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The effects of different soil substrates and potassium applications on Chickpea (Cicer arietinum L.) some plant yield and membrane permeability under dry conditions

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Abstract

This study was conducted as a pot experiment potassium fertilizer different doses effects were investigated plant growth and membrane permeability on chickpea plants in dry conditions. The experiment was designed as a randomized block design with 3 replications. The 18 pots were composed of two different textures as 1:1 peat+soil and only soil in the experiment. Three different doses of potassium fertilizer (Control: 0ppm K, 100ppm K, 200ppm K) were given with seed sowing. The chickpea plants were harvested at the end of 8 weeks and results were evaluated. Plant dry matter yield was found between 19.60g/pot and 52.25g/pot. As applied potassium fertilizer dose has decreased plant root and leaf dry matter yield has also decreased when potassium doses increased these values have increased. Peat+soil mixture texture has supported plant growth. The effect of potassium fertilizer on plant growth and membrane permeability was found statistically significant ($p<0.05$). Membrane permeability values were decreased as the amount of applied potassium doses increased. The highest membrane permeability was obtained from 0ppm K and only soil texture group with 48.4%. In this application, the cell membrane has been damaged at the highest level. The lowest membrane permeability value was obtained from 100ppm K and peat+soil mixture texture with 18.6%. As a result of this study, it was determined that organic matter contains texture supported plant growth and K fertilizer especially protected chickpea plant from water stress under dry conditions.

Keywords: Peat+soil, potassium, fertilization, membrane, growth.

1. INTRODUCTION

Agricultural production is carried out under difficult conditions in arid and semi-arid regions. Rainfall and lack of nutrients are very important in plants grown in these regions. If we try to remedy these stress conditions with some applications, we will provide suitable conditions for the growth of plants and increase of yield. In terms of plant nutrition and fertilization, potassium is a plant nutrient that regulates the water level in plants. Potassium element increases root growth in plants and improves stress conditions. Potassium also increases the fixation of nitrogen by promoting root development in plants. Abdalla and Abdelwahab (1995), as a result of the study of the element in the plant, the water level of potassium in the plant body and roots have found that increase the yield of dry matter.

Chickpea is one of the first plants to be cultured over the world. As a gene center, Turkey has been shown to be located in the Eastern Mediterranean region. Dry grains contain a high percentage of protein (15-32%) and carbohydrates (50-74%), as well as minerals such as phosphorus, calcium and iron, and rich in A, B and Niacin vitamins (Smithson et al.1985). Chickpea plants are most resistant to drought and low heat take placed the second legume after red lentil. It is not very selective in terms of soil demand. Drainage is well, slightly acid or alkaline reaction, limestone and arid soils are grown. It is resistant to drought due to its small vegetative parts and pile root system. It increases its agricultural importance. In this form, cereal-fallow is one of the few plants in the rotation system (Azkan, 1989; Isik, 1992; Sepetoglu, 1994).

Plants need nutrients to growth. They take most of their nutrients from the soil by their roots. Fertilization should be done if there are insufficient nutrients in the soil for the plant to grow. Nutrients that are missing in soil should be given to soil in order to obtain high quality products in agricultural production. The most effective breeding process for the yield and quality of plants is fertilization (Ertekin et al., 2020; Ertekin et al., 2022). However, excessive fertilization should be refrained (Aygün and Mert, 2021).

Water needs provided for the plant nutrients to be effective. In some regions of our country, agricultural production is continued without irrigation and fertilization. Water needed in agricultural production is provided from rain water in semi-arid climate conditions (Bellitürk et al., 2019).

