Impact of various levels of Poly Ethylene Glycol (PEG) on germination parameters of different advanced wheat lines

Muhammad Faisal*, Fazal Munsif*, Muhammad Bilal*, Muhammad Arif Taj*, Ilyas Khan*, Misbah Ullah*, Mujeeb Ahmad*, Barkat Ali** and Adnan Hussain**

*The University of Agriculture Peshawar, Amir Muhammad Khan Campus Mardan Pakistan

**Sichuan Agricultural University, Chengdu, China

ABSTRACT

Drought stress is a serious problem in crop production and high level of drought stress can significantly inhibit seed germination and seedling growth, due to combined effect of high drought stress and PEG solution. Thirty different wheat lines for germination under drought stress using PEG in different percentage (5% and 10%) and compared with normal condition (0% PEG). Findings revealed significant differences among the wheat lines and under PEG concentrations, while MGR was found non-significant for PEG. Germination percentage was highest of all genotypes across PEG levels except B_1SN37, B_3SN56, B_1SN48, B_3SN31, and B_3SN44 while line B_1SN 44, B_1SN52, B_1SN45, B_2SN29, B_1SN61, B_3SN83, B_2SN45 were poor in germination index. The mean germination rate was similar for all the lines across stress. In case of germination speed, B_3SN56, B_1SN44, B_3SN44 and B_1SN45 had the least GS and B_3SN56, B_2SN48 and B_1SN99 with least GR values. Coefficient of variance of germination was the lowest for B_1SN44 and B_2SN26 and B_1SN52. The line B_2SN26 and B_1SN52 and B_1SN45 had the least germination energy. The lines B2SN48, B_1SN44, B_2SN26, B_2SN29 and B_1SN61 had the least values for germination rate index. Decrease in germination traits were lesser under 5% PEG concentration as compared with 10% PEG. It was concluded that the advance lines showed a wide range of phenotypic variation at germination stage in response to drought-induced stress using PEG and drought stress had resulted in reduction in germination traits of all studied wheat lines, however line B_2SN25, B_1SN81 were found superior among the tested line under moderate stress while line B_3SN27 and B_2SN23 were performed better in germination and early seedling growth under severe drought stress.

Keywords: *Wheat, Drought, PEG, Germination and Development*

INTRODUCTION

Wheat (*Tritcium aestivum* L.) has been playing an important role in the development of civilization since immemorial time and is the cereal of choice in many countries of the world. It is a chief source of food for a great deal of population and is known as the king of cereals. It is the staple food for the people of Pakistan and meets the major dietary requirements, supplies about 73% of the calories and protein of the average diet. A decrease in wheat production severely affects the economy of a country and increases the miseries of the inhabitants (Ilyas *et al*., 2006). Besides its tremendous significance, average yield is far below than developed countries (FAO, 2010), although the genetic potential of local varieties is not less than any country in the region. Major yield limiting factors includes delayed sowing, high weeds infestations, and water shortage at critical growth stages and imbalance and non-judicious fertilizers use (Khan *et al*., 2010).

Drought is one of the major abiotic stresses constraining crop productivity worldwide, it reduces plant productivity by inhibiting growth and development (Singh *et al*., 2014). Drought severely limits wheat productivity and in dry environments, wheat production can be depressed by 50–90% of the crop potential (Reynolds *et al*., 2007). Moreover, the recent global warming phenomenon is giving rise to an aggravating climatic instability that adversely affects ecosystem quality, plant growth, and agricultural production (Schauberger *et al*., 2017; Hassan *et al*., 2020). Global warming and the forcing factors of climate change suggest that more frequent, longer and severe droughts are expected in the 21st century across many regions of the world (Trenberth *et al*., 2014, Schwalm *et al*., 2017). Projected climate changes include more erratic rainfall resulting in increasing droughts, especially in drier northern and western regions of the country (MoEF *et al*., 2009). This predicted drought severity will constrain wheat cultivation and productivity in the future due to the lack of drought tolerant varieties since the modern wheat varieties are not sufficiently tolerant against abiotic stresses (Hussain *et al*., 2016). Therefore, the effort ought to be made to minimize the yield reduction by screening or developing drought-tolerant wheat varieties. It becomes crucial to screen drought-tolerant wheat genotypes under actual dry environmental condition (Tuberosa *et al*., 2006) as drought cannot be easily maintained in the field because of different precipitations that can hamper water deficiciency (Muscoloa *et al*., 2014). Seed germination and early seedling growth are potentially the most critical stages for water stress (Ahmad *et al*., 2009). Thus, in vitro screening method is evidently effective in the selection of drought-tolerant wheat genotypes.

