ASSESSMENT OF TOLERANCE TO DIFFERENT CONCENTRATIONS OF KCL IN THE GENOTYPES OF *AEGILOPS NEGLECTA* REQ. EX BERTOL.

Gergana Desheva[1], Manol Deshev[1], Evgeniya Valchinova[1], Albena Pencheva[1], Bozhidar Kyosev[1], Gordana Petrović[2]

[1]*Agricultural Academy, Institute of Plant Genetic Resources "Konstantin Malkov", 2 Druzhba str., 4122 Sadovo, Bulgaria*
[2]*Institute of Field and Vegetable Crops, 30 Maksima Gorkog str., 21101 Novi Sad, Serbia*
e-mail: gergana_desheva@abv.bg

INTRODUCTION

Soil salinity is a major environmental constraint affecting agricultural productivity worldwide, particularly in arid and semi-arid regions (Tarolli et al., 2024). The accumulation of soluble salts in the soil inhibits plant growth through osmotic stress, ion toxicity, and nutrient imbalance (Pandit et al., 2024). The continuous use of irrigation water, coupled with poor drainage and inappropriate agricultural practices, exacerbates the problem, leading to significant economic losses and threatening food security (Parra-López et al., 2025; Balasubramanya and Stifel, 2020).

Potassium chloride (KCl) is a significant contributor to soil salinity in many agricultural areas (Pereira et al., 2019). While potassium is an essential macronutrient for plant growth, excessive concentrations of Cl- ions can be toxic, disrupting cellular processes and hindering plant development (Johnson et al., 2022). Seed germination and seedling establishment are critical stages in the plant life cycle and are highly sensitive to environmental stresses, including salinity (Ghosh et al., 2025). Salt stress can inhibit seed germination by reducing water uptake and disturbing enzymatic activities necessary for the mobilization of stored reserves (Ali et al., 2024). Similarly, seedling growth is severely affected by salinity due to impaired photosynthesis, nutrient uptake, and protein synthesis (Muhammad et al., 2024).

The aims of this study was to investigate the effects of varying KCl concentrations on the germination and seedling growth of Aegilops neglecta seeds.

MATERIAL AND METHODS

Seed Material:

Seeds from five *Aegilops neglecta* accessions were obtained from the National Genebank of Bulgaria's working collection (Table 1). Seeds from each accession were selected for uniformity of size and appearance, in order to minimise variations in germination potential.

Experimental Design:

The experiment was conducted using a completely randomized design with seven treatments and two replicates per treatment. The treatments consisted of different concentrations of KCl: 0 mM KCl (Control), 50 mM KCl, 100 mM KCl, 150 mM KCl, 200 mM KCl, 250 mM KCl and 300 mM KCl. KCl solutions were prepared by dissolving analytical grade KCl in distilled water.

Germination Assay:

Two replicates of 50 surface-sterilized seeds (soaked in 1% sodium hypochlorite for 5 minutes, followed by rinsing with distilled water), were placed on two layers of filter paper with 20 ml of the test solutions. The paper with the seeds was placed in plastic bags to prevent water loss and incubated in a growth chamber with controlled conditions: 20°C temperature, 16/8 hour light/dark photoperiod, and 60% humidity. Germination was scored daily for 14 days. A seed was considered germinated when the radicle protruded at least 2 mm. The following germination characteristics were recorded: Germination Percentage (G), Germination Rate index (GRI), Mean Germination Time (MGT). After 14 days, 10 randomly selected seedlings from each replicate were used to measure the following growth parameters: Root and Shoot Length (mm), Fresh Shoot and Root Weight (mg/plant) and Dry Shoot and Root Weight (mg/plant).

Statistical Analysis:

Data were subjected to analysis of variance (ANOVA) using SPSS software (version 22). Significant differences between treatment means were determined using Duncan´s multiple range

In order to characterize the response of the genotypes at different salinities and select the most tolerant genotype, the following tolerance and susceptibility indices were calculated using the user-friendly online iPASTIC software: Relative Stress Index (RSI), Mean Productivity (MP), Harmonic Mean (HM), Yield Stability Index (YSI), Geometric Mean Productivity (GMP), Stress Susceptibility Index (SSI) and Stress Tolerance Index (STI), as well as the Yield Index (YI) (Pour-Aboughadareh et al., 2019).

Table 2. Influence of salinization with KCl on germination characteristics in 5 populations of *Aegilops neglecta* Req. ex Bertol.

