JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2024, 25(7), 178–186
https://doi.org/10.12911/22998993/188333
ISSN 2299–8993, License CC-BY 4.0

Received: 2024.05.01
Accepted: 2024.05.16
Published: 2024.06.01

Effects of Salinity and Drought of Germination Parameters of Seeds of *Triticosecale*

Sirojiddin Urokov[1*], Makhliyo Usmanova[1], Djurakul Xadjayev[1], Zukhra Jurayeva[1], Alisher Khujanov[1], Maftuna Raimkulova[1]

[1] Department of Plant Physiology and Microbiology, Institute of Biochemistry of Samarkand State University named after Sharof Rashidov, University Boulevard 15, 140104 Samarkand, Uzbekistan

* Corresponding author's e-mail: usiroj1981@mail.ru

ABSTRACT

Over the past 50 years, salinity and drought coverage have increased dramatically. The effect of salinity and drought is manifested as a stress factor in the development of agricultural crops. As a result, there is an increasing need for research aimed at evaluating the impact of extreme factors on the development of agricultural crops, including cereals and forage crops, and increasing their productivity in saline and arid regions. Triticale - *Triticosecale* is a hybrid of wheat (*Triticum* L) and rye (*Secale* L). It is of great importance as food for humans and fodder for livestock. This research is one of the first researches of this type, aimed at determining the germination of seeds in different cultivars of Triticale under salinity and drought conditions. Although information on the effect of temperature on the growth of the seeds of this plant is recorded in scientific sources, the lack of information on the diversity of the indicators of seed germination in Triticale cultivars under the influence of various stress factors indicates that in-depth research has not been conducted in this regard. According to the results of the research carried out in laboratory conditions, salinity and drought have a direct effect on the germination parameters of the seeds of different cultivars of Triticale. As salinity and drought levels increase, seed germination rates decrease. The data presented in the article serve to explain the difference in the germination indicators of the seeds of different cultivars of Triticale under salinity and drought, and to choose the right approach for growing this crop in saline and arid regions.

Keywords: drought, germination, salinity, seed, Triticale - *Triticosecale*.

INTRODUCTION

Soil salinity and drought are stressors that limit the development and yield of agricultural crops (Liu et al., 2015). The stress caused by these factors has a negative effect on functional cellular processes in plants such as water absorption, photosynthesis, nutrient absorption and metabolism, and can lead to the cessation of crop growth and development (Pham et al., 2023). Therefore, the rapid increase in salinity and drought coverage in the whole world is causing a sharp decrease in the productivity of agricultural crops (Akramov et al., 2023; Alikulov et al., 2023). The situation calls for research into the possibility of growing agricultural crops under salinity and drought conditions. Experts note that salinity and drought have a negative effect on all stages of the growth period of plants. Among the periods of plant growth and development, seed germination is the most sensitive period to the effects of stress factors during the entire growth and development of plants (Lu et al., 2022; Ruziyev et al., 2023). Seed germination is the starting point of plant life, and water is one of the necessary conditions for seed germination. Water deficit affects the activity of internal enzymes in seeds, cell division and other physiological metabolic processes. At the same time, water deficit can cause seeds to lose viability due to their inability to absorb enough water at the same time, which affects seed germination (Long et al., 2023; Tursunov et al., 2023). Triticale - *Triticosecale* is a hybrid of wheat (*Triticum*) and rye (*Secale*) and was first developed by Scottish and German scientists at the end of the 19th century (Stace 1987). Triticale has increased winter hardiness (more than winter wheat), resistance against fungal and viral diseases, reduced demands on soil fertility, and contains a lot of protein in the grain (Feledyn-Szewczyk et al., 2020). The protein content in triticale is 1.0–1.5% higher than that of wheat, and 3–4% than that of rye. In terms of fractional composition, triticale proteins occupy an intermediate position between the proteins of wheat and rye. They form gluten in quantitative terms, close to wheat, but worse in quality. The digestibility of wheat and triticale proteins is almost the same – 89.3 and 90.3%, respectively. Triticale grain is not inferior to wheat grain in terms of the content of macro- and microelements (Zhu 2018; Iskierko et al., 1980). In terms of nutritional value, the grain of wheat-rye hybrids is not inferior to the grain of barley and sorghum and can replace it in the diet of pigs, as well as in concentrate mixtures for fattening cattle, dairy cows, and sheep (Grela et al., 2023). Triticale straw is fed to animals as roughage. Triticale provides approximately as much green mass as wheat, oats and rye. Today, triticale is used both as a food and forage crop (Ates et al., 2017). The world's triticale production has risen steadily in recent years. Triticale grain has a higher biological value than wheat and rye; in terms of exchange energy content, it outperforms wheat by 14% and rye by 23% on average (Kamanova et al., 2023).

In scientific sources, some information on the effect of external environmental factors on the germination of the seeds of Triticale was recorded (Mehmet et al., 2006). However, the paucity of data on the variation of seed germination parameters in Triticosecale cultivars under salinity and drought conditions in these records indicates that in-depth studies have not been conducted in this area.

According to the data analyzed above, drought and salinity affect the parameters of important processes in plants, including seed germination. Therefore, it is important to study the effect of these stress factors on the germination of seeds of different cultivars of Triticale, one of the important crops. The purpose of the research work is to determine the germination parameters of the seeds of different cultivars of Triticale under salinity and drought conditions.