Many chemical desiccants can be used for inducing in vitro drought stress. Polyethylene glycol (PEG) acts as osmoticum to reduce water potential of culture medium, thus creating drought stress on plant tissues by the outward flow of water from plant tissues to a concentrated solution of PEG (Meneses *et al*., 2011). PEG molecules are inert in nature, non-ionic, and induce uniform drought stress without entering the plant cells (Djibril *et al*., 2005). Many early drought screening studies had also involved PEG-6000 solutions for induction of dehydration or drought under controlled environments [(Jatoi *et al*., 2014); (Ghosh *et al*., 2020)].

PEG-6000 induced drought can alter many morphological, phenological, and physiological characters of wheat seedlings. Seedling's shoot and root length and biomasses were reduced with a decrease in osmotic potential (Faisal *et al*., 2019). Other researchers (Ahmed *et al*., 2020) also assessed the decline in the growth, length, and weight of seedlings in PEG-induced drought conditions. The superior seedling dry weight under PEG stress has been considered as a reliable drought-tolerant criterion for different plant species, including wheat (Chachar *et al*., 2016). Many researchers suggested root-to-shoot ratio (Bilal *et al*., 2015) and seedling vigor (Noorka *et al*., 2013) could be used as selection criteria for drought tolerance in wheat. Relative water content (RWC) and cell membrane stability (CMS) are useful indices for the rapid evaluation of drought response in wheat breeding.

Keeping in view the prevailing condition of drought stress worldwide including Pakistan, the present study was designed to evaluate germination characters and seedling growth of wheat as screening criteria against drought stress. This will help to expand wheat cultivation and to sustain wheat yield under drought prone areas of the country.

MATERIAL AND METHODS

A laboratory experiment was conducted in the department of Agronomy, Amir Muhammad Khan Campus Mardan. The experiment was conducted during 2020-21 Rabi season. The experiment comprised 33 lines. Peat moss was used as a medium for plant growth and each line was sown in triplicate in plastic tray. Peat moss (composed of organic material with a higher water retention (88-92%), carbon (50-60%), hydrogen (5-7%), nitrogen (2-3%), phosphorus (<0-2%) and traces of micro-nutrients and developed from layers of partially decomposed plants remains for 9 months) which was obtained from NARC Islamabad. The 46 days laboratory experiment was started, consisting of two levels of PEG (5 and 10) including control where only distilled water was applied under room temperature 10-25 ℃. The respective treatment were applied in form of sprinkle irrigation 20 ml per application was on daily basis till the achievement of required level of the respective treatment at morning time to meet the water requirement of the crop. The only distilled water used to meet crop water requirement after treatment completion. The plants were kept exposed to sunlight for 6 hours daily and then the plant sample was collected.

