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Araştırma Makalesi

The Effect of Polymeric Hydrogel Application on Germination Under Saline Irrigation Water: Case Study of Barley

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ÖZ

Son yıllarda tarımsal üretimde hafif bünyeli toprakların su tutma kapasitesini artırmaya yönelik olarak kullanılan polimerik hidrojellerin kullanım alanları artırılmaya çalışılmaktadır. Yapılan bu çalışmada, polimerik hidrojelin düşük kalite sulama sularının kullanıldığı şartlarda arpa tohumların çimlenmesi üzerine etkileri incelenmiştir. Bu amaç için sulama suyu Elektriksel İletkenlik (ECi) değeri 0 [kontrol], 6, 8, 10, 12 ve 15 dS m-1 ve Sodyum Absorbsiyon Oranı (SAR) 3'ten küçük olacak şekilde hazırlanmış sulama suları 0.01 gramlık hidrojelin yerleştirildiği petri kaplarına eklenmiştir. Aynı petri kaplarına iki sıralı arpa (Hordeum vulgare Conv. Distichon) çeşidinden 10'ar tohum eklenmiştir. Çalışma sonunda elde edilen verilerle yapılan varyans analiz sonuçlarına göre, artan sulama suyu tuzluluğunun, arpanın çimlenme hızı ve çimlenme gücü üzerine %5 önem düzeyinde etkili olduğu belirlenmiştir. Ancak hidrojel uygulamasının araştırılan konular arasındaki farkı, istatistiksel açıdan anlamlı bulunmamıştır. Artan sulama suyu ECi değerine karşılık, arpanın çimlenme hızı ve çimlenme gücü azalmıştır. Artan ECi değeri koşullarında hidrojel uygulamasının arpanın çimlenme hızı ve çimlenme gücü üzerine her hangi bir etkisinin olmadığı belirlenmiştir.

Anahtar kelimeler: Sulama Suyu Kalitesi, EC, SAR

Tuzlu Sulama Suyu Koşullarında Polimerik Hidrojel Uygulamasının Çimlenmeye Etkisi: Arpa Örneği

ABSTRACT

In recent years, it has been tried to increase the usage areas of polymeric hydrogels, which are used to increase the water holding capacity of light textured soils in agricultural production. In this study, the effects of polymeric hydrogel on the germination of barley seeds under low quality irrigation water conditions were investigated. For this purpose, irrigation water prepared with an Electrical Conductivity (ECi) value of 0 [control], 6, 8, and 12 dS m-1 and Sodium Absorption Rate (SAR) less than 3 is placed in petri dishes in which 0.01 grams hydrogel has been added. 10 seeds of barley (Hordeum vulgare conv. distichon) variety were added to the same petri dishes. According to the results of variance analysis made with the data obtained in the study, it was determined that increasing irrigation water salinity was effective at the 5% significance level on the germination rate and seedling dry weight of barley. However, the difference between the subjects treated with hydrogel was not statistically significant. In response to the increased irrigation water ECi value, the germination rate and germination power of barley decreased. It was determined that hydrogel application did not have any effect on the germination rate and germination power of barley under increasing ECi value conditions.

Key words: Irrigation water quality, EC, SAR

INTRODUCTION

In sustainable agricultural production, water quality and salinity of the plant root zone are important issues to be considered together. In recent years, water resources have been exposed to great pressures due to the negative effects of climate irregularity and increasing demands. In addition, water resources are deteriorating day by day both in terms of quality and quantity. This deterioration is more evident especially in arid and semi-arid regions. Excess dissolved salts in soil and irrigation water are one of the major limiting factors for agricultural production. An excess of ions in the rhizosphere can gradually accumulate in the upper part of the soil, causing severe damage to plant metabolism, as well as injury to plant roots. As a result, besides stunted growth, decreases in yield and quality occur.

The quality of irrigation water is evaluated not only by the total amount of salt it contains, but also by the type of salts. With the increase in the total salt content of the water, soil and plant related problems will arise. The quality of the water or its suitability for use is evaluated depending on the potential problems that may arise with the long-term use of the water. Problems commonly encountered in irrigated agriculture depending on water quality can be grouped under four main headings. These are plant root zone salinity, water infiltration rate, specific ion toxicity and other problems (Ayers and Westcot, 1994; Tas, 2017; Kunt and Tas, 2019).

Is barley grown in regions with salinity problems? Or is there a salt sensitivity in the germination of barley? why barley? One or two sentences can be written.