№ of accessions	BGR43668	BGR43678	BGR43687	BGR43479	BGR43706	Average
Concentration	0 mM KCl					
GRI,% day^{-1}	34.58b	37.5b	36.25b	25.21a	28.00a	32.31
MGT, day	2.43b	2.31b	2.54b	3.28a	3.50a	2.82
Germination,%	80.00b	80.00b	85.00c	70.00a	70.00a	77
Concentration	50 mM KCl					
GRI,% day^{-1}	18.00b	25.83c	29.58c	15.47b	7.84a	19.35
MGT, day	3.91b	2.50a	2.73a	5.33c	6.12c	4.12
G,%	60.00b	60.00b	75.00c	60.00b	45.00a	60
Concentration	100 mM KCl					
GRI,% day^{-1}	12.91c	20.83d	17.16d	8.72b	0.00a	11.93
MGT, day	4.20c	3.46b	3.81bc	6.50d	0.00a	3.60
G,%	50.00bc	55.00bc	60.00c	45.00b	0.00a	42.00
Concentration	150 mM KCl					
GRI,% day^{-1}	4.97b	12.38c	14.26c	4.68ab	0.00a	7.26
MGT, day	6.33c	4.16b	4.50b	6.66c	0.00a	4.33
G,%	30.00b	40.00b	60.00c	30.00b	0.00a	32.00
Concentration	200 mM KCl					
GRI,% day^{-1}	0.00a	7.71c	8.59c	2.84b	0.00a	3.83
MGT, day	0.00a	5.08b	5.45b	7.75c	0.00a	3.66
G,%	0.00a	35.00c	45.00d	20.00b	0.00a	20.00
Concentration	250 mM KCl					
GRI,% day^{-1}	0.00a	0.00a	5.92b	0.00a	0.00a	1.19
MGT, day	0.00a	0.00a	7.85b	0.00a	0.00a	1.57
G,%	0.00a	0.00a	35.00b	0.00a	0.00a	7.00
Concentration	300 mM KCl					
GRI,% day^{-1}	0.00a	0.00a	3.09b	0.00a	0.00a	0.62
MGT, day	0.00a	0.00a	8.33b	0.00a	0.00a	1.66
G,%	0.00a	0.00a	20.00b	0.00a	0.00a	4.00

CONCLUSION

This study demonstrates that KCl significantly inhibits the germination and seedling growth in the studied genotupes of *A. neglecta* Req. ex Bertol. The observed reductions in germination percentage, germination rate, root length, shoot length, and biomass accumulation are indicative of the stressful effects of KCl on plant development. However, *A. neglecta* exhibits some degree of tolerance to KCl stress, suggesting the presence of underlying salt tolerance mechanisms. Understanding these mechanisms is crucial for exploiting the genetic potential of *A. neglecta* for improving salt tolerance in cultivated wheat. Future research should focus on identifying the specific physiological and molecular traits that contribute to salt tolerance in *A. neglecta* Req. ex Bertol. and utilizing this knowledge to develop salt-tolerant wheat varieties. Based on the integrated analysis of tolerance and susceptibility indices, genotype BGR43687 was identified as highly tolerant to salinity stress, suggesting it potential utilization as valuable sources for salt tolerance genes in wheat breeding programs.

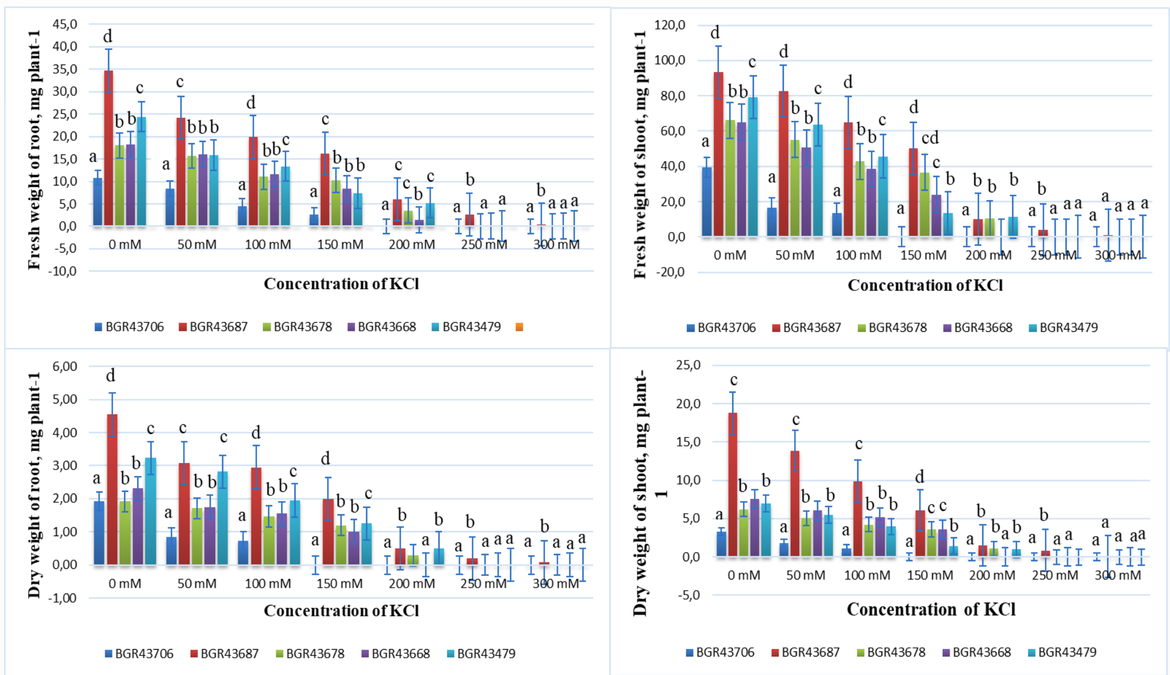


Fig.1 Effect of KCl concentration on the fresh and dry weights of shoots and roots
(means followed by different letters are significantly different at $p < 0.05$ (Duncan's Multiple Range Test))

Table 1. Tolerance and susceptibility indices at different salinity level of five genotypes of *Aegilops neglecta* Req. ex Bertol.