Plant traits Measurement

Data was recorded on the following parameters:

Emergence percentage

Counting was started immediately when first seedling emerged in any bag from then to onwards measurements were made on daily basis. The number of visible seedlings was recorded. The measurement continued until there was no further increase and was calculated according to the formula derived by Smith and Millet (1964). Seed germination was counted daily as germinated when the visible radical length reached to 1 mm.

$$\text{Emergence }\% = \frac{\text{Total number of seedling emerged 14 days after planting}}{\text{Total number of seed sown}} \times 100$$

Germination index (GI)

It is the estimate of emergence rate of seedlings and was calculated as described in Association of Official Seed Analysis (1983).

$$\text{EI} = \frac{\text{No. of seeds emerged at first count} + \ldots + \text{ No. of seeds emerged at final count}}{\text{Days of first count} + \ldots\ldots + \text{days of final count}}$$

Mean Germination Rate (MGR)

Mean Germination Rate (MGR) is defined as reciprocal of the mean germination time and was calculated according to the following formula of Ranal and Santana (2006)

$$\text{MGR} = \frac{1}{\text{MGT}}$$

Germination rate index (GRI)

Emergence rate index for each treatment and replication was calculated as emergence index divided by emergence percentage.

$$\mathrm{ERI} = \frac{\text{Emergence index}}{\text{Emergence percentage}}$$

Energy of germination (EG)

Energy of emergence was computed according to the method as delineated by Ruan *et al*., (2002). It is the percentage of emerged seedlings three days after sowing.

Mean Germination time (MET)

Mean Germination Time (MGT) was calculated according to the following formula of Ellis and Roberts (1981):

$$\mathrm{MET} = \frac{\sum \mathrm{Dn}}{\sum \mathrm{n}}$$

Where, n is the number of seeds, which were germinated correspondent to the day D observation (not the accumulated number) and D is number of days counted from the beginning of germination.

Coefficient of Velocity of Germination (CVG)

Coefficient of Velocity of Germination (CVG) was calculated according to the following formula by Scott *et al*., (1984):

$$\mathrm{CVG} = \frac{\sum \mathrm{N_i}}{\mathrm{N_i T_i}}$$

Where, N is the number of seeds germinated on day i and T is the number of days from seeding corresponding to N.

Mean Daily Germination (MDG)

Mean Daily Germination (MDG) was calculated according to the following formula by Scott *et al*., (1984):

$$\mathrm{MDG} = \frac{\mathrm{FGP}}{\mathrm{D}}$$

Where, FGP is a final germination percent, D is day of maximum germination (experiment period).

Plant pigments

Chlorophyll (Chl a and Chl b), total chlorophyll and Caroteniods content were determined spectrophotometrically using 200 mg FW of leaf material immersed in 8 ml of acetone 80% solution (v/v) and were kept at -4^{0}C in dark for 48 hours. The absorbance of the extract was read at 663.6, 646.6, and 440.5 nm and pigment concentrations were calculated according to Lichtenthaler (1987) and were expressed in mg per g of FW.

$$\text{Chl a } (\mu g/\ ml) = 12.25A_{663.6} – 2.55A_{646.6}$$

$$\text{Chl b } (\mu g/\ ml) = 20.31A_{646.6} – 2.55A_{663.6}$$

$$\text{Tchl } (\mu g/\ ml) = 17.76A_{646.6} – 7.34A_{663.6}$$

$$\text{Chl CAR } (\mu g/\ ml) = 4.69A_{440.5} – 0.267A\text{Chl a + Chl b}$$

Whereas, A663.6, A646.6, and A440.5 are the absorbance readings recorded from the spectrophotometer during sample analysis.

Shoot weight

The shoot weight of three seedlings were randomly picked from each experimental units were weighed with the help of electronic balance and average shoot weight of individual seedling was calculated and expressed in mg per plant.

Total weight

Three seedlings of each line were randomly uprooted along roots from each experimental unit and weighed after 46 days of sowing, were weighed using sensitive balance and average was determined.

