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Effects of Mg/Ca Sulfate on Forage Crops Seedling Growth and Germination under Various Environmental Stress

Khulan Sharavdorj[1], Jin-Woong Cho[1]*

[1]College of Agricultural and Life Sciences, Chungnam National University, Daejeon, 34134, Korea

[Introduction]
Plants regularly face abiotic stress conditions during growth and development, such as drought, chilling, freezing, high temperatures and salinity. Forage legumes benefit pastures and hay crops by fixing N, improving the seasonal distribution of growth, and enhancing animal performance. This study was carried out to investigate the effects of environmental stress on forage crops germination and seedlings and additional application of Magnesium and Calcium sulfate on seedlings of those forage crops.

[Material and Methods]
Germination experiments were conducted in the chamber set at 15°C, 20°C, 25°C, 30°C and photoperiod (16h light/8h dark). Seeds were germinated in distilled water (0mM), and in 25mM, 50mM, 100mM of NaCl solutions under these temperatures and photoperiod. All the seeds from the previous germination tests which did not germinate after 20 days at different NaCl treatments, were placed in new Petri dishes with filter paper and distilled water and incubated under the same temperatures for 10 days to investigate the recovery of germination. Seedling test were performed at growth chamber and seeds were planted in plastic seedling trays (110 ml) containing horticulture soil and 50 seeds were planted per hole. Experimental treatments were: Control ((CON) no stress, no additional application of $CaSO_4$ or $MgSO_4$); Salinity stress ((100 NaCl) 100 mM NaCl); Calcium sulfate ((5 CS) 5 mM, (7.5 CS) 7.5 mM, (10 CS) 10 mM) and Magnesium sulfate ((0.5 MS) 0.5 mM, (1 MS) 1 mM, (2 MS) 2 mM) and salinity stress plus Calcium/Magnesium sulfate (5 CS + NaCl, 7.5 CS + NaCl, 10 CS + NaCl, 0.5 MS + NaCl, 1 MS + NaCl, 2 MS + NaCl). Treatments started after seeds were sown and applied for three days and experiment run for 20 days under 20°C and 30°C with 16h light/8h dark photoperiod. Data analysis included two-way ANOVA was carried out to detect the treatments and species, and one − way ANOVA to detect treatments and Duncan's test was used to estimate the least significant range between means ($p < 0.01$). All measurements represent the means and standard errors (SE).

[Results and Discussion]
Forages can be a simple answer to soil erosion and decline in organic matter and fertility, a problem caused by modern cultivation and fallowing practices on much of the farmland. Salinity stress had a strong inhibitory effect on germination, perhaps by preventing the uptake of inorganic ions that are required to trigger the germination process. Our results suggest that salinity and temperature stress had great effects on germination. Germination percentage and rate were high at 20°C in all species which were indicating that are cool-season forages. Seeds incubated under high temperatures with high NaCl concentrations seemed to be subjected to heavy stress, as indicated by delayed germination. For the seedling experiment, salinity decreased the seedling's growth and length of root and shoot height and the effect of $CaSO_4$ and $MgSO_4$ were affected differently depending on species and temperature. *F. arundinacea* was more heat - sensitive than *T. pratense* and *M. sativa. F. arundinacea* is known as cool-season grass and the optimum growth temperatures are between 15°C and 20°. Moreover, the biomass of all species was decreased under salinity stress specifically under high temperatures. In our result, P content was increased in shoots of *F. arundinacea* at high temperature but overall, it was found highest at optimum temperature in roots of *M. sativa* and *T. pratense*. Furthermore, K contents were increased during the high temperature when seedlings were exposed to salinity stress. Treatments of $MgSO_4$ and $CaSO_4$ on seedlings turned to be in efficient under abiotic stresses. Therefore, it might be practical relevance to add $CaSO_4$ during the low temperature and supply $MgSO_4$ during the high temperature to the plants that exposed to the salinity stress.

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*Corresponding author: E-mail. jwcho@cnu.ac.kr