Genotype	Yp	Ys	RC	MP	GMP	HM	SSI	STI	YI	YSI	RSI	ASR
50 mM KCl												
BGR43706	3.30	1.80	45.45	2.55	2.44	2.33	1.84	0.08	0.28	0.55	0.72	4.73
BGR43687	18.80	13.80	26.60	16.30	16.11	15.92	1.08	3.52	2.14	0.73	0.97	2.18
BGR43678	6.20	5.10	17.74	5.65	5.62	5.60	0.72	0.43	0.79	0.82	1.09	2.91
BGR43668	7.60	6.10	19.74	6.85	6.81	6.77	0.80	0.63	0.94	0.80	1.07	2.09
BGR43479	7.00	5.50	21.43	6.25	6.20	6.16	0.87	0.52	0.85	0.79	1.04	3.00
100 mM KCl												
BGR43706	3.30	1.10	66.67	2.20	1.91	1.65	1.55	0.05	0.23	0.33	0.59	4.73
BGR43687	18.80	9.90	47.34	14.35	13.64	12.97	1.10	2.53	2.03	0.53	0.93	2.18
BGR43678	6.20	4.20	32.26	5.20	5.10	5.01	0.75	0.35	0.86	0.68	1.19	3.00
BGR43668	7.60	5.20	31.58	6.40	6.29	6.18	0.73	0.54	1.07	0.68	1.20	1.82
BGR43479	7.00	4.00	42.86	5.50	5.29	5.09	0.99	0.38	0.82	0.57	1.00	3.27
150 mM KCl												
BGR43706	3.30	0.00	100.00	1.65	0.00	0.00	1.52	0.00	0.00	0.00	0.00	4.73
BGR43687	18.80	6.10	67.55	12.45	10.71	9.21	1.03	1.56	2.07	0.32	0.94	1.91
BGR43678	6.20	3.60	41.94	4.90	4.72	4.56	0.64	0.30	1.22	0.58	1.69	2.18
BGR43668	7.60	3.60	52.63	5.60	5.23	4.89	0.80	0.37	1.22	0.47	1.38	2.09
BGR43479	7.00	1.45	79.29	4.23	3.19	2.40	1.21	0.14	0.49	0.21	0.60	3.91
200 mM KCl												
BGR43706	3.30	0.00	100.00	1.65	0.00	0.00	1.09	0.00	0.00	0.00	0.00	3.91
BGR43687	18.80	1.50	92.02	10.15	5.31	2.78	1.00	0.38	2.08	0.08	0.95	1.91
BGR43678	6.20	1.10	82.26	3.65	2.61	1.87	0.90	0.09	1.53	0.18	2.11	2.27
BGR43668	7.60	0.00	100.00	3.80	0.00	0.00	1.09	0.00	0.00	0.00	0.00	3.73
BGR43479	7.00	1.00	85.71	4.00	2.65	1.75	0.94	0.10	1.39	0.14	1.70	2.45
250 mM KCl												
BGR43706	3.30	0.00	100.00	1.65	0.00	0.00	1.02	0.00	0.00	0.00	0.00	2.45
BGR43687	18.80	0.90	95.21	9.85	4.11	1.72	0.97	0.23	5.00	0.05	2.28	1.36
BGR43678	6.20	0.00	100.00	3.10	0.00	0.00	1.02	0.00	0.00	0.00	0.00	2.36
BGR43668	7.60	0.00	100.00	3.80	0.00	0.00	1.02	0.00	0.00	0.00	0.00	2.18
BGR43479	7.00	0.00	100.00	3.50	0.00	0.00	1.02	0.00	0.00	0.00	0.00	2.27
300 mM KCl												
BGR43706	3.30	0.00	100.00	1.65	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.45
BGR43687	18.80	0.10	99.47	9.45	1.37	0.20	1.00	0.03	5.00	0.01	2.28	1.36
BGR43678	6.20	0.00	100.00	3.10	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.36
BGR43668	7.60	0.00	100.00	3.80	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.18
BGR43479	7.00	0.00	100.00	3.50	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.27

Yp- shoot dry weight under control, mg/plant, Ys- shoot dry weight under salinity condition, RC-relative change, MP-Mean productivity, GMP-Geometric mean productivity, HM-Harmonic mean, SSI-Stress susceptibility index, Stress tolerance index, YI-Yield index, YSI-Yield stability index, RSI- Relative stress index, ASR-average sum of ranks

ACKNOWLEDGEMENTS:

This work was financially supported by the Bulgarian National Science Fund, Ministry of Education and Science under the project КП-06-ПН76/3 „Study of the genetic diversity of *Aegilops* species in the flora of Bulgaria".