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# Effect of Salinity in Irrigation Water on Some Plant Development Parameters of Sainfoin (*Onobrychis viciifolia* Scop.) and Soil Salinity

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**Abstract:** Effect of irrigation water salinity was investigated on both the yield and quality of sainfoin and soil salinization under greenhouse conditions in 35 cm wide and 65 cm long PVC columns. Sainfoin was chosen because it is grown in arid and semiarid region with salinity problems and it is cold resistant. 5 levels of water salinity (0.27, 3.5, 7, 10 and 13 dS $m^{-1}$) and two levels of alkalinity (SAR=0.35 and 10) were evaluated as a factorial in a randomized - plot design with three replicates. Sainfoin was harvested twice. Plants got shorter and dry hay yield and crude protein ratio were declined as the levels of salt and alkalinity increased for both harvests. There were no live plants in the second harvest when salt concentration and alkalinity was highest. Increase in soil salinization was also observed with increasing water salt level.

**Key Words**: Sainfoin, irrigation water salinity, salinity-yield relation.

## Sulama Suyu Tuzluluğunun Korunganın (*Onobrychis viciifolia* Scop.) Bazı Bitki Gelişim Parametreleri ve Toprak Tuzluluğuna Etkisi

**Öz**: Bu çalışma sulama suyu tuzluluklarının korunganın verimi ve kalitesi ile toprak tuzlulaşması üzerine olan etkilerini ortaya koymak amacıyla serada, 35 cm çapında ve 65 cm yüksekliğinde PVC kolonlarda yapılmıştır. Korunga tuzluluk sorunu olan kurak ve yarı kurak bölgelerde yetiştiği ve soğuğa dayanıklı olduğu için seçilmiştir. 5 sulama suyu tuzluluğu (0.27, 3.5, 7, 10 ve 13 dS $m^{-1}$) ve iki alkalilik düzeyinde (SAR= 0.35 ve 10) 3 tekrarlamalı olarak, tesadüf parsellerinde faktöriyel düzende ele alınmıştır. Kolonlardan 2 kere biçim yapılmıştır. Her iki biçimde de artan tuz miktarı ve alkalilikle bitki boyu kısalmış, kuru ot verimi ve ham protein oranı azalmıştır. Hatta en yüksek tuz konsantrasyonu ve alkalilikte ikinci biçimde canlı bitki kalmamıştır. Ayrıca sulama suyu tuzluluğunun artışına bağlı olarak toprak tuzluluğu artış göstermiştir.

**Anahtar Kelimeler**: Korunga, sulama suyu tuzluluğu, tuzluluk-verim ilişkisi.

## Introduction

Providing sufficient and good quality irrigation water is getting harder in the agricultural lands. Decrease or pollution in natural resources makes it obligatory to use low quality waters for irrigation. Soil salinization is an important constraint in arid and semiarid regions influencing directly soil yield potential. Accumulation of soil salinity in the root zone influences plant yield and quality in time. Deleterious effects of soil salinity are a complex situation arising from osmotic stress, ion toxicity and lack of minerals (Hasegawa et al. 2000; Munns 1993, Munns 2002, Neumann 1997, Yeo 1998). The high salt environment may cause a loss of water from the cells and a decrease in turgor. Plant has smaller leaves, short stature and low economic yield (Shannon et al. 1994). The extent of this impact is dependent on climate, water quality, soil characteristics, plant, growing type, drainage capacity and water management (Launchi and Epstein 1990). Sainfoin (*Onobrychis viciifolia* Scop.), a forage crop highly resistant to salinity and drought can grow on step and calcareous soils where other plants cannot develop. Sarmandia and Bagheri (1990) determined salinity and drought resistant sainfoin populations.

Sainfoin enriches soil with nitrogenous compounds. It is of, therefore, big importance in soil improvement. Its roots can go into 8-10 m deep in dry regions, drawing up water and nutrition towards soil surface. It is therefore preferred to other forage plants in dry lands. It resists salinity quite well. It provides satisfying hay and seed yield under not highly saline soils (Açıkgöz 2001).

