Jatoi et al., 2014. ***Sci. Tech. and Dev.*** **33 (1): 1-6**

COMPARATIVE ASSESSMENT OF WHEAT LANDRACES AGAINST POLYETHYLENE GLYCOL SIMULATED DROUGHT STRESS

SHAKEEL AHMAD JATOI*, MUHAMMAD MUZAMAL LATIF, MUHAMMAD ARIF, MUHAMMAD AHSON, ASHTAR KHAN AND SADAR UDDIN SIDDIQUI

Plant Genetic Resources Institute, National Agriculture Research Centre, Islamabad-45500, Pakistan.

Abstract

The current investigation reports a comparative assessment and relative performance of 10 wheat accessions including check variety Inqilab-91 against polyethylene glycol (PEG) simulated drought stress at seedling. Wheat genotypes were tested against 0, 19, 21, 23 and 25% solutions of PEG 6000. The young seedlings were observed for germination (%) and root length (cm). In general, a decrease in germination percentage was observed with the increase in PEG concentration. All the investigated wheat genotypes performed better than the check variety Inqilab-91. The wheat accession 18699 that had more than 30% surviving seedlings at the highest concentration of used PEG was rated as the tolerant genotype. On the other hand, 18671 and 18698 appeared to be less tolerant having less than 5% germination at 25% PEG. Similarly, the root length decreased with the increase in PEG concentrations. The mean root length of all the wheat accessions, which were studies, was comparatively less affected than control (Inqilab-91). The wheat genotypes 18670 and 18671 were the better performers than the rest of genotypes investigated and belonged to rainfed area of the Pothowar region. A detailed investigation of these genotypes in the field conditions is suggested.

Keywords: Wheat landraces, Polyethylene glycol (PEG), Drought, Germination, Root length.

Introduction

Water stress is a detrimental factor affecting all stages of plant growth and development, and hampers successful crop production. Wheat production is severely affected by water stress in many parts of the world. The considerable area of developing countries comprises on semiarid environments with low water posing a major constraint on wheat production (Shafeeq et al., 2006). This factor becomes more crucial in developing countries like Pakistan, where wheat yield is two and a half times low as compared to advanced wheat producing countries of the world (Khan et al., 2000). Better management practices and identification of new wheat genotypes with the ability to produce economic yields under limited water condition could be a solution to boost wheat production.

Efforts have been made in the past to screen wheat varieties which differed in drought tolerance (Szegletes et al., 2000; Salama et al., 1994). Various approaches have been employed from time to time to identify drought tolerant genotypes. Polyethylene glycol (PEG), being a high molecular weight ostmotic substance, has been used frequently as artificial abiotic stress inducer in many studies (Turkan et al., 2005; Landjeva et al., 2008). Hamayun et al. (2010) have also studied the effect of PEG induced stress on physio-hormonal attributes of soybean. Due to many reasons, PEG is considered superior to other solutes to induce water stress (Kaur et al., 1998).

Current study was initiated with the objective to determine the effect of different concentrations of PEG6000 on germination and root length of selective wheat genotypes and to find optimised dose for further screening of large number of wheat accessions/landraces originated from different ecological zones of Pakistan.

Materials and Methods

The study explored the relative performance of nine wheat accessions/landraces from *barani* (rainfed) areas against drought stress induced by polyethylene glycol (PEG). The study was undertaken at Seed Preservation Lab of Plant Genetic Resources Programme, National Agriculture Research Centre (NARC), Islamabad, in 2009. Wheat landraces were evaluated against different concentrations (0, 19, 21, 23, 25%) of PEG6000 at seedling stage. The data pertaining to germination (%) and root length (cm) was recorded.

Seed material

Germplasm of wheat landraces (018670, 018671, 018672, 018673, 018691, 018698, 018699, 018701 and 018703) and control variety 'Inqilab-91' were obtained from National Genebank, Institute of Agri-Biotechnology and Genetic Resources, National Agriculture Research Centre, Islamabad. Seed quality was tested through germination test and

*** sajatoi@gmail.com**

seedling growth rate as per International Seed Testing Association rule (ISTA, 1993) and the Association of Official Seed Analysts (AOSA, 1983). Each treatment was replicated three times.