MATERIALS AND METHODS

Research objects and experimental site

Seeds of the triticale cultivars Farxod, Odessiy, Valentin, Svat and Tixon were used (Fig.1). The seeds were obtained from the seed collection of the Institute of Biochemistry of Samarkand State University. The experiment was conducted in the laboratory of the Department of Plant Physiology and Microbiology of the Biochemistry Institute of Samarkand State University.

Determination of the optimum temperature for seed germination

The method of Vandelook et al (2008) was used to determine the optimum temperature for triticale seed germination. In the experiments, seeds were germinated at 7 different temperatures ranging from 5 °C to 35 °C. Experiments were carried out on 50 seeds for each cultivars, based on 5 replications (Vandelook et al., 2008). Germination power (1) and germination rate (2) were calculated using the following formulas:

$$\text{Germination power} = \frac{\text{The number of seeds germinated in 3 days}}{\text{Total number of seeds}} \times 100 \quad (1)$$

$$\text{Germination rate} = \frac{\text{The number of seeds germinated in 7 days}}{\text{Total number of seeds}} \times 100 \quad (2)$$

Determination of the optimal dormancy period for seed germination

Experiments to determine the effect of seed dormancy on seed germination were performed using the method recommended by Klupczyńska et al (2021). Seeds 3, 6, 9, 12 and 15 days after harvesting were used in the experiments. The seeds were collected in a thermostat at 20 °C, which is optimal for seeds of triticale cultivars

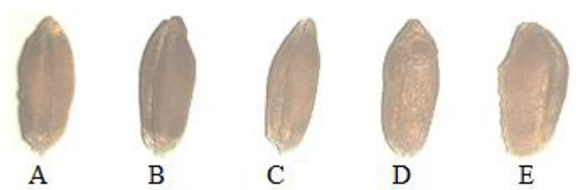

Figure 1. Research object – seeds of cultivars of *Triticale*: (a) Farxod, (b) Odessiy, (c) Valentin, (d) Swat, (e) Tixon

(Klupczyńska et al., 2021). The germination power and germination rate of the seeds were calculated using the formulas (A, B) given above.

Determination of the effect of salinity on seed germination

The method of Guo et al (2023) was used to determine the germination parameters of seeds of different cultivars of triticale under salinity conditions. 0.5%, 1% and 1.5% solutions of NaCl were used in the experiments. The seeds were collected in a thermostat at 20 °C, which is optimal for seeds of triticale cultivars (Guo et al., 2023). The germination power and germination rate of the seeds were calculated using the formulas (A, B) given above.

Determination of the effect of drought on seed germination

The determination of germination parameters of seeds of different cultivars of Triticale under drought conditions was carried out using the method of Li et al (2013). Sucrose solutions with the following concentrations were used as a drought factor in the experiments (Table 1). The seeds were collected in a thermostat at 20 °C, which is optimal for seeds of triticale cultivars. The germination power and germination rate of the seeds were calculated using the formulas (1, 2) given above.

Statistical analysis

Statistical processing and drawing of the results were performed using Microsoft Excel 2013 (USA) computer program. The results of the experiment were statistically summarized by evaluating the arithmetic averages of 5 repeated experiments at the level of statistical reliability of $p \leq 0.05$. In the mathematical-statistical analysis, the mean values and deviations of the indicators, as well as the calculation of the probability, were carried out according to the method of (Lakin, 1990).

Table 1. Sucrose concentration vs. osmotic pressure

Sucrose concentration, %	Osmotic pressure, atm
11.9	10
15.8	14
17.7	16
19.3	18
22.4	22

RESULTS AND DISCUSSION

Optimum temperature of seeds of Triticale

In our research, experiments aimed at determining the optimal temperature required for seed germination of triticale cultivars were conducted. In the experiments, seeds were collected at 7 different temperatures (5 °C, 10 °C, 15 °C, 20 °C, 25 °C, 30 °C, 35 °C). According to the data of Figure 2a, the germination power of different cultivars of triticale at 5 °C is equal to 5.0–12.5%, depending on the cultivar. At this temperature, the highest power of germination (12.5%) was recorded in the Svat cultivar, while the lowest rate (5.0%) belonged to the Odessa cultivar. It was observed that the germination power of triticale cultivars at 10 °C increased by 0.8–2.2 times from the values at 5 °C, depending on the cultivar. It was found that the germination power of triticale seeds at 15 °C increased dramatically from the indicators at 10 °C, reaching 55.5% in some cultivars. The results of seed germination power at 20 °C showed that the optimum temperature for Triticale seeds is 20 °C. At this temperature, the seed germination power of triticale cultivars reached 93.5%. In particular, it was noted that the lowest indicator of germination power at 20 °C belongs to the Tixon cultivar (82.5%), the highest indicator belongs to the Odessiy cultivar (93.5%), while this indicator is 90.5%, 92.0% and 86.5% in Farxod, Valentin and Swat cultivars, respectively. Inversely proportional to the increase in temperature from 25 °C → 30 °C → 35 °C, there was a tendency for the seed germination power to decrease in triticale cultivars. In this regard, germination power decreased from 90.5% to 32.5% in Farxod cultivar, from 93.5% to 31.0% in Odessiy cultivar, from 92.0% to 23.5% in Valentin cultivar, from 86.5% to 22.5% in Svat cultivar and from 82.5% to 29.5% in Tixon cultivar (Fig. 2a).

