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Soil Structure and Moisture Constants Changed by Tobacco Waste Application in a Clay Textured Field

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Abstract

In this study, effect of tobacco waste (TW) application on soil structural parameters and water holding capacity were determined in a clay field. Tobacco waste was applied into a clay soil surface (0 - 15 cm) with 4 different rates (0, 2, 4 and 6%) and three replications in a randomized plot design. After eight months, changes in soil organic carbon content, bulk density (BD), total porosity (F), gravimetric (W) and volumetric (θ) water content, air filled porosity (Fa) and relative saturation (RS) values were determined in clay soil for each treatment. TW application rates significantly increased organic C contents and F values while they significantly decreased bulk density values of the clay soil. Although the W values significantly increased over the control, the θ and RS values decreased with increasing the F values by the application of TW. The high application rates of TW (4 and 6%) increased moisture content at permanent wilting point (PWP) more than at field capacity (FC). Thus, AWC values in higher rates of TW were lower than the AWC values in 2% rate of TW and control treatments. Increasing Fa is important for plant root respiration and microbial activity especially in the clay soils. The high rates of TW increased F values but decreased the AWC of clay soil over the control treatment.

Key words: Tobacco waste, clay soil, structure, field capacity, wilting point, relative saturation.

Kil Bünyeli Bir Arazide Toprak Strüktürü ve Nem Sabitlerinin Tütün Atığı Uygulamasıyla Değişimi

Öz

Bu çalışmada, tütün atığı (TW) uygulamasının kil bünyeli bir arazide toprak strüktürü ve su tutma kapasitesine etkisi belirlenmiştir. Tütün atığı kil bünyeli toprak yüzeyine (0-15 cm) 4 farklı oranda (% 0, 2, 4 ve 6) ve tesadüf parselleri denme deseninde üç tekrarlamalı olarak uygulanmıştır. Sekiz ay sonra, toprak organik karbon içeriği, hacim ağırlığı (BD), toplam gözeneklilik (F), gravimetrik (W) ve hacimsel (θ) su içeriği, hava dolu gözeneklilik (Fa) ve nispi doygunluk (RS) değerlerindeki değişimler belirlenmiştir. Tütün atığı uygulama oranları, killi toprağın hacim ağırlığı değerlerini önemli ölçüde düşürürken, organik C içeriği ve F değerlerini önemli ölçüde artırmıştır. Gravimetrik nem değerleri kontrole göre önemli ölçüde artmasına rağmen, TW uygulaması ile F değerlerinin artması ile θ ve RS değerleri azalmıştır. TW'nin yüksek uygulama oranlarında (%4 ve %6), devamlı solma noktası (PWP)'daki nem içeriğini tarla kapasitesi (FC)'ne göre daha fazla arttırmıştır. Böylece daha yüksek TW oranlarındaki yarayışlı nem (AWC) değerleri, %2 TW dozu ve kontrol uygulamalarındaki AWC değerlerinden daha düşük olmuştur. Özellikle killi topraklarda Fa'nın artışı bitki kök solunumu ve mikrobiyal aktivite için önemlidir. Yüksek TW oranları, F değerlerini artırmış, ancak kontrol muamelesine göre killi toprağın AWC'sini azaltmıştır.

Anahtar Kelimeler: Tütün atığı, kil bünyeli toprak, strüktür, tarla kapasitesi, solma noktası, nispi doygunluk.

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INTRODUCTION

The intensive agricultural practices have significant effects on soil degradation through loss of soil organic matter, decline of soil structure, resulting soil compaction and root growth (Usowics and Lipiec, 2009; Busscher and Bauer, 2003). Agricultural waste treatments affect soil hydraulic properties due to mineralization of organic matter in soil (Gülser and Candemir, 2015). Gülser et al., (2017) found that application of hazelnut husk into a sandy clay loam soil increased OC content, basal soil respiration, saturated hydraulic conductivity and aggregate stability during the 16 weeks of incubation. They also determined that basal soil respiration as an indicator of soil microbial activity had significant positive correlations with OC, aggregate stability and total soil porosity. Demir and Gülser (2021) reported that the rice husk compost treatments in the field and greenhouse conditions had positive effects on soil properties with increasing organic matter content, electrical conductivity, field capacity, permanent wilting point, available water content and reducing soil pH and soil bulk density over the control. A measure of soil microstructure can be an index of soil physical quality that is consistent with observation on soil compaction, on effects of soil organic matter content and on root growth (Dexter, 2004). Organic waste application into soil causes changes in soil structure and aggregate size distribution with increasing pore and aggregate sizes in bulk soil (Gülser et al., 2015). Soil compaction, occurs usually loss or reduced in size of the largest pores, increases soil bulk density and soil strength, and decreases macro porosity, soil water infiltration and water-holding capacity (Dexter, 2004).

There is a close interrelationship between bulk density and porosity with porosity decreasing as bulk density increases. The lower porosity provides poor aeration, which often is associated with reduced plant growth and, at times, may be related to certain soilborne plant diseases (Miller and Donahue, 1995; Selvi et al., 2019). Gülser and Candemir (2012) found that bulk density, relative saturation and penetration resistance decreased while mean weight diameter, total porosity, gravimetric water and organic matter contents of a clay soil increased with increasing application rates of agricultural wastes. They also reported that while the lowest penetration (0.72 MPa) was determined in 6% doses application of hazelnut husk including the highest C:N ratio, the highest penetration (1.72 MPa) was in the control soil. Weil and Magdoff (2004) reported that organic matter increases the soil's capacity to hold water by direct absorption of water and by enhancing the formation and stabilization of aggregates containing an abundance of pores that hold water under moderate tensions.

Tobacco is one of the most important agricultural products in the Black Sea region of Turkey. There are large quantities of tobacco wastes around this region. Recycling organic wastes in soil is important to help reducing the greenhouse gas emission from agricultural production areas. There is a little information about the effect of tobacco waste application on soil physical properties. Therefore, effect of tobacco waste (TW) application on soil structural parameters and water holding capacity were determined in a clay field in this study.

MATERIAL AND METHODS

A field experiment was conducted at the Experimental Field of Agricultural Faculty in Ondokuz Mayıs University, Samsun. The long term climatic data of mean air temperature and precipitation for Samsun is given in Table 1. The annual mean air temperature is 13.13 °C and annual total precipitation is 936 mm in Samsun.