Standard germination

Standard germination was conducted using between paper (BP) method of germination and twenty five seeds per replication were sown on paper towel (22 × 23 mm; Victory brand, Shinbashi Paper Company, Shizuoka, Japan. Germination test was conducted as per ISTA rules (ISTA, 1993). Seeds were placed on the surface of double sheets of paper towel which were moistened with distilled water (control) and PEG6000 solution accordingly. The seeds were covered with another sheet of paper towel. The sheets were rolled and placed vertically in a plastic beaker, covered with polythene bag and placed at 25°C in a germinator. The data was recorded on 8th day. Germination percentage was calculated on the basis of number of normal seedlings (AOSA, 1983; ISTA, 1993).

Root length

Normal seedlings were used to record the root length (cm), which was measured from point of root emergence to root-tip.

Results and Discussion

Analysis of variance

Germination rate in wheat landraces in response to varying levels of PEG remained non-significantly different (Table 1), which depicted a nil impact of different doses of PEG on germination in wheat genotypes. However, behaviour of each genotype provided a useful trend against varying levels of PEG. Wheat genotypes, different levels of PEG as well as their interaction yielded significant differences for root length, which is very important attribute in drought studies (Table 1).

Table 1. Analysis of variance for germination (%) and root length (cm) in wheat landraces.

	Sum of Squares	Mean Square	F value	Probability
Germination (%):				
Factor A	724.303	181.076	2.2396	0.0702^{NS}
Factor B	906.047	100.672	1.2451	0.2769
A × B	2023.425	56.206	0.6952	
Root length (cm)				
Factor A	1069.294	267.323	207.284	0.0000**
Factor B	97.968	10.885	8.4406	0.0000**
A × B	118.316	3.287	2.5484	0.0001*

*: $p < 0.05$, **: $p < 0.01$

Germination

A varying response of wheat landraces against various concentrations of PEG was observed (Fig.1). With the exception of one landrace (018691), a linear decline in germination percentage was observed with the increase in PEG concentrations in all wheat accessions as well as check variety (Fig. 1-E). The germination at distilled water varied from 95 to 100% in the wheat landraces including check variety Inqilab-91 (Table 2), whereas even the lowest PEG level (19%) caused reduction in germination, which ranged between 71% (18698) to 92% (18703) (Fig. 1). At the highest PEG concentration (25%) a drastic reduction in germination was noted in the wheat landraces, which ranged between 0 to 72% (Table 2). PEG proved to be the most detrimental solute, where its moderate intensities delayed germination and elevated doses reduced final germination (Almansouri et al., 2001). Kaur et al. (1998) also found decrease in percent germination in chickpea with increasing concentrations of exogenous PEG6000. All the wheat landraces performed better than check variety Inqilab-91.

The relative decrease in germination at 25% PEG observed in wheat landraces have been in the range of 72.16% (18699) to 95.79% (18671) whereas it was 100% in case of check variety Inqilab-91. Among wheat landraces, the two genotypes (18699 and 18703) have shown low relative decrease in germination and three genotypes (18671, 18673 and 18698) were highly affected with high PEG concentration (Table 2).

The number of abnormal seedlings has also been proportionally increased with the increasing level of PEG in wheat landraces. The combined average across 9 genotypes revealed that abnormal seedlings were less in landraces as compared to the control and this difference increased at high levels (19%-25%) of PEG (Fig. 3). The highest abnormal seedlings were observed in Inqilab-91 at the highest concentration of PEG used.

In general, germination was around 75% in all wheat accessions including check variety at the lowest stress (19%) applied (Fig. 1). However, significant differences were observed at 21% PEG level, where 7 out of 9 local landraces performed better than check variety. These 7 potentially

tolerant accessions at the seedling stage maintained their differences to check variety with little decline. The highest dose of PEG (25%) yielded the lowest germination (4% ~ 30%) in all the wheat landraces studied. However, for rest of the PEG concentrations a genotype dependant response was observed. The wheat landraces (18703 and 18691) showing more than 25% germination even at the highest dose of PEG can be a potential germplasm for drought prone areas. However, further studies to explore this germplasm under field conditions are necessary.

Root length

The response of wheat genotypes against varying PEG levels yielded an informative outcome. The root length at control varied between 9.59 to 12.80 cm in the wheat landraces including check variety Inqilab-91 whereas the lowest level of PEG (19%) has resulted in reduction in the root length ranging from 7.92 (18672) to 13.77 cm (18691) (Fig. 2). At the highest concentration of PEG (25%) a drastic reduction in root length in wheat landraces was noted which ranged from 2.44 cm (Inqilab-91) to 4.92 cm (18671).

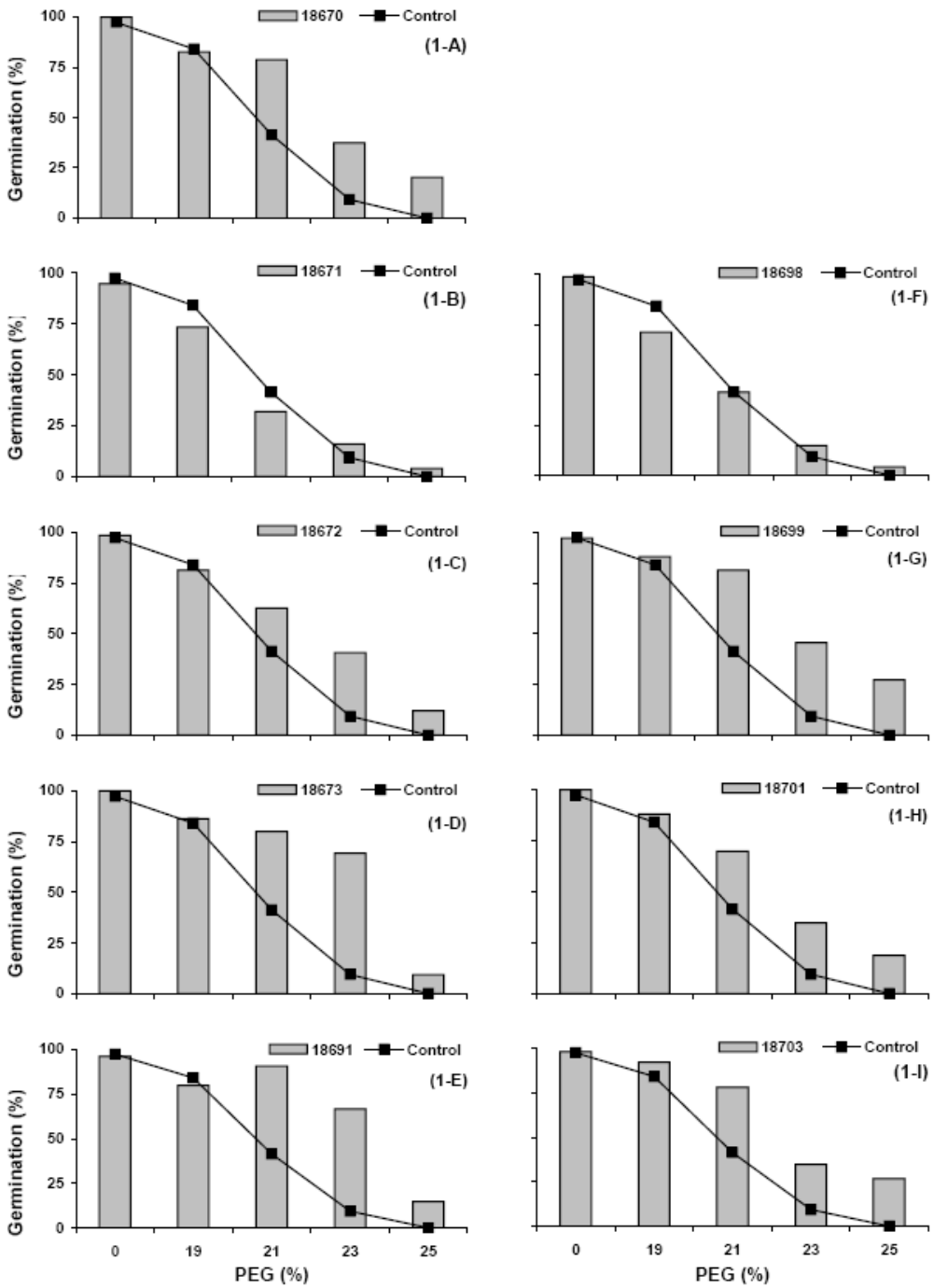

Fig. 1. Germination (%) of wheat local germplasm as affected by different concentrations of PEG6000 as compared to control (Inqilab-91).

Table 2. Relative decrease in wheat landraces as compared to Inqilab-91 (control) at the highest (25%) PEG level studied. [Germination: upto 80% =I, 80-90% = II, above 90% = III; Root length: upto 60% = I, 60% to 70% = II, above 70% = III].

Wheat Landraces	Germination (%)		Root Length (cm)	
	Relative Decrease		Relative Decrease	
	Group	(%)	(%)	Group
18671	III	95.79	56.58	I
18703	I	72.45	58.54	I
18670	II	80.00	62.73	II
18691	II	84.38	60.61	II
18701	II	81.00	67.99	II
18673	III	91.00	63.59	II
18672	II	87.88	70.01	III
18699	I	72.16	71.03	III
18698	III	95.96	77.21	III
Inqilab-91	--	100	74.56	--

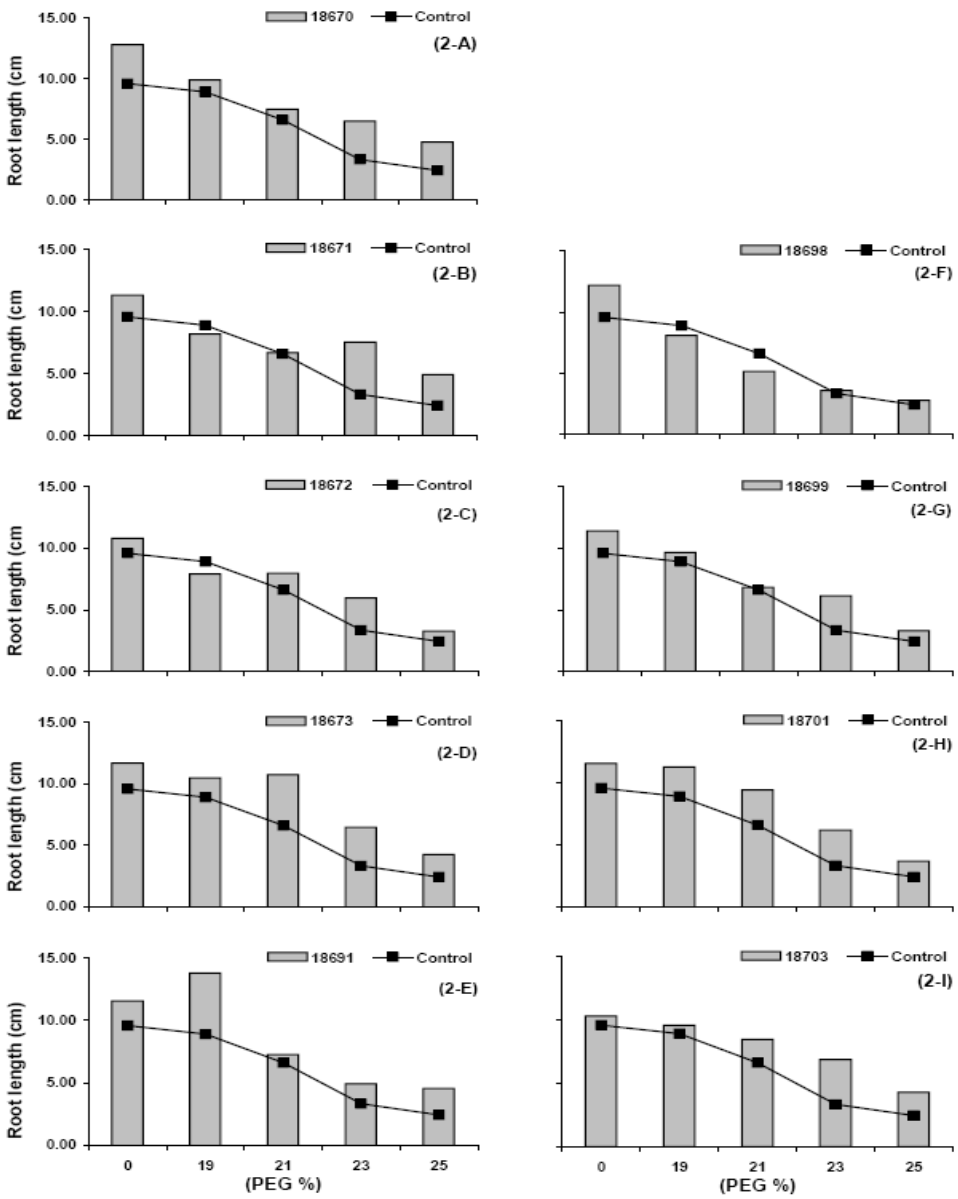

Fig. 2. Root length (cm) of wheat local germplasm as affected by different concentrations of PEG6000 in comparison to control (Inqilab-91).

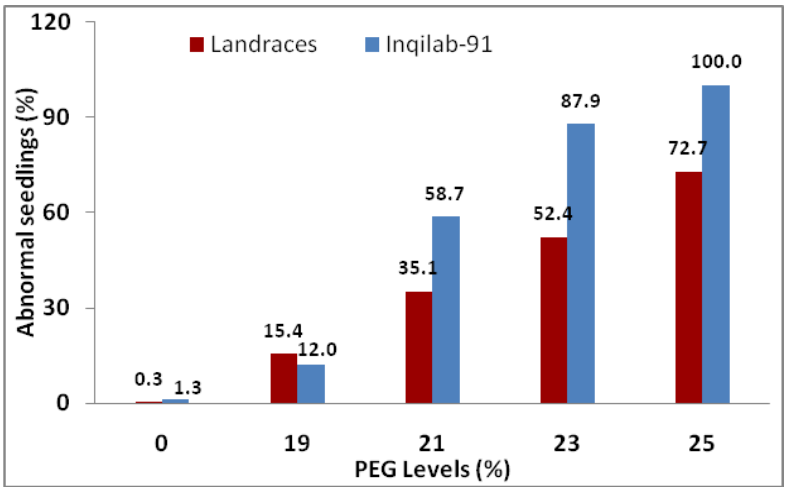

Fig. 3. Trend of abnormal seedlings observed in wheat landraces and control (Inqilab-91).

The relative decrease in root length at 25% PEG observed in wheat landraces has been in the range of 56.58% (18671) to 77.21% (18698) whereas it was 100% in case of check variety Inqilab-91 (Table 2). Among wheat landraces, the two genotypes (18671 and 18703) have shown low relative-decrease in root length whereas two genotypes (18698 and 18699) were highly affected with high PEG concentration. The response of various wheat genotypes for root length was more or less similar against varying levels of PEG. The common feature among all was a reduction in root length with an increase in PEG concentration. In general, the wheat landraces showed better response than the check variety Inqilab-91. The root length of all the genotypes including check variety Inqilab-91, with few exceptions, reduced gradually with the increasing PEG concentrations (Fig. 2). In general, average root length recorded for Inqilab-91 at all PEG levels was less than root length observed in land races investigated.

It is important to note that with minor exceptions, all the genotypes including Inqilab-91 have shown a common trend that a linear decrease in root length from lower concentrations of PEG to elevated concentrations of PEG was observed. However, the decrease rate in root length varied in the genotypes investigated. Another highlighting point observed in this study was that the stress induced by PEG has been tolerated better by wheat landraces as compared to Inqilab-91. It is evident from Fig. 2 that root length observed in Inqilab-91 has been less at higher (23 and 25%) PEG levels than the wheat landraces studied.

Relative decrease and grouping pattern

The wheat landraces based on their relative decrease in germination and root length against PEG levels were categorised into three respective groups (Table 2). Group I represented accessions with low relative decrease, Group II with medium relative decrease and Group III having high relative decrease in respective parameters (% germination and root length). This grouping pattern for germination and root length assigned two accessions in Group I (each category), 4 accessions in Group II and three accessions in Groups III (Table 2).