With the increase in irrigation water pollution, the variety and applicability of agricultural techniques that can be applied are also decreasing. The salts transmitted to the root zone of the plant by irrigation and accumulated there must be removed from the area after a certain period of time. In other words, if a problem-free agriculture is desired in areas where salty water is used, the salts accumulated during the irrigation season must be able to be removed from the area with winter precipitation. If this is not possible, salts should be removed from the root zone at the end of the growing season using good quality washing water. Unless this can be done, salts accumulated over time will reduce soil fertility. Mixing the potential salty ground water with the surface water and using it as irrigation water again is a method that can be used for controlling the ground water in water management. However, in order to irrigate in this way, the type of plant, the salinity level of the water to be used in irrigation, the periods in which the plants are sensitive and the effect of the climate, the salinity level of the ground water and the type of salts in both the irrigation water and the ground water should be determined (Yurtseven, 1997; Kara and Apan, 2000).

Hydrogels are polymers that are cross-linked, have a three-dimensional network, have high hydrophilic properties and can swell without being dissolved in water (Gupta et al., 2002; Qui and Park, 2001; Tan, 2008). Hydrogels, which have become increasingly popular in recent years, have the ability to absorb water at a rate of approximately 250-1500 times their own weight. These substances are used in a wide variety of fields such as mining, prevention of environmental pollution, treatment plants, laboratories, irrigation, soil improvement, especially in medicine and industry (Johnson 1984, Bowman and Evans 1991, Barverik 1994, Bouranis et al., 1995, Ohkawa et al., 1998; Ersen Dudu, 2018). Hydrogels, which are superabsorbent natural or synthetic polymers in the form of small crystals or beads, are commonly marketed in agricultural use under various trade names such as root irrigation crystals, drought crystals, water trap.

Hydrogels are used in seed germination, seedling growth, plant transpiration, plants' use of soil water, reducing the effect of salt in the soil, bacteria and mycorrhiza inoculation, loosening clayey tight soils, increasing the water holding capacity of coarse sandy soils, correcting the structure and preventing erosion (Callaghan et al., 1989), increasing the water holding capacity of the soil in arid regions with irrigation water problems, increasing the porosity due to its aggregation in heavy clay and coarse sandy soils, increasing the infiltration rate and drainage, reducing the compaction of heavy clay soils, loosening the rhizosphere and reducing the volume weight, tillage in heavy soils. It increases the water holding capacity of the soil, field capacity, available moisture, aggregate stability and hydraulic conductivity, as well as reducing the labor force in planting and seed planting (Azzam, 1980, Teyel and El-Hady 1981, Helalia and Latey 1998). The thrust also increases the water use efficiency and the amount of plant dry matter (Aslan, 2004; Kant, 2008). In addition, depending on the increase in water holding capacity, the plant watering frequency and number of irrigations are significantly reduced. In addition to germination of seeds in precipitation-based agriculture, it makes great contributions in passing critical stages in plant growth and development.

Humic acid and hydrogel application to the soil increased soil moisture parameters (saturation percentage, field capacity, permanent wilting point, available moisture capacity) while decreasing pH and electrical conductivity values. Hydrogel was more effective than humic acid in increasing and decreasing aspects of these parameters. In addition, it was determined that humic acid and hydrogels applied to the soil under salt stress conditions increased the chlorophyll A, chlorophyll B, nitrate, salt tolerance index and leaf area index of the bean (Phaseulus vulgaris L.) plant, and decreased the proline content and cell permeability (Kant, 2008).

In this study, the effect of polymeric hydrogel used in agricultural application on germination under saline irrigation water conditions was investigated. Evaluations were made in barley.

MATERIALS AND METHOD

The study was carried out in Canakkale Onsekiz Mart University Faculty of Agriculture, Department of Agricultural Structures and Irrigation Application Laboratory in 2017. In the study, two rows of barley seeds Hordeum vulgare conv. distichon (cv. İnce 04) were used. The experiment was set up in randomized plots according to the split plot design with 4 replications. The “Sodium Adsorption Rates” (SAR) of the irrigation waters used in the experiment were adjusted to be less than 3. Different salt sources (NaCl, MgSO4, CaCl2) were used in this. Considering the work done by Kunt and Tas (2019) to determine the germination threshold value for the variety in question, 0 [control], 6, 8, and 12 dS m-1 ECi levels were included in the study. In addition, the calcium-magnesium ratio was provided to be greater than 2 to prevent possible magnesium damage. 0.01 grams of the hydrogel obtained from the market was weighed and placed in 9 cm diameter petri dishes containing Watman no:1 filter paper. After this stage, 15 ml of germination water was added to each petri dish in the brine irrigation waters prepared. Before sowing, the hydrogels were expected to swell and then barley seeds were sown. Seeds were sterilized in 5% HCl solution before planting in petri dishes. Subsequently, 10 intact seeds were planted in each petri dish. After the sowing process was finished, the lids of the petri dishes were closed; Petri dishes were covered with parafilm to prevent evaporation. During the study, the laboratory temperature was 22±1 oC and the relative humidity was measured as 75±2%.

Swelling tests of the hydrogels used in the application were made before the application and it was determined that 10 ml of irrigation water provided sufficient swelling for the appropriate amount of 0.01 grams hydrogel.

The seeds left to germinate were followed for 7 days. At the end of this period, the experiment was terminated. In line with the recommendations of Wang et al., (2009) and Kusvuran (2015), it was accepted that the seed germinated after rootlets appeared. At the end of the 7th day, after counting the rooting seeds (Figure 1) for each petri dish, they were placed in a paper bag and dried in an oven at 60°C for 48 hours, and their dry weight was measured.

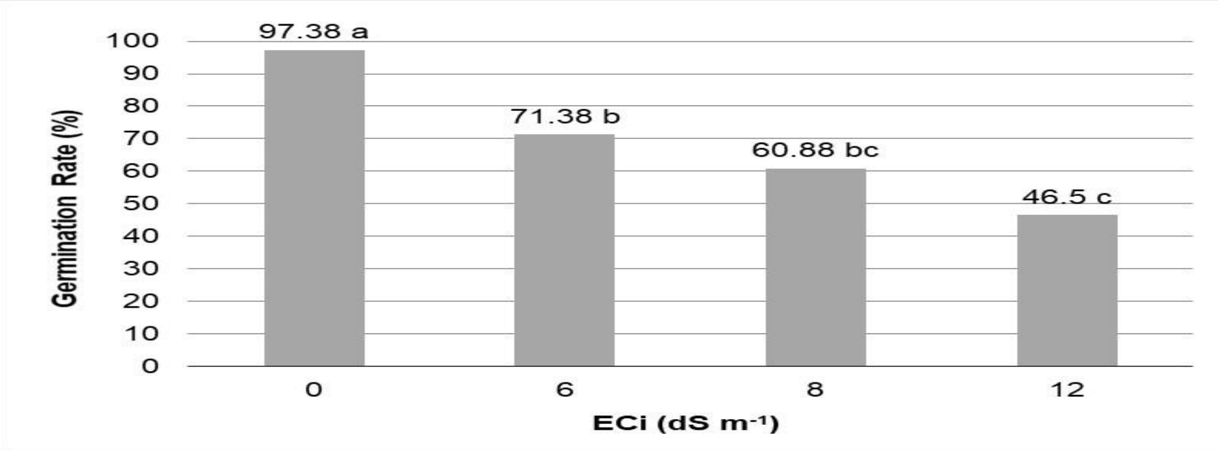
Figure 1. Barley seeds germinated in hydrogel-added media at different salinity levels

The germinated seeds in each petri dish were converted to percentages as suggested by Atak et al., (2006). The data obtained at the end of the study were analyzed with the help of the JMP 11 statistical package program and the important parameters were compared with the student's t test.

RESULTS AND DISCUSSION

The effect of irrigation water salinity on germination rate was statistically significant (P<0.01) as a result of variance analyzes performed on the data. The interaction of hydrogel application and "hydrogel x irrigation water ECi levels" was determined to be insignificant. The groups formed as a result of the student's t test applied to the averages are given in Figure 2. In terms of germination rate, the highest value was obtained from the control application with 97.38%. Considering the ECi levels, the germination rates obtained at all levels showed lower values than the control, forming a separate group.

The germination rate of barley decreased with increasing irrigation water ECi value. In other words, the increase in irrigation water salinity negatively affects the germination of barley. It was determined that the germination rate started the decrease with 6 dS m^{-1} ECi. The decrease of germination rate values with increasing irrigation water salinity show similarities with the results obtained by the some other researchers (Huang and Redmann, 1995; Pancholi et al., 2001; Prazak 2001; Senay et al. 2005; Kara et al. 2011; Benlioglu and Ozkan 2015).



*: There is a statistical significance (P<0.01) between the averages shown with the different letters in the same column.
Figure 2. Barley seed germination ratios at different ECi levels (0.01 grams of hydrogel was applied)

When we looked at the effects on the germination rate of irrigation water salinity level in hydrogel application, the highest value was obtained the control application at 69.75%. Hydrogel application was 61.71%. In general, hydrogel treatment was no effect the germination (Table 1).

