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Short Communication

Early Growth Behaviour of Wheat Genotypes as Affected by Polyethylene Glycol (PEG-6000)

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Abstract. Polyethylene glycol (PEG-6000) is often used for the early establishment screening of the wheat genotypes against drought stress conditions. A collection of twenty-one newly developed bread wheat genotypes (developed through conventional and mutational breeding techniques) and four commercial drought tolerant check varieties were included in screening at seedling stage under three treatments of PEG-6000; T1 (0.5 MPa) and T2 (0.75 MPa) along with control T3 (distill water only). Three important early growth establishment traits like germination percentage, root length and shoot length of the wheat genotypes were observed. Significant variation among genotypic means regarding the observed traits was recorded at both the treatments. Wheat genotypes performance including check varieties for germination percentages was recorded as T1 (86.1%), T2 (72.4%) with reduction percentage of 12.5% and 33.8%. Root length of genotypes decreased by 37.0% in 0.5 MPa and 82.75% in 0.75 MPa, whereas, shoot length reduction was recorded as 38.9% (T1) and 84.6% (T2) as compared to control. This study provided essential information about the performance of advanced wheat genotypes under water stress conditions at early seedling establishment.

Keywords: moisture stress, PEG-6000, germination percentage, root length, shoot length

Wheat (*Triticum aestivum* L.) is staple food source and leading cereal crop of Pakistan (Anwar *et al*., 2011). It adds 10.0% value in agriculture and 2.1% to the GDP with the yield of 25.478 million tonnes (PESR, 2015). Moisture stress is one of the environmental constraints of wheat along with salinity and high temperature (Sial *et al*., 2013; 2007; Blum *et al*., 1980), which reduces plant growth, development and ultimately causes reduction in the productivity. Early seedling establishment is a very critical growth stage to determine the tolerance of genotypes to moisture stress (Baloch *et al*., 2012). Water stress during early stages can adversely affect plant growth and ultimately its final yield (Sial *et al*., 2013). Tolerance to biotic and abiotic stresses and ultimate high potential for grain yield determines the productivity of the wheat genotypes (Seher *et al*., 2015).

Several drought-related morphological and physiological characteristics under *in vivo* field conditions have been proved to be useful in screening of drought studies in wheat (Razzaq *et al*., 2013). The early seedling water stress can be evaluated *in vitro* through different techniques by artificially imposing drought stress through high molecular weight chemicals such as polyethylene glycol (PEG) (Khan *et al*., 2012). Earlier studies reported that PEG can induce stress to the plant in a relatively controlled manner through modifying the osmotic potential of the nutrient solution culture (Meneses *et al*., 2011; Zhu *et al*., 1997).

Present studies were designated to observe the effects of artificial osmotic stress at early seedling stage of wheat genotypes induced through two PEG-6000 concentrations. 21 newly evolved wheat genotypes (advance/mutant lines) along with four check commercial wheat varieties were screened at Nuclear Institute of Agriculture (NIA), Tandojam Sindh, Pakistan. Moisture stress was imposed through two levels of PEG-6000 (T1=0.5 MPa, T2=0.75 MPa) along with control (T3=0.0 MPa). The experiment was conducted in complete randomized design (CRD) with 3 replications. Healthy seeds of each wheat genotype were surface sterilized with 5% sodium hypochlorite (NaOCl) solution for 10 min, followed by washing with distilled water for several times on a blotting paper. Surface sterilized 10 seeds of each genotype were sown separately for germination on soaked filter paper using sterilized petri dishes. Filter papers in the petri dishes of T1 and T2 were moisturized by adding 10 mL PEG-6000 solution with 0.5 MPa and

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0.75 MPa concentrations, respectively, whereas normal sowing with distilled water was applied in T3 as control. Data pertaining to the germination percentage, root length (cm) and shoot length (cm) were recorded after eight days of sowing from randomly selected seedlings. Data were statistically analysed for analysis of variance (ANOVA) and means were compared using Duncan's multiple range test (DMRT). Percent reduction in root and shoot length, root length drought tolerance index and shoot length drought tolerance index of each wheat genotype was calculated.

Significant variability among the means of the wheat genotypes for germination percentage, root length and shoot length was observed in both T1 (0.5 MPa) and T2 (0.75 MPa) treatments as induced by PEG-6000 with comparison to control T3 (distill water) (Table 1). Overall performance of all wheat genotypes including check varieties for germination percentages was recorded as 86.1% in 0.50 MPa and 72.4% in 0.75 MPa with the respective reduction percentages of 12.5% and 33.8%. Highly significant and the highest means for germination percentage under T1 (0.5 MPa) and T2 (0.75 MPa) was found among the NIA-8/7 (T1=94.6%; T2=83.6%), NIA-10/8 (T1= 93.6%; T2=81.6%), SI-9196 (T1=93.0%; T2=81.6) which suggested that these genotypes could be drought-tolerant and possess early growth vigour during early seedling stage. Wheat genotypes NIA-28/4 and BWM-84 both had lowest germination percentages with the respective values of 73.3% and 73.0% under T1 (0.5 MPa), while highly significant and lowest means for germination percentage under T2 (0.75 MPa) was expressed by NIA-30/5 (61.6%), SI-9590 (61.0%), MSH-17 (60.6%), BMW-84 (62.3%) and BWM-47 (61.0%). Root length reduction percentage of all the genotypes at T1 and T2 was calculated as 37.0% and 82.7%, respectively, as compared to T3. *In vitro* development of root length at seedling stage provides a valid estimate about the root growth in field conditions (Bibi *et al*., 2012). Wheat genotype SI-9196, followed by ESW-9525 showed significantly maximum root length with the values of 14.07 cm and 13.63cm. NIA-25/1 had the maximum (95.6%) root length reduction percentage at T1 as compared to the control. Shoot length of wheat genotypes showed the overall reduction in means by

Table 1. Effect of f PEG-6000 on germination percentage, root length and shoot length of wheat genotypes

Genotypes	Germination (%)			Root length (cm)			Shoot length (cm)		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
BWM-3	86.6^{abc}	76.0^{abc}	95.0^{ab}	10.8^{cde}	8.36^{ef}	13.9^{bcd}	17.7^{abc}	13.1^{bcd}	21.5^{abc}
NIA-8/7	94.6^{a}	83.6^{a}	100.0^{a}	12.4^{abc}	9.80^{abc}	15.4^{abc}	19.6^{a}	15.5^{a}	22.9^{abc}
NIA-9/5	91.3^{ab}	74.3^{abc}	96.6^{ab}	9.73^{bcd}	7.63^{j}	10.8^{e}	12.3^{jkl}	11.7^{def}	19.7^{bcd}
NIA-37/6	89.6^{ab}	62.3^{f}	93.3^{bc}	11.5^{bcd}	9.46^{bcd}	15.1^{abc}	12.9^{h}	11.2^{efg}	20.6^{bcd}
NIA-10/8	93.6^{a}	81.6^{a}	96.6^{ab}	11.9^{abc}	8.53^{def}	17.1^{ab}	12.4^{jkl}	13.8^{abc}	19.1^{cde}
NIA-25/1	87.6^{ab}	67.3^{cde}	100.0^{a}	8.96^{hij}	5.83^{g}	17.6^{ab}	14.2^{fgh}	11.2^{efg}	20.8^{bcd}
NIA-28/4	73.3^{e}	63.3^{ef}	86.6^{d}	9.23^{gh}	6.06^{g}	11.0^{e}	15.6^{cde}	8.63^{h}	22.7^{abc}
NIA-30/5	77.0^{de}	61.6^{f}	90.0^{cd}	9.16^{ghi}	7.13^{fg}	14.3^{abc}	13.1^{gh}	8.96^{gh}	14.7^{i}
NIA-25/5	80.0^{cde}	78.3^{abc}	93.3^{bc}	8.9^{hij}	6.46^{g}	11.0^{e}	15.6^{cde}	10.3^{fgh}	22.7^{abc}
ESW-9525	91.0^{ab}	83.0^{a}	99.3^{a}	13.6^{ab}	9.30^{bcd}	16.7^{ab}	19.1^{ab}	16.2^{a}	22.9^{ab}
SI-9196	93.0^{a}	81.6^{a}	99.3^{a}	14.0^{a}	11.47^{a}	16.5^{ab}	18.3^{abc}	15.0^{ab}	21.8^{abc}
SI-9590	86.6^{abc}	61.0^{f}	93.0^{bc}	10.1^{efg}	7.10^{fg}	12.6^{cde}	11.2^{l}	9.96^{fgh}	20.2^{bcd}
MSH-14	90.0^{ab}	79.6^{ab}	98.0^{ab}	12.2^{abc}	9.36^{bcd}	16.3^{abc}	16.7^{bcd}	12.4^{cde}	22.6^{abc}
MSH-17	76.6^{de}	60.6^{f}	95.0^{ab}	9.06^{ghi}	6.00^{g}	11.6^{de}	12.6^{ijk}	9.16^{gh}	20.4^{bcd}
MSH-36	88.6^{ab}	79.0^{ab}	99.3^{a}	11.2^{cde}	8.63^{cde}	14.0^{bcd}	15.4^{cde}	12.3^{cde}	18.4^{def}
MSH-22	83.3^{bcd}	66.6^{def}	99.3^{a}	11.1^{cde}	8.70^{bcd}	15.4^{abc}	10.8^{l}	9.96^{fgh}	20.4^{bcd}
BWQ-4	87.3^{abc}	68.6^{bcd}	100.0^{a}	13.5^{ab}	10.2^{abc}	17.4^{ab}	17.5^{abc}	11.1^{efg}	20.0^{bcd}
BWS-77	76.6^{de}	63.3^{ef}	99.6^{a}	8.63^{ij}	6.36^{g}	14.5^{abc}	16.4^{bcd}	9.13^{gh}	24.6^{a}
BWM-84	73.0^{e}	62.3^{f}	95.3^{ab}	9.50^{fgh}	6.33^{g}	11.7^{de}	12.2^{kl}	8.90^{gh}	16.8^{hi}
BWS-78	89.6^{ab}	80.6^{a}	100.0^{a}	13.0^{abc}	10.3^{abc}	18.1^{a}	18.3^{abc}	10.7^{efg}	21.1^{abc}
BWM-47	77.0^{de}	61.0^{f}	96.0^{ab}	9.33^{fgh}	5.66^{g}	15.5^{abc}	12.3^{jkl}	7.6 0^{l}	17.5^{fgh}
Sarsabz (Check)	92.0^{a}	82.6^{a}	99.6^{a}	12.1^{abc}	9.30^{bcd}	16.6^{ab}	15.1^{def}	11.8^{def}	21.8^{abc}
Thorhi (Check)	91.6^{a}	77.0^{abc}	98.6^{a}	10.7^{def}	10.4^{ab}	16.8^{ab}	14.7^{efg}	12.0^{cde}	18.0^{efg}
Margalla-99 (Check)	92.0^{a}	74.3^{abc}	99.6^{a}	10.0^{efg}	10.2^{abc}	14.9^{abcd}	12.3^{jkl}	10.9^{efg}	20.4^{bcd}
Chakwal-86 (Check)	90.3^{ab}	80.0^{ab}	99.0^{a}	12.4^{abc}	10.2^{abc}	16.5^{ab}	15.8^{cde}	14.2^{abc}	17.3^{gh}
Mean	86.1	72.4	96.9	10.9	8.4	14.8	14.9	11.4	20.4

T1 = (0.5 MPa); T2 = (0.75 MPa); T3 = control (0.0 MPa); values followed by the common letters are not significant to each other at $p<0.05$.

applying PEG-6000 concentrations as 14.9 cm (T1=0.5 Mpa), 11.4 cm (T2=0.75 MPa) and 20.4 cm (T3=0.0 Mpa) (Table 1). Reduction percentage of the shoot length on an average was found as 38.9% (T1) and 84.6% (T2). Wheat genotypes NIA-8/7 (19.60 cm) and ESW-9525 (19.10 cm) expressed the highly significant and the maximum values for shoot length under T1 (0.5 MPa) than all other genotypes. These results suggested that the genotypes NIA-8/7 and ESW-9525 could be more tolerant to moisture stress imposed at early growth stage. Present studies have provided the valid information regarding stress tolerance in newly evolved genotypes. The promising wheat genotypes NIA-8/7 and ESW-9525 along with MSH-22, NIA-9/5, NIA-10/8 and SI-9196 will be further evaluated in future breeding for improvement of water stress tolerance.

Table 2. Decrease (%) in germination percentage, root length and shoot length of wheat genotypes due to PEG-6000 induced stresses (T1, T2) as compared to control (T3)

Genotypes	Germination (%)		Root length (cm)		Shoot length (cm)	
	T1	T2	T1	T2	T1	T2
BWM-3	9.6	25.0	29.6	66.7	22	64.9
NIA-8/7	5.6	19.5	24.2	57.1	16.8	47.7
NIA-9/5	5.9	30.1	12.4	43.4	58.9	68.4
NIA-37/6	4.0	49.8	31.3	58.9	60.5	84.8
NIA-10/8	3.2	18.4	44.5	102.4	54	37.4
NIA-25/1	14.0	48.6	95.6	203.4	46.2	86.6
NIA-28/4	18.3	37.0	19.6	80.3	46.2	165.1
NIA-30/5	16.9	45.9	55.4	101.4	11.4	63.3
NIA-25/5	16.6	19.2	24.7	70.8	45.2	119.2
ESW-9525	9.1	19.6	22.8	79.6	20.4	42
SI-91196	6.8	21.5	17	43.5	19.7	45
SI-9590	7.3	52.5	23.5	77.5	81.3	103
MSH-14	8.9	23.0	32	71.3	35.3	80.8
MSH-17	23.9	56.5	28.6	95	61.4	122.8
MSH-36	12.0	25.7	23.9	62.8	18.7	49.6
MSH-22	19.2	48.9	38.7	77	89.8	105
BWQ-4	14.5	45.6	29.6	71.6	14.3	80.2
BWS-77	30.0	57.5	68.6	126.6	50.6	171.4
BWM-84	30.5	53.0	23.2	85.7	37.7	88.8
BWS-78	11.5	23.9	39.2	74	15.3	97.2
BWM-47	24.7	57.4	67.7	173.7	43.1	131.6
Sarsabz	8.4	20.6	36.1	78.5	43.4	84.7
Thori	7.6	28.2	56.5	61	23.1	50.8
Margalla-99	8.4	34.2	49	44.7	64.5	87.2
Chakwal-86	9.6	23.8	32	61.8	9.5	21
Mean	12.5	33.8	37	82.75	60.5	84.8

T1= (0.5 MPa); T2= (0.75 MPa); T3=Control (0.0 MPa).

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