Table 1. Climatic data for Samsun (https://tr.climate-data.org/asya/turkiye/samsun/samsun-268).
Çizelge 1. *Samsun ili iklim verileri*

	January	February	March	April	May	June	July	August	September	October	November	December
Mean. Temp. (°C)	4.5	5.2	7.2	10.6	15	19.3	22	22.7	19.2	15	10.5	6.4
Precipitation (mm)	85	77	97	87	87	64	43	43	74	96	85	98

Tobacco waste (TW) was mixed into surface soil (0 - 15 cm) using a hoe with 0, 2, 4 and 6% of dry weight basis with three replications in a completely randomized plot design on October 2002. There was no plantation until the soil sampling time and after eight months, some physical characteristics of the soil were determined in the soil samples taken from 15 cm soil depth before planting. After determining the BD, total porosity (F) was calculated by F=1-BD/2.65, volumetric water content (θ) values were determined multiplying natural moisture (gravimetric water, W) content of soil samples by the bulk densities (θ =W.BD/ density of water). The relative saturation (RS) values were calculated dividing volumetric water contents by total porosity values (RS= θ/F). Air filled porosity was calculated subtracting volumetric water content from total porosity (Fa=F - θ). Moisture contents at the field capacity (FC) and the permanent wilting point (PWP) were determined equilibrating soil moisture of the saturated samples on the ceramic pressured plates at 33 kPa for 24 hours and 1500 kPA for 96 hours, respectively (Demiralay, 1993). Soil reaction (pH), electrical conductivity, and organic carbon content were determined according to Kacar (1994). According to the soil physical and chemical properties, the results can be summarized as; the textural class is clay (56%), none saline (0.60 dS/m), neutral in pH (7.00), moderate in organic matter (3.4%) (Soil Survey Staff, 1993). Statistical analysis of the results was done by standard analysis of variance, pairs of mean values compared by Duncan test using SPSS 17.

RESULTS AND DISCUSSIONS

The application of TW increased organic matter content in the 0-15 cm soil layer (Table 2). The increments in mean values of OC content with the application rates were significantly different from the control (P<0.01). Tobacco waste treatment decreased the bulk density values and increased total porosity values significantly (P<0.05). The increments in total porosity with the application rates were

Table 2. The effect of tobacco waste (TW) application on soil organic C (OC), bulk density (BD), total porosity (F) and gravimetric (W) water contents.

Çizelge 2. *Tütün atığı (TW) uygulamasının toprak organik C (OC), hacim ağırlığı (BD), toplam gözeneklilik (F) ve gravimetrik (W) nem içeriklerine etkisi.*

Treatments	OC, %	BD, g/cm³	F, %	W, %
TW 0%	1.99 c**	1.11 a*	58.26 b*	35.99 b*
TW 2%	2.85 bc	1.01 ab	61.78 ab	33.07 b
TW 4%	3.77 ab	0.89 b	66.38 a	33.62 b
TW 6%	4.29 a	0.89 b	66.25 a	41.44 a

**significant at 0.01 level, *significant at 0.05 level.

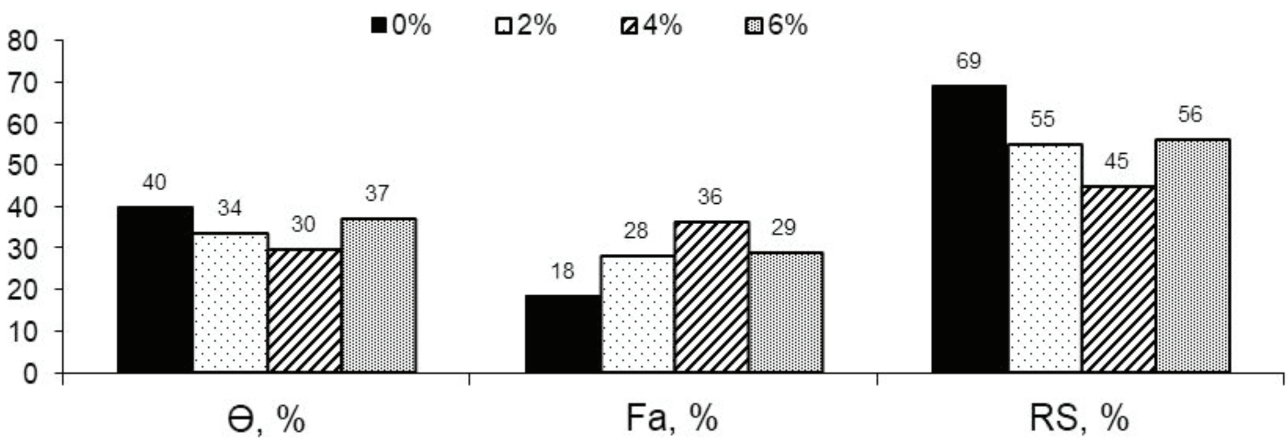

Figure 1. The effects of tobacco waste application doses on volumetric water content (θ), air filled porosity (Fa) and relative saturation (RS).

Şekil 1. *Tütün atığı uygulama dozlarının hacimsel su içeriği (θ), hava dolu gözenekler (Fa) ve nispi doygunluk (RS) üzerine etkileri.*

significantly different from the control application ($P<0.05$). In many studies, it is reported that addition of organic wastes into soils reduces bulk density and increases total porosity (Anikwe, 2000; Marinari et al., 2000; Candemir and Gülser, 2011). Although the gravimetric water contents (W) increased according to the control significantly ($P<0.05$), the volumetric water contents (θ) decreased due to reducing bulk densities by the application of TW (Figure 1). The relative saturation values also decreased with increasing the application rates of tobacco waste (Figure 1). Generally, increments in the total porosity caused decreases in the RS. Although the highest moisture content (41.44%) was determined in 6% of TW treatment, the lower RS values were found with the TW treatments due to having higher total porosity values (Table 2). Increasing the application rates of tobacco waste increased the Fa compared to the control treatment (Figure 1). According to the control treatment, increases in mean Fa values by the TW treatments were obtained in the following order; TW2% (28%) < TW6% (29%) < TW4% (36%). Candemir and Gülser (2011) reported that increasing aeration due to aggregation occurred by the organic waste application caused increases in basal soil respiration or microbial activity in clay soil.

While TW application rates increased FC values insignificantly, PWP values significantly increased by increasing the application rates of TW ($P<0.05$) compared to the control treatment (Figure 2). The highest FC (40.1%) and PWP (31.2%) were determined with 6% application rate of TW. The highest AWC (10,9%) was determined in 2% of TW application while the lowest AWC (8.1%) was determined in 4% rate of TW application (Figure 2). Addition of organic matter to soils increases water holding capacity (Gupta et al., 1977; Candemir and Gülser, 2011; Mamedov et al., 2016). Addition of higher rates of TW (4 and 6%) in a clay soil increased PWP values more than FC values. Therefore, AWC values in higher dose applications of TW (4 and 6%) were found lower than the AWC values in 2% of TW and control treatments.

