condition might be due to reduction in new cell production rate which may inhibit plant growth. Plant growth is also retarded by modification of cell wall, which is due to rigidity of cell wall induced by salinity stress as reported by (Radi et al., 2013). The seed priming technique has non-significantly (P>0.05) improved the shoot length, compared with control. The seed priming has slightly improved shoot length (29.41 cm) by 0.69% compared with shoot length (29.21 cm) from control. (Cha-um et al., 2012) improved plant height with $CaCl_2$ priming than control treatment. Our results of seed priming were further confirmed by the research of (Moghanibashi et al., 2012) on root and shoot length of wheat genotypes which were reduced significantly due to salinity induction; however, the reduction in hydro-priming was non significantly less as compared to other seed treatments. The steady increase in the salinity levels has gradually shortened wheat shoot length. The wheat shoot length was gradually reduced by 14.27%, 31.23% and 47.71% with enhancing salinity levels of 45, 90, and 135mM NaCl. The gradual elevation in the salinity stress has steadily shortened wheat shoot and root length. Hussain et al. (2013) reported that increasing salinity levels decrease the shoot length. Elouaer et al. (2012) concluded that inhibition of root and shoot length is due to increasing salinity levels.

Conclusions

Seed priming with $CaCl_2$ (halopriming) has alleviated the adverse effects of salinity stresses in wheat varieties. Maximum germination (%), leaves plant^{-1}, tillers plant^{-1}, leaf area (cm^2) and shoot length (cm) was observed due to seed priming technique with variable response across varieties. The ameliorative effect of seed priming was highest in wheat varieties (Lalma-2013; Shahkar-2013; Pirsabak-2005) compared to salinity sensitive varieties (Inqilab-1991; Uqab-2000; Saleem-2000). Increasing salinity levels had decreased the plant performance in all varieties except Lalma-2013, Insaf-2015, Shakar-2013 and Pirsabak-2005 when the seeds were primed. It is concluded that salinity stresses has adversely affected growth traits of wheat varieties however, seed priming with $CaCl_2$ has alleviated the adverse effects of salinity in salinity tolerant wheat varieties.

Authors Contribution

Attaullah conducted the experiments and collected samples, Mohammad Shafi designed the experiments, Jehan Bakht analyzed the data. Shazma Anwar reviewed the manuscript. All authors read and approved the final manuscript

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