Statistical analysis

Data were subjected to two way of analysis using completely randomized design and mean separation was performed by fishers least significant differences (LSD) test was significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

1. Germination percentage (%)

Percent germination of different wheat lines under drought stress are reported in Table 01. Wheat lines varied from each other under drought stress for percent germination. Across drought stress, the lines were also found varied for percent germination. Among lines, line B_1SN59 and B_1SN61 resulted in lesser germination (80% and 75%, respectively) under 5% PEG concentration of drought stress while the line B_2SN42, B_1SN9 and B_3SN73 were not influenced by 5% PEG for percent germination. Whereas under 10% PEG concentration, line B_1SN81, B_2SN25, B_2SN3, B_3SN29 were found the best lines with no reduction in percent germination while lines B_3SN83, B_1SN61 and B_3SN56 were found with least germination (40%) while the rest of lines were found moderate for germination percentage under 10% PEG concentration as compared to no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for development of drought tolerant varieties. Similar results were also reported by Bilgili *et al*., (2019) who found significant differences among genotypes under drought stress.

2. Germination rate index (GRI)

Germination rate index of wheat genotype under different PEG level are given in table 3. The result shows that across drought stress, the lines were also found varied for germination rate index. Among lines, line B_1SN59 and B_1SN99 resulted in lesser germination (24% and 18%, respectively under 5% PEG concentration of drought stress while the line B_1SN61, B_1SN59 and B1SN44 were not influenced by 5% PEG for germination index. Whereas under 10% PEG concentration, line B_1SN69, B_3SN73, B_2SN3, B_3SN37, were found the best lines with no reduction in germination rate index while lines B_1SN59, B_3SN83 and B_1SN29 were found with least germination (21%) followed by lines B_1SN1920, B_1SN1920, B_2SN1920, B_3SN1920 and B_2SN1920 (18%) while the rest of lines were found moderate for germination percentage under

10% PEG concentration as compared no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for development of drought tolerant varieties. The same results were also reported by Saya *et al*., (2010) who found significant differences among genotypes under drought stress.

3. Germination energy (GE)

Germination energy of different wheat lines under drought stress are reported in table 4. Wheat lines were differed from each other under drought stress for germination energy. Across drought stress, the lines were also found varied for germination energy. Among lines, line B_3SN83, B_1SN59, B_1SN50 resulted lesser germination (50% and 40%, respectively) under 5% PEG concentration of drought stress while the line B_1SN99, B_3SN73, and B_2SN45 were not influenced by 5% PEG for percent germination. Whereas under 10% PEG concentration, line B_1SN69, B_1SN81, B_2SN25, B_2SN23, B_3SN29, B_2SN44, were found to be the best lines with no reduction in germination energy while lines B_3SN83, B_1SN61,B_1SN99, were found to have least germination energy (50%) while the rest of lines were found moderate for germination energy under 10% PEG concentration as compared to no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for development of drought tolerant varieties. The same results were also reported by Rana *et al*., (2017) who found significant differences among genotypes under drought stress.

4. Mean daily germination (MDG)

Mean daily Germination of wheat lines under drought stress are reported in table 5. Wheat lines showed variations among each other under drought stress for mean daily germination. Among lines, line B_1SN61, B_1SN45, B_1SN52 and B_1SN59 resulted in lesser germination (30%) and 25% respectively, under 5% PEG concentration of drought stress while the line B_1SN99, B_2SN27, B_2SN29 and B_2SN19 were not influenced by 5% PEG for mean daily germination. Whereas under 10% PEG concentration, line B_1SN69, B_2SN25, B_1SN81 were found to be the best lines with no reduction in mean daily germination while lines B_1SN44, B_3SN31, B_3SN83, were found with least germination (40%) followed by lines B_1SN44, and B_3SN69 (60%) while the rest of lines were found moderate for germination percentage under 10% PEG concentration as compared to no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for the development of drought tolerant varieties. The same results were also reported by Bilgili *et al*., (2019) who found significant differences among genotypes under drought stress.

