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Determination of The Effect of Growth Regulators on Germination Properties of Silage Sorghum

Serap KIZIL AYDEMİR[1*], Ali DEVLET[1]
[1]Bilecik Şeyh Edebali University, Faculty of Agriculture and Natural Sciences, Department of Field Crops, Bilecik
[*]Sorumlu Yazar (Corresponding author): serap.kizil@bilecik.edu.tr

Abstract
Due to the decrease in the quantity and quality of water resources in the world, drought stress becomes important in plant cultivation and causes changes in the physiological functions of economically important plants. In order to obtain products in an economic sense, the optimum environmental requirements of the plant species or variety grown must be met. In order to increase these environmental demands, the use of plant growth regulators, inspired by the regulating hormones naturally found in the plant itself, is a common method recently. In our study, it was aimed to increase germination and germination factors by using plant growth regulators in silage sorghum. In the research, Nes sorghum variety, which was determined to be compatible with the region in the previous cultivar yield study in the region, and Zeatin and Brassinolides growth regulators were used as materials. Sorghum seeds were placed in each petri dish with filter paper. Germination experiments of seeds were carried out at 20/25°C (day/night) for 10 days. Germinated seeds were counted at the same time each day. When the rootlet reached 2 mm, the seed was considered to be germinated and removed from the petri dish. At the end of the research, the highest germination rate of sorghum seeds for silage was obtained from 1% Zeatin + 1% Brassinolides application with a value of 98.97%. Average values between 2.15 and 1.93 in the period until 50% germination were obtained from the control application with the highest value of 2.15. Average germination index values varied between 36.80 and 28.84, and the highest germination index was obtained from 1% Zeatin + 1% Brassinolides application. At the end of the research, it was determined that hormone applications had positive effects on the germination of silage sorghum seeds.

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1. Introduction

Drought is an important, slowly developing natural disaster that has very negative effects on the air, water and soil in the affected area. Spatial and temporal distribution of precipitation is irregular in Turkey, which is located in a semi-arid climate zone. Our current water resources cannot meet the needs of the rapidly increasing population and industry, a large part of the water is used unconsciously in agricultural production with surface irrigation methods, and the quality of our drinking, utility and irrigation water is gradually decreasing as a result of increasing industry and other environmental pollution. When global climate change is added to all these negativities, various difficulties are experienced in agricultural production in our country, and a serious problem arises in plant development, yield and quality (Iqbal et al., 2018). When plants are exposed to adverse environmental conditions (lack of nutrients, lack of water, low or high temperature, UV, salinity, diseases and pests), their growth is adversely affected. This condition is called vegetative stress. Stress can last for a long time or come and go. Plants encounter many stress factors during their lifetime. These stress factors, which can rarely affect the plant alone, usually exert their effects simultaneously. Biotic (pathogen, competition with other organisms, etc.) and abiotic (drought, salinity, radiation, high temperature or frost, etc.) stresses cause changes in the normal physiological functions of all plants, including grains of economic importance. All these stresses reduce the biosynthetic capacity of plants, change their normal functions and cause damage that can lead to the death of the plant. There are many alternative fodder plants in our country that can adapt to different climatic and soil conditions. At the beginning of these plants are sorghum species and hybrids. Sorghum and Sorghum X Sudan grass hybrids are the plants preferred in recent years due to their ability to withstand drought and high temperatures more than corn, to reappear after forming, to have a nutritional value close to corn, and to have high water use efficiency (Iqbal, 2018).

Sorghum (*Sorgum bicolor* L.) ranks fifth after wheat, corn, paddy and barley with a cultivation area of 44 million hectares and a production amount of 62 million tons worldwide. Sorghum (*Sorghum bicolor* L.) is one of the C4 group plants that is moderately tolerant to salinity and can adapt very well to semi-arid and arid regions where salinity is a problem in plant production (Şimşek et al., 2018). Due to its tolerance to adverse environmental conditions, it ranks fifth among the cereals grown in the world. It is inevitable to use salt-tolerant species and cultivars in such areas for successful crop production because of the difficult, costly and long-term reclamation of agricultural soils that are facing the salinity problem, and the decrease in the quality and amount of irrigation water used in agricultural areas. Knowing in advance the salt tolerance of the plant or plants to be produced in order to be able to grow successfully in these conditions provides the grower with both time and economic benefits. Silage sorghum replaces silage maize in most developed countries. Sorghum is a multifunctional plant whose grain can be consumed directly as human food, and whose grain and other above-ground parts can be used for animal feed, alcohol, fuel, sugar, syrup and paper production. The use of sorghum, which has such a useful area, is limited to animal feeding in our country (Eren and Öztürk, 2021). Besides this multifunctionality, another feature of sorghum that makes it important is its tolerance to drought and high temperature. Today, where drought and water scarcity have emerged as one of the most important problems in many parts of the world and in our country in recent years, sorghum is the most important plant that can be substituted for corn, which is very sensitive to water scarcity, in silage production (Aras and Keskin, 2018). Global climate change increases the pressure on cultivated plants depending on many factors. For this reason, many studies are carried out to reduce the negative effects of abiotic stress factors on plants. The most important of these studies are the studies carried out by using plant growth regulators obtained in medicine, inspired by the regulatory hormones naturally found in the plant itself, in order to take precautions against drought or other factors that damage plants or to increase the resistance to adverse physiological events in the plant (Yavaş et al., 2016). The aim of this study is to ensure that the plants pass through the stages in the normal life process in the arid conditions that await us due to global warming, and to maximize sustainable feed production, yield and endurance. In our study, it was aimed to increase germination and germination factors by using plant growth regulators in silage sorghum.

2. Materials and Methods

2.1. Materials

In the research, Nes sorghum variety, which was determined to be compatible with the region in the previous cultivar yield study in the region, and Zeatin and Brassinolides growth regulators were used as materials.

2.2. Methods

The germination experiment was carried out in a randomized factorial design with 3 replications. In the research, 1. Zeatin application 2. Brassinolides application 3. Zeatin + Brassinolides application 4. Applications without application took place. Germination experiments of seeds were carried out at 20/25°C (day/night) for 10 days. Sorghum seeds were placed in each petri dish with filter paper. Germinated seeds were counted at the same time each day. When the rootlet reached 2 mm, the seed was considered to be germinated and removed from the petri dish.

Germination percentage (GP) was determined according to the formula given below (Geçer, 2003).

$$GP = (GSN/N)*100$$

In equality; GSN number of germinated seeds,

N represents the total number of seeds used.

Germination index (GI) was calculated according to the formula below (Abazarian et al., 2011).

$$GI = S1/t1+S2/t2+\ldots\ldots+Sn/tn$$

In equality; S, n. the number of seeds germinated per day,

n represents the number of days during which germination takes place.

3. Results and Discussion

3.1. Germination rate

The average values of the effect of the growth regulators applied to the silage sorghum plant on the germination rate of the silage sorghum before germination and the difference groupings of the averages are given in Table 1.

Table 1. Germination rate average values obtained from growth regulators applied to sorghum silage plant before germination

Implementation		Average Values (%)
Exogenous Implementation to Seeds Before Planting	% 1 Zeatin	97.30 b
	% 1 Brassinolides	95.93 b
	% 1 Zeatin + % 1 Brassinolides	98.97 a
Control	No Exogenous Implementation	91.43 c
Average		95.91
LSD (%5)		1.412

The first basic step in plant cultivation is the germination of the seed under suitable conditions. However, adverse ecological conditions, technical errors (such as low soil temperature, formation of a cream layer in the soil) and negativities arising from the structure of the seed at this stage negatively affect germination and seedling emergence. It has been determined that GA and ABA applications have significant effects on germination in mutant plants showing intrinsic hormone deficiency (Karakurt et al., 2010). With the discovery of plant hormones, one of the most important internal factors that play a role in plant growth and development, it has been possible to control plant growth and many activities related to growth. Of these, auxins, gibberalins, abscisic acid (ABA) and cytokinins have a wide variety of physiological effects (Ünyayar and Topçuoğlu, 1998).

In this study, as seen in Table 1, there was a statistical difference between the germination rate values of the growth regulators applied to the silage sorghum plant before germination, however, the mean germination rate of the control plot was obtained as 95.91% with 3 different applications. It is seen that 1% Zeatin + 1% Brassinolides regulator mixture formed the highest germination rate (98.97%) in exogenous application of seeds before sowing. Similar to our findings, in a study conducted, it was determined that the ABA content in the seeds was 1.8 ± 0.2 ng.seed-1, while the germination was 15%, and 1 year after the dry storage, the ABA content was 0.8 ± 0.1 ng.seed-1 and the germination was 95% (Hilhorst and Karssen, 1992).

2. Time to 50% germination

The mean values and difference groupings of the effects of growth regulators applied to the silage sorghum plant on the time until 50% germination of the silage sorghum before germination are given in Table 2.

Table 2. Average values of time to 50% germination obtained from growth regulators applied to silage sorghum plant before germination

Implementation		Average Values
Exogenous Implementation to Seeds Before Planting	% 1 Zeatin	1.93 bc
	% 1 Brassinolides	1.98 b
	% 1 Zeatin + % 1 Brassinolides	1.85 c
Control	No Exogenous Implementation	2.15 a
Average		1.98
LSD (%5)		0.085

As seen in Table 2, there is a statistical difference between the values of the growth regulators applied to the silage sorghum plant before germination in the period until 50% germination. The average was calculated as 1.98. The control plot without exogenous application was found to be the highest value with 2.15. Similar to our study, Yavaş et al. (2016). In their study to increase the drought resistance of plants in Aydın ecological conditions; They determined that osmotic preservatives (cytokinin, mannitol, abscisic acid, proline, glycinebetaine, polyamine etc.) helped to eliminate the negative effects of reactive oxygen species. Rham et al. (2020) applied phytohormones against abiotic stress factors in the seed preparation process and determined that the factors related to abiotic factors were improved in seeds. Studies are carried out to increase the germination rates of the seeds of temperate climate fruit species with hormone application without the folding process. Studies have been carried out on some olive seeds on this subject. In the study, the endocarps of the first group were removed from the seeds divided into 3 groups and planted in culture media containing GA and Indole Acetic Acid (IAA) under laboratory conditions. Another group was folded, half sown on hot and the other half on cold pillows, and no treatment was given to the 3rd group seeds. As a result of the studies, GA and IAA created a higher germination rate compared to other applications, while at the same time shortening the germination period (Yüce, 1979).

3. Germination index

The average values of the germination index effect of the silage sorghum and the difference groupings of the growth regulators applied to the silage sorghum plant before germination are given in Table 3.

Table 3. Germination index average values obtained from growth regulators applied to sorghum silage plant before germination

Implementation		Average Values
Exogenous Implementation to Seeds Before Planting	% 1 Zeatin	32.44 b
	% 1 Brassinolides	31.31 b
	% 1 Zeatin + % 1 Brassinolides	36.80 a
Control	No Exogenous Implementation	28.84 c
Average		32.35
LSD (%5)		1.425

As seen in Table 3., there was a statistical difference between the germination index values of the growth regulators applied to the silage sorghum plant before germination. The germination index, which was a mixture of 1% Zeatin + 1% Brassinolides used before planting, was the highest with the exogen application rate of 36.80. Similar to our study, Sheikhzadeh et al. (2021), in the research on the effect of hormones on the germination of seeds; It was observed that seed germination was decreased when borage plant was given cadmium stress. Combined hydro and hormone (Giberellic acid) were used at all levels of cadmium stress (especially 150 mg L-1 GA3) and it was determined that positive effects were seen on seed germination and growth.

It is stated that cytokinins, especially in seed germination, have a positive effect indirectly by reducing or removing the effect of inhibitors such as ABA (Hartmann et al., 1990).

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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