

Effects of Different Salt Doses on Germination and Seedling Development in Triticale

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Received: December 29, 2025, Accepted: 23 Şubat 2026

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Absract

Objective: This study, which was conducted to determine the effects of different salt doses on germination and seedling development in Triticale, was carried out in the laboratories of Ordu University Field Crops Department in 2024.

Materials and Methods: The Alperbey triticale variety was used in the study. Salt (NaCl) doses of 0 (control), 50, 100, 150, 200, and 250 mM were used in the experiment. The experiment was conducted in randomized plots with four replications. Observations such as germination rate (%), potential germination rate (%), germination uniformity (%), germination speed (%), average germination time (days), radicle length (cm), plumule length (cm), and seedling fresh weight (g) were determined.

Research Findings: In the research, germination rates of triticale seeds varied between 23% and 61%, potential germination rate between 23% and 53%, germination uniformity between 11.50% and 24.63%, germination speed between 2.88% and 6.60%, average germination time between 2.00 and 2.50 days, radicle length between 0.24 and 5.28 cm, plumule length between 0.14 and 2.58 cm and seedling fresh weight between 0.08 and 2.34 g.

Results: Studies have shown that increasing salt concentrations have a significant effect on all traits studied. Salt did not significantly affect germination in triticale plants at doses up to 200 mM, did not significantly affect seedling development at doses up to 100 mM, and negatively affected germination and seedling degradation at later doses.

Keywords: Seed, Radicula, Plumula, Stress

Farklı Tuz Dozlarının Triticale'de Çimlenme ve Fide Gelişimine Etkileri

Öz

Amaç: Triticalede farklı tuz dozlarının çimlenme ve fide gelişimine etkilerini belirlemek amacıyla yapılan bu çalışma, Ordu Üniversitesi Tarla Bitkileri Bölümü laboratuvarlarında 2024 yılında gerçekleştirilmiştir.

Materyal ve Yöntem: Çalışmada Alperbey tritikale çeşidi kullanılmıştır. Denemede tuzun (NaCl) 0 (kontrol), 50, 100, 150, 200 ve 250 mM dozları kullanılmıştır. Deneme tesadüf parsellerinde deneme desenine göre 4 tekrarlamalı olarak yürütülmüştür. Araştırmada, çimlenme oranı (%), potansiyel çimlenme oranı (%), çimlenme üniformitesi (%), çimlenme hızı (%), ortalama çimlenme süresi (gün), radikula uzunluğu (cm), plumula uzunluğu (cm) ve fide yaş ağırlığı (g) gibi gözlemler belirlenmiştir.

Araştırma Bulguları: Yapılan araştırmada, tritikale tohumlarında çimlenme oranları %23-%61 arasında, potansiyel çimlenme oranı %23 ila % 53 arasında, çimlenme üniformitesi %11.50-%24.63 arasında, çimlenme hızı %2.88-%6.60, ortalama çimlenme süresi 2.00-2.50 gün arasında, radikula uzunluğu 0.24-5.28 cm arasında, plumula uzunluğu 0.14-2.58 cm arasında ve fide yaş ağırlığı 0.08-2.34 g arasında değişim göstermiştir.

Sonuç: Yapılan araştırma sonuçlarına göre, artan tuz konsantrasyonlarının incelenen tüm karakterler üzerine istatistiksel olarak önemli düzeyde etki yaptığı görülmüştür. Tuzun tritikale bitkisinde 200 mM dozuna kadar çimlenmeyi fazla etkilemediği 100 mM dozuna kadarda fide gelişimini etkilemediği ve daha sonraki dozlar da çimlenme ve fide gelişimini olumsuz yönde etkilediği tespit edilmiştir.