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Saline water or soil is usually associated with reduced biomass production (Rogers et al. 1997, Noaman and El-Haddad 2000). Kazemabad et al. (1989) stated that plant height, root weight and length, and leaf area of sainfoin decreased as the salinity increased. Hay yield and root development of alfalfa (*Medicago sativa* L.) also reduced with increased salinity (Vaughan et al. 2002). Alfalfa watered with 1.65 g $l^{-1}$ total dissolve solid concentration and 5.1-9.6 Sodium Adsorption Ratio (SAR) had 50 % less seedling emergence and 20-60 % less seedling development (Bauder et al. 1992).

This study research was performed to determine both the effect of irrigation water salinity on yield and quality of sainfoin grown under greenhouse conditions and the amount of salt accumulation in the soil.

## Material and Methods

A greenhouse experiment was conducted using 35 cm wide, 65 cm long PVC columns. Greenhouse was used to eliminate leaching due to rainfall. 6.35 mm sieved soil was obtained from the experimental fields of the Faculty of Agriculture, University of Ankara, Turkey, and mixed 1:1 with fine sand. Columns were packed with a bulk density of approximately 1.49 g $cm^{-3}$. Columns were rested on 3-4 cm high gravel for drainage purposes. Some physical and chemical features of the soil were given in Table 1.

Treatments consisted of 5 levels of irrigation water ($T_0$= 0.27, $T_1$=3.5, $T_2$=7, $T_3$=10 and $T_4$=13 dS $m^{-1}$) and 2 levels of alkalinity (SAR $S_0$=0.35 and $S_1$=10), arranged as factorial in a randomized-plot design with 3 replicates in 30 columns. Easily dissolving salts of NaCl, $MgSO_4$ and $CaCl_2$ were used for preparation of different quality irrigation waters. Ca/ Mg ratio was preserved as 1: 1 in added base in preparation of irrigation waters used in the study due to its similar effects on soil physical characteristics (Poonia and Pal 1979). Irrigation experiments were prepared in 45 lt containers depending on their subjects for $T_0S_0$ level, untreated tap water was used. Analysis results of the waters were presented in Table 2.

8 sainfoin seeds were sown on April 17, 2004 and 5 were left in columns after emergence. Fertilization was done with 2 kg N and 5 kg $P_2O_5$ per da. Saline irrigation was applied on May 27, when seedlings reached to 3-4 cm. When 50 % of available water was consumed by plants, they were irrigated with 30 mm water for each irrigation application. Plants were irrigated 8 times till the first harvest on July 4, and 12 times till the second harvest on August 12, 2004. Each column had 600 mm water throughout the experiment. Nisorun and Falcon were used against red spider and leaf aphids, respectively.

Table 1. Some physical and chemical properties of the soil.

| Sand (%) | Silt (%) | Clay (%) | Texture | Field capacity (%) | Wilting point (%) |
|---|---|---|---|---|---|
| 66.86 | 14.25 | 18.89 | Sandy loam | 14.59 | 7.88 |
| Bulk density (g $cm^{-3}$) | pH | EC (dS $m^{-1}$) | Organic matter (%) | Available phosphorus (kg $ha^{-1}$) | Total nitrogen (%) |
| 1.49 | 7.86 | 0.23 | 1.09 | 0.65 | 0.05 |

Table 2. Irrigation waters analysis used in experiment.

| Treatment | pH | EC (dS $m^{-1}$) | Cations (me $l^{-1}$) | | | | | Anions (me $l^{-1}$) | | | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $Na^+$ | $K^+$ | $Ca^{++}$ | $Mg^{++}$ | Total | $HCO_3^-$ | $Cl^-$ | $SO_4^{-2}$ | Total | |
| $T_0S_0$ | 7.33 | 0.27 | 0.35 | 0.07 | 1.25 | 1.34 | 3.01 | 2.20 | 0.50 | 0.31 | 3.01 | 0.31 |
| $T_0S_1$ | 7.12 | 1.17 | 10.06 | 0.07 | 1.50 | 0.22 | 11.85 | 2.32 | 7.28 | 2.25 | 11.85 | 10.85 |
| $T_1S_0$ | 7.06 | 3.61 | 1.56 | 0.06 | 12.13 | 20.43 | 34.18 | 3.52 | 19.25 | 11.41 | 34.18 | 0.39 |
| $T_1S_1$ | 7.21 | 3.78 | 25.75 | 0.07 | 5.42 | 7.58 | 38.82 | 4.00 | 24.00 | 10.82 | 38.82 | 10.10 |
| $T_2S_0$ | 7.14 | 7.02 | 2.46 | 0.07 | 21.13 | 46.28 | 69.94 | 3.36 | 27.75 | 38.83 | 69.94 | 0.42 |
| $T_2S_1$ | 7.23 | 7.17 | 41.53 | 0.06 | 10.29 | 22.14 | 74.02 | 3.76 | 52.50 | 17.76 | 74.02 | 10.31 |
| $T_3S_0$ | 7.19 | 10.07 | 3.13 | 0.07 | 27.48 | 69.76 | 100.44 | 2.88 | 58.50 | 39.06 | 100.44 | 0.45 |
| $T_3S_1$ | 7.26 | 10.74 | 53.48 | 0.07 | 12.97 | 43.61 | 110.13 | 4.00 | 71.50 | 34.63 | 110.13 | 10.05 |
| $T_4S_0$ | 7.41 | 13.18 | 3.25 | 0.06 | 23.54 | 114.29 | 141.14 | 3.68 | 85.75 | 51.71 | 141.14 | 0.39 |
| $T_4S_1$ | 7.69 | 13.27 | 66.44 | 0.08 | 19.76 | 63.40 | 149.68 | 4.08 | 98.50 | 37.10 | 149.68 | 10.30 |

Plants harvested were measured for plant length and main stem thickness. Dry matter and crude protein contents were determined as described by Martin et al. (1990). After each harvest, soil samples were collected from different depths (0-20, 20-40 and 40-60 cm) and EC values (1: 2.5 soil water $^{-1}$) were established.

Analyses on soil samples performed according to Tüzüner (1990) were consisted of texture, field capacity and wilting point, bulk density, pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, and water analyses (pH, EC, cations and anions).

Data were analyzed by analysis of variance using MSTAT-C program, and means were compared using Duncan's multiple range test at the $P \leq 0.05$ level.

## Results and Discussion

**Plant Length:** Increasing salt concentration and SAR levels caused plants to be shorter at each harvest. In the second harvest, shortening was at a significant level. Plants died at the highest salt concentration and SAR level (Table 3). Plant length was 34.13 cm in first harvest and 2.00 cm in the second at the highest salt concentration.

Anand et al. (2000) found that photosynthesis in two alfalfa genotypes was higher when plants were tap-watered compared to 4 dS $m^{-1}$ water containing $Cl^-$ and $SO_4^{-2}$ salts. They reported that certain doses of salts might induce photosynthesis, hence, plant growth.

**Main Stem Thickness:** Main stem thickness of sainfoin decreased as the salt level increased. Control plants' main stems were 3.26 cm wide in the first harvest, while it diminished to 2.67 cm in the second harvest. SAR applications did not make a significant influence on main stem growth (Table 3)

**Dry Matter Yield:** As the salt concentration and alkalinity went up, dry matter yield diminished (Table 4). The most reduction in the first harvest was from 13 dS $m^{-1}$ salt level (22.83 g column$^{-1}$) and significant decreases were also recorded for other salt levels. Control, $T_1$, $T_2$ and $T_3$ resulted in close values to each other. Dry matter yields were determined as 31.00, 29.33, 28.17 and 26.67 g colon$^{-1}$, respectively. Since the saline applications continued until the second harvest causing soil salinity increase, dry matter yield reduced more dramatically. No viable plants were obtained from $T_4$ and $S_1$ treatments, resulting in significant loss in the yield.

**Crude Protein Content:** In the first harvest, crude protein content was affected by salt concentration, alkalinity and their interaction. Increase in salt and alkalinity induced a reduction in crude protein. Control plants had the highest amount (16.19%) and it was 14% at $T_4$. The other salt concentrations resulted in close values. In the second harvest, highest salt level reduced crude protein content. Consequently, plants were very weak. Kacar et al. (2002) indicated that as the salt concentration increases plants take up less water, ion balance ($K^+$+ $Ca^{++}$ / $Na^+$) in protoplasm is disrupted with the increase in $Na^+$ cation and $Cl^-$ and $SO_4^{-2}$ anions, enzyme activity depletes and protein synthesis decreases.

Table 3. Plant length and main stem thickness of sainfoin that irrigated by irrigation water with different saline levels.

| Salt Types | Salt concentration | | | | | |
|---|---|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ | $T_4$ | Mean |
| | | | Plant length (cm) (First harvest) | | | |
| $S_0$ | 40.40 ± 2.09 | 44.60 ± 2.83 | 38.07 ± 1.75 | 36.73 ± 5.13 | 35.93 ± 2.86 | 39.15 a |
| $S_1$ | 36.30 ± 3.70 | 36.80 ± 2.95 | 35.60 ± 4.38 | 34.53 ± 5.46 | 32.33 ± 2.08 | 35.11 b |
| Mean | 38.35 | 40.70 | 36.83 | 35.63 | 34.13 | 37.13 |
| | | | Plant length (cm) (Second harvest) | | | |
| $S_0$ | 31.27 ± 0.31 | 29.00 ± 3.46 | 26.67 ± 3.82 | 22.07 ± 3.86 | 4.00 ± 6.93 | 22.60 a |
| $S_1$ | 30.87 ± 2.44 | 24.73 ± 2.66 | 23.20 ± 3.86 | 17.73 ± 1.60 | 0.00 ± 0.00 | 19.31 b |
| Mean | 31.07 a | 26.87 b | 24.93 b | 19.90 c | 2.00 d | 20.95 |
| | | | Main stem thickness (mm) (First harvest) | | | |
| $S_0$ | 3.40 ± 0.14 | 3.33 ± 0.07 | 3.30 ± 0.35 | 3.14 ± 0.33 | 2.74 ± 0.34 | 3.18 |
| $S_1$ | 3.13 ± 0.13 | 3.30 ± 0.12 | 3.00 ± 0.33 | 2.85 ± 0.15 | 2.81 ± 0.24 | 3.02 |
| Mean | 3.26 ab | 3.31 a | 2.99 ab | 3.15 bc | 2.77 c | 3.10 |
| | | | Main stem thickness (mm) (Second harvest ) | | | |
| $S_0$ | 2.87 ± 0.10 | 2.55 ± 0.06 | 2.03 ± 0.08 | 2.14 ± 0.11 | 0.58 ± 1.00 | 2.03 |
| $S_1$ | 2.48 ± 0.09 | 2.51 ± 0.17 | 2.12 ± 0.15 | 1.97 ± 0.10 | 0.00 ± 0.00 | 1.81 |
| Mean | 2.67 a | 2.53 a | 2.07 b | 2.05 b | 0.29 c | 1.92 |

a-c; Means in the same column or row followed by the same letter for each criterion are not significantly different at the 0.05 level.

Table 4. Dry matter yield and crude protein content of sainfoin that irrigated by irrigation water with different saline levels.

| Salt Types | Salt concentration | | | | | |
|---|---|---|---|---|---|---|
| | Control | $T_1$ | $T_2$ | $T_3$ | $T_4$ | Mean |
| | | | Dry matter yield (g colon$^{-1}$) (First harvest ) | | | |
| $S_0$ | 29.33 ± 2.31 b | 34.00 ± 2.00 a | 29.00 ± 1.00 b | 28.67 ± 2.31 b | 24.67 ± 1.15 c | 29.13 a* |
| $S_1$ | 32.67 ± 1.15 a | 24.67 ± 1.15 c | 27.33 ± 1.15 b | 24.67 ± 1.15 c | 21.00 ± 0.00 d | 26.07 b |
| Mean | 31.00 a | 29.33 ab | 28.17 bc | 26.67 c | 22.83 d | 27.60 |
| | | | Dry matter yield (g colon$^{-1}$) (Second harvest ) | | | |
| $S_0$ | 28.33 ± 2.31 a | 24.67 ± 1.15 bc | 24.00 ± 0.00 bc | 21.33 ± 3.05 c | 2.67 ± 4.62 e | 20.20 a |
| $S_1$ | 25.33 ± 1.15 ab | 21.33 ± 1.15 c | 12.00 ± 2.00 d | 9.67 ± 0.58 d | 0.00 ± 0.00 e | 13.67 b |
| Mean | 26.83 a | 23.00 b | 18.00 c | 15.50 d | 1.33 e | 16.93 |
| | | | Crude protein content (%) (First harvest ) | | | |
| $S_0$ | 15.98 ± 0.25 ab | 15.91 ± 0.06 ab | 15.12 ± 0.01 bcd | 15.30 ± 0.40 bc | 14.14 ± 0.18 e | 15.29 a |
| $S_1$ | 16.41 ± 0.18 a | 14.62 ± 0.23 | 14.37 ± 1.31 de | 14.28 ± 0.21 de | 13.86 ± 0.01 e | 14.71 b |
| Mean | 16.19 a | 15.26 b | 14.74 b | 14.79 b | 14.00 c | 15.00 |
| | | | Crude protein content (%) (Second harvest ) | | | |
| $S_0$ | 14.9 ± 0.36 | 14.49 ± 0.03 | 14.34 ± 0.21 | 13.64 ± 0.53 | 4.01 ± 2.32 | 12.28 |
| $S_1$ | 14.69 ± 0.23 | 12.53 ± 0.72 | 13.64 ± 0.20 | 12.57 ± 0.26 | 0.00 ± 0.00 | 10.69 |
| Mean | 14.80 a | 13.51 a | 13.99 a | 13.10 a | 2.00 b | 11.48 |

a-e; Means in the same column or row followed by the same letter for each criterion are not significantly different at the 0.05 level.

3.5 dS m$^{-1}$ salt application caused on increase in plant length, however increasing levels shortened plants. Shannon et al. (1994) reported that salinity decreased plant growth, leaf area, plant height and economical yield.

It was recorded in the experiment that increases in salinity reduced yield. Leaf water potential lessened with salt stress causing loss of turgosity and available water in the cells (Munns 2002, Neuman 1997). Salinity-caused loss of turgosity adversely affected plant development (Munns 2002). Poljakoff-Mayber and Lerner (1999) also stated that negatively affected cell growth generated smaller leaves, consequently a reduction in photosynthesis and dry matter yield. Results obtained here are in consistent with the works of Thimmaiah (2002) and Yurtseven et al. (2002).

**Soil Salinity:** In order to establish salt accumulation in the soil, samples were taken from the columns at the depth of 0-20, 20-40 and 40-60 cm. Values of salinity in the beginning and at the end of the study were shown in Figure 1. White areas show the salinity level in the beginning, black areas after the first harvest and grey areas after the second harvest.

Soil salinity generally increased starting from the surface. Salinity in 3 different depths (0-20, 20-40, 40-60 cm) for $T_0S_0$, $T_0S_1$, $T_1S_0$ and $T_1S_1$ were close to each other. Highest salt accumulations were from $T_4S_1$ treatments at 0-20 cm depth. As seen in the figure, salt was stored more when salt concentration of the water increased. Similar results were gained by Singh et al. (1992), Van Hoorn et al. (2002), Tedeschi and Dell’ Aquila (2005).

## Conclusion

Increase in salt concentration and alkalinity caused sainfoin plants to have short stature, thin main stem and decreases in dry matter yield and crude protein content. Especially, 13 dS m$^{-1}$ and SAR=10 treatments resulted in no live plants until the second harvest. Depending on the increase in the salinity in the irrigation waters, plant length decreased from 38.35 cm in the first harvest to 34.13 cm and from 31.07 cm to 2 cm in the second harvest. Increased alkalinity reduced plant length from 39.15 cm to 35.11 cm in the first harvest, and from 22.60 cm to 19.31 cm in the second harvest. Main stem thickness decreased as the salinity increased (3.26 cm to 2.77 cm) in the first harvest. Similarly, alkalinity reduced it from 3.18 mm to 3.02 mm. Same tendency was also observed in the second harvest. Dry matter and crude protein ratio were also decreased in both harvests as the salinity and alkalinity increased. Dry matter diminished harvest from 31 g colon$^{-1}$ to 22.83 g colon$^{-1}$ in the first harvest and decreased to 14 % in the highest salinity level. In the second harvest, it dropped to 2 % from 14.80 %. Soil salinity also showed a rise depending on the increase in salt levels in water. Irrigated saline soils require the knowledge of salt tolerance of the plant. The results obtained in this study would guide procedures both in use of saline water without damaging plants and in the field experiments.

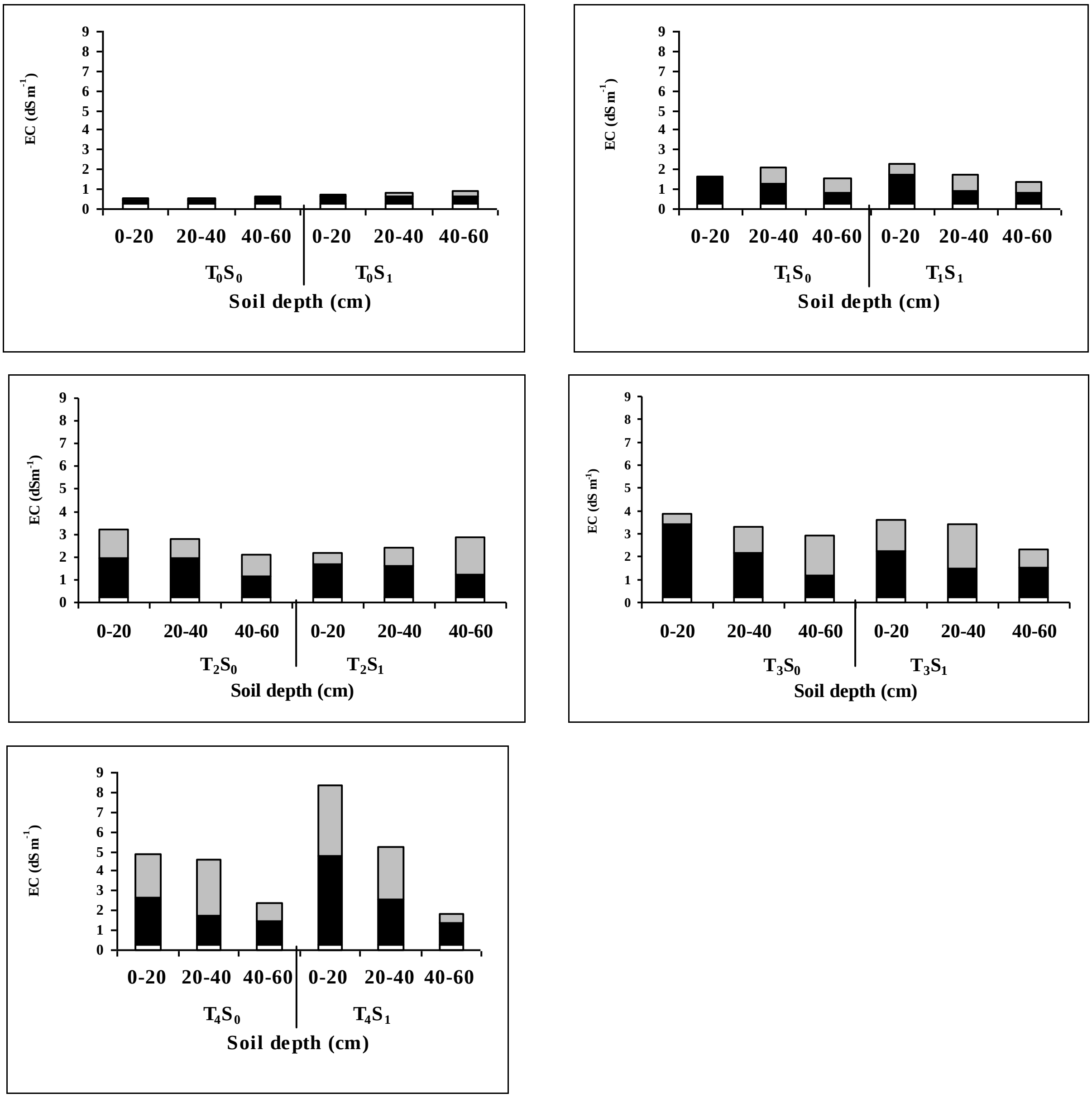


Figure 1. Soil salinity levels

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