Soil organic C content had the significant positive correlations with F (0.818**), Fa (0.675*), PWP (0.850**), and significant negative correlations with BD (-0.818**), RS (-0.622*) and AWC (-0.630*) (Table 3). Increasing soil organic C content by the application of TW caused decreases in BD, θ and RS with increasing the total porosity. In many studies, it is indicated that soil organic matter content gives a significant negative correlation with bulk density and a significant positive correlation with total porosity (Candemir and Gülser, 2011; Gülser et al., 2016, Gülser et al., 2020). Demir and Gülser (2015) investigated the effects of rice husk compost on some soil quality parameters under greenhouse conditions. They reported that the highest positive correlations among the soil quality parameters were determined between OM and PWP (0.924**), AWC and FC (0.907**), OM and FC (0.897**), CO_2 and PWP (0.862**), PWP and FC (0.791**); while the highest negative correlations were found between BD and FC (-0.854**), BD and PWP (-0.871**), BD and OM (-0.868**), BD and CO2 (-0.838**), BD and P (-0.821**), Ca and FC (-0.812**). Gülser (2006)

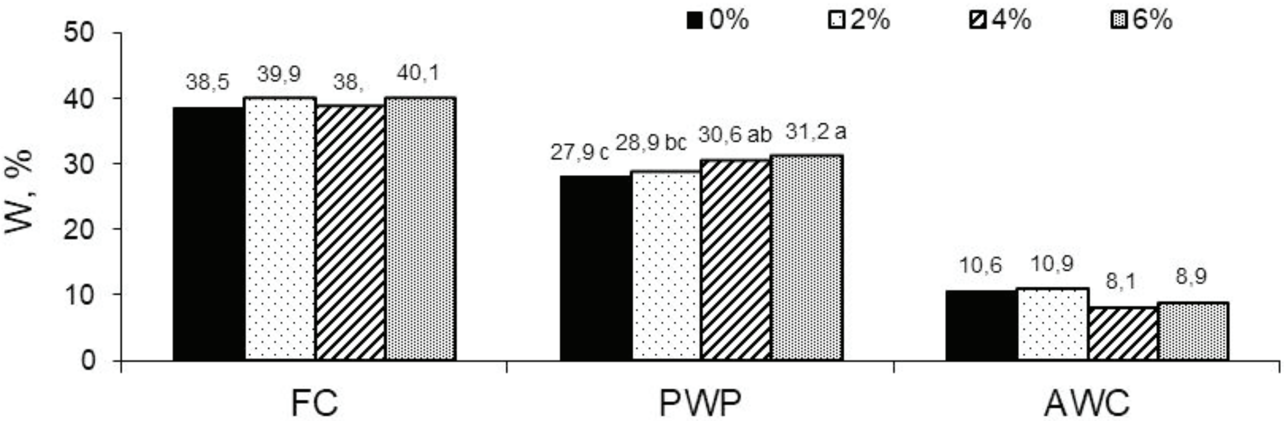

Figure 2. The effects of tobacco waste application rates on moisture content (W) at field capacity (FC), permanent wilting point (PWP) and available water content (AWC).

Şekil 2. *Tütün atığı uygulama dozlarının tarla kapasitesi (FC), daimi solma noktası (PWP) ve yarayışlı su (AWC) içeriğiindeki nem miktarın (W) üzerine etkileri.,*

Table 3. The correlations among the soil properties.
Çizelge 3. *Toprak özellikleri arasındaki korelasyonlar.*

	BD	W	θ	RS	F	Fa	FC	PWP	AWC
OC	-0.818**	0.288	-0.473	-0.622*	0.818**	0.675*	0.199	0.850**	-0.630*
BD		-0.089	0.749**	0.893**	-1.000**	-0.924**	-0.123	-0.675*	0.522
W			0.592*	0.364	0.089	-0.299	0.502	0.296	0.040
θ				0.965**	-0.749**	-0.946**	0.215	-0.357	0.444
RS					-0.893**	-0.996**	0.076	-0.491	0.478
F						0.924**	0.124	0.675*	-0.521
Fa							-0.064	0.537	-0.512
FC								0.131	0.484
PWP									-0.805**

Correlation significant ** at 0.01 level, * at 0.05 level.

reported that increasing macroaggregation in a clay soil due to forage cropping caused increases in organic matter content in soil and decreases in bulk density values. In another study, Gülser (2004) found that increasing soil organic matter content decreased bulk density with increasing total porosity. Air filled porosity had significant positive correlation with F (0.924**), and negative correlations with BD (-0.924**), θ (-0.946**) and RS (-0.996**). PWP also gave significant positive correlation with F (0.675*), and significant negative correlations with BD (-0.675*) and AWC (-0.805**). Iqbal et al. (2005) studied spatial variability of OM, FC, PWP and AWC values and reported that increasing OM content in the field caused increases in FC and PWP values.

CONCLUSION

Addition of TW into the clay soil increased organic C content, F, Fa, FC and PWP by reducing RS and bulk density. According to the control treatment, decreases in RS and increases in F, Fa, FC and PWP by the different rates of TW were generally in the same order as follows; TW6% > TW4% > TW2%. The different rates of TW had different effects on soil structural properties of clay soil with increasing organic matter content and reducing BD. It can be concluded that tobacco waste application had positive effects on improving soil structural properties. Although application of TW to the clay soil increased gravimetric water content over the control, air filled porosity increased with increasing F and decreasing RS. It is important for plant root respiration and microbial activity especially in clay soils. The higher application dose of TW increased total porosity but decreased AWC of clay soil over the control treatment. The application dose of organic wastes, like a TW application, to clay soils should be selected carefully with considering the soil moisture characteristic curve behavior. Local agricultural wastes can be used as a soil conditioner to improve soil physical properties of soils located under similar climatic conditions of Black Sea Region.

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Evaluation of Quality of Some Well Waters Used in Agricultural Irrigation in terms of Plant Nutrition

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Abstract

In this study, where the suitability of groundwater for irrigation in terms of soil and plants was evaluated, samples were taken from 11 drilling wells used for irrigation in some regions of Kahramanmaraş province. Chemical parameter values such as pH, EC, RSC, SAR, TDS, TH, Na%, PI, SSP, MR, KR, PS were determined in the assessment of irrigation water quality. According to irrigation water quality criteria, all samples except for two samples were in the medium salt/low sodium water (C2S1) class in terms of EC values. TH values were determined as soft water in all well waters. It was determined that the well waters were not suitable for irrigation in terms of plants and soils, including 3 in terms of Na%, SSP, MRI and KR values, 2 for Boron, SAR and RSC values, and one each for pH and PI values. As a result, these wells, which are evaluated problematic for soil and plants in terms of special ionic, salinity and alkalinity, should be used by taking the necessary precautions or should not be used for irrigation.