5. Coefficient variance germination (CVG)

Coefficient variance germination of different wheat lines under drought stress are reported in table 6. Wheat lines were varied among each other under drought stress for coefficient variance germination. Across drought stress, the lines were also found varied for coefficient variance germination. Among lines, line B_1SN1920and B_3SN1920 resulted in lesser germination (50% and 45%, respectively) under 5% PEG concentration of drought stress while the line B_3SN1920, B_1SN1920, B_2SN1920, B_1SN1920, and B_2SN1920 were not influenced by 5% PEG for coefficient variance germination. Whereas under 10% PEG concentration, line B_2SN1920, B_1SN1920, B_3SN1920, B3SN1920 were found the best lines with no reduction in coefficient variance germination while lines B_2SN1920, B_2SN1920 and B_1SN1920 were found with least germination (50%) followed by linesB_2SN1920, B_1SN1920, B_1SN1920 (37%) while the rest of lines were found moderate for coefficient variance germination under 10% PEG concentration as compared no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for development of drought tolerant varieties. Similar results were also reported by Rana *et al*., (2017) who found significant differences among genotypes under drought stress.

6. Germination rate (GR)

Germination rate of different wheat lines under drought stress are reported in table 7. Wheat lines were varied among each other under drought stress for germination rate. Across drought stress, the lines were also found varied for germination rate. Among lines, line B_1SN1920 and B_1SN1920 resulted in lesser germination (40% and 50%, respectively) under 5% PEG concentration of drought stress while the line B_1SN1920, B_1SN1920, B_1SN1920, and B1SN1920 were not influenced by 5% PEG for germination rate. Whereas under 10% PEG concentration, line B_1SN1920, B_1SN1920, B_2SN1920 were found the best lines with no reduction in germination rate while lines B_3SN1920, B_1SN1920 and B_1SN1920 were found to have least germination rate (60%) followed by lines 40 and 44 (40%) while the rest of lines were found moderate for germination rate under 10% PEG concentration as compared no stress. The differences among the lines under different PEG concentration may be due to their inherent capabilities and the most efficient lines may be included in the breeding programme for development of drought tolerant varieties. The same results were also mentioned by Bilgili *et al*., (2019) who found significant differences among genotypes under drought stress.

Table 1. Percentage germination (%) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	100.00	100.00	75.00	91.67a-c
B1SN69	100.00	100.00	100.00	100.00a
B1SN37	100.00	87.50	37.50	75.00c-g
B1SN81	100.00	87.50	62.50	83.33a-e
B1SN81	100.00	100.00	100.00	100.00a
B2SN25	100.00	100.00	100.00	100.00a
B3SN56	100.00	75.00	37.50	70.83d-g
B1SN99	100.00	62.50	37.50	66.67e-g
B3SN73	100.00	75.00	100.00	91.67a-c
B3SN37	100.00	100.00	87.50	95.83ab
B2SN48	100.00	87.50	37.50	75.00c-g
B3SN27	100.00	75.00	62.50	79.17a-d
B2SN58	100.00	100.00	87.50	95.83ab
B2SN3	100.00	100.00	100.00	100.00a
B2SN42	100.00	75.00	87.50	87.50ab
B1SN6	100.00	87.50	62.50	83.33ab
B1SN44	100.00	87.50	25.00	70.83ab
B2SN26	87.50	87.50	62.50	79.17ab
B1SN52	87.50	75.00	75.00	79.17ab
B1SN45	87.50	87.50	75.00	83.33ab
B2SN29	100.00	75.00	62.50	79.17ab
B1SN59	62.50	87.50	37.50	62.50a-d
B1SN61	87.50	87.50	37.50	70.83ab
B3SN83	100.00	87.50	25.00	70.83ab
B2SN19	100.00	75.00	87.50	87.50ab
B3SN80	87.50	100.00	87.50	91.67a-c
B3SN29	100.00	87.50	100.00	95.83ab
B2SN44	87.50	87.50	100.00	91.67a-c
B2SN30	87.50	87.50	100.00	91.67a-c
B2SN45	100.00	87.50	62.50	83.33a-e
B3SN44	100.00	100.00	37.50	79.17ab
B3SN31	100.00	50.00	25.00	58.33e-g
B3SN27	100.00	75.00	75.00	83.33a-e
Mean	96.21a	85.98b	68.18c	