Quite useful information has been generated with this grouping pattern. The accession 18703 was the only accession which remained in Group I as the best performer displaying low relative decrease in germination as well as root length. Similarly, three accessions (18670, 18691 and 18701) were found in Group II as moderate performer for the two parameters. In Group III, the only one accession (18698) has been observed as poor performer. Rest of the genotypes showed varying performance and grouped differently for the two traits. It can be deduced from this grouping that 18703 was the only accession which has shown better performance than the rest of the genotypes investigated.

Conclusion

Current study was aimed at optimising a suitable doze of PEG for further screening of indigenous wheat germplasm. It is interesting to note that most of the landraces investigated performed better than control (Inqilab-91) at all PEG levels. The origin of the seed has also a relationship with the resistance to drought (Saint-Clair, 1980; Radhouane, 2007). These landraces, being originated from salt range areas, have the mechanism to withstand the abiotic stress and attained a better crop stand at low moisture level in field. It highlights the importance of these landraces to be included in the breeding programme for the wheat improvement particularly for drought prone areas.

Similarly, a better root development under drought stress enables plant to reach deeper available water in the soil and hence survive to maturity (Radhouane, 2007). This study has cultured the PEG concentration to be used for screening our local wheat genetic resources and also screened one potential wheat accession for further detailed studies.

Acknowledgements

The study was partly supported by Global Crop Diversity Trust of FAO under grant number GS08028.

References

Almansouri, M., J.M. Kinet and S. Lutts. 2001. Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). *Plant and Soil*. 231: 243–254.

AOSA (Association of Official Seed Analysts). 1983. Seed vigour testing handbook. Contribution No. 32 to the Handbook of seed testing.

Hamayun, M., S.A. Khan, Z.K. Shinwari, A.L. Khan, N. Ahmad and I.J. Lee. 2010. Effect of polyethylene glycol induced drought stress on physio-hormonal attributes of soybean. *Pak. J. Bot*. 42: 977-986.

ISTA (International Seed Testing Association). 1993. International rules for seed testing. *Seed Sci. Tech*. 21 supplement.

Kaur, S., A.K. Gupta and N. Kaur. 1998. Gibberellic acid and kinetin partially reverse the effect of water stress on germination and seedling growth in chickpea. *Plant Growth Regulation*. 25: 29–33.

Khan, M.A., I. Hussain and M.S. Baloch. 2000. Wheat yield potential – current status and future strategies. *Pak J. Biol. Sci*. 3: 82-86.

Landjeva, S., K. Neumann and U.B. Lohwasser. 2008. Molecular mapping of genomic regions associated with wheat seedling growth under osmotic stress. *Biologia Plant*. 52: 259-266.

Radhouane, L. 2007. Response of Tunisian autochthonous pearl millet (*Pennisetum glaucum* (L.) R. Br.) to drought stress induced by polyethylene glycol (PEG) 6000. *Afr. J. Biotechnol*. 6: 1102-1105.

Saint-Clair, P.M. 1980. La germination du Mil exposé à la contrainte hydrique développée par le PEG. Comparison avec le sorgho grain. *Agro. Trop*. 22: 178-182.

Salama, S., S. Trivedi, M. Busheva, A.A. Arafa, G.Y. Garab and L. Erdei. 1994. Effects of NaCl salinity on growth, cation accumulation, chloroplast structure and function in wheat cultivars differing in salt tolerance. *J. Plant Physiol.* 144: 241-247.

Shafeeq, S., M.U. Rahman and Y. Zafar. 2006. Genetic variability of different wheat (*Triticum aestivum* L.) genotypes/cultivars under induced water stress. *Pak. J. Bot.* 38: 1671-1678.

Szegletes, Z.S., L. Erdei, I. Tari and L. Cseuz. 2000. Accumulation of osmoprotectants in wheat cultivars of different drought tolerance. *Cereal Res. Commu.* 28: 403-410.

Turkan, I., M. Bor, F. Zdemir and H. Koca. 2005. Differential responses of lipid peroxidation and antioxidants in the leaves of drought-tolerant *P. acutifolius* and drought-sensitive *P. vulgaris* subjected to polyethylene glycol mediated water stress. *Plant Sci*. 168: 223-231.