Anahtar Kelimeler: Tohum, Radikula, Plumula, Stres

Introduction

Integrating the high grain yield of wheat and the resistance of rye to cold, drought, and disease stresses, triticale also exhibits high adaptability to infertile soils. Triticale can grow in cold, high-altitude areas, in sandy, infertile soils, and in arid conditions where the available moisture must be utilized optimally. According to Martin and Maurer (1974), triticale is more productive than wheat in regions with shallow, barren, arid soils, and very harsh winters. It is reported to have a better soil utilization ability compared to other cereals and to be less affected by changing environmental conditions (Gregory, 1975). Triticale is cultivated in areas with acidic soils, high plateaus, and stony soils where wheat yield is low due to widespread diseases. Because of these characteristics, it is more suitable to grow triticale instead of wheat and barley for animal feed purposes in both normal, stony, and sloping areas where irrigation is not possible. Among the limiting factors of plant cultivation, soil salinity is also holding an importance. In addition to the other agronomic characteristics, knowing the responses of plant species and varieties to salt stress is crucial for evaluating areas experiencing salinity problems. Since reclaiming saline soils is not economically feasible (Turhan and Şeniz, 2010), cultivating salinity-tolerant plants in these areas can make these lands usable and contribute to plant production. Therefore, in recent years, studies on the salinity tolerance of plant species and varieties have intensified. In plant cultivation, germination and early seedling stages are critically important for yield and quality. Ensuring optimum plant population and homogeneous plant development directly depends on the number of germinating seeds and strong seedling development. Many studies to date have shown that salinity significantly reduces or even completely stops germination, depending on plant species, variety, and salt concentration (Acar et al., 2011; Şentürk and Sivritepe, 2015; Aşçı and Üney, 2016). In this context, this study was conducted to determine the effects of different salt concentrations on germination and seedling development in triticale.

Materials and Methods

This research was executed as a petri dish study within the laboratories of the Department of Field Crops at Ordu University in 2024. Seeds of the Alperbey variety of triticale were used in the study. The experiment was conducted in Completely Randomized Design (CRD) with 4 replications, and

salt (NaCl) concentrations of 0 (control), 50, 100, 150, 200, and 250 mM were used. The petri dishes used in the study were first sterilized in a 5% sodium hypochlorite (NaClO) solution and then rinsed with pure water. After disinfection, two layers of blotting paper were placed inside each petri dish. Then, 25 disinfected triticale seeds were placed between the blotting paper, 15 ml of salt solution was added, and germination was carried out at 24 ± 1 °C in a completely dark environment (Aşçı et al. 2024). Distilled water was used as control treatment. Seeds showing radicle emergence were considered germinated. Germinated seeds were counted at 24-hour intervals from the start of the study up to 8th day and after that, the study was terminated. In the study, germination (G) (%), potential germination (PG) (%) (Ren et al., 2020), germination uniformity (GU), germination rate (GR), mean germination time (MGT) (days), radicle length (RL) (cm), plumule length (PL) (cm), and seedling fresh weight (SFW) (g) were determined.

The data obtained from the study were first tested for normality using the Shapiro-Wilk test and for homogeneity by Levene test. The results showed that the PG and GU data exhibited both normal distribution and homogeneity, while the other parameters were found to be abnormally distributed and/or non-homogeneous. Therefore, $\sin^{-1} x$, transformation was applied to the G values, and $\sqrt[3]{x + 1}$ transformation was applied to the remaining parameters. Statistical analysis was performed on the transformed data for parameters other than PG and GU. The Tukey multiple comparison test was applied to compare salt concentrations. SPSS v26 software package was used for statistical analysis. The graph was plotted using Excel.

Results and Discussion

The mean values and statistical groupings of the effects of different concentrations of salt (NaCl) on some germination characteristics and seedling development of triticale seeds are presented in Table 1. As seen in the table, germination percentage in triticale seeds ranged from 23% to 61%, with the highest value obtained from the control concentration and the lowest value from the 250 mM concentration. The effect of salt concentrations on germination rates was found to be statistically significant. While there was no significant difference in germination percentage between the control concentration and the 50, 100, 150, and 200 mM salt concentrations, the 250 mM salt concentration

significantly reduced the germination percentage compared to the control. The effect of different salt concentrations applied to triticale seeds on the potential germination varied between 23% and 53%, and was statistically significant. The highest potential germination was obtained from the control concentration, similar to the germination percentage, and the lowest was obtained from the 250 mM salt concentration, and the difference was found to be statistically significant. Although there was a decrease between the control and other concentrations, and was not statistically significant (Table 1). Salt stress reduces germination in seeds due to osmotic and/or toxic effects (Aşçı and Üney, 2016; Demirkol et al., 2019; Irik and Bikmaz., 2024). Studies have reported that salt concentrations reduce germination percentage in triticale (Akgün et al., 2011; Kara et al., 2011; Doğan and Çarpıcı, 2016). Our

findings are similar to those of the aforementioned researchers. Indeed, (Kara and Kara Uysal., 2010; Van Hoorn et al., 2001) also stated that almost all plants are sensitive to high salinity during germination and initial seedling development stages. When the germination percentage, potential germination (Table 1), and cumulative germination (Figure 1) are examined together, it is understood that, except for the 250 mM salt concentration, salt stress reduces the number of germinating seeds and causes germination to take longer than 3 days in other treatments. At the 250 mM concentration, the fact that the potential germination and the germination percentage are the same indicates that all seeds germinated within the first 3 days; however, when the cumulative germination graph (Figure 1) is examined, it is understood that germination is completed in 2 days. This situation may be due to secondary dormancy or negative effects on seed viability.

Table.1. Mean values and statistical groups of the effects of different salt concentrations on some germination characteristics and seedling development of triticale seeds.

Salt Concentrations (mM)	Germination (G) (%)		Potential Germination (PG) (%)		Germination Uniformity (GU)		Germination Rate		Mean Germination Time (MGT) (Days)		Radicle Length (RL) (cm)		Plumule Length (PL) (cm)		Seedling Fresh Weight (SFW) (g)	
	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.	Mean. Error	±std.
0	61.00±4.12a		53.00±3.42a		24.63±1.04a		6.60±0.35a		2.47±0.11ab		1.61±0.51b		2.58±0.70a		0.99±0.35b	
50	58.00±3.46ab		48.00±5.66ab		23.31±1.91ab		6.40±0.40a		2.50±0.09a		1.07±0.44bc		1.60±0.82ab		0.66±0.33bc	
100	51.00±15.09ab		41.00±10.88ab		20.01±5.04ab		5.38±1.39ab		2.49±0.13ab		5.28±0.43a		2.27±0.52a		2.34±0.26a	
150	31.00±5.26ab		28.00±5.16ab		13.03±2.90ab		3.68±0.72ab		2.48±0.17ab		0.43±0.15bc		0.27±0.05b		0.20±0.05bc	
200	26.00±4.16ab		25.00±4.12ab		12.38±2.07b		3.18±0.51b		2.11±0.11ab		0.50±0.16bc		0.40±0.10b		0.25±0.08bc	
250	23.00±2.52b		23.00±2.52b		11.50±1.26b		2.88±0.32b		2.00±0.00b		0.24±0.05c		0.14±0.04b		0.08±0.02c	
P	0.007** (F=4.596)		0.007** (F=4.592)		0.007** (F=4.674)		0.002** (F=5.915)		0.011* (F=4.126)		0.000*** (F=23.757)		0.000*** (F=8.154)		0.000*** (F=13.831)	

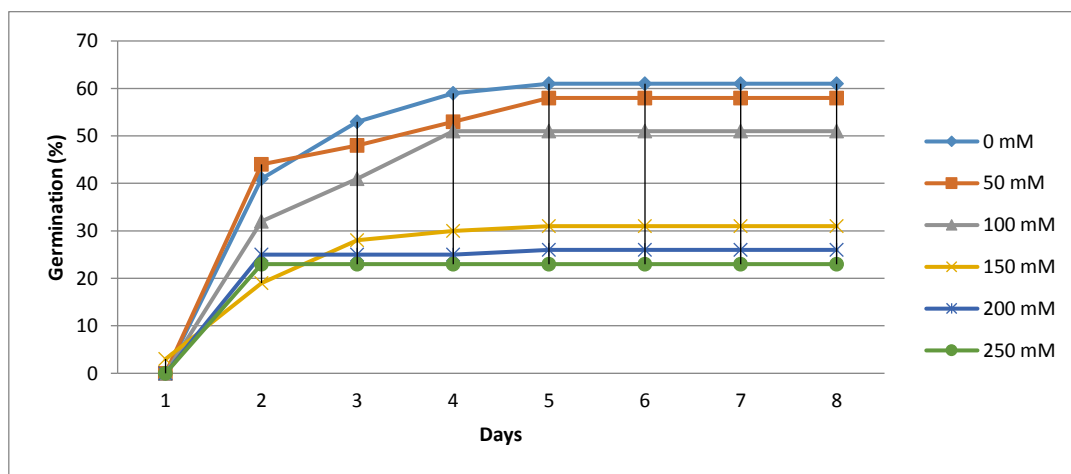


Figure 1. Cumulative germination (%) of Triticale at different salt concentrations.