Keywords: Kahramanmaraş, irrigation water quality parameters, plant and soil, salinity and alkalinity, SAR

Tarımsal Sulamada Kullanılan Bazı Kuyu Sularının Kalitelerinin Bitki Besleme Açısından Değerlendirilmesi

Öz

Yeraltı sularının toprak ve bitkiler açısından sulama için uygunluğunun değerlendirildiği bu çalışmada, Kahramanmaraş ilinin bazı yörelerinde sulama amacıyla kullanılan 11 adet sondaj kuyusundan örnekler alınmıştır. Sulama suyu kalitesinin değerlendirilmesinde pH, EC, RSC, SAR, TDS, TH, Na%, PI, SSP, MR, KR, PS gibi kimyasal parametre değerleri belirlenmiştir. Kalite kriterlerine göre, iki örnek dışında tüm örnekler EC değerleri bakımından orta tuzlu/az sodyumlu su (C2S1) sınıfında yer almışlardır. TH değerleri, bütün kuyu sularında yumuşak su olarak saptanmıştır. %Na, SSP, MR ve KR değerleri bakımından 3, Bor, SAR ve RSC değerleri için 2, pH ve PI değerleri bakımından ise birer adet olmak üzere kuyu sularının bitki ve toprak açısından sulamaya uygun olmadığı tespit edilmiştir. Sonuç olarak, özel iyonik, tuzluluk ve alkalilik açısından toprak ve bitkiler için problemli olarak değerlendirilen bu kuyular gerekli önlemler alınarak kullanılmalı ya da sulama amaçlı kullanılmamalıdır.

Anahtar Kelimeler: Kahramanmaraş, sulama suyu kalite parametreleri, bitki ve toprak, tuzluluk ve alkalilik, SAR

INTRODUCTION

The quality of irrigation water is very important in terms of soil fertility and plant nutrition, and it is adversely affected by the mixing of agricultural (fertilizers and pesticides), industrial and domestic wastewater with underground and surface waters, as it varies depending on the geology of

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its location (Kaykıoğlu and Ekmekyapar, 2005). The amount of cations and anions dissolved in the irrigation water determines the quality of that water and plays an important role directly and indirectly in terms of plant nutrition. It is an indirect effect that salt accumulated in the soil with water increases the osmotic pressure in the soil and causes physiological drought. The fact that elements and chemical compounds such as B, Cl, Na and HCO_3 in the irrigation water accumulate in the plant in large amounts and the growth of the plant slow down to the point, which it stops, is also direct effect (Grismer, 1990; Arslan et al., 2007; Jalali and Merrikhpour, 2008; Laz et al., 2018). However, the quality of irrigation water may also vary according to plant types such as halophyte and glycophite plant groups. In determining the quality of irrigation water; Electrical Conductivity (EC), anion (HCO_3^-, CO_3^{-2}, Cl-, SO_4^{-2}), cation (Na^+, K^+, Ca^{+2}, Mg^{+2}) content, various parameters [(Sodium Adsorption Rate (SAR), Residual Sodium Carbonate (RSC), Percent Sodium (Na%), Kelley Ratio (KR), Magnesium Content (MR), Permeability Index (PI), Total Hardness (TH), Potential Salinity (PS)] and graphical methods (Piper, US salinity, Wilcox diagrams, etc.) are used. Many researchers have used SAR, RSC, KI, PI, MR, PS and Na% values to evaluate the use of surface and groundwater as irrigation water (Arumugam and Elangovan, 2009; Ishaku et al., 2012; Nag and Ghosh, 2013; Wanda et al., 2013; Vincy et al., 2015; Al-Omran et al., 2017). In this study, it was aimed to determine for the suitability of the quality of groundwater taken from 11 wells used for agricultural irrigation in terms of plant nutrition in Onikişubat, Dulkadiroğlu, Göksun and Çağlayancerit regions of Kahramanmaraş in 2019 and 2020.

MATERIAL AND METHOD

Taking Groundwater Samples from Wells

In line with the demands of the farmers and water samples from 11 different boreholes used for irrigation in their fields at the locations and dates indicated in Table 1 two samples were taken from each well in line with the criteria determined by Ayyıldız (1990). Water samples were stored in 250 ml sterilized polyethylene plastic bottles at +4 °C in the refrigerator until analysis time.

Table 1. Locations and dates of samples taken from wells
Çizelge 1. *Kuyulardan alınan örneklerin lokasyonları ve tarihler*

Well Number	Taken place (district-neighborhood)	Year	Month
1. Well	Onikişubat - Suçatı	2019	April
2. Well	Onikişubat - Kümperli	2019	April
3. Well	Dulkadiroğlu - Çınar	2019	August
4. Well	Onikişubat - Kılavuzlu	2019	September
5. Well	Oniki şubat - Ilıca	2020	April
6. Well	Göksun - Taşoluk	2020	April
7. Well	Çağlayancerit - Fatih	2020	August
8. Well	Dulkadiroğlu - Çokyaşar	2020	August
9. Well	Dulkadiroğlu - Osman Bey	2020	August
10. Well	Onikişubat - Hacımustafa	2020	August
11. Well	Onikişubat - Kürtül	2020	August

Analysis of Taken Water Samples

In order to determine the properties of the samples taken, EC, pH, Na, Ca, K, Mg, CO_3, HCO_3, Cl and SO_4 analyzes were made. Their pH was determined by Mettler Toledo Seven Compact pH meter and electrical conductivity (EC) by Ezdo PL-700 AL brand EC meter devices. Taken from wells, concentrations of 4 major elements (Na, K, Ca, Mg) (me L^{-1}) and 12 trace elements (Al, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, and Zn) (mg L^{-1}) were measured by Agilent 5100 SVDV brand ICP-OES device (APHA, 1989). CO_3^{-2}, HCO_3^-, SO_4^{-2} and Cl^- concentrations were determined by titration method (Richards, 1954). The following 10 equations were used to determine the suitability of the well waters in terms of quality classes and plant nutrition:

Residual sodium carbonate (RSC): *$(CO_3^{-2}+HCO_3^{-2})-(Ca^{+2}+Mg^{+2})$ (meq L^{-1})*, (*Eaton*, 1950; Ragunath, 1987; *Aghazadeh and Mogoddam*, 2010). (1)

Sodium adsorption rate (SAR): [*$Na/\sqrt{((Ca+Mg)/2)}$*] (*meq L^{-1}*), (*Catrol*, 1962; *Freeze and Cherry*, 1979). (2)

Total amount of dissolved matter (TDS): 0.64**EC* (*mg L^{-1}*), (*Catrol*, 1962; *Freeze and Cherry*, 1979). (3)

Total hardness (TH): 2.497*Ca+4.115*Mg (*mg L^{-1} Ca CO_3*), *Sawyer and McCartly*, 1967; *Todd*, 1980). (4)

Exchangeable sodium percentage (Na%, ESP): [*Na⁺/(Na⁺+K⁺+Ca⁺²+Mg⁺²)*]*100 (%), (*Wilcox*, 1955; *Todd*, 1960). (5)

$$[Na^{+}/(Na^{+}+K^{+}+Ca^{+2}+Mg^{+2})]*100\ (\%)$$

Permeability index (PI): $[(Na^{+}.\sqrt{HCO_3})/(Na^{+}+Ca^{+2}+Mg^{+2})]*100\ (\%)$, (*Doneen*, 1964). (6)

Soluble sodium percentage (SSP): $[(Na^{+}+K^{+})/(Na^{+}+K^{+}+Ca^{+2}+Mg^{+2})]*100\ (\%)$, (*Todd*, 1960). (7)

Magnesium ratio (MR): $[Mg^{+2}/(Mg^{+2}+Ca^{+2})]*100\ (\%)$, (*Szabolcs and Darab*, 1964; *Raghunath*, 1987). (8)

Kelley ratio (KR): $Na^{+}/(Ca^{+2}+Mg^{+2})$ (*meq* L^{-1}), (*Kelley*, 1963). (9)

Potential salinity (PS): $Cl^{-} + {}^{1}/_{2}.SO^{-2}$ (*meq* L^{-1}), (*Doneen*, 1964). (10)

Statistical Analysis

Descriptive statistical analyzes of the data obtained as a result of laboratory studies were made using IBM SPSS Statistics 25.0 program.

RESULTS AND DISCUSSION

Descriptive Statistics of Chemical Parameters of Well Waters

Descriptive statistical data of chemical analysis of samples uptaken from wells are given in Table 3. The calculated coefficient of variation (CV) values were the highest parameter, RSC (817.42%), while the lowest parameters were Cd (0.00%), Co (0.00%), Cu (0.00%), Ni (0.00%) and Zn (0.00%) is. Generally, it shows low variability if CV <10%, moderate variability if 10%< CV< 100%, and high variability when CV> 100% (Zhou et al., 2012; Ağca, 2014). According to this classification, pH, Cd, Co, Cu, Ni and Zn values of waters are low variability, and RSC, Boron, Na, K, Cl, SO4, Al, Cr, Fe, Mn, Pb, %Na, PI, SSP, KR and PS values showed high variability, while other parameters also showed moderate variability (Table 3). Low CV values indicate homogeneous distribution of parameters, while high CV values indicate non-homogeneous distributions (Ağca, 2014). While the cation sequences were from large to small, $Na^{+} > Ca^{+2} > Mg^{+2} > K^{+}$, the anion sequences were determined as $HCO_3^{-} > Cl^{-} > SO_4^{-2}$. The sequence in the trace elements was also obtained as Al> Fe> Pb> Cd = Co = Cr = Cu = Mn = Ni = Zn (Table 3). Piper (1944) diagram was used to classify the types of according to the major anions and cations of the well waters used in this study. According to this; it was determined that wells of 1, 2, 4, 5, 6, 8 and 9th were Mg-HCO_3 type, wells 3 and 7 were Na-Cl type, well of 10th was mixed type and well of 11th was Na-HCO_3 type waters. Since the mineral content of the water varies according to the rocks it is in contact with and the dissolving conditions affecting these rocks, it is closely related to the interaction also with the bedrock and parent material it passes through (Karataş et al., 2016). Dissolved ions in excessive amounts in irrigation water adversely affect the chemical and physical structure of the soil and the growth of plants. The suitability of groundwater for irrigation in terms of plant nutrition depends on the effect of mineral concentrations on the soil and plants (Ekmekçi et al., 2005). Increased the concentration of dissolved ions in its content increases the electrical conductivity value (EC) and thus the total dissolved matter amount (TDS). TDS amount of water increases depending on natural resource, agricultural, urban, sewage and industrial wastewater (WHO, 2003). Since the hardness (TH) of the water is caused by the dissolved Ca^{+2} and Mg^{+2} ions, the excess of these ions has an enhancing effect TDS and EC.

Quality Parameters of Well Water and Suitability for Irrigation

pH: It affects the heavy metal content, carbonate balance and relative proportion of nitrogen components, thus soil quality and plant growth. In acidic waters, calcium and magnesium cannot be absorbed sufficiently by plants. Alkaline waters provide a better environment for plants to absorb various metals and plant nutrients. However, basic waters are responsible for the accumulation of calcium carbonate, which affects the physical structure of water (Şimşek and Gündüz, 2007). The absence of CO_3 in water indicates that pH is mainly related to HCO_3 hydrolysis (Zhou et al., 2012). The pH of the wells in this study varies between 7.20-9.70 and they are slightly alkaline waters with an average value of 7.83 (Table 3). Ayers and Westcot (1985) stated that the appropriate pH value for irrigation water is between 6.50-8.40. For this reason, only the third well out of the 11 sampled wells are not suitable for irrigation (Tables 2 and 4).