In the Farxod cultivar of triticale, the seed germination rate increased in the order of 54.5% 79.5% 93.5% 99.5% in the sequence of 5 °C → 10 °C → 15 °C → 20 °C. In Odessiy, Valentin and Tixon cultivars, the level of seed germination reached 100.0% at 20 °C, and the same indicator as Farxod cultivar was recorded in Svat cultivar. A process similar to seed germination was observed in triticale cultivars in the sequence 25 °C → 30 °C → 35 °C. In this case, the level of germination of seeds decreased with increasing temperature (Fig. 2b). The obtained data showed that

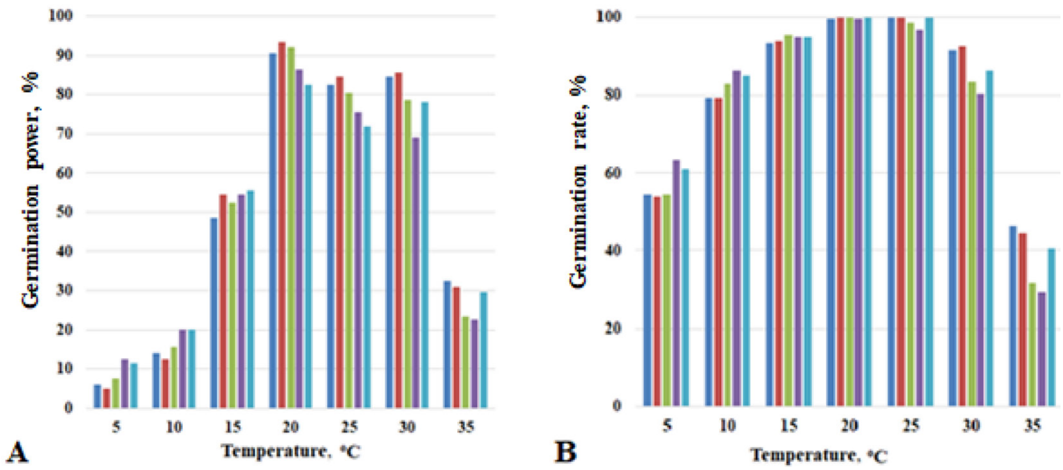

Figure 2. Effect of temperature on the germination power (a) and germination rate (b) yield strength and seed germination of seeds of cultivars of Triticale (n=5)

the optimum temperature for the seeds of triticale cultivars is 20 °C. Therefore, it was considered appropriate to conduct the next stages of the research at 20 °C. As a result of studies on determining the effect of temperature on the germination of *Brassica napus* L and *Triticum aestivum* L seeds, it was noted that the importance of temperature for seed germination, the optimal temperature for seeds varies depending on the type of plants and their adaptation to the living environment (Haj Sghaier et al., 2022; Sharma et al., 2022).

Effect of seed dormancy on the germination of seeds of Triticale

Dormancy period is one of the important factors affecting seed germination. Therefore, we conducted experiments to determine the effect of seed dormancy on triticale seed germination for use in the next stages of our research. In experiments, seeds with 5 different dormancy periods (3 days, 6 days, 9 days, 12 days and 15 days) were collected at 20 °C. According to the results of the experiment, in accordance with the increase of the rest period in the seeds, their fertility indicators also increase. For example, it was noted that in the Farxod cultivar of triticale, the germination power is 40.5% and the germination rate is equal to 76.5% in seeds with a resting period of 3 days, while in this cultivar, the germination power is 89.0% and the germination rate is 100.0% in seeds with a resting period of 15 days. It was found that the fertility rate of Odessiy cultivar in seeds with rest period of 3 → 6 → 9 → 12 → 15 days is 46.5% → 76.0% → 82.5% → 84.5% → 90.0%, and the level of fertilization is 79.0% → 93.0% → 95.0% → 98.5% → 100.0%. It was observed that in Valentin cultivar, the germination indicators of seeds with dormancy period of 3 and 6 days were lower than other studied cultivars. In the 15-day variant, which is considered the best dormancy period for other cultivars, the seed germination rate was 86.0%, and the germination rate was 98.5%. Relatively close indicators to this cultivar were also recorded in the experiments conducted on the seeds of the Svat cultivar. In the Tixon cultivar, the germination power of 3 days of dormancy is 40.5%, and the germination rate is 61.5%, while in this cultivar, the germination power of 15 days of dormancy is 81.0%, and the germination rate is 99.5% (Fig. 3).

Seed dormancy allows seeds to overcome periods that are unfavorable for seedling establishment and is therefore important for plant ecology and agriculture (Bentsink et al., 2008). In cereal plants, the seed dormancy period serves as a preparatory period for the normal passage of the next stages of plant development. During this period, plant hormones and biologically active substances are produced in grain (Rodríguez et al., 2015). The data obtained as a result of the experiments conducted by a number of researchers (Nyachiro et al., 2002; Tuan et al., 2015) confirm that the development of crops is delayed in a normal state when the dormancy period of seeds in cereal plants is at least 12–15 days.

