Combining ability analysis and effect of seed priming on seedling traits in Sunflower (Helianthus annus).

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ABSTRACT: Pakistan is facing severe shortage of edible oil. Sunflower can be a good alternative for fulfilling oil requirement due to its ideal characteristics. Seed priming is a technique which is used to decrease the harmful effects of different abiotic factors and to increase the seed germination and crop production. It was indicated from emergence index that high value of SCA for a single cross A6.12124×A11.8 and lowest value for a single cross, A6.12124×A6.5 was reported under 1.50% seed priming level of calcium chloride. A2.2×A6.5 showed the highest specific combining ability while A2.2×A11.8 showed the poorest specific combining ability under normal condition while higher value for specific combining ability of a sing cross A2.2×A6.5 was recorded and poorest value of combining ability of A2.2×A6.5 was observed under 2.50% level of seed priming. It was suggested that A6.1238 among the parents while A6.12124×A6.5, C2.1818×A6.5, A2.2×A6.5 and B2.1×C2.21 among the hybrids may be used to select for development of drought and saline tolerant genotypes with better germination.
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1. Introduction

Sunflower (*Helianthus annuus* L.) is an oilseed crop having high oil contents (39-52%) and protein contents (42%). It belongs to family *Astraceae,* its oil is rich in linoleic acid and oleic acid (Arshad *et al.,* 2007; Arshad and Amjad, 2012) which are very important unsaturated fatty acids. It is highly adaptable to harsh environmental conditions such as in arid and semi-arid regions (Flagella *et al.,* 2002; Kazemeini *et al.,* 2009).

Being a dual season oilseed crop, sunflower can be used for fulfilling our local oilseed requirement. It can also be easily fitted to our cropping pattern due to its short life cycle of 90 to 110 days. Sunflower was cultivated on an area of 1750 thousand hectares while its estimated production was 378 thousand tons (Govt. of Pakistan, 2012-13). In Pakistan, there are many constraints behind the low production of sunflower; among them less availability of local varieties and costly imported hybrids is one of the main problems of sunflower which have to be addressed through local production. Different abiotic factors such as soil salinity, high temperature and water deficiency etc. are the major constraints of seed germination which alter different metabolisms of carbohydrates and transportation of sucrose during seedling stage (Gupta *et al*., 1993; Kaya *et al*., 2006).

Sunflower is susceptible to water shortage at germination stage. Seed germination percentage and various abiotic stresses have negative correlation. Osmotic stress of sunflower seed increases at germination stage due to salinity and drought stress which affects the uptake of water and increase the germination time, ultimately decrease total plant population and harvest index (Ahmad *et al.,* 2009). Seed priming helps in rapid and uniform germination and ultimately increases crop production (Basra *et al.,* 2005). It also decreases the harmful effects of various stress factors on growth of crop plants. Seed priming includes the techniques like hydro priming, hardening, osmo conditioning and osmo hardening (Chiu *et al.,* 2002; Windauer *et al.,* 2007). Seed priming is a technique by which seeds are partially hydrated to a point where germination process initiated early but radicle emergence does not occur. There are different types of chemicals like poly ethylene glycol solution, ascorbic acid and alpha tocopherol which are being used for sunflower seed priming (Basra *et al*., 2005). In this study, $CaCl_2$ will be used as a suitable method in improving the germination percentage and salt tolerance of sunflower. Although there is lot of research work on seed priming but certain physiological fluctuations persuaded by $CaCl_2$ priming have been infrequently studied in plants (Cayuela *et al.,* 1996). Present research will be helpful in studying those physiological changes and to enhance the germination and address the early maturity issues.
The objective of proposed research study will be:

1. To develop new genetic material in field by using line × tester mating design.
2. To evaluate the germination percentage of developed genetic material by $CaCl_2$ priming
3. To evaluate the tolerance of newly developed genetic material against salt stress.

2 Materials and methods

The present research was conducted in two parts in the field and green house of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during 2013-14. 15 accessions (5 female and 3 male) of Sunflower was sown and crossed according to line × tester mating design. Seed obtained by these crosses was primed with $CaCl_2$ solution for 24 hours at room temperature and dry them completely (Cayuela *et al* 1996). After this germination test was done by sowing in petri dishes for 5 days and sown in Complete Randomized Design in three replications in pots. All the agronomic practices recommended for sunflower were followed throughout growing season. The data were observed for germination percentage (%), emergence rate, time to 50 % emergence, mean emergence time, emergence index, survival rate , shoot length, root length, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, root shoot ratio, chlorophyll content , leaf area

Statistical Analysis

The data were subjected to analysis of variance to determine the genetic variability following Steel *et al*. (1997). Line × Tester analysis was applied by using the method of Kempthorne (1957) for evaluating general and specific combining abilities.

3. Results

3.1. Germination percentage (%)

The line C2.1818 showed highest significant and positive estimates of GCA for germination percentage. The table 1 showed that C2.1818 showed the highest GCA value (11.276) for germination (%) followed by A6.5 (3.804) and A11.8 (-0.657) while the lowest value (-1.98) was reported for A2.2 under normal condition. The range of germination percentage (%) of GCA value 33.313 to -10.831 was observed for germination (%) under 2.50% calcium chloride seed priming solution. C2.1818 showed the highest value for GCA (33.202) and lowest value reported by A6.1238 and A6.12124 under 2.50% calcium chloride seed priming solution. Under the level of 1.50% calcium chloride seed priming solution, Table 2 highest SCA (4.157) value among crosses for A6.12124×C2.21 while lowest value (-5.471) for single cross A6.1238×A6.5 under normal condition. Under 2.50% calcium chloride seed priming solution, C2.1818×A11.8 showed the highest value (14.69) of specific combining ability followed by A6.12124×C2.21 with a value of 14.247 while lowest value reported by A6.12124×A11.8 with a value of -12.187. It was shown from table 2 that higher value reported for a single cross C2.1818×A6.5 (19.764) while the lowest value reported by C2.1818×C2.2 under 1.50% seed priming calcium chloride solution. C2.1818×A6.5 showed the highest value for SCA value under 0.50% seed priming calcium chloride solution. Highest value of GCA was reported for C2.1818 with 24.116 followed by A6.5 and A6.1238 and lowest value was reported for A2.2 and A6.12128. It was observed that high value for C2.1818 was reported followed C2.21 while lowest value of GCA observed for B2.1 under 0.50% calcium chloride seed priming solution.

Table 1 General combining ability for germination (%) of sunflower under four seed priming levels

Genotypes	Normal	2.50%	1.50%	.50%
C2.1818	11.276	33.313	24.116	11.356
B2.1	-5.391	-0.678	-10.612	-6.867
A6.1238	-0.391	-9.202	4.388	-0.089
A6.12124	-3.514	-10.831	-7.279	-2.200
A2.2	-1.981	-12.602	-10.612	-2.200
A11.8	-0.657	4.187	-3.079	1.667
A6.5	3.804	3.059	7.024	-2.933
C2.21	-3.147	-7.247	-3.946	1.267

Table 2 Specific combining ability for germination percentage of sunflower under four seed priming levels

Hybrids	Normal	2.50%	1.50%	0.50%
C2.1818×A11.8	2.324	14.693	-0.649	0.778
C2.1818×A6.5	2.863	10.867	19.764	7.378
C2.1818×C2.2	-5.187	-25.560	-19.116	-8.156
B2.1×A11.8	3.991	2.330	-0.254	5.667
B2.1×A6.5	-0.471	-6.208	-5.358	-5.067
B2.1×C2.21	-3.520	3.878	5.612	-0.600
A6.1238×A11.8	3.991	0.780	4.746	-6.444
A6.1238×A6.5	-5.471	-2.795	-5.358	3.489
A6.1238×C2.21	1.480	2.014	0.612	2.956
A6.12124×A11.8	-6.699	-12.187	1.412	0.000
A6.12124×A6.5	2.543	-2.059	-8.691	-5.400
A6.12124×C2.21	4.157	14.247	7.279	5.400
A2.2×A11.8	-3.606	-5.616	-5.254	0.000
A2.2×A6.5	0.536	0.195	-0.358	-0.400
A2.2×C2.21	3.070	5.421	5.612	0.400

3.2. Emergence index

It was indicated from table 3 that the line C2.1818 showed highest significant and positive estimates of GCA for germination index. It was persuaded from table 3 that C2.1818 showed the highest GCA value (7.030) for germination index followed by B2.1 (1.338) and A6.1238 (1.031) while the lowest value (-0.902) was reported for A11.8 under normal condition. The range of GCA 0.778 to -0.667 was observed for germination index under 2.50% calcium chloride seed priming solution. B2.1 showed the highest value for GCA and lowest value reported by A6.1238 and A6.12124 under 2.50% calcium chloride seed priming solution. Under the level of 1.50% calcium chloride seed priming solution, highest value of GCA was reported for B2.1 with 1.067 followed by A2.2 and A11.8 and lowest value was reported for A612124 and C2.1818. It was observed that high value for B2.1 was reported followed A2.2 while lowest value of GCA observed for A6.12124 under 0.50% calcium chloride seed priming solution. For SCA (table 4) indicates that single cross B2.1×A11.8 showed the highest specific combining ability (9.835) while B2.1×C2.21 showed the poorest specific combining ability (-6.260) under normal condition while (table 4.1.12) indicates that high value for specific combining ability (2.333) of a sing cross A2.2×C2.21 was recorded while poorest value of combining ability (-3.000) of A6.1238×C2.21 and A2.2×A11.8 was observed under 2.50% level of seed priming. It was indicated from table 4 that high value of SCA (2.533) for a single cross A6.12124×A11.8 and lowest value for a single cross, A6.12124×A6.5 was reported under 1.50% seed priming level of calcium chloride.

Table 3 General combining ability for emergence index traits of sunflower under four seed priming levels

Genotypes	Normal	2.50%	1.50%	.50%
C2.1818	7.030	0.444	-0.156	-0.156
B2.1	1.338	0.778	1.067	1.400
A6.1238	1.031	-0.667	-0.711	-0.933
A6.12124	-5.772	0.111	-0.933	-1.267
A2.2	-3.626	-0.667	0.733	0.956
A11.8	-0.902	-0.422	0.022	0.067
A6.5	0.759	0.644	0.089	0.067
C2.21	0.143	-0.222	-0.111	-0.133

Table 4 Specific combining ability for emergence index traits of sunflower under four seed priming levels

Hybrids	Normal	2.50%	1.50%	0.50%
C2.1818×A11.8	-3.590	0.422	-0.911	-1.178
C2.1818×A6.5	5.682	-0.644	1.689	2.156
C2.1818×C2.2	-2.092	0.222	-0.778	-0.978
B2.1×A11.8	9.835	0.089	-1.133	-1.400
B2.1×A6.5	-3.576	-0.978	0.467	0.600
B2.1×C2.21	-6.260	0.889	0.667	0.800
A6.1238×A11.8	-1.608	1.533	1.311	1.600
A6.1238×A6.5	-0.589	1.467	-0.422	-0.400
A6.1238×C2.21	2.197	-3.000	-0.889	-1.200
A6.12124×A11.8	-1.245	0.756	2.533	3.267
A6.12124×A6.5	-2.906	-0.311	-2.533	-3.400
A6.12124×C2.21	4.150	-0.444	0.000	0.133
A2.2×A11.8	-3.392	-2.800	-1.800	-2.289
A2.2×A6.5	1.388	0.467	0.800	1.044
A2.2×C2.21	2.004	2.333	1.000	1.244

3.3. Mean emergence time

The data analyzed presented in table 5 showed that unprimed seed of sunflower had taken maximum mean mergence time (0.171) and lowest vale (-0008) Analysis of data pertaining to mean emergence times are given table 4.1.8 showed that variation in sunflower hybrid had significant effect on mean mergence time. Under 2.50 % calcium chloride seed priming solution A2.2 performed best while lowest value (-0.0.096). A6.12128 showed the best general combiner and C2.1818 showed the lowest general combiner under 0.50% % calcium chloride seed priming solution. It was persuaded for mean emergence time (table 6) that single cross A2.2×A6.5 showed the highest specific combining ability (0.224) while A2.2×A11.8 showed the poorest specific combining ability -0.250) under normal condition while (table 6) indicates that high value for specific combining ability (0.736) of a sing cross A2.2×A6.5was recorded while poorest value of combining ability (-0.440) of A2.2×A6.5 was observed under 2.50% level of seed priming. It was indicated from table 6 that high value of SCA (0.137) for a single cross C2.1818×A11.8 and lowest value for a single cross, A6.12124×A6.5 was reported under 1.50% seed priming level of calcium chloride. It was observed that high value of that high value of SCA for a single cross A6.12124×C2.21 was (0.160) observed and lowest value (-0.179) reported for a single cross A2.2×C2.21 under 0.50% priming with calcium chloride.

Table 5 General combining ability for mean emergence time under four seed priming levels

Genotypes	Normal	2.50%	1.50%	.50%
C2.1818	-0.008	-0.410	-0.189	-0.068
B2.1	-0.192	0.087	-0.173	-0.101
A6.1238	0.046	-0.201	0.071	0.072
A6.12124	-0.018	-0.021	0.394	-0.006
A2.2	0.171	0.545	-0.103	0.103
A11.8	-0.066	-0.018	-0.001	0.012
A6.5	0.047	-0.096	-0.045	0.008
C2.21	0.018	0.115	0.045	-0.020

Table 6 Specific combining ability for mean emergence time of sunflower under four seed priming levels

Hybrids	Normal	2.50%	1.50%	0.50%
C2.1818×A11.8	0.029	0.089	0.137	0.011
C2.1818×A6.5	-0.124	-0.059	-0.025	-0.023
C2.1818×C2.2	0.095	-0.030	-0.112	0.012
B2.1×A11.8	0.047	-0.114	-0.169	-0.063
B2.1×A6.5	0.054	-0.129	0.041	0.004
B2.1×C2.21	-0.101	0.243	0.128	0.059
A6.1238×A11.8	0.086	0.240	0.044	0.024
A6.1238×A6.5	-0.070	-0.108	-0.099	0.027
A6.1238×C2.21	-0.015	-0.132	0.055	-0.051
A6.12124×A11.8	0.089	-0.599	0.097	-0.082
A6.12124×A6.5	-0.084	0.736	-0.115	-0.078
A6.12124×C2.21	-0.005	-0.137	0.018	0.160
A2.2×A11.8	-0.250	0.384	-0.109	0.110
A2.2×A6.5	0.224	-0.440	0.198	0.070
A2.2×C2.21	0.026	0.056	-0.089	-0.179

3.4. Time to 50% emergence

It was observed from table 7 that A6.12124 showed the higher general combining ability (1.100) followed by A6.5 and C2.21with the value of 0.100, 0.100 respectively among all inbred lines without seed priming while lowest performance was reported for B2.1 with the value of -0.789. It was observed that 0.411 to -0.033 for general combining ability under seed priming of 2.50% calcium chloride solution. A6.12128 showed the highest value for GCA (0.189) while the lowest value (-0.144) reported for A2.2 under seed priming of 2.50% calcium chloride solution and A6.12128 showed the highest value for GCA (0.189) while the lowest value was reported for B2.1 under seed priming of 0.50% calcium chloride solution. It was reported from (table 8) that single cross B2.1×A6.5 and B2.1×C2.2 showed the highest specific combining ability (0.789) and (0.789) respectively while A6.12124×C2.21 showed the poorest specific combining ability (-0.767) under normal condition while (table 8) indicates that high value for specific combining ability (0.656) of a sing cross A6.12124×A6.5 was recorded while poorest value of combining ability (0.400) of A6.1238×C2.21 was observed under 2.50% level of seed priming. It was indicated from table 4.1.15 that high value of SCA (0.511) for a single cross A6.12124×A6.5 and lowest value (-0.322) for a single cross, C2.1818×A6.5 was reported under 1.50% seed priming level of calcium chloride. It was observed that high value of that high value of SCA (0.511) for a single cross A6.12124×A6.5 was observed and lowest value (-0.322) reported for a single cross C2.1818×A6.5 under 0.50% priming with calcium chloride.

Table 7 General combining ability for time to 50% emergence under four seed priming levels

Genotypes	Normal	2.50%	1.50%	.50%
C2.1818	-0.678	-0.033	0.022	0.022
B2.1	-0.789	-0.256	-0.200	-0.200
A6.1238	-0.067	-0.367	0.133	0.133
A6.12124	1.100	0.244	0.189	0.189
A2.2	0.433	0.411	-0.144	-0.144
A11.8	-0.200	-0.133	-0.011	-0.011
A6.5	0.100	0.067	-0.011	-0.011
C2.21	0.100	0.067	0.022	0.022

Table 8 Specific combining ability for time to 50% emergence of sunflower under four seed priming levels

Hybrids	Normal	2.50%	1.50%	0.50%
C2.1818×A11.8	-0.356	0.133	0.178	0.178
C2.1818×A6.5	-0.322	-0.400	-0.322	-0.322
C2.1818×C2.2	0.678	0.267	0.144	0.144
B2.1×A11.8	-1.578	0.356	0.233	0.233
B2.1×A6.5	0.789	-0.178	-0.100	-0.100
B2.1×C2.21	0.789	-0.178	-0.133	-0.133
A6.1238×A11.8	0.700	0.133	-0.267	-0.267
A6.1238×A6.5	-0.100	-0.400	0.067	0.067
A6.1238×C2.21	-0.600	0.267	0.200	0.200
A6.12124×A11.8	0.533	-0.811	-0.489	-0.489
A6.12124×A6.5	0.233	0.656	0.511	0.511
A6.12124×C2.21	-0.767	0.156	-0.022	-0.022
A2.2×A11.8	0.700	0.189	0.344	0.344
A2.2×A6.5	-0.600	0.322	-0.156	-0.156
A2.2×C2.21	-0.100	-0.511	-0.189	-0.189

3.5. Survival rate (%)

Table 9 showed that C2.21 showed the highest GCA value (5.400) for survival rate followed by B2.1 and A6.5 (2.800) while the lowest value (-2.867) was reported for A6.1238 under normal condition. The range of GCA 5.800 to -8.11 was observed for survival rate under 2.50% calcium chloride seed priming solution. C2.21 showed the highest value for GCA (5.400) and lowest value reported by A11.8 and A2.2 under 2.50% calcium chloride seed priming solution. Under the level of 1.50% calcium chloride seed priming solution, C2.21 showed the highest value for GCA (5.400) and lowest value reported by A11.8 and A2. It was persuaded from (table 10) that single cross C2.1818×A11.8 showed the highest specific combining ability (14.867) while A2.2×A11.8 showed the poorest specific combining ability (-21.800) under normal condition while (Table 10) indicates that high value for specific combining ability (14.867) of a sing cross C2.1818×A11.8 was recorded while poorest value of combining ability (-21.800) of C2.1818×A11.8 was observed under 2.50% level of seed priming. It was indicated from table 10 that high value of SCA (14.867) for a single cross C2.1818×A11.8 and lowest value (-21.800) for a single cross, A2.2×A11.8 was reported under 1.50% seed priming level of calcium chloride. It was observed that high value of that high value of SCA (1.956) for a single cross B2.1×A11.8 was observed and lowest value (-1.378) reported for a single cross A2.2×A11.8 under 0.50% priming with calcium chloride.

Table 9 General combining ability for survival rate rate under four seed priming levels

Genotypes	Normal	2.50%	1.50%	.50%
C2.1818	1.133	1.133	1.133	3.356
B2.1	4.467	4.467	4.467	1.578
A6.1238	-0.533	-0.533	-0.533	-2.089
A6.12124	-2.867	-2.867	-2.867	-2.756
A2.2	-2.200	-2.200	-2.200	-0.089
A11.8	-8.200	-8.200	-8.200	0.044
A6.5	2.800	2.800	2.800	-0.022
C2.21	5.400	5.400	5.400	-0.022

Table 10 Specific combining ability for survival rate of sunflower under four seed priming levels

Hybrids	Normal	2.50%	1.50%	0.50%
C2.1818×A11.8	14.867	14.867	14.867	-0.489
C2.1818×A6.5	-6.133	-6.133	-6.133	0.244
C2.1818×C2.2	-8.733	-8.733	-8.733	0.244
B2.1×A11.8	-3.467	-3.467	-3.467	1.956
B2.1×A6.5	0.533	0.533	0.533	-0.978
B2.1×C2.21	2.933	2.933	2.933	-0.978
A6.1238×A11.8	6.533	6.533	6.533	0.622
A6.1238×A6.5	0.533	0.533	0.533	0.689
A6.1238×C2.21	-7.067	-7.067	-7.067	-1.311
A6.12124×A11.8	3.867	3.867	3.867	-0.711
A6.12124×A6.5	-7.133	-7.133	-7.133	-0.644
A6.12124×C2.21	3.267	3.267	3.267	1.356
A2.2×A11.8	-21.800	-21.800	-21.800	-1.378
A2.2×A6.5	12.200	12.200	12.200	0.689
A2.2×C2.21	9.600	9.600	9.600	0.689

3.6. Mean value for seeding traits

It was suggested from table 11 that maximum shoot length was recorded for inbred line B2.1 a value of (43.544 cm) while lowest shoot length was observed for A6.1238 with value of 29.144 cm under normal condition. It was evident from table 11 that a range 29.144 to 51.244 was observed for shoot length. It was reported from table 11 that higher root length was observed for a single cross B2.1×C2.21 while lowest value recorded for a single cross C2.1818×A6. Among the inbred lines B2.1 showed the better results while A6.1238 showed the low performance among as inbred lines. Table 11 revealed that root shoot ratio ranged from maximum mean value 0.8400 to minimum value of A6.1238. The highest root shoot length ratio was given by the genotype B2.1×C2.21 followed by A6.1238×A1 and B2.1×A11.8. The lowest mean value for root shoot length ratio was observed for inbred line C2.1818 with the value 0.7942. The genotypes selected on the basis of root shoot length ratio may be useful to develop the drought resistance maize genotypes. Shoot dry weight varied from 1.1350 g to 1.6750 g (table 4.2.5). The higher value of a single cross B2.1×C2.21 was observed followed by B2.1×A6.5 and B2.1×A11.8 while the lowest value was reported for B2.1 and C2.1818×A1 with the value of 1.1350, 1.2550 respectively. Root fresh weight varied from 2.350 g to 2.986 g (table 11). The inbred line B2 showed the better results. (Table 11). The hybrid C2.1818×A1 indicated the better results among all genotypes with securing value of 2.9867g while lowest performance was for A6.1238×A1 (2.4117g) followed by B2.1×C2.21 with value of (2.3217g) and B2.1×A6.5 with 2.350g. Root dry weight varied from 1.225g to 1.386g (table 11). The inbred line A6.1238 performed better (Table 4.1.2). The hybrid A6.1238 ×A1 performed better among all genotypes with securing value of 1.3868g while lowest performance was for C2.1818 (1.225 g) followed by C2.1818×A6 with value of (1.3301g) and C2.1818×C2 with 1.3201g. Higher leaf area was reported among genotypes for B2.1 with the value of 61.43 cm^2 while lowest value was reported by 59.38cm. Among crosses C2.1818×C2 and B2.1×A6.5 performed best while B2.1×A11.8 reported the lowest performance. Chlorophyll contents varied from 39.353% to 16179% (Table 11). The inbred line (A6.1238) performed better while lowest performance was reported by B2.1 among parent (Table 11). Higher chlorophyll contents were reported by a single cross B2.1×C2.21 with the value of 39.352 % while the lowest value was observed by a single cross B2.1×A11.8 with (16%).

Table 11 Mean and statistical significance for seedling traits in sunflower under four seed priming levels.

Genotypes	CC	LA	RDW	RFW	RL	RSR	SDW	SFW	SL
A6.1238	33.972C	59.388F	1.3251D	3.1683B	8.932D	0.7983A	1.2250D	8.459D	29.144I
A6.1238×A1	28.232F	71.71A	1.3868A	.4117D	10.743A	0.8408A	1.425B	12.84A	43.544F
B2.1	26.953G	61.438E	1.2851E	3.4308A	9.259C	0.7942A	1.165D	9.419C	43.264F
B2.1×A11.8	16.179H	56.59G	1.3501C	2.6467C	9.014CD	0.8258A	1.6250A	6.249E	45.424D
B2.1×A6.5	35.542B	68.808B	1.3651B	2.3500D	10.883A	0.8392A	1.6650A	10.65B	45.964C
B2.1×C2.21	39.352A	46.71H	1.3801A	2.3217D	10.963A	0.8400A	1.6750A	12.78A	51.244A
C2.1818	32.942D	63.33D	1.2251F	3.6092A	9.579B	0.7967A	1.1350D	12.88A	40.884G
C2.1818×A1	30.662E	64.938C	1.3451C	2.9867B	9.637B	0.811A	1.2550D	8.299D	49.774B
C2.1818×A6	33.542D	64.497C	1.3301D	2.7950C	9.231C	0.8142A	1.4650B	8.249D	36.754H
C2.1818×C2	34.972B	68.698B	1.3201D	3.1683B	9.257C	0.8183A	1.365BC	9.559C	44.434E

3.7. Genetic variability for sunflower seedling traits

Table 12 showed the significant differences between the genotypes and within the genotype components such as parent, crosses, parent v crosses and all other interactions for germination percentage (%), time to 50% emergence, mean emergence time and emergence index. Within the crosses F x Pr , MxF were significant variation for germination percentage (%) as shown in table 12. However, the interaction for male showed the non-significant differences for germination percentage (%). The interaction between M×F× Pr. and crosses × Pr. were also significant for germination percentage showed in table 12. It was also significant difference reported for G× Pr. Interaction. It was reported that parent vs hybrid and M × Pr. showed the non-significant difference for 50% emergence. Males were also showed the non-significant variation for time to 50% emergence. Analysis of variance (table 12) showed the significant differences between the genotypes and within the genotype components such as parent, crosses, parent v crosses and all other interactions for germination percentage (%). Within the crosses F x Pr , MxF were significant variation for germination percentage (%) as shown in table 12. However, the interaction for male showed the non-significant differences time to 50% emergence.

Female interaction was observed non-significant for mean emergence time. MxF was also showed non-significant variation for mean emergence time as table 12. However, the interaction for male showed the non-significant differences for mean emergence time. M×Pr. showed the non-significant variation for mean emergence time. The interaction between M×F× Pr. and crosses × Pr. were also significant for germination percentage showed in table 12. It G× Pr. interaction was also significant. For the crosses F x Pr, MxF were significant variation for emergence index as shown in table 12. However, the interaction for male showed the non-significant differences for emergence index. The interaction between M×F× Pr. and crosses × Pr. were also significant for germination percentage showed in table 12. It was also significant difference reported for G× Pr. interaction. Within the crosses F x Pr , MxF were significant variation for survival rate as shown in table 12. However, the interaction for male showed the non-significant differences for survival rate. The interaction between M×F× Pr. and crosses × Pr. were also significant for survival rate showed in table 12 and interaction for G× Pr. was also significant.

Table 12 Abstract of analysis of variance of combining ability for seedling traits in sunflower under four seed priming level with calcium chloride

S.O.V.	GP	T 50%E	MET	EI	SV
Priming (Pr)	7036.957	8539.351	349.977	8539.35	646.908
Genotype (G)	2690.292	45.007	1.153	45.007	906.134
G x Pr	417.07	33.656	0.815	33.656	101.13
Parents	1880.022	38.572	1.187	38.572	981.333
P x Pr	363.058	11.333	0.585	11.333	151.238
Crosses ©	1806.607	51.273	1.169	51.273	760.737
C x Pr	250.179	32.471	0.669	32.471	83.283
Parents vs. Hybrids	20733.76	2.32	0.702	2.32	2415.31
Female (F)	4626.25	82.442	2.135	82.442	246.8
F x Pr	457.917	57.162	1.226	57.162	10.6
Male (M)	503.75	6.876	0.085	6.876	1368.09
M x Pr	308.75	2.253	0.029	2.253	179.244
MxF	722.5	46.787	0.956	46.787	865.867
MxFxPr	131.667	27.679	0.551	27.679	95.633
Error	0.583	3.238	0.178	3.238	21.047
S.O.V.	7036.957	8539.351	349.977	8539.35	646.908

3.8. Genetic components

It was persuaded from table 13 that 31.235 value of grand mean was reported for chlorophyll contents. Table 13 showed the higher value of genotypic variance value (245.293) than environmental variance (0.711) for chlorophyll contents. It was reported that highest heritability (99.7%) was observed for chlorophyll contents while highest value of genetic advance was also observed 1393.93 (%).Higher value of heritability and genetic advance indicated the dominance gene of action. It was persuaded from table 13 that 62.614 value of grand mean was reported for leaf area. Table 13 the higher value of genotypic variance value (311.938) than environmental variance (0.667) for leaf area.

Higher value for leaf area indicated that trait is more heritable and showed that environmental effects were very low. It was reported that highest heritability (99.8%) was observed for shoot leaf area while highest value of genetic advance was also observed 884.292.

It was persuaded for from table 13 that 9.942 value of grand mean was reported for shoot length. Table 12 showed the higher value of genotypic value (244.116) than environmental variance for shoot length. It was reported that highest heritability (99.9%) was observed for shoot length while highest value of genetic advance was also observed 4358.24 (%). Table 13 showed that 9.75 value of grand mean was reported for root length. Table 12 showed the higher value of genotypic value (3.767) than environmental variance for root length. It was reported that highest heritability (96.7%) was observed for root length while highest value of genetic advance was also observed 68.582 (%). It was reported from table 13 that 0.817 value of grand mean was reported for root shoot ratio. Table 13 showed the higher value of genotypic value (-0.006) than environmental variance for root length. It was reported that higher heritability (61.7%) was observed for root length while highest value of genetic advance was also observed 68.582 (%). It was persuaded from table 13 that high value of genotypic variance as compared to phenotypic variance was observed and genotypic coefficient of variance (41.83) while phenotypic coefficient of variance observed high as compared to other variances. It was reported from table 12 that 95.9 % heritability was observed and 74.24% genetic advance for root fresh weight. It was persuaded from table 13 that high value of genotypic variance (0.14) as compared to phenotypic variance (0.001) was observed and genotypic coefficient of variance (1.03) while phenotypic coefficient of variance (1.04) observed high as compared to other variances. It was reported from table 13 that 98.1% heritability was observed and lower genetic advance (1.83%) for root dry weight.

Table 13 genetic components of sunflower under four seed priming level.

Genetic components	CC	LA	RDW	RFW	RL	RSR	SDW	SFW	SL
Grand Mean	31.235	62.614	1.331	2.842	9.75	0.817	1.4	9.9422	9.9422
Environmental Variance	0.711	0.661	0.001	0.05	0.127	0.017	0.031	0.032	0.294
Genotypic Variance	245.293	311.938	0.014	1.189	3.767	-0.006	0.238	3.508	244.116
Phenotypic variance	246.004	312.599	0.014	1.239	3.894	0.01	0.269	3.541	244.41
Coefficient of Genotypic Variance	785.314	498.193	1.031	41.83	38.638	-0.783	16.964	35.285	2455.35
Coefficient of Phenotypic Variance	787.591	499.248	1.044	43.599	39.939	1.27	19.193	35.611	2458.3
Heritability h^2(bs) %	99.7	99.8	98.7	95.9	96.7	61.7	88.4	99.1	99.9
Genetic advance %age	1393.93	884.292	1.83	74.248	68.582	1.39	30.112	62.631	4358.24