Electrical conductivity (EC): The EC concentrations of the waters taken from the wells are 345-2100 µS cm^{-1}, and the average is 740.55

Table 2. Classification of irrigation water quality criteria
Çizelge 2. *Sulama suyu kalite kriterlerinin sınıflaması*

Parameter	Range	Water class	Parameter	Range	Water class
pH[1]	6.5-8.4	Appropriate		<25	Class III-Not suitable
			PI (%)[9]	25-75	Class II-Good
	0-250	C1 Slightly saline water		>75	Class I-Excellent
	250-750	C2 Moderately saline water			
EC (μmbos cm^{-1})[2]	750-2250	C3 Strongly saline water		0-20	Excellent
	>2250	C4 Very strongly saline water		20-40	Good
			SSP (%)[8]	40-60	Permissible
	<1.24	Safe		60-80	Suspicious
RSC (me L^{-1})[3]	1.24-2.5	May vary depending on the plant		>80	Not available
	>2.5	Not available			
			MR (%)[10-11]	<50	Appropriate
	0-10	S1 Less sodium water		>50	Not available
	10-18	S2 Moderately sodium water			
SAR[2]	18-26	S3 Strongly sodium water		<1	Appropriate
	>26	S4 Very strongly sodium water	KR (me L^{-1})[12]	1-2	Suitable marginally
				>2	Not available
	<1000	Fresh water			
	1000-10000	Brackish water		<5	Excellent
TDS (mg L^{-1})[4-5]	10000-100000	Slightly Saline	PS (me L^{-1})[13]	5-10	From good to harmful
	>100000	Very strongly saline water		>10	Not available
	<75	Soft		<4	Excellent
	75-150	Moderately hard		4-7	Good
TH (mg L^{-1} $CaCO_3$)[6-7]	150-300	Hard	Cl^{-} (meL^{-1})[14]	7-12	Permissible
	>300	Strongly hard		12-20	Suspicious
				>20	Not available
	<20	Excellent			
% Na[8]	20-40	Good		<4	Excellent
	40-60	Permissible		4-7	Good
	60-80	Suspicious	SO_4^{-} (me L^{-1})[14]	7-12	Permissible
	>80	Not available		12-20	Suspicious
				>20	Not available

Bor (mg L^{-1})[3]			
Sensitive plants	Moderately sensitive plants	Resistant plants	Evaluation
0-0.32	0-0.66	0-0.99	None (Very good)
0.33-0.66	0.67-1.32	1.00-1.99	Slighly (good)
0.67-0.99	1.33-1.99	2.00-2.99	Moderately (Available)
1.01-1.25	2.00-2.50	3.00-3.75	Much (Suspicious)
>1.25	>2.50	>3.75	Too Much (Unavailable)

[1]Ayers ve Westcot (1989); [2]Tüzüner (1990); [3]Tuncay (1986); [4]Catrol (1962); [5]Freeze and Cherry (1979); [6]Sawyer and McCartly (1967); [7]Todd (1980); [8]Todd (1960); [9]Doneen (1964)); [10]Szabolcs and Darab (1964); [11]Raghunath(1987); [12]Kelly (1963); [13]Doneen (1962); [14]Ayyıldız (1983)

μS cm^{-1} (Table 3). 1., 2., 3., 4., 6., 7., 8. and 9. wells are in class C2 (medium salt water), 5., 7., 10. and 11. wells are in class C3 (high salt water) (Tables 2 and 4). C3 class waters cannot be used in lands with insufficient drainage. Even if the drainage is good, salt-resistant plants should be selected and special precautions should be taken to control salinity.

Boron: It is an element found in all waters, necessary for plant growth, but toxic at concentrations above the appropriate value. Although 0.2 mg L^{-1} boron is required in water for some plants, 1-2 mg L^{-1} can be toxic (Anonymous, 2020). Boron values in our water samples varied between 0.01-2.90 mg L^{-1}, and average is 0.48 mg L^{-1} (Table 3). Accordingly, the 7th and 11th wells are not suitable for irrigation for plants sensitive to boron (Tables 2 and 4).

Sodium percentage (Na%): It is used to determine the suitability of groundwater for agricultural irrigation (Wilcox, 1955). High amounts of Na in irrigation water are adsorbed by clay particles and replaced by Mg and Ca ions. The increase the Sodium Adsorption Rate (SAR) in irrigation water, means an increase also the SAR value of the soil saturation extract. As a result of this, the exchangeable sodium percentage (ESP) of the soil increases and the soil shows to tend to sodification (Sağlam and Adiloğlu, 1995). Na% concentrations of uptaken well waters, It varied between 1.92-95.64% and its average was determined as 32.60% (Table 3). Therefore, it has been determined that the 3rd, 7th and 11th well waters are not suitable for soil and plants according to Todd (1960) (Tables 2 and 4).

Sodium adsorption rate (SAR): Since it measures the danger of alkali/sodium, it is an important parameter that determines the appropriateness of the use of groundwater for irrigation water purpose (Subrahmani et al., 2005). The excess Na^+ makes the tillage difficult by reducing the permeability of the soil and negatively affects the plant growth (Todd, 1980; Todd and Mays, 2005; Berhe et al., 2015). For well waters SAR values, it was between 0.06-17.14, and its average also determined as 4.30 (Table 3). According to Table 2, the waters of the 3rd and 7th wells are in S2 class (medium sodium water), the others are in S1 (low sodium water) class (Table 4). In S1 class water can be used safely for irrigation of almost every type of soil. However, harmful amounts of sodium may accumulate in the bodies of stone fruit trees such as almond and apricot that are too sensitive to sodium. Class S2 waters have high cation exchange

Table 3. Descriptive statistical data of well water parameters (n = 11)
Çizelge 3. *Kuyu suyu parametrelerinin tanımlayıcı istatistiksel verileri (n=11)*

	n	Minimum	Maximum	Mean	Std. Deviation	Coefficient of variation (CV)
pH	11	7.20	9.70	7.83	0.67	8.51
EC (μmbos cm^{-1})	11	345.00	2100	740.55	507.97	68.59
Bor (mg L^{-1})	11	0.01	2.90	0.48	0.95	198.24
Na^+ (meq L^{-1})	11	0.08	21.94	4.05	6.57	162.24
K^+ (meq L^{-1})	11	0.00	0.12	0.03	0.03	112.55
Ca^{+2} (meq L^{-1})	11	0.09	5.67	2.71	1.49	55.24
Mg^{+2} (meq L^{-1})	11	0.16	6.70	2.43	2.19	90.42
HCO_3- (meq L^{-1})	11	2.27	9.21	5.51	2.06	37.38
Cl^- (meq L^{-1})	11	0.03	19.24	2.97	5.60	188.59
SO_4^{-2} (meq L^{-1})	11	0.04	3.25	0.72	0.90	124.42
RSC (meq L^{-1})	11	-5.11	6.15	0.39	3.14	817.42
SAR	11	0.06	17.14	4.30	6.73	156.53
TDS (mg L^{-1})	11	220.80	1344	473.95	325.10	68.59
TH (mg L^{-1} $CaCO_3$)	11	0.85	35.57	16.73	11.09	66.33
%Na	11	1.92	95.64	32.60	38.08	116.83
PI (%)	11	3.68	231.7	76.78	86.44	114.06
SSP (%)	11	2.12	96.03	32.89	38.21	116.18
MR (%)	11	6.46	75.67	44.60	19.10	42.83
KR (meq L^{-1})	11	0.02	24.1	3.33	7.24	217.65
PS (meq L^{-1})	11	0.05	19.68	3.33	5.65	169.79

capacity (CEC) and can therefore be used in coarse and organic soils with high permeability.