Effect of salinity on the germination of seeds of Triticale

Today, salinity in agriculture of arid regions is a factor limiting the productivity and sustainable

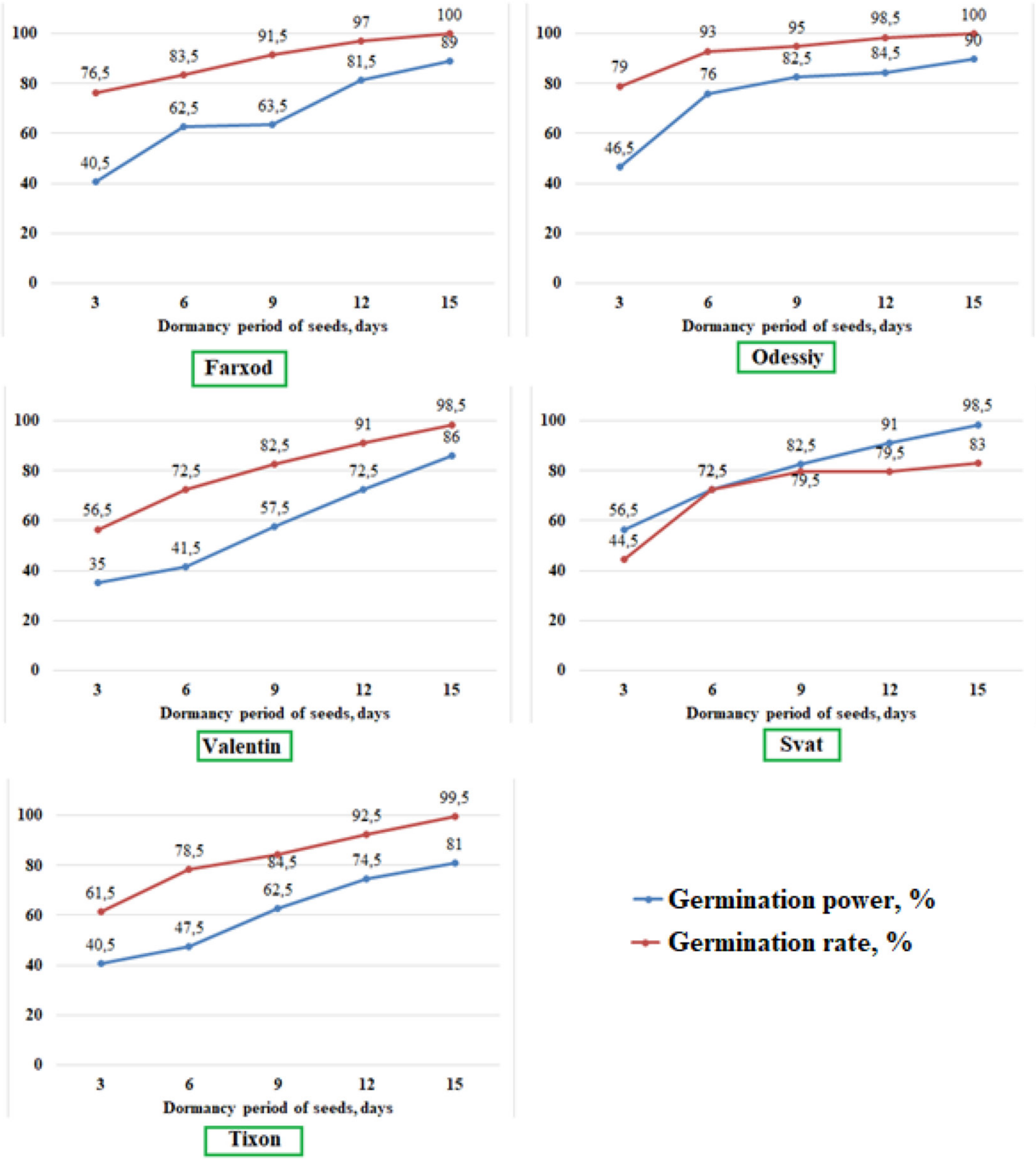

Figure 3. Effect of seed dormancy on the germination power and germination rate of seeds of cultivars of Triticale (n=5)

development of agricultural crops. Therefore, in our research, we conducted experiments aimed at determining the effect of salinity on the germination parameters of triticale seeds. In the experiments, the seeds were collected in the environment treated with 3 different concentrations of NaCl solutions (0.5%, 1.0%, 1.5%) at 20 °C.

Water-treated medium was used as a control. It was noted that in the Farxod cultivar of triticale, in the environment with 0.5% NaCl, the germination power of seeds was 8.0% lower than the control variant, and the level of germination was 1.4% lower. In this cultivar, the germination rate of seeds in 1.0% NaCl medium was 58.0%, and the germination rate was 92.0%. It was found that in the Farxod cultivar, in the environment with 1.5% NaCl, the fertility indicators of the seeds decreased sharply, in this variant, the fertility power was 49.3% lower than the control variant, and the level of fertility was 25.4% lower than the control variant. The trend of decreasing seed germination with increasing NaCl concentration in the environment was also observed in other studied varieties of triticale. When analyzing the germination parameters of the seeds in the section of the cultivars, the germination power in the medium with 1.5% NaCl increased from 90.6% to 41.3% in the Odessiy cultivar, from 89.3% to 42.6% in the Valentin cultivar, from 84.0% to 30.6% in the Svat cultivar, and from 81.3% to 33.3% in the

Tixon cultivar. decreased to %. When the same analysis was done on the level of seed germination, the germination rate in 1.5% NaCl medium was from 100.0% to 69.3% of the control option in the Odessiy cultivar, from 100.0% to 88.6% in the Valentin cultivar, from 100.0% to 61.3% in the Swat cultivar, and from 100.0% in the Tikhon cultivar. It was observed that it decreased to 72.0% (Fig. 4–5). The data obtained as a result of studies aimed at evaluating the effect of salinity on grain seed germination on sorghum (Rajabi et al., 2020) and sunflower (Wu et al., 2015) support a decrease in seed germination with increasing NaCl concentration. In experiments conducted by Mehmet et al (2006) on 3 varieties of triticale, it was proved that 2.0% NaCl reduces seed germination by 34–36% and has a negative effect on the development of stems and roots in plants (Mehmet et al., 2006).

Effect of drought on the germination of seeds of Triticale

Drought, like salinity, is one of the stress factors that negatively affect plant development. Therefore, in our research, we conducted experiments aimed at determining the effect of drought on seed germination of triticale varieties. In the experiments, the seeds were collected in the medium treated with solutions of 5 different concentrations of sucrose (11.9%, 15.8%, 17.7%, 19.3% and 22.4%) at 20 °C based on the recommended method. In the control option, the germination of seeds in all varieties was 100.0%. When analyzing the germination power of the seeds, it was noted that it was from 80.1±2.0% to 89.6±2.2% in the 11.9% sucrose variant, and the highest value belonged to the Odessiy cultivar. In the 15.8% sucrose variant, it was observed that the seed germination power was from 52.9±1.6% to 78.7±2.0%.

In the variants with 17.7% and 19.3% sucrose, the germination power of seeds was equal to 45.8±3.5% (Odessiy cultivar) and 28.5±1.6% (Tixon cultivar), respectively. In the 22.4% sucrose variant, it was found that the germination power of the seeds varied from 6.4±1.0% to 15.2±1.7, the highest value belonged to the Odessiy cultivar (Table 2, Figure 6).

When the level of seed germination was analyzed, it was noted that it was 97.2±1.0% to 100.0% in the 11.9% sucrose version, and the highest value belonged to the Odessiy cultivar. In the 15.8% sucrose variant, it was observed that the seed germination power was from 78.7±2.2% to 97.2±1.0% in the section of varieties. In the variants with 17.7% and 19.3% sucrose, the germination power of seeds was equal to 89.2±1.6%

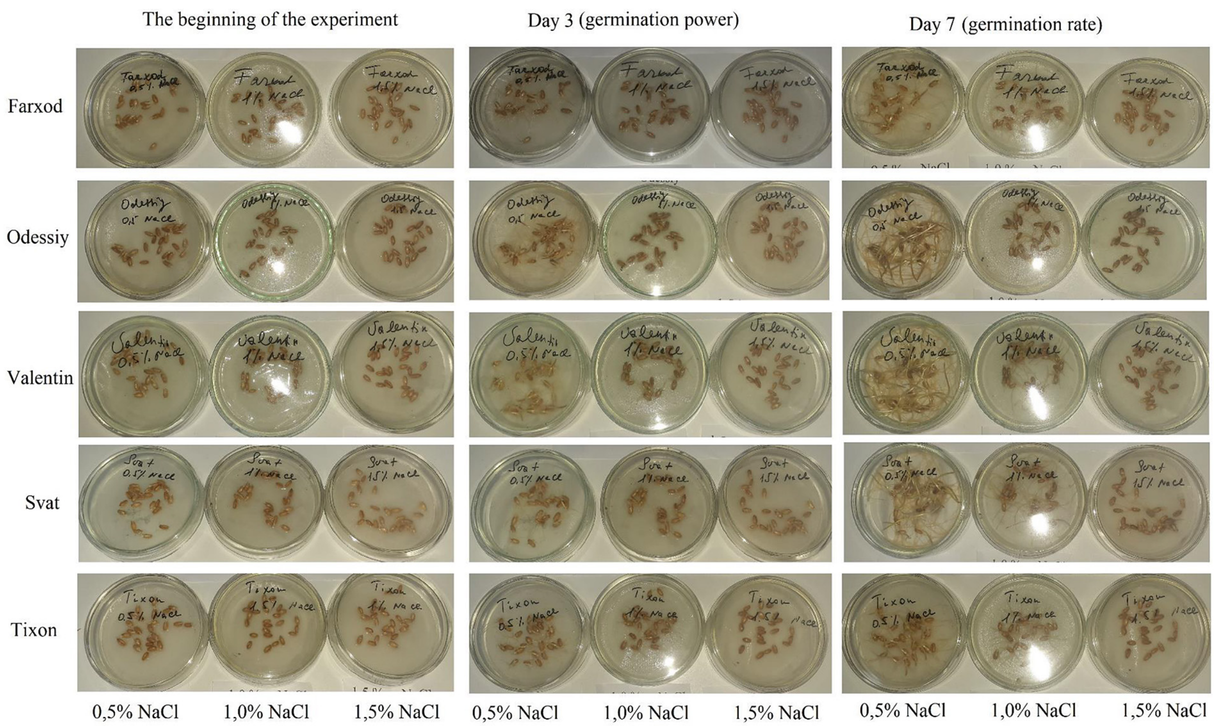

Figure 4. Effect of salinity on the germination power and germination rate of seeds of cultivars of Triticale