$LSD_{0.05}$ for wheat Lines = 20.21

$LSD_{0.05}$ for PEG =3.7662

Table 2. Germination rate index (GRI) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	7.66	6.28	7.56	7.17a-c
B1SN69	5.75	10.00	9.41	8.39a
B1SN37	9.41	5.53	2.74	5.89b-f
B1SN81	8.07	5.61	2.99	5.56c-h
B1SN81	4.70	8.25	7.66	6.87a-d
B2SN25	8.12	9.35	7.83	8.43a
B3SN56	5.00	3.94	2.99	3.98h-m
B1SN99	3.91	3.09	1.34	2.78m
B3SN73	7.79	6.60	6.25	6.88a-d
B3SN37	10.00	8.20	6.36	8.19a
B2SN48	5.30	5.11	1.85	4.09g-m
B3SN27	5.16	6.49	4.59	5.41d-i
B2SN58	9.00	7.41	5.69	7.37ab
B2SN3	11.50	7.12	6.83	8.48a
B2SN42	6.18	5.93	4.53	5.55c-h
B1SN6	6.76	6.22	3.51	5.50c-i
B1SN44	4.58	5.19	1.19	3.65j-m
B2SN26	4.99	4.18	2.60	3.92h-m
B1SN52	4.65	4.17	3.08	3.97h-m
B1SN45	6.36	4.09	2.88	4.44f-m
B2SN29	7.08	4.08	2.52	4.56f-l
B1SN59	2.75	4.24	1.65	2.88lm
B1SN61	6.23	2.84	1.53	3.53k-m
B3SN83	5.52	4.69	1.27	3.83i-m
B2SN19	7.50	5.84	3.77	5.70b-g
B3SN80	5.36	6.12	4.39	5.29d-j
B3SN29	8.70	5.36	4.87	6.31b-e
B2SN44	7.52	4.97	4.70	5.73b-g
B2SN30	7.05	5.59	4.95	5.86b-f
B2SN45	5.95	2.36	2.55	3.62j-m
B3SN44	7.31	6.20	1.90	5.14e-k
B3SN31	6.98	3.56	0.94	3.83i-m
B3SN27	7.57	6.35	3.81	5.91b-f
Mean	6.68a	5.61b	3.96c	

$LSD_{0.05}$ for PEG =0.314

$LSD_{0.05}$ for wheat Lines =1.6987

Table 3. Germination energy (GE) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	100.00	87.50	75.00	87.50ab
B1SN69	100.00	100.00	100.00	100.00a
B1SN37	100.00	87.50	37.50	75.00a-c
B1SN81	100.00	87.50	62.50	83.33ab
B1SN81	100.00	100.00	100.00	100.00a
B2SN25	100.00	100.00	100.00	100.00a
B3SN56	100.00	75.00	37.50	70.83a-c
B1SN99	100.00	50.00	37.50	62.50a-c
B3SN73	100.00	62.50	100.00	87.50ab
B3SN37	100.00	100.00	87.50	95.83a
B2SN48	100.00	87.50	37.50	75.00a-c
B3SN27	100.00	62.50	62.50	75.00a-c
B2SN58	100.00	100.00	87.50	95.83a
B2SN3	100.00	100.00	100.00	100.00a
B2SN42	100.00	75.00	87.50	87.50ab
B1SN6	100.00	87.50	62.50	83.33a
B1SN44	100.00	87.50	25.00	70.83a-c
B2SN26	87.50	87.50	62.50	79.17d
B1SN52	87.50	75.00	75.00	79.17d
B1SN45	87.50	75.00	75.00	79.17d
B2SN29	100.00	75.00	62.50	79.17d
B1SN59	50.00	87.50	37.50	58.33d
B1SN61	75.00	75.00	37.50	62.50a-c
B3SN83	62.50	87.50	25.00	58.33d
B2SN19	100.00	87.50	75.00	87.50ab
B3SN80	87.50	100.00	87.50	91.67a
B3SN29	87.50	87.50	100.00	91.67a
B2SN44	75.00	87.50	100.00	87.50ab
B2SN30	75.00	87.50	100.00	87.50ab
B2SN45	87.50	25.00	62.50	58.33d
B3SN44	100.00	100.00	37.50	79.17d
B3SN31	75.00	50.00	25.00	50.00d
B3SN27	100.00	75.00	75.00	83.33ab
Mean	92.05a	82.20b	67.80c	