Soluble sodium percentage (SSP): It helps to determine the Na hazard of irrigation water. When the Na^+ concentration is excess, it is adsorbed by clay particles and replaced by Ca^{+2} and Mg^{+2} ions. This change reduces permeability in the soil and causes poor internal drainage (Saleh et al., 1999; Collins and Jenkins, 1996) and can stop plant growth (Joshi et al., 2009). SSP values of the wells studied, it varied between 2.12-96.03%, and its average was found to be 32.60% (Table 3). Quality classes, 1., 2., 6., 8., 9. and 10. wells excellent, 4. and 5. wells good but, 3., 7. and 11. wells are not suitable for irrigation (Tables 2 and 4).

Residual sodium carbonate (RSC): It is used to determine the effect of carbonate and bicarbonate in irrigation water on water quality. In soils irrigated for a long time with irrigation waters of which RSC value exceeds 2.5 me L^{-1}, Na accumulation causes salinization and sodification problems in soils over time. The RSC values of groundwater uptaken from the wells were between -5.11-6.15 me L^{-1}, and its average was also found 0.38 me L^{-1} by us (Table 3). Accordingly, the 5th and 11th wells are not suitable, the 3rd, 4th and 7th wells differ depending on the plant, the other wells have been determined in the safe class (Tables 2 and 4).

Total amount of dissolved matter (TDS): It is another indication of salinity in water. When there is excessive amount of salt coming from major ions in irrigation water, it affects the osmotic activities of plants and prevents adequate aeration (Obiefuna and Sheriff, 2011). The calculated TDS values of the well waters ranged between 220.80-1344 mg L^{-1}, and its average was also found to be 473.95 mg L^{-1} (Table 3). According to the class values in Table 2, it was determined that only the 7th well water is brackish water and the others are in the fresh water class (Table 4).

Total hardness (TH): The hardness of the waters comes from the ions of calcium and

Table 4. Chemical analysis data of well waters
Çizelge 4. *Kuyu sularının kimyasal analiz verileri*

Parameter	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
pH	8.00	7.49	9.70	7.92	7.20	7.55	7.68	7.55	7.91	7.40	7.71
EC (µmhos cm^{-1})	345.00	434	433	490	1050	388	2100	580	560	935	831
Boron (mg L^{-1})	0.01	0.01	0.04	0.13	0.32	0.01	2.90	0.05	0.03	0.03	1.76
Na^+ (me L^{-1})	0.08	0.10	5.81	2.68	3.80	0.09	21.94	0.20	0.20	0.99	8.61
K^+ (me L^{-1})	0.01	0.01	0.02	0.04	0.05	0.00	0.12	0.01	0.01	0.02	0.04
Ca^{+2} (me L^{-1})	2.84	2.99	0.09	2.50	4.12	3.47	1.64	2.15	3.11	5.67	1.17
Mg^{+2} (me L^{-1})	1.07	2.10	0.16	1.91	1.86	0.24	1.63	6.70	4.96	5.21	0.83
CO_3^{-2} (me L^{-1})	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCO_3^- (me L^{-1})	3.36	4.41	2.27	6.64	9.21	3.72	5.20	6.45	5.48	5.76	8.14
Cl^- (me L^{-1})	0.48	0.50	0.55	0.45	0.11	0.03	19.24	2.24	2.22	5.18	1.67
SO_4^{-2} (me L^{-1})	0.16	0.29	3.25	0.04	0.52	0.06	0.89	0.37	0.59	0.94	0.83
RSC (me L^{-1})	-0.55	0.68	2.03	2.23	3.23	0.01	1.92	-2.40	-2.60	-5.11	6.15
SAR	0.06	0.06	16.73	1.80	2.20	0.06	17.14	0.10	0.10	0.42	8.63
TDS (mg L^{-1})	222.80	277.76	277.12	313.60	672.00	248.32	1344.00	371.20	358.40	598.40	531.84
TH (mg L^{-1} $CaCO_3$)	11.49	16.11	0.85	14.11	17.94	9.66	10.82	32.93	28.20	35.57	6.31
% Na	2.00	1.92	95.64	37.56	38.67	2.29	86.61	2.22	2.46	8.30	80.90
PI (%)	3.68	4.05	144.66	97.34	117.97	4.41	198.41	5.64	5.77	19.96	231.70
SSP (%)	2.25	2.12	96.03	38.12	39.19	2.37	87.07	2.32	2.57	8.44	81.28
MR (%)	27.37	41.26	64.73	43.35	31.07	6.46	49.85	75.67	61.45	47.88	41.52
KR (me L^{-1})	0.02	0.02	24.10	0.61	0.64	0.02	6.70	0.02	0.03	0.09	4.32
PS (me L^{-1})	0.56	0.65	2.18	0.47	0.36	0.05	19.68	2.42	2.52	5.65	2.09
Water class	C2S1	C2S1	C2S2	C2S1	C3S1	C2S1	C3S2	C2S1	C2S1	C3S1	C3S1

magnesium, which were dissolved in it (Varol et al., 2005; Boysan and Şengörür, 2009). It is measured in German, French, American and British degrees of hardness. The THs of the sampled well waters were found between 0.85-35.57 mg L^{-1} $CaCO_3$ and the average was determined as 16.73 mg L^{-1} $CaCO_3$ by us (Table 3). Hard waters are preferred in terms of irrigation water quality. Because, hard water forms soft soil and soft water forms hard soil (Sağlam and Adiloğlu, 1997). Since the waters of all the wells studied are <75 mg L^{-1} $CaCO_3$, they are in the soft water class (Tables 2 and 4). Therefore, continuous use of these waters will cause problems for plants as they will harden the soil over time.

Permeability index (PI): PI value is used to determine the possible effect of water quality on the physical properties of the soil. PI values in the water samples uptaken ranged from 3.68% to 231.70% and the average was found to be 72.78% (Table 3). Accordingly, the 1st, 2nd, 6th, 8th, 9th and 10th wells are not suitable for irrigation for plants (III. Class), and the 3rd, 4th, 5th, 7th and 11th wells are It has been identified as perfect water (Class I) (Tables 2 and 4).