In the world, 12.7 million hectares of chickpeas are cultivated and 12.1 million tons of products are obtained from this area. The world average yield is 95.6 kg per decare (FAO 2016). Among the legumes in our country, chickpea takes the first place with 359 thousand ha cultivation area and 460 thousand tons production, while it is 224 thousand ha cultivation area and 360 thousand tons production of lentils. (Red-green) and is followed by dry bean planting area of 94 thousand hectares and 235 thousand tons. The yields of these products are respectively 128, 286 and 251 kg (TUIK, 2016). Sangakkara et al. (1996), the environmental effects of stress, and especially the negative effects of water stress on plants, can be reduced by potassium fertilization can be reduced and as a result of their research in leguminous plants, potassium fertilization, the body and roots in the amount of dry matter caused by the increase in the amount of water and negative effects of stress reported.

Alpaslan and Güneş, (2001) reported that the salt stress and boron toxicity they applied to the tomato and cucumber plants they grow caused a decrease in the amount of dry matter in the stem and roots. Under the same conditions, they stated that these stress conditions increased membrane permeability and that boron application under salted conditions had no effect on membrane permeability. Inal and Tarakçıoğlu (2001), as a result of the application of ammonium, as per a result of ammonium application, membrane permeability values of 30%, as a result of application of urea as a result of mixed application of 25%, as a result of mixed application of 25% and 27% as a result of nitrate application. Kaya et al. (2001), the cultivated tomato plant, a high level of NaCl application, a significant decrease in the amount of dry matter was observed. Potassium and phosphorus application increased the amount of dry matter in the stem and stem. While membrane permeability value increased with high NaCl application, it was determined that membrane permeability decreased as a result of application of potassium and phosphorus to plants.

Liang et al. (2001) found that toxic application of barley plant to aluminum increases the permeability of membrane. At the same time root length of the plants, dry matter yield in the root and stem, nitrogen and phosphorus concentrations in the plant body and nitrogen and potassium concentrations in the root decreased. Kaya et al. (2002), in vegetables grown under salt and alkali conditions, membrane permeability, while increasing the dry matter yield was determined to decrease. They concluded that saline conditions reduce water use and increase alkaline conditions. They obtained low dry matter content at high pH. Dry matter and chlorophyll formation were higher in pepper plant than tomato and cucumber. Kaya et al. (2003), high NaCl grown in the strawberry plant in the amount of dry matter, fruit yield and chlorophyll concentration was lower than control. It was observed that the negative effects of salt conditions on plant growth and fruit yield decreased in the subject applied calcium nitrate and potassium nitrate. In saline conditions, membrane permeability increased.

Kırnak et al. (2003), pepper plant nitrogen application, mulch and water stress, to investigate the effects on yield and quality; in their studies, they applied nitrogen at doses of 70, 140 and 210 kg / ha; found that water stress increases membrane permeability value and decreases nitrogen, phosphorus, potassium, calcium and magnesium concentrations in plant leaves. As a result of mulch application, water use efficiency increased by 12% compared to the control subject and fruit yield, fruit size, dry matter amount and chlorophyll concentration increased. Within the scope of sustainable agriculture, natural origin soil conditioners are used to achieve high efficiency in agricultural production (Aygün and Mert, 2020). Peat is a natural medium material which can be used for all kinds of plant breeding. It is a material with high ventilation capacity and at least 30% organic material. Organic fertilizers increase the content of organic matter in the soil and this means it can be increase of soil fertility and quality.

In this study, it was aimed to determine the effects of potassium fertilizer applied on soil and peat + soil mixture environment on growth development and membrane permeability in chickpea plant. It is known that potassium increases the resistance against drought and affects the yield positively. In order to increase the yield in areas with low rainfall, the possible effects on membrane permeability and potential increase in yield of potassium fertilizers were investigated.

2. MATERIAL and METHODS

This study was conducted as a pot experiment under dry conditions. Gökçe chickpea variety seeds were used as plant material. In the study, potassium sulfate fertilizer, peat, soil and pot was used as material.