$LSD_{0.05}$ for wheat Lines =22.80

$LSD_{0.05}$ for PEG =4.247

Table 4. Mean daily germination (MDG) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	25.00	25.00	18.75	22.92a
B1SN69	25.00	25.00	25.00	25.00a
B1SN37	25.00	21.88	9.38	18.75c-g
B1SN81	25.00	21.88	15.63	20.83a-e
B1SN81	25.00	25.00	25.00	25.00a
B2SN25	25.00	25.00	25.00	25.00a
B3SN56	25.00	18.75	9.38	17.71d-g
B1SN99	25.00	15.63	9.38	16.67d-g
B3SN73	25.00	18.75	25.00	22.92a-d
B3SN37	25.00	25.00	21.88	23.96ab
B2SN48	25.00	21.88	9.38	18.75c-g
B3SN27	25.00	18.75	15.63	19.79b-g
B2SN58	25.00	25.00	21.88	23.96a-d
B2SN3	25.00	25.00	25.00	25.00a
B2SN42	25.00	18.75	21.88	21.88a-d
B1SN6	25.00	21.88	15.63	20.83a-f
B1SN44	25.00	21.88	6.25	17.71d-g
B2SN26	21.88	21.88	15.63	19.79b-g
B1SN52	21.88	18.75	18.75	19.79a-f
B1SN45	21.88	21.88	18.75	20.83b-g
B2SN29	25.00	18.75	15.63	19.79b-g
B1SN59	15.63	21.88	9.38	15.63d-g
B1SN61	21.88	21.88	9.38	17.71d-g
B3SN83	25.00	21.88	6.25	17.71d-g
B2SN19	25.00	18.75	21.88	21.88ab
B3SN80	21.88	25.00	21.88	22.92a-d
B3SN29	25.00	21.88	25.00	23.96a-d
B2SN44	21.88	21.88	25.00	22.92a-d
B2SN30	21.88	21.88	25.00	22.92a-d
B2SN45	25.00	21.88	15.63	20.83a-f
B3SN44	25.00	25.00	9.38	19.79b-g
B3SN31	25.00	12.50	6.25	14.58g
B3SN27	25.00	18.75	18.75	20.83a-e
Mean	24.05a	21.50b	17.05c	

