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THE EFFECT OF GIBBERELLIC ACID APPLICATION ON GERMINATION CHARACTERISTICS OF COMMON VETCH (*Vicia sativa* L.) UNDER SALT STRESS

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Abstract
Common vetch is an annual legume plant widely cultivated all over the world. Salinity is one of the most important abiotic stress factors. Successful germination and seedling development are very important for obtaining high yield. The aim of this study was to determine the performance of different doses of gibrylic acid (GA3) under saline conditions. In the study, control, 100 and 200 ppm giberylic acid and control, 5 and 10 EC salt were used. In the study, germination percentage, shoot and root length, wet and dry weight data were analysed. According to the results obtained, the highest germination percentage, shoot and root length and wet and dry weight were determined as 95.33%, 5.43 cm, 4.40 cm, 4.10 mg and 0.59 mg in 100 ppm control salt treatment, respectively. The lowest germination percentage was obtained in 200 ppm GA3 application in 10 EC salt application, the lowest shoot and root length was obtained in 10 EC salt and control GA3 application and the lowest wet and dry weight was obtained in 200 ppm GA and 10 EC salt application. As a result of the study, it was determined that GA3 application at increasing salt doses reduced the damage of salt stress.

Keywords: *Abiotic stress, Common vetch, Gibberellic acid (GA), Germination*

1. INTRODUCTION

Common vetch (*Vicia sativa* L.) is included in the genus vetch (Vicia) of the legume family (Fabaceae). Vetch species can be cultivated in a wide range from semi-tropical climate zone to continental climate and from cool and humid regions to arid areas (Açıkgöz, 2021; Odat et al., 2021; Yildirim et al., 2022). Common vetch improves both the physical and chemical structure of the soil within sustainable agricultural systems, leaves organic nitrogen for the next plant and provides quality roughage required by livestock (Yücel and Avcı, 2009; Okumus and Cetin 2022). In addition, the grass and grain of this plant are utilised as roughage and concentrate feed in animal feeding due to its high protein, vitamin and mineral content (Erdurmuş et al., 2010). Legume crops, which fix free nitrogen in the air thanks to biological nitrogen fixation, are very sensitive to drought (ÁlvarezAragón et al., 2023). More than 60% of legume production worldwide occurs under potential drought conditions (Daryanto et al., 2015). Common vetch (*Vicia sativa* L.), which is one of the important legume forage crops, is an annual plant that stands out with its features such as being a protein-rich feed additive for ruminants, being a green manure plant, and its green/dry grass and silage can be used as animal feed (Okumuş and Çetin 2022). In general, legume crops are

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sensitive to many abiotic threats and drought stress has been reported to be a major constraint limiting crop yield (Micheletto et al., 2007). Common vetch is known to have a stronger adaptation potential compared to other annual or perennial legume forage crops, especially under changing climatic conditions (Chai et al., 2017; Huang et al., 2017; Huang et al., 2021).
Common vetch is an important fodder plant that can be utilised as a source of valuable roughage (Açıkgöz, 2021), its seeds are a source of concentrate feed, and the remaining straw can also be utilised after the seed is removed (Çaçan et al., 2018). One of the most practical ways to increase yield and quality in agricultural production is the selection of appropriate seed (Sürmen et al., 2019). Common vetch seeds show superior characteristics in terms of physical properties (such as germination rate and duration) compared to hairy vetch and Hungarian vetch seeds (Dumanoğlu 2021).
Some hormones (auxins, gibberellins and cytokinins) and inorganic salts (potassium nitrate, hydrogen peroxide, thiourea, etc.) are also widely used in priming applications in order to increase the germination performance of seeds (Heydecker and Coolbear, 1977). Great losses in germination and seedling emergence and significant disruptions in production occur. In order to eliminate or minimise these disruptions, optimum conditions must be created (Fahad et al., 2017). However, it is not completely possible to achieve optimum conditions in nature. In such cases, pre-applications to increase the germination and seedling emergence performance of seeds are seen as a solution. One of these is giberellic acid applications (Çetinkaya et al., 2021). Among the natural growth hormones, gibberellic acid (GA3) has a special place in terms of promoting plant growth. Externally applied GA3 increases not only vegetative growth but also grain yield, thousand grain weight and seed number (İslam et al., 2021). Giberellins promote growth by stimulating cell division and increasing plastids in cell walls, converting carbohydrates into sugars and reducing the pressure in the cell wall. Thus, as water is taken into the cell, cell elongation occurs (Arteca 1996). In addition, GA3 increases the height of short plants, thins the stem thickness, reduces the leaf area and causes the green colour of the leaves to lighten. Giberellins are also widely used to increase seed germination and to eliminate dormancy. Giberellins are usually applied directly to seeds and increase germination. Giberellin application to seeds also promotes the production of some hydrolase enzymes such as α-amylase (Taiz and Zeiger 1991).
Salinity is one of the most common abiotic stress factors encountered worldwide. Salinity adversely affects the early developmental period of plants (Okumus et al., 2023; Okumus and Dalda-Sekerci 2024). The aim of this study was to investigate the effect of different doses of GA3 on the early developmental period of vetch seed under salt stress.

2. MATERIALS AND METHODS

Alınoğlu common vetch cultivars were used as plant material in the study. NaCl (Merck, Germany) was used for salt stress in the study. Salt levels were adjusted as control, 5 EC and 10 EC. The study was carried out under controlled conditions at 25^{o}C temperature.
The seeds to be used in the study were sterilised with 1% sodium hypochlorite for 5 minutes and then rinsed 3 times with pure water. The seeds were sown in 25 replicates between 3 filter papers and sealed with a ziplock bag to prevent moisture loss. For each filter paper, 7 mL of solution was added. Seeds were considered germinated when the root (≥2 mm) emerged and germinated seeds were counted for 14 days. At the end of the 14th day, germination percentage (number of germinated seeds/25 x 100) was calculated and shoot and root length, wet weight and dry weight data were analysed in 10 randomly selected seedlings.

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Seed pretreatment procedures:
In the study, 100, 200 ppm GA3 solutions were used for seed pretreatment.
Preparation of GA3 (100 ppm): To prepare 100 ppm GA3, 1g GA3 tablet was dissolved in 1 lt water and 100 ml of this solution was taken with a measuring cylinder and added to 1 lt water.
Preparation of GA3 (200 ppm): To prepare 200 ppm GA3, 1g GA3 tablet was dissolved in 1 lt water and 200 ml of this solution was taken with a measuring cylinder and added to 1 lt water.
In the experiment, pretreated seeds were treated with different doses of GA3 (100, 200 ppm) (Wahid et al. 2008; Doruk Kahraman and Okumus, 2024) for 4 hours and untreated seeds were used as control.

Statistical Analysis

The research was established as a factorial trial design in random plots with 3 replications. The data obtained as a result of the research were analysed on the computer with the 'JMP 13.2.0' programme according to the factorial trial design in random plots. Treatment means were compared using Tukey Multiple Comparison Test (Snedecor and Cochran, 1967).

3. RESULTS AND DISCUSSIONS

According to the analysis of variance obtained, germination percentage, shoot and root length, wet and dry weight were found significant at $p<0.01$ level and $p<0.5$ level in salt doses; germination percentage, shoot and root length, wet and dry weight were found significant at $p<0.01$ level and $p<0.5$ level in GA3 doses; and germination percentage, shoot and root length, wet and dry weight were found significant at $p<0.5$ level in NaCl x GA3 interaction (Table 1).
When the germination percentage data were analysed, the highest germination percentage was determined as 95.33% in 100 ppm GA3 application in the control salt application. The lowest germination rate was 68.66% in 10 EC salt application and 200 ppm GA3 acid application. 100 ppm GA3 decreased this negativity since increasing salt doses negatively affected germination. When shoot and root length data were analysed, the highest shoot and root lengths were determined as 5.43 cm and 4.40 cm in 100 ppm GA3 application in the control salt application. The lowest shoot and root length was determined as 2.06 cm and 1.43 cm in 10 EC salt application and control G3A acid application. When wet and dry weight data were examined, the highest was determined as 4.10 and 0.59 mg in 100 ppm GA3 application in control salt application. The lowest wet and dry weights were determined as 2.50 mg and 0.36 mg in 10 EC salt application and 200 ppm GA3 acid application (Table 1).
Doruk Kahraman and Okumus (2024) also comprehensively investigated the effects of GA3 on germination and early development stages in wheat (*Triticum aestivum*) seeds and found that GA3 application had a positive effect on germination in wheat seeds. Pavindran and Kumar (2019) examined the effects of GA3 on *Arabidopsis thaliana* seeds, a model plant. In the study, it was determined that GA3 application shortened the dormancy period under light conditions and increased germination rates by 30%. In another study on rice (*Oryza sativa*) seeds, Gao et al. (2020) investigated the effect of GA3 on the mobilisation of starch stored in the endosperm during germination. It was confirmed that GA3 increased α-amylase production in the aleurone layer, converting starch molecules into sugars and making them available to the embryo. In the study, 50 ppm GA3 application increased the germination rate of rice seeds by 25%. In a study by Essa et al. (2019), the effects of salinity stress and application of giberellic acid on barley seeds were investigated. In the study, salinity conditions were created with NaCl (sodium chloride) and GA3 (100 ppm) was applied. The results showed that high salt concentrations decreased the germination