Table 1. Soil analysis results

Soil Depth	pH	EC(%)	Organic matter (%)	Lime(%)	Texture
0-30cm	7.33	0.087	0,97	42	%20 sand %56 clay %24 loam

The study was designed with 2 repetitions and 3 replications according to the randomized block design. Pots with a capacity of 5 liters were filled with the peat and soil material mixed in 1:1. Fertilization subjects consist of control, 100ppm K application, and 200ppm K application. The study consisted of 18 pots with 6 subjects and 3 pots in each subject. 10 pieces of chickpea seeds were planted in each pot and 6 best plants were developed after the first true leaves were formed. Seeds were sown on 05.03.2019 and 30.04 .2019 and harvested 8 weeks later. Potassium Sulphate fertilizer was used as a source of potassium. Irrigation water has not been applied to the chickpea plant; it was grown under dry conditions. Rainfall is given in Table.2 between these dates.

Table 2. Total Rainfall between Sowing and Harvest Dates (kg/m^2)

Year	March	April
2019	38.7	47.1

In heavy rainy days, the plants were taken to the closed environment in order to prevent damage from rain water.

Trial topics:

T0: Soil culture in pot (unfertilized)

T1: Soil culture + 100 ppm K in pot

T2: Soil culture + 200 ppm K in pot

T3: Peat + Soil culture (unfertilized) in pot

T4: Peat + Soil culture + 100 ppm K in pot

T5: Peat + Soil culture + 200 ppm K in pot

Examined Properties and Methods

2.1. Determination of dry matter in the root and stem of the plant (g/pot):

After harvesting the plants, the root and body parts are separated from each other, washed with water and then washed with pure water for the last time. The results are expressed as g/pot. (Chapman & Pratt, 1982).

2.2. Determination of membrane permeability (%): From each plant, one young leaf sample was taken and fragmented 1 cm in size and shaken with pure water for 24 hours at 25 °C. As a result of this procedure EC_1 value was read and samples were taken at 1200ºC, after waiting 20 minutes, EC_2 value was read and membrane permeability was determined with EC_1/EC_2 x 100 formula. (Lutts et al. 1996).

2.3. Statistical Analysis

The results were compared subjected to variance analysis (Açıkgöz et al. 1993).Statistically different means were grouped according to LSD (5%) test.

3. RESULTS AND DISCUSSION

3.1. Plant Dry Matter Yield (g/pot)

According to the results, relationship between dry matter yield and K fertilization were statistically significant at 5%. Table.3 shows that the average dry matter yield values in the plant body ranged from 19.60 to 52.25 g/pot. Cultivation environment has also positively affected plant growth. It is less or no rainfall in dates; potassium reduced the negative effects of water stress in chickpea plants.

Table 3. Average Plant Dry Matter Yield (g/pot)

Nutrition Treatments	Soil Culture	Soil+Peat Culture
Control	19.60c	30.17b
100ppm K	29.36b	42.23ab
200ppm K	41.66ab	52.25a
LSD(%5)	0.72	

In the study, the highest average yield values were obtained from the subject of T_5(Soil+Peat Culture+200ppm K) with 52.25g/pot and 42.23 g/pot with T_4(Soil+Peat Culture+100ppm K) and 41.66 g/pot with T_2 (Soil Culture+200ppmK) subjects. The lowest yield was found 19.60 g/pot from Control application. The effect of potassium fertilizer and mixture on dry matter yield was the same, peat and soil mixture media were found to be more successful than the control. It has been observed that negative effects of water stress can be reduced by potassium fertilization. This results supported to Mengel and Kirkby (1987), Abdalla and Abdclwahab (1995), and Sangakkara et al. (1995), Kaya et al. (2001).

3.2. Root Dry Matter Yield (g/pot)

As seen in Table 4, effects of peat mixture and potassium application on dry matter yield were found to be significant. As seen from Table 4, the dry matter yield values in the root ranged between 18.13 and 38.42 g/pot. In the study, the highest yield was obtained from T_5(Soil+Peat Culture+200ppm K) with 38.42 g/pot. The lowest yield was obtained from T_0 (control) with 18.13 g/pot. Root dry matter yield was low in only plants grown in soil environment. It is known that nitrogen fixation increases in leguminous plants grown in water stress as a result of potassium fertilization. With the increase of nitrogen fixation in the roots, root branching, growth and development are also has been observed.