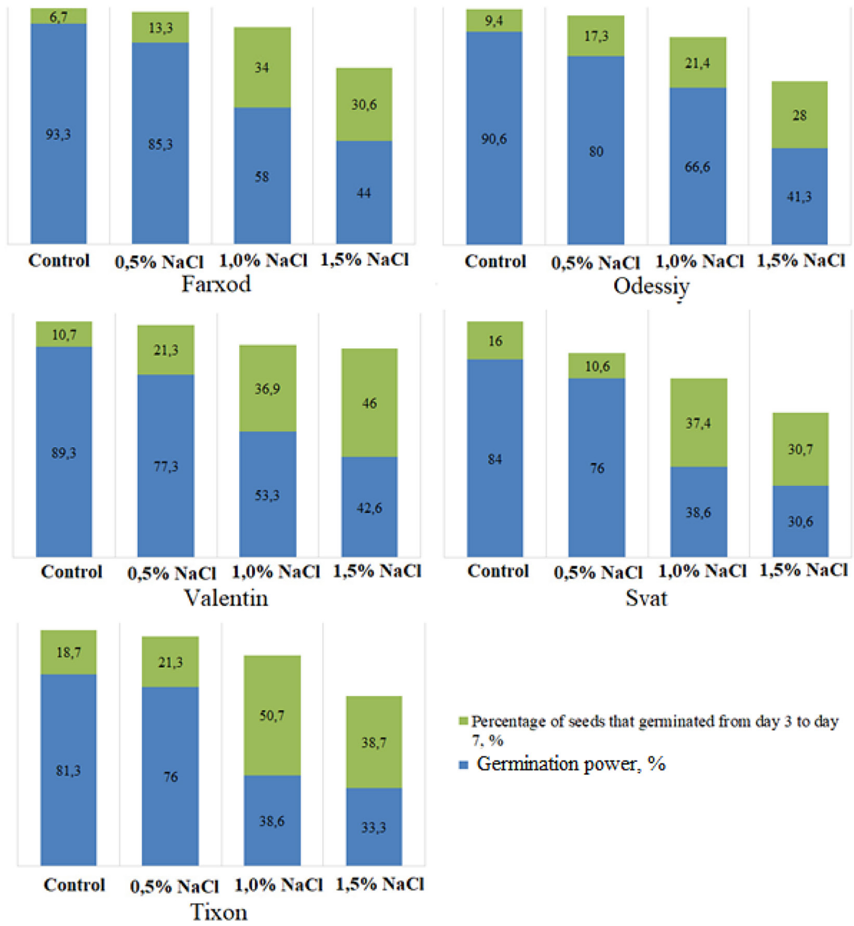

Figure 5. Effect of salinity on the germination power and germination rate of seeds of cultivars of Triticale (n=5)

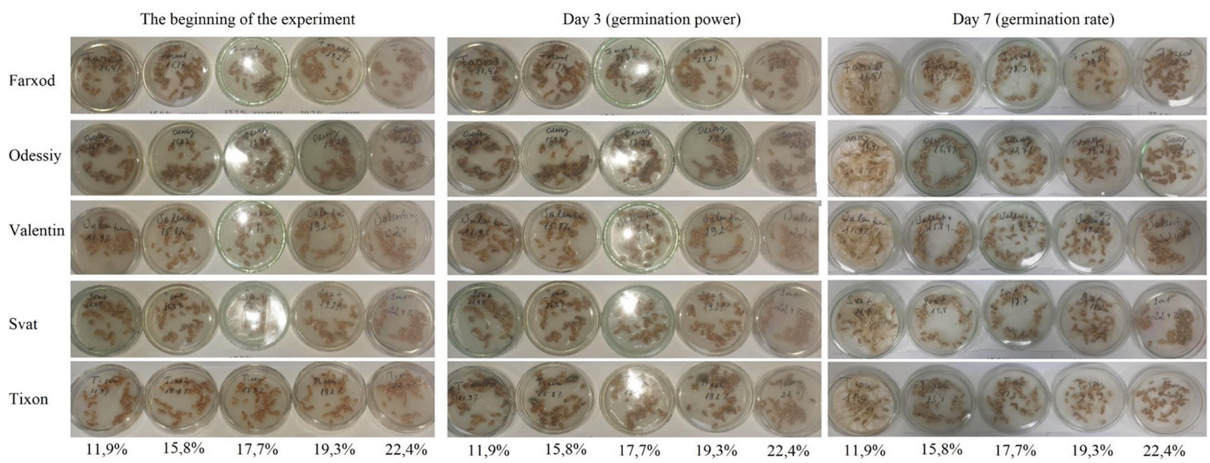

Figure 6. Effect of drought on the germination power and germination rate of seeds of cultivars of Triticale

(Odessiy cultivar) and 77.8±2.0% (Odessiy cultivar), respectively. In the 22.4% sucrose variant, it was found that the germination power of the seeds varied from 19.8±1.7% to 54.6±2.2%, the highest value belonged to the Odessiy cultivar (Tab. 1, Fig. 6). The analysis of the obtained data showed that the increase in sucrose concentration (pressure) in the medium leads to a decrease in the indicators of seed germination. As a result of the study of the germination parameters of *Eremosparton songoricum* (Fabaceae), *Elymus nutans* and *Portulaca oleracea* seeds under drought conditions, it was noted that the germination of seeds decreased by 35–80% inversely proportional to