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rate of barley seeds by 30%, but GA3 application significantly stabilised this decrease. GA3 increased germination rates despite salt stress by promoting embryo growth and increasing the permeability of the seed coat (Essa et al., 2019). In another study by Topcuoğlu et al. (2020), wheat seeds were exposed to salinity stress with NaCl and the effects of different GA3 concentrations (50, 100 and 200 ppm) on germination under these conditions were examined. Salinity significantly reduced the germination rate and germination speed of wheat seeds compared to the control group. However, 100 ppm GA3 application increased the germination rate by 40% and made the seeds grow faster under salinity stress. GA3 was found to help maintain osmotic balance and reduce ion toxicity under salt stress (Topcuoğlu et al., 2020). In another study by Rodríguez et al. (2006), rice seeds were exposed to salinity stress with NaCl and GA3 applications were made. GA3 increased the germination of rice seeds despite salt stress and shortened the germination time. The study showed that GA3 accelerated embryo development and promoted root development by improving osmotic regulation in rice seeds under salt stress. The most effective GA3 dose was determined as 100 ppm (Lee et al., 2019).

Table 1. Germination percentage (%), shoot and root length (cm) and wet and dry weight data of vetch seeds at different salt and GA doses

NaCl	Gibberellic Acid (GA3)	Germination Percent (%)	Shoot Lenght (cm)	Root Leght(cm)	Fresh Weight (mg)	Dry Weight (mg)
Control	Control	90.66 ab	5.06 ab	3.93 bc	3.90 ab	0.56 ab
	100 ppm	95.33 a	5.43 a	4.40 a	4.10 a	0.59 a
	200 ppm	88.00 b	4.90 bc	4.03 abc	3.60 cd	0.51 bcd
5 EC	Control	80.66 c	4.60 cd	4.16 abc	3.40 de	0.49 cde
	100 ppm	86.00 b	5.06 ab	4.30 ab	3.70 bc	0.53 bc
	200 ppm	77.33 cd	4.20 d	3.86 c	3.33 def	0.48 de
10 EC	Control	70.00 e	2.06 f	1.43 d	2.80 fg	0.40 fg
	100 ppm	75.33 d	2.70 e	1.80 d	3.10 efg	0.44 ef
	200 ppm	68.66 e	2.57 e	1.53 d	2.50 g	0.36 g
NaCl		**	**	**	*	*
GA3		**	**	**	*	*
NaCl x GA3		*	*	*	*	*

* p<0.5, p<0.01

4. CONCLUSIONS

Salinity stress is an important environmental factor that negatively affects the germination rate and speed of seeds. However, roberellic acid stands out as an effective hormone that can increase the germination potential of seeds under such stress conditions. GA3 can significantly increase germination rates by maintaining the osmotic balance of seeds, promoting embryo development and increasing the permeability of the seed coat. Therefore, GA3 applications in plant species grown in saline soils have a great potential to improve agricultural yield. The use of GA3 in agricultural production processes can increase production efficiency, especially in plant species with low germination rates. According to the results obtained, it was determined that GA3 application reduced the effect of salt stress.

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