Table 4. Root Dry Matter Yield (g/pot)

Nutrition Treatments	Soil Culture	Soil+Peat Culture

Control	18.13c	21.86b
100ppm K	22.72b	31.68ab
200ppm K	30.22ab	38.42 a
LSD(%5)	0.78	

(Kadıoğlu and Canpolat, 2019), in their study was conducted to determine the effects of plant growth promoting rhizobacteria on wheat and maize plant growth in different environments. According to the research results; when 100% pumice material increases dry root and stem weight and 100% peat material increases the number of bacteria. When the soil amount increased in the substrate/soil mixtures, dry root and stem weight and plant nitrogen, phosphorus and potassium content increased and the number of bacteria decreased.

(Ahmed, 2019) in wheat grown under salt stress conditions, increasing levels of salt application caused a statistically significant decrease in the green parts and root dry matter productions of the genotypes.

Similar results were obtained in this study. It can be said that potassium fertilization increases root growth in plants and hence also increases the dry matter yield in the root. The mixture of peat and soil increased branching in plant roots. The soil+peat texture has increased plant roots growth. Soil texture has been insufficient in terms of plant root development.

3.3. Membrane Permeability (%)

If the plant is exposed to stress conditions in the environment of the cell membrane is damaged and membrane permeability value increases. In this study, it was determined that membrane permeability values decreased in the conditions where the retention and water holding capacity of the growing environment were suitable. The effects of peat breeding medium on the development of chickpea and permeability were found to be significant.

Table 5. Average Membrane Permeability Values (%)

Nutrition Treatments	Soil Culture	Soil+Peat Culture
Control	48.4c	20.2a
100ppm K	43.7c	18.6a
200ppm K	32.6b	19.3a
LSD(%5)	1.18	

P>0.05 significant

Potassium fertilizer has less effected on membrane permeability than soil+peat mixture. This may be due to the fact that the plants did not have any stress conditions as they had sufficient water and ventilation conditions in the peat environment. In the study, the highest mean membrane permeability values were taken from control (T_0 group) with 48.4%. In this group, the cell membrane was damaged at the highest level.

The lowest membrane permeability was obtained from T_4 (Soil+Peat Culture+100ppm K) group with 18.6%. T_2 (Soil Culture+200ppmK) was found to be more successful than T_1 (Soil Culture+100ppmK) in membrane permeability. Although the data were close to the figures, they were statistically different. It can be said that potassium nutrients reduce the harmful effects of water stress on membrane permeability. As a result of water stress, salt stress and application of some elements to the researched plant, the value of membrane permeability was found to be increased (Liang et al. 2001).

(Ahmed, 2019), in wheat grown under salt stress conditions, it was observed that the average membrane permeability values of the varieties increased significantly due to the increased salt application.

4. CONCLUSION and SUGGESTIONS

In arid and semi-arid regions, plants are not able to supply enough water because they cannot supply enough water. Water stress is known to be the most important factor limiting agricultural production in arid and semi-arid regions. In this study, the effects of peat environment on the development of chickpea plant and cell membrane permeability were investigated with potassium fertilization. Potassium is a nutrient that promotes the use of water within the plant, so it may be advisable to apply it in arid regions, but the amount of potassium present in the soil should also be taken into account for this application.

The soils of Southeastern Anatolia are dense clay. For this reason, in the root developments of plants are occasionally negative. Mixing of these soils with organic material containing peat farm manure such as leonardite, and supporting it, can increase the productivity of the plant by providing positive growth. In semi-arid conditions, the use of peat materials is recommended in dry production enterprises.

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