The germination uniformity of triticale seeds at different salt concentrations ranged from 11.50 to 24.63. The highest germination uniformity was obtained with control treatment, but no statistically significant difference was found between control and the 50, 100, and 150 mM salt concentrations. On the other hand, the lowest germination uniformity was obtained from the 200 and 250 mM salt concentrations, and the difference between this and the control was statistically significant (Table 1). The germination rate of triticale seeds at different applied salt concentrations ranged from 2.88 to 6.60, with the highest germination rate obtained from the control and the 50, 100, 150 mM salt concentrations. The germination rate decreased significantly at the 200 and 250 mM salt concentrations (Table 1). Although germination percentage is important in terms of the number of plants per unit area, achieving an optimum number of plants per unit area, along with simultaneous growth and development of plants, is desirable for yield and quality of the crop and for determining the correct harvest time. Therefore, homogeneous and rapid germination is desired in plant seeds, along with a high germination percentage. The study showed that germination uniformity and rate were high up to a salt concentration of 150 mM, and decreased at higher concentrations (200 mM and 250 mM). The decrease in germination uniformity and rate with an increase in salt concentration indicates that homogeneous germination did not occur. Similarly, it was determined that increasing salt stress reduced germination uniformity and rate in sweet sorghum (Özyazıcı and Açıkbaş., 2021), lentil (Ceritoglu et al., 2023), and in soybean (Açıkbaş et al., 2023). As shown in Table 1, the mean germination time of triticale seeds varied between 2.00 and 2.50 days at different salt concentrations applied. The presence of 50 mM salt in the medium had a delayed germination effect compared with control, and this effect continued up to the 200 mM. However, a statistically significant difference in mean germination time was determined only between 50 mM and 250 mM (Table 1). Similarly, in a study conducted with triticale genotypes, it was evident that salt stress, depending on the concentration, first lengthened and then shortened the mean germination time (Ramadan et al., 2023). Radicle length of seedling which triticale seeds germinated at different salt concentrations ranged from 0.24 cm to 5.28 cm. The longest radicle was obtained at a salt concentration of 100 mM, and the shortest at 250 mM,

and both salt concentrations were found to be statistically different from the control (Table 1). Root length is one of the most important parameters for salt stress because roots are in direct contact with the soil and absorb water from the soil, transporting it to other organs of the plant. Therefore, root length can provide important clues in determining the responses of plants to salt stress (Bahrani and Hagh Joo., 2012). If there is no obstruction in water uptake during germination, the radicle shows normal development. As is known, salt stress causes drought and/or toxic ion effects in plants. Since triticale is drought-tolerant, it may have increased its radicle length to avoid the drought stress caused by the 100 mM concentration. At higher salt concentrations, radicle length may have decreased. Similar to the results of a study by (Atak et al., 2006), determined that radicle growth of triticale varied depending on salt concentration and variety, with increased radicle length at lower concentrations and decreased radicle length at higher quantities. In this study, plumule length varied between 0.14 cm and 2.58 cm depending on salt concentration, and the difference among salt treatments was statistically significant. Increased salt stress negatively affected plumule length, and the first statistically significant negative effect occurred at a dose of 150 mM (Table 1). Salt stress negatively affected seedling development more in the early stages than germination. Indeed, the first negative effect of NaCl on germination percentage occurred at a dose of 250 mM, while its effect on plumule length was observed at a dose of 150 mM. This was likely due to the inhibitory/protective effects of salt on the embryo's access to the testa and other surrounding tissues. Similar results regarding the effect of salt on plumule length were also obtained by (Kara et al., 2011; Çiftci et al., 2013; Doğan and Çarpıcı 2016). In the study, the fresh weight of seedlings developing at different salt concentrations ranged from 0.08 g to 2.34 g. The highest seedling fresh weight was obtained at 100 mM salt dose, and the lowest seedling fresh weight was obtained from the 250 mM. Both treatments were statistically significantly different from the control. However, salt concentration above 100 mM caused progressively decreases in seedling fresh weight (Table 1). As is known, seedling fresh weight is determined by the water content and development of the seedling. In addition, the turgor status of the cell controls cell growth and division. Salt stress reduces or inhibits growth and division in cells by reducing their water content and/or through toxic effects. In this study, the

highest seedling fresh weight was determined at the 100 mM, which is due to the fact that the best radicle growth occurred at the same salt concentration. Studies have shown that many plants experience significant reductions in the fresh weight of shoots and roots under salt stress (Irshad et al., 2002).

Conclusion

In studies examining the effects of salt stress on plants, it is necessary to focus more on germination and seedling development stages when comparing the developmental stages of the plant. Therefore, this study aimed to determine the effects of different salt concentrations on germination and seedling development in the Alperbey variety of Triticale. According to the research results, it was observed that increasing salt concentrations had a statistically significant effect on all the parameters examined. It was determined that salt did not significantly affect germination up to a concentration of 200 mM, did not affect seedling development up to a dose of 100 mM, and negatively affected germination and seedling development at higher doses than these. Supporting these laboratory findings with field experiments will confirm that selecting salt-tolerant varieties is key to stabilizing yields in saline-affected areas.

Conflict of Interest

The authors have declared no conflict of interest.

Author Contrubiton Statement

The authors have equal contributions.

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