Table 2. Effect drought on the germination power and germination rate of seeds of cultivars of Triticale (n=5)

Cultivars	Control		11.9%		15.8%		17.7%		19.3%		22.4%	
	A*	B*	A	B	A	B	A	B	A	B	A	B
Farxod	91.4±1.9	100,0±0.0	87.2±1.7	99.0±0.5	52.9±1.6	91.6±1.3	21.1±3.9	60.8±0.9	11.0±3.2	46.7±1.0	6.4±1.0	19.8±1.7
Odessiy	92.2±1.5	100,0±0.0	89.6±2.2	100,0±0.0	78.7±2.0	97.2±1.0	45.8±3.5	89.2±1.6	25.7±3.3	77.8±2.0	15.2±1.7**	54.6±2.2
Valentin	93.0±1.2	100,0±0.0	83.5±1.3	98.5±0.8	61.8±1.9	93.2±1.8	28.9±1.8**	65.0±2.2	14.7±3.1	47.6±2.1	6.8±2.1	28.2±2.3
Svat	83.5±2.1	100,0±0.0	80.1±2.0	97.2±1.0	55.4±1.7**	78.7±2.2	40.3±1.7	81.9±1.2	27.2±2.6	54.8±1.5	8.7±1.0	32.7±1.0
Tixon	85.8±1.6	100,0±0.0	79.7±1.8	98.1±0.8	54.0±2.6	89.3±1.4	35.7±2.9	79.7±1.3	28.5±1.6	61.1±1.7	11.3±1.1	40.4±1.6

Note: *A – germination power, %; B – seed germination, %; ** $P < 0.05$.

the increase in the level of drought in these plants (Li et al., 2013, Pham et al., 2023, Long et al., 2023). These data confirm the validity of our results regarding the effect of drought on seed germination of triticale cultivars.

CONCLUSIONS

Variations in temperature, seed dormancy, salinity and drought have been reported to affect the germination parameters of triticale cultivars. An increase in the period of dormancy leads to an improvement in the fertility indicators of triticale, and an increase in salinity and drought causes a decrease in the fertility indicators of the seeds. The obtained data allow to choose the optimal conditions of temperature, resting period, salinity and drought in terms of seed germination indicators in triticale varieties, as well as to explain the diversity of these indicators in them.

Acknowledgements

The authors would like to thank the laboratory of the Department of Plant Physiology and Microbiology of the Biochemistry Institute of Samarkand State University for providing appropriate equipment and reagents for conducting research experiments.

REFERENCES

1. Akramov I., Axanbayev Sh., Alikulov B., Mukhtorova S., Ergashev A., Ismailov Z. 2023. Plant growth-promoting properties of endophytic bacteria isolated from some xerophytic plants distributed in arid regions (Uzbekistan). Plant Science Today, 10(4), 228–237. https://doi.org/10.14719/pst.2725
2. Alikulov B., Gulboev D., Maxammadieva D., Tillaeva Z., Olimjonova S., Ismailov Z. 2023. Isolation and characterization of endophytic bacteria from some halophytes in saline desert regions of Uzbekistan. Biodiversitas, 24(2), 1279–1288. https://doi.org/10.13057/biodiv/d240270
3. Ates S., Keles G., Demirci U., Dogan S., Ben Salem H. 2017. Biomass yield and feeding value of rye, triticale, and wheat straw produced under a dual-purpose management system. Journal of Animal Science, 95(11), 4893–4903. https://doi.org/10.2527/jas2017.1888
4. Bentsink L, Koornneef M. 2008. Seed dormancy and germination. Arabidopsis Book, 6:e0119. https://doi.org/10.1199/tab.0119
5. Feledyn-Szewczyk B, Nakielska M, Jończyk K, Berbeć AK, Kopiński J. 2020. Assessment of the Suitability of 10 Winter Triticale Cultivars (x T*riticosecale* Wittm. ex A. Camus) for Organic Agriculture: Polish Case Study. Agronomy, 10(8), 1144. https://doi.org/10.3390/agronomy10081144
6. Grela E.R., Kowalczuk-Vasilev E., Świątkiewicz M., Skiba G. 2023. Triticale, or Rye? The Type of Grain Can Affect the Growth Performance and Meat Quality of Sustainable Raised Pigs. Animals, 13(8), 1331. https://doi.org/10.3390/ani13081331
7. Guo J, Du M, Tian H, Wang B. 2020. Exposure to High Salinity During Seed Development Markedly Enhances Seedling Emergence and Fitness of the Progeny of the Extreme Halophyte *Suaeda salsa*. Front Plant Sci, 11, 1291. https://doi.org/10.3389/fpls.2020.01291
8. Haj Sghaier A., Tarnawa Á., Khaeim H., Kovács G.P., Gyuricza C., Kende Z. 2022. The Effects of Temperature and Water on the Seed Germination and Seedling Development of Rapeseed (*Brassica napus* L.). Plants, 11(21), 2819. https://doi.org/10.3390/plants11212819
9. Iskierko J., Górski A. 1980. Porównawcza analiza białek pszenicy, zyta i dwóch odmian pszenzyta T275 i T294. V. Własności fizykochemiczne i biologiczne gliadyn i glutenin [Comparative analysis of proteins of wheat, rye and 2 cultivars of Triticale T-275 and T-294. V. Physicochemical and biological properties of gliadins and glutenins]. Ann Univ Mariae Curie Sklodowska Med, 35, 179–86.

10. Kamanova S., Yermekov Y., Shah K., Mulati A., Liu X., Bulashev B., Toimbayeva D., Ospankulova G. 2023. Review on nutritional benefits of triticale. Czech J. Food Sci, 41, 248–262. https://doi.org/10.17221/67/2023-CJFS
11. Klupczyńska E.A., Pawłowski T.A. 2021. Regulation of seed dormancy and germination mechanisms in a changing environment. Int J Mol Sci, 22(3), 1357. https://doi.org/10.3390/ijms22031357
12. Lakin G.F. 1990. Biometrics. Moscow (Russia): Higher school, 352.
13. Li H., Li X., Zhang D., Liu H., Guan K. 2013. Effects of drought stress on the seed germination and early seedling growth of the endemic desert plant *Eremosparton songoricum* (Fabaceae). EXCLI J, 4(12), 89–101.
14. Liu M., Li M., Liu K., Na S. 2015. Effects of drought stress on seed germination and seedling growth of different Maize Cultivars. Journal of Agricultural Science, 7(5), 231–240. https://doi.org/10.5539/jas.v7n5p231
15. Long J., Dong M., Wang C., Miao Y. 2023. Effects of drought and salt stress on seed germination and seedling growth of *Elymus nutans*. PeerJ, 11, e15968. https://doi.org/10.7717/peerj.1596
16. Lu Y., Liu H., Chen Y., Zhang L., Kudusi K., Song J. 2022. Effects of drought and salt stress on seed germination of ephemeral plants in desert of northwest China. Front. Ecol. Evol, 10, 1026095. https://doi.org/10.3389/fevo.2022.1026095
17. Mehmet A., Mehmet D., Gamze K., Yakup S., Cemalettin Y.C. 2006. Effects of NaCl on the germination, seedling growth and water uptake of Triticale. Turkish Journal of Agriculture and Forestry, 30, 1, 39–47.
18. Nyachiro J., Clarke F., DePauw R. 2002. Temperature effects on seed germination and expression of seed dormancy in wheat. Euphytica, 126, 123–127. https://doi.org/10.1023/A:1019694800066
19. Pham A.C., Vo T.C., Vu H.D., Tran D.Q. 2023. Effects of salinity and drought stress on seed germination of common purslane (*Portulaca oleracea*). Biol. Life Sci. Forum, 27(31). https://doi.org/10.3390/IECAG2023-14974
20. Rajabi D.A., Zahedi M., Ludwiczak A., Cardenas Perez S., Piernik A. 2020. Effect of salinity on seed germination and seedling development of Sorghum (*Sorghum bicolor* (L.) Moench) Genotypes. Agronomy, 10(6), 859. https://doi.org/10.3390/agronomy10060859
21. Rodríguez M.V., Barrero J.M., Corbineau F., Gubler F., Benech-Arnold R.L. 2015. Dormancy in cereals (not too much, not so little): about the mechanisms behind this trait. Seed Science Research, 25, 2, 99–119. https://doi.org/10.1017/S0960258515000021
22. Ruziyev F., Djabbarov I., Olimjonova S., Niyozov U., Urokov S., Ishankulova D., Bakhadirov U. 2023. Grain quality indicators and their phenotypic variability of ancient cultivars of *Triticum aestivumin* the mountains of Uzbekistan. Biodiversitas, 24, 5995–6001. https://doi.org/10.13057/biodiv/d241119
23. Sharma S., Singh V., Tanwar H., Mor S., Kumar M., Punia R.C., Dalal M.S., Khan M., Sangwan S., Bhuker A., et al. 2022. Impact of high temperature on germination, seedling growth and enzymatic activity of wheat. Agriculture, 12, 9, 1500. https://doi.org/10.3390/agriculture12091500
24. Stace C.A. 1987. Triticale: A Case of Nomenclatural Mistreatment. Taxon, 36, 445–452. https://doi.org/10.2307/1221447
25. Tuan P.A., Kumar R., Rehal P.K., Toora P.K., Ayele B.T. 2018. Molecular mechanisms underlying abscisic acid/gibberellin balance in the control of seed dormancy and germination in cereals. Front. Plant Sci, 9, 668. https://doi.org/10.3389/fpls.2018.00668
26. Tursunov A., Urokov S. 2023. Effect of microelements (B, Zn) on Cotton plant's productivity, its leaf area and plant height. American Journal of Plant Sciences, 14, 955–967. https://doi.org/10.4236/ajps.2023.148064
27. Vandelook F., Van Assche J.A. 2008. Temperature requirements for seed germination and seedling development determine timing of seedling emergence of three monocotyledonous temperate forest spring geophytes. Ann Bot, 102(5), 865–875. https://doi.org/10.1093/aob/mcn165
28. Wu G.Q., Jiao Q., Shui Q.Z. 2015. Effect of salinity on seed germination, seedling growth, and inorganic and organic solutes accumulation in sunflower (*Helianthus annuus* L.). Plant Soil Environ, 61(5), 220–226. https://doi.org/10.17221/22/2015-PSE
29. Zhu F. 2018. Triticale: Nutritional composition and food uses. Food Chemistry, 241, 468–479. https://doi.org/10.1016/j.foodchem.2017.09.009