$LSD_{0.05}$ for wheat Lines = 5.0552

$LSD_{0.05}$ for PEG = 0.9415

Table 5. Coefficient of variance germination (CVG) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	0.12	0.12	0.13	0.12ab
B1SN69	0.11	0.13	0.13	0.12ab
B1SN37	0.13	0.12	0.12	0.12ab
B1SN81	0.12	0.12	0.11	0.12ab
B1SN81	0.11	0.12	0.12	0.12ab
B2SN25	0.12	0.13	0.12	0.12ab
B3SN56	0.11	0.11	0.12	0.12ab
B1SN99	0.10	0.11	0.10	0.11b
B3SN73	0.12	0.13	0.12	0.12ab
B3SN37	0.13	0.12	0.12	0.12ab
B2SN48	0.11	0.11	0.11	0.11b
B3SN27	0.11	0.13	0.12	0.12ab
B2SN58	0.13	0.12	0.12	0.12ab
B2SN3	0.13	0.12	0.12	0.12ab
B2SN42	0.12	0.12	0.11	0.12ab
B1SN6	0.12	0.12	0.12	0.12ab
B1SN44	0.11	0.11	0.11	0.11b
B2SN26	0.12	0.11	0.11	0.11b
B1SN52	0.11	0.11	0.11	0.11b
B1SN45	0.12	0.11	0.10	0.11b
B2SN29	0.12	0.11	0.11	0.11b
B1SN59	0.11	0.11	0.11	0.11b
B1SN61	0.12	0.10	0.11	0.11b
B3SN83	0.12	0.11	0.11	0.11b
B2SN19	0.12	0.12	0.11	0.12ab
B3SN80	0.12	0.12	0.11	0.11b
B3SN29	0.12	0.12	0.11	0.12ab
B2SN44	0.13	0.11	0.11	0.12ab
B2SN30	0.12	0.12	0.11	0.12ab
B2SN45	0.12	0.10	0.11	0.11b
B3SN44	0.12	0.12	0.11	0.12ab
B3SN31	0.12	0.12	0.15	0.13ab
B3SN27	0.12	0.12	0.11	0.12ab
Mean	0.12ab	0.12ab	0.11b	

$LSD_{0.05}$ for wheat Lines =0.0175

$LSD_{0.05}$ for PEG =3.263E-03

Table 6. Germination rate (GR) of wheat lines under different PEG levels.

Lines	0	5%	10%	Mean
B2SN v-10	10.50	9.25	8.50	9.42a-h
B1SN69	9.50	11.25	11.25	10.67a-e
B1SN37	11.13	8.63	3.88	7.88b
B1SN81	9.75	8.63	5.38	7.92b
B1SN81	7.63	10.75	10.38	9.58a-h
B2SN25	10.25	10.75	10.63	10.54a-e
B3SN56	8.13	6.75	3.38	6.08c
B1SN99	7.38	5.00	2.63	5.00c
B3SN73	9.00	7.38	9.75	8.71a
B3SN37	10.63	10.50	9.13	10.08a-e
B2SN48	8.50	8.38	3.25	6.71c
B3SN27	7.38	7.63	6.50	7.17b
B2SN58	10.25	10.50	8.63	9.79a-g
B2SN3	11.63	10.25	10.13	10.67a-e
B2SN42	8.63	8.13	7.50	8.08a
B1SN6	8.63	8.88	5.38	7.63b
B1SN44	8.13	8.38	1.75	6.08c
B2SN26	8.13	7.50	5.00	6.88c
B1SN52	8.00	6.88	6.00	6.96c
B1SN45	9.13	6.63	5.75	7.17b
B2SN29	10.25	6.75	4.88	7.29b
B1SN59	4.63	7.25	3.13	5.00b
B1SN61	8.13	5.38	3.00	5.50c
B3SN83	07.50	8.00	2.25	5.92c
B2SN19	10.50	8.38	6.88	8.58c
B3SN80	8.50	9.63	7.75	8.63a
B3SN29	10.00	8.50	8.75	9.08a
B2SN44	8.75	8.00	8.63	8.46c
B2SN30	8.50	8.38	8.88	8.58b
B2SN45	9.00	3.75	4.38	5.71c
B3SN44	10.38	9.63	3.38	7.79b
B3SN31	8.75	4.75	1.63	5.04c
B3SN27	9.50	7.88	6.75	8.04a
Mean	8.99a	8.13b	6.21c	

$LSD_{0.05}$ for wheat Lines =2.0764

$LSD_{0.05}$ for PEG =0.3867

CONCLUSION

It was concluded that the advance lines showed a wide range of phenotypic variation at germination stage in response to drought-induced stress using PEG and drought stress had resulted in reduction in germination traits of all studied wheat lines, however line B_2SN25, B_1SN81 were found superior among the tested line under moderate stress while line B_3SN27 and B_2SN23 were performed better in germination and early seedling growth under severe drought stress.

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