4. Discussions

Virupakshappa *et al.* (1997) found that higher GCA effects were observed in plant height, 50 % flowering, days to maturity and for oil contents. For yield and its components performance considered as a good criteria for the selection. Similar results were reported by Khan (2001); Tahir *et al*. (2002); Sharma et al. (2003); Ahmad *et al*. (2004); Kaya and Atakisi (2004). Table 13 showed higher heritability and lower genetic advance predicted the partial dominance effect of genes. It was suggested on the basis of higher heritability and genetic advance that selection may be effective for development high yielding inbred lines under drought and saline conditions. Higher root dry weight indicated that higher root dry weight was due to higher absorption of water and uptake of nutrients to make plant photo-synthetically efficient. Lines were evaluated on the bases of better parent and varieties were checked under these four environmental conditions Gill *et al*. (1998). It was shown that A6.12124×A11.8 performed better for GCA under priming level. It can be used for breeding program. Similar findings were reported by Kaya and Ibrahim (2004) and Maria *et al*. (2005).

It was concluded that inhibition of germination at the same water potential of NaCl and PEG resulted from osmotic effect rather than salt toxicity. Hydropriming increased germination and seedling growth under salt and drought stresses Gvozdenovic *et al*. (2005); Kandalkar (1997); Lande *et al*. (1997); Virupakshappa *et al.* (1997) and Yenice and Arslan (1997). Ghassemi 2008 evaluated the effects of hydro and osmo - priming (PEG: Polyethylene glycol 6000 at -0.8MPa) on seed germination and field emergence of lentil. Analysis of variance for laboratory data showed that hydropriming significantly improved germination rate and root weights, compared to other seed treatments. However germination percentage for seeds primed with water and PEG were statistically similar, but higher than those for unprimed seeds. Over all, hydropriming treatment was comparatively superior in laboratory tests. Invigoration of lentil seeds by hydropriming resulted in higher seedling emergence in the field, compared to control and seed priming with PEG. Seedling emergence rate was also enhanced by priming seed with water. Thus, hydropriming could be used as a simple method for improving seed germination and seedling emergence of lentil in the field. It was concluded that seed priming were positively correlated with shoot length, dry weight of shoot and root. Higher value of GCA showed that inbred may be selected for breeding program under normal condition and all other three seed priming levels. Selection may be fruitful for development of synthetic variety which have high germination percentage (Wahid *et al*. 2008). Kausar *et al*. (2009) studied that sunflower seeds at high temperature and high relative humidity lose their vigor during storage. Seed priming with KH_2PO_4 (Ψ=-1.25 MPa) in four hybrids (Hysun 33, Hysun 38, Hysun 44 & F-330) was directed to invigorate the performance of low-vigor seeds. Priming was effective in decreasing the time for 50% germination and mean germination time (MGT) and increase in germination percentage in low-vigor seeds of all hybrids. Priming of normal/low-vigor seeds developed the vigor of seedling in term of radicle length, plumule length and their root/shoot fresh weight. Priming significantly improve the banding pattern and intensity of protein of low-vigor seeds. Ehsanullah et al. (2011) found that fresh primed achenes performed better. During this study it was concluded that the hydroprimed achenes performed better compared with achene priming with SA at all concentrations. Yadav et al. (2011) described the performance of the plants obtained from primed seeds was better than control, suggesting chemical seed priming was a cost-effective and eco-friendly approach for developing cold or salt-stress tolerance in capsicum. It was observed that hydro priming for short duration (6 hours) had significant positive effects on seed germination at water stress condition as compare to longer duration (18 hours). So they suggested that hydro priming for more than 6 hours had negative influence on germination indices. Higher value for leaf area indicated that trait is more

heritable and showed that environmental effects were very low Sheidaie *et al*. 2013). Same finding were reported by Habib *et al*. (2006); Binodh *et al*. (2008); Neelima and Parameshwarappa (2009); Rauf et al., (2009); Karasu *et al*. (2010); Ghaffari *et al*. (2011) and Yadav et al. (2011).

5. Conclusions

It was concluded that emergence index that high value of SCA for a single cross A6.12124×A11.8 and lowest value for a single cross, A6.12124×A6.5 was reported under 1.50% seed priming level of calcium chloride. A2.2×A6.5 showed the highest specific combining ability while A2.2×A11.8 showed the poorest specific combining ability under normal condition while higher value for specific combining ability of a single cross A2.2×A6.5 was recorded and poorest value of combining ability of A2.2×A6.5 was observed under 2.50% level of seed priming. It was suggested that A6.1238 among the parents while A6.12124×A6.5, C2.1818×A6.5, A2.2×A6.5 and B2.1×C2.21 among the hybrids may be used to select for development of drought and saline tolerant genotypes with better germination.

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