Magnesium ratio (MR): High Mg^{+2} ratio in water makes the soil salty and negatively affects plant growth and yield (Joshi et al., 2009; Venugopal et al., 2009). The MR rates of the well waters varied between 6.46-75.67% and the average was determined as 44.60% (Table 3). According to these data, except the 3rd, 8th and 9th wells, the others were found to be suitable for irrigation (Table 4).

Kelley ratio (KR): Against the amount of Na^{+}, it is expressed as Ca^{+2} and Mg^{+2} ratio. Water with a Kelley ratio of <1 is considered suitable for irrigation. The KR values of the examined wells varied between 0.02-24.10 me L^{-1}, and the average was found to be 3.32 me L^{-1} (Table 3). According to these values, the 3rd, 7th and 11th wells are not suitable for irrigation (Tables 2 and 4).

Potential salinity (PS): Depending on the chlorine and sulfate, it determines the danger of the high amount of salt that will occur. The PS amounts of the well waters uptaken was found between 0.05 me L^{-1} and 19.68 me L^{-1} and its average as also 3.33 me L^{-1} by us (Table 3). The potential salinity classes of well waters, the 7th well is not suitable for irrigation, the 10th well varies from good to harmful and the other wells are determined as excellent water. According to the analysis results, it was determined that the waters uptaken from 11 wells are suitable for continuous irrigation in every soil in terms of trace elements such as Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn. Because the determined concentrations of these elements were found to be far below the upper limit values that should be found in irrigation water (Table 5). Since the trace elements cannot accumulate in the soil with irrigation water, it will not be a problem for the plants.

CONCLUSIONS

In this study, the suitability of groundwater for irrigation in terms of plant nutrition was

Table 5. Trace element tolerance limits in irrigation water and irrigation duration
Çizelge 5. *Sulama suyunda iz element tolerans sınırları ve sulama süresi*

		1. Well	2. Well	3. Well	4. Well	5. Well	6. Well	7. Well	8. Well	9. Well	10. Well	11. Well	Continuous for every soil (mg L^{-1})	Short term in fine textured soils (mg L^{-1})
Al	(mg kg^{-1})	0.01	0.01	0.02	0.01	0.32	0.03	0.00	0.00	0.00	0.00	0.02	1.00	20.00
Cd		0.000	0.000	0.000	0.001	0.002	0.000	0.001	0.001	0.001	0.001	0.001	0.005	0.05
Co		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	10.00
Cr		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00	5.00	20.00
Cu		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	5.00
Fe		0.00	0.00	0.01	0.01	0.26	0.01	0.01	0.01	0.01	0.01	0.01	2.00	5.00
Mn		0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.00	20.00
Ni		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.50	2.00
Pb		0.00	0.00	0.12	0.01	0.01	0.00	0.01	0.03	0.01	0.02	0.01	5.00	20.00
Zn		0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	5.00	10.00

evaluated, belonging to 11 different wells used in Kahramanmaraş. In determining the use of well waters as irrigation water, evaluations were made using chemical parameters such as pH, EC, TDS, SAR,% Na, RSC, SSP, MR, KI, PI, PS, TH. Accordingly, 5 out of 11 wells showed low variability, 8 of them moderate and 17 of them high variability. From this situation, it is understood that the waters have a partially homogeneous distribution (in 5 wells). In terms of pH, it was determined that all well waters except well number 3 are suitable for irrigation in terms of plant nutrition and soil fertility. In terms of EC values, wells 5 and 7 are respectively in strongly saline/low sodium water (C3S1) and strongly saline/moderately sodium water (C3S2) class. Since C3S1 type waters is not suitable as irrigation water, salt-resistant plants should be selected, regular washing and special soil cultivation programs should be applied. Since C3S2 type waters are not suitable for irrigation, salt-resistant plants should be chosen and they should be used in coarse-textured or organic soils, rich in gypsum with good permeability. Other wells are C2S1 type waters (moderately saline/ low sodium water) and can be used for all plants. It was determined that the 7th and 11th wells were not suitable for irrigation for Boron sensitive plants. Except for the 7th well, the TDS values of other 10 wells were classified as fresh water. TH values were determined as soft water in all well waters. In terms of Na% and SSP values, 8 wells other than the 3rd, 7th and 11th wells were found to be in the appropriate class for soil and plants. According to the SAR values of the well waters, 9 wells except the 3rd and 7th wells are low sodium water (S1). In terms of PI values, 1st, 2nd, 6th, 8th, 9.ve 10th wells are not suitable for irrigation for plants (III. class), 3rd, 4th, 5th, 7.ve 11th wells are excellent waters in feature (I. Class). According to the RSC values, the wells other than the 5th and 11th wells, according to the MR values the wells other than the 3rd, 8th and 9th wells, according to the KR values, the wells other than the 3rd, 7th and 11th wells and according to PS values the wells other than the 7th well have been found suitable for irrigation. In the evaluations made, determined as problematic for soil and plants in terms of special ion, salinity and alkalinity, and the well waters given its numbers above should be used by taking the necessary precautions or not used for irrigation.

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A Study on Expansion Possibilities of Irrigated Areas in Uluırmak Irrigation Basin and Production Planning According to Water

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Abstract

In this study, it is aimed to determine the current irrigation management and performance data in Uluırmak irrigation, to investigate the possibilities of expanding the irrigated areas in the network, and to calculate the optimum production patterns of agricultural enterprises. This study was carried out in 1995 and the results of this study were comparatively reviewed between 1995 and 2020 years. The data used in the study consists of primary data obtained from the surveys conducted with face-to-face interviews with a total of 72 enterprises in the region, determined by stratified sampling method. Linear programming method was used to determine the optimum production patterns according to the current situation in the irrigation basin and the expansion of irrigated areas. The average width of the farmland in the region is 74.42 decares (da), 47.75 da of which is irrigated agricultural land. After the planning made in accordance with the current conditions in the enterprises examined, wheat came to the plan with a maximum of 20.92 da, respectively, sugar beet (9.87 da), sunflower (5.89 da), beans (4.78 da), alfalfa (2.78 da), vegetables (2.89 da), and barley (1.12 da). In addition, the total gross profit of the enterprise reaches 445.4 TL, with 2.29 dairy cows (cultural hybrid) and 18.95 sheep coming to the plan in planned production. In case of the completion of the missing investments in the irrigation network and the expansion of the irrigated lands, the irrigated lands will increase by 33.33% and the gross profit will increase by 60.48% compared to the current situation and reach 472.4 TL. One of the important results of the study is that the average irrigated field land, which is 47.75 da, has increased to 64.20 da (34.45%) with the expansion of irrigated lands and planned water use.

Keywords: Production planning, optimization, irrigation management

Uluırmak Sulama Havzasında Sulanