

# Effects of Early Drought Stress on Germination and Seedling Growth Parameters of Kırık Bread Wheat (*Triticum aestivum* L.)

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## Article Info

## ABSTRACT

### Article History

Received: 22.11.2022

Accepted: 30.12.2022

Published: 31.12.2022

### Keywords:

PEG-6000,  
Germination,  
Wheat.

This study is to evaluate effects of polyethylene glycol (PEG-6000) on germination and seedling growth parameters and determine the optimal dose which can be used in Kırık wheat (*Triticum aestivum* L.) mutation breeding programs. In this study, 11 different PEG-6000 application doses [0 (control), -1, -2, -3, -4, -5, -6, -7, -8, -9 and -10 bar] were applied as randomized designs. Germination percentage (GP), mean germination time (MGT), root (RL) and shoot length (SL) were measured. Analysis of variance indicated that different concentration of PEG-6000 was significant ( $P < 0.01$ ) in GP, MGT, RL and SL parameters. The highest GP, RL and SL were obtained at control concentration, whereas; the highest MGT was observed at high -10 bar concentration. As the concentration of PEG-6000 increased, the germination percentage, root length and shoot length decreased significantly, while the mean germination time was prolonged. Based on the data obtained, it was concluded that an effective selection could be achieved at a concentration of -10 bar and this osmotic potential, can be used to select the drought tolerant during the germination period.

## Erken Kuraklık Stresinin Kırık Ekmeklik Buğdayın (*Triticum aestivum* L.) Çimlenme ve Fide Parametrelerine Etkisi

## Makale Bilgileri

## ÖZ

### Makale Geçmişi

Geliş: 22.11.2022

Kabul: 30.12.2022

Yayın: 31.12.2022

### Keywords:

PEG-6000,  
Çimlenme,  
Buğday.

Bu çalışma, polietilen glikolün (PEG-6000) çimlenme ve fide parametreleri üzerindeki etkilerini değerlendirmek ve Kırık buğdayı (*Triticum aestivum* L.) mutasyon ıslah programlarında kullanılabilecek optimal dozu belirlemek amacıyla yapılmıştır. Bu çalışmada 11 farklı PEG-6000 uygulama dozu [0 (kontrol), -1, -2, -3, -4, -5, -6, -7, -8, -9 ve -10 bar] tesadüf deneme desenine göre yapılmıştır. Çimlenme oranı (GP), ortalama çimlenme zamanı (MGT), kök (RL) ve sürgün uzunluğu (SL) ölçülmüştür. Varyans analizi, farklı PEG-6000 konsantrasyonunun GP, MGT, RL ve SL parametrelerinde önemli olduğunu ( $P < 0.01$ ) göstermiştir. En yüksek GP, RL ve SL kontrol konsantrasyonunda elde edilirken; en yüksek MGT, -10 bar konsantrasyonda gözlenmiştir. PEG-6000 konsantrasyonu arttıkça çimlenme oranı, kök uzunluğu ve sürgün uzunluğu önemli ölçüde azalırken, ortalama çimlenme zamanı uzamıştır. Elde edilen verilere dayanarak, -10 bar'lık bir konsantrasyonda etkili bir seleksiyonun gerçekleştirilebileceği sonucuna varılmış ve bu ozmotik potansiyel, çimlenme döneminde kuraklığa dayanıklı çeşidin seçiminde kullanılabileceği sonucuna varılmıştır.



Atf/Citation: Türkoglu, A., Tosun, M., Haliloglu, K. & Karagöz, H. (2022). Effects of Early Drought Stress on Germination and Seedling Growth Parameters of Kırık Bread Wheat (*Triticum aestivum* L.), *Eregli Journal of Agricultural Science*, 2(2), 75-80.

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## INTRODUCTION

Wheat still maintains its status as the leading basic nutrient in the in our country and world, as a result, it is widely grown. Most of the wheat produced in Erzurum is consumed by producer families. Producers prefer the Kırık variety because of its alternative character and white grain, suitable for traditional bread making. In order to increase wheat production, many varieties (Doğu 88, Karasu 90, Palandöken 97, Nenehatun) that can be grown in barren and irrigated conditions and are compatible with the ecology of the region have been registered and offered to the use of farmers in recent years, although these varieties are not sufficient enough by the regional farmer due to their insufficient quality characteristics and their production is not widespread. This is due to the fact that the new breeding varieties do not have the appropriate quality characteristics as Kirik and the planting of these varieties, all of which are absolute winter, could not be done on time for various reasons. The most important reason why Kırık is still the most preferred variety by local farmers is its high bread quality and alternative character (Hosseinpur, 2016). The quality feature of the variety is always evaluated in terms of yield. Despite these characteristics, it has been noted that it is a low-yielding, weak-stemmed and drought-sensitive variety compared to other registered varieties grown in the region (Öztürk, 2011).

Product production in the world is greatly limited by environmental stresses. It is estimated that only 10% of arable land in the world is free from some forms of stress. The main factor responsible for the difference between potential yield and obtained yield is environmental stress. One of the common problems in crop production areas is water shortage. Plants require large amounts of water to grow, and drought restricts not only plant size but also the development of various plant parts. The effect is sometimes so great that the yield approaches zero (Blum, 1989). Considering the changes in the climate in recent years, it is stable, highly productive; development of high-quality wheat varieties that are resistant to drought, diseases and pests are among the most important goals of breeding studies. Therefore, in today's breeding studies; yield and quality factors are considered together, on the one hand, the possibilities of increasing the amount of yield obtained from the unit area are investigated, on the other hand, it is aimed to improve the quality characteristics that can meet the demands of different consumer segments (Kaya, 2006). One of the breeding studies that can be done to develop a biotic and abiotic stress resistant variety is mutation breeding. If the desired mutant types can be obtained, the result will be achieved in a shorter time and at a lower cost with mutation breeding than with hybrid breeding. The success of the mutation breeding program largely depends on (1) the type of mutations desired, (2) the ability of specific mutations to induce a maximum number of independent mutations (the efficiency of mutagenic treatment), and (3) the selection method employed to select the desired mutations. Induction of mutations is a matter of chance, and the selection of desired mutants may depend on the selection method to be applied (Tosun, 2015). In order to select the desired mutants, effective selection method should be applied and sufficient amount of M<sub>2</sub> and/or M<sub>3</sub> line material should be kept. Polyethylene Glycol (PEG) compound has been widely used to simulate *in vitro* osmotic stress effects to maintain uniform water potential for plants throughout the experimental period (Khayatnezhad *et al.*, 2010). One of the critical stages in drought tolerance is the germination period (Hossein pour, 2016). In mutation breeding, studies on drought, examining the parameters of PEG concentrations at different doses in the germination and seedling stages are important criteria in the selection applications to be made in the early stages. Therefore, the effects of different concentrations of PEG, which is a selection tool in eraly drought studies, on the germination and seedling growth parameters of the Kırık bread wheat variety were investigated.

## MATERIAL and METHOD

The study was performed in Atatürk University Faculty of Agriculture. Kırık bread wheat as plant material were used. After washing the seeds in tap water, they were mixed in 70% ethyl alcohol (EtOH) for 3 minutes, washed 3 times with sterile deionized water in a sterile cabinet and mixed in 20% sodium hypochlorite containing a few drops of Tween 20 (Sigma) for 15 minutes. In this experiment, 11 different PEG concentrations [0 (control), -1, -2, -3, -4, -5, -6, -7, -8, -9 and -10 bar] was carried out in 4 repetitions according to the randomized plot design. The osmotic potentials generated at different concentrations of PEG were calculated according to Michel and Kaufmann (1973). The seeds were taken to germinate in the germination cabinet between paper in petri dishes. 14 ml of their respective dose of PEG-6000 concentration was added for each application. During germination, the temperature was adjusted to 25 °C and 16 hours of light and 8 hours of dark periods were applied. After the seeds were placed in the germination medium, germination data were obtained by counting every day for 14 days (the ones with a root length of 1 mm and above were considered germinated). (Haliloğlu *et al.*, 2022).

### Germination and seedling related parameters

Germination percentage (GP) (%), and mean germination time (MGT) (day) characters were obtained at the end of the 14th day (Hosseinpour *et al.*, 2021). 14 days after the seeds were placed in the germination medium, 10 seedlings were randomly taken from each petri dish, including root length (cm) (RL), shoot length (cm) (SL) characters were measured (Hosseinpour *et al.*, 2021).

### Statistical Analysis

The effect of the 11 different PEG-6000 concentration was analyzed in according randomized design. Differences between the means of variation sources in terms of germination and seedling growth characteristics were determined by Duncan's test multiple comparison test at 5% significance level.

## RESULTS

The averages of germination percentage (GP), mean germination time (MGT), root length (RL) and shoot length (SL) and variance analysis results of different PEG-6000 concentration are given in Table 1. PEG-6000 concentrations had significant effects on all germination and seedling growth parameters ( $P < 0.01$ ). GP was higher for control group (100%). The lowest germination percentage was found in -10 bar (0.00%) concentration. Seeds exposed to germination test under different PEG-6000 concentration showed reduced germination percentages than the control. As can be seen from these results, the germination rate did not show a change in parallel with the increase in concentration. MGT of kırık belong to control group were 1.94 day. The highest MGT value was obtained at -9 bar concentration (3.00 day). The highest MGT (3.00 day) was obtained in -9 bar concentration. MGT increases as the concentration of drought increases. The results showed that no seeds germinated at a concentration of -10 bar. RL ranged from 0.00 cm (-10 bar) to 5.20 cm (0 bar) under different PEG-6000 concentrations. The results showed that RL increases as the concentration of drought increases. Also the result showed control groups had the highest SL (13.50 cm) in the study and the lowest SL (0.00 cm) were found under high PEG-6000 concentrations (Table 1).

**Table 1.** Variance Analysis Mean Values of Germination and Seedling Growth Parameters in Kirik Bread Wheat under Drought Stress

PEG-6000 concentration (bar)	GP (%)	MGT (day)	RL (cm)	SL (cm)
0	100.00 <sup>a</sup>	1.94 <sup>i</sup>	5.20 <sup>a</sup>	13.50 <sup>a</sup>
-1	99.00 <sup>a</sup>	1.95 <sup>h</sup>	5.20 <sup>a</sup>	12.75 <sup>ab</sup>
-2	98.00 <sup>a</sup>	1.96 <sup>h</sup>	5.05 <sup>a</sup>	12.25 <sup>b</sup>
-3	96.00 <sup>ab</sup>	1.97 <sup>g</sup>	4.95 <sup>a</sup>	11.00 <sup>c</sup>
-4	90.00 <sup>b</sup>	1.99 <sup>f</sup>	4.85 <sup>a</sup>	10.00 <sup>d</sup>
-5	87.00 <sup>b</sup>	2.00 <sup>e</sup>	4.20 <sup>b</sup>	8.75 <sup>e</sup>
-6	83.00 <sup>b</sup>	2.10 <sup>d</sup>	4.05 <sup>b</sup>	7.25 <sup>f</sup>
-7	20.00 <sup>c</sup>	2.50 <sup>c</sup>	2.95 <sup>c</sup>	4.25 <sup>g</sup>
-8	13.00 <sup>cd</sup>	2.60 <sup>b</sup>	1.75 <sup>d</sup>	2.25 <sup>h</sup>
-9	2.00 <sup>d</sup>	3.00 <sup>a</sup>	1.25 <sup>e</sup>	1.50 <sup>h</sup>
-10	0.00 <sup>e</sup>	0.00 <sup>j</sup>	0.00 <sup>f</sup>	0.00 <sup>i</sup>
Means	62.54	2.00	3.58	7.59
Mean Square	7488.29**	2.251**	13.39**	94.61**

## DISCUSSION

Drought is an important problem that severely restricts crop production worldwide, and today, global climate change makes this situation even more serious (Pan *et al.*, 2003). The effect of arid conditions on plant growth and grain yield depends on the severity of the drought and the development period of the plant in the drought period. Seedling emergence is one of the growth periods sensitive to water deficiency. The rate and degree of the seedling plant; are important factors that determine the yield and maturity time (Rauf *et al.*, 2007). Therefore, for a good plant establishment, characteristics such as seed germination, vermilion and coleoptile length should be at a sufficient level. One of the breeding studies that can be done to develop a biotic and abiotic stress resistant variety is mutation breeding. The success of the mutation breeding program largely depends on the selection method employed to select the desired mutations. In the selection to be made in terms of drought resistance in the early development period of the seedlings, chemicals such as PEG are frequently used in the germination medium to stimulate drought. It has been reported that PEG can be used to modify the osmotic potential of the nutrient solution culture, thereby providing water deficiency in plants in a relatively controlled manner in accordance with experimental protocols (Zhou, 1997). Seed germination parameters could be used to identify early drought stress at germination stage. Different seed parameters were calculated using germination and seedling growth parameters. Analysis of variance indicated that different concentration of PEG-6000 was significant in GP, MGT, RL and SL parameters. The highest GP, RL and SL were obtained at control concentrations, whereas; the highest MGT was observed at high -10 bar. As the concentration of PEG-6000 increased, the germination percentage, root length and shoot length decreased significantly, while the mean germination time was prolonged. Similar to the findings obtained in the research (Hossein Pour *et al.*, 2013), it was determined that the germination rate and the development of the grass decreased due to the increase in the PEG concentration in their study on the wheat plant. Alam *et al.* (2002) determined that the germination rate and the development of grass decreased depending on the increase in PEG concentration in their study on the rice plant. In another study Zeid and Shedeed (2006) in alfalfa, it was determined that increasing PEG concentration caused a decrease in germination rate, hypocotyl length, root and shoot fresh and dry weight. In this study analysis of variance indicated that different concentration of PEG-6000 was significant ( $P < 0.01$ ) in GP, MGT, RL and SL parameters. The highest GP, RL and SL were

obtained at control concentration, whereas; the highest MGT was observed at high -10 bar concentration. As the concentration of PEG-6000 increased, the germination percentage, root length and shoot length decreased significantly, while the mean germination time was prolonged. Based on the data obtained, it was concluded that an effective selection could be achieved at a concentration of -10 bar and this osmotic potential was used to select the drought tolerant ones during the germination period.

### Conflict of Interest Statement

The authors declare that there is no conflict of interest between them.

### Author Contributions

MT and KH designed the research. AT conducted the study and HK analyzed the data. All authors contributed to the writing of the article and took part in the publication process of the article and read and approved it.

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