Table 1. Effect of germination ratio of different application

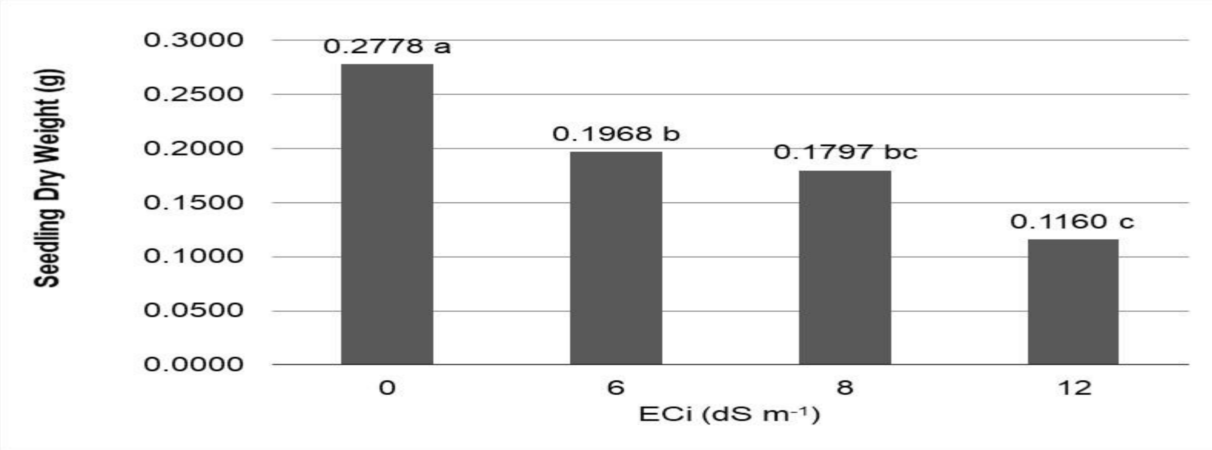
Applications	Germination rate (%)
Control	69.75
Hydrogel	61.71ns

ns: There is no statistical significance (P> 0.05) between the averages shown with the same letters in the same column.

The effects of level of irrigation water salinity on seedling dry weight was found statistically significant (P<0.01). The hydrogel application and the "hydrogel x irrigation water EC levels" interaction were determined to be insignificant (P> 0.05). The highest value for dry weight of seedlings was obtained 0.2778 g from control application all saline irrigation water applications constituted distinct group with significantly lower values than the control (Figure 3). The lowest value for dry weight of seedlings was obtained 0.1160 g from the application of 12 dS m^{-1}.

As a result of the student's t test of multiple comparisons, the seedling dry weight was decreased due to the increase of salinity level of irrigation water. Out of control application, all of the level of irrigation water EC were be different groups. A significant decrease in seedling dry weight was found after 6 dS m^{-1} of irrigation water EC level.

As a result, it has been determined that irrigation water salinity has negative effects on germination rate and seedling growth of barley. Those negative effects were increased in parallel with the increase EC level of irrigation water. But it can be said that the application of hydrogel application in seed bed does not an effect on the irrigation water salinity.



*: There is a statistical significance (P<0.01) between the averages shown with the different letters in the same column.

Figure 3. Student's t multiple comparison of seedling dry weight under the different irrigation water salinity level (0.01 grams of hydrogel was applied)

Irrigation water salinity level have a negative impact to germination rate of the barley seeds shows similarities with different study of researchers (Al-Karaki, 2001; Huang and Redmann, 1995; Benlioglu and Ozkan, 2015). In the seedling dry weight, irrigation water salinity and level were affected negatively. This result has similarities with different study of researchers (Benlioglu and Ozkan, 2015; Yildiz and Terzi, 2011; Ekmekci et al., 2005).

The discussion should be more understandable with the results that Hydrogel application has shown in different studies.

SUGGESTIONS AND CONCLUSION

Despite various beneficial effects of hydrogel addition, some studies have shown little or no benefit with hydrogel addition (Conover and Poole 1976; James and Richards 1986; Ingram and Yeager 1987; Wang 1987; Akhter et al., 2004). Therefore, information regarding the effects of a given gel type and species responses under specific soil conditions is necessary before field applications. Furthermore, timely supplies and the cost of hydrogel are important factors in the success and economics of projects envisaging the rehabilitation of sandy and arid areas through increased plant establishment and productivity in World. In this study, it was concluded that polymeric hydrogel has no effect on barley germination under saline irrigation water conditions. Another conclusion is the decrease of germination rate and seedling dry weight of barley started at 6 dS m-1 ECi level.

Conflict of Interest Declaration: The authors have no conflict of interest concerned to this work.

Contribution Rate Statement Summary: The authors declare that they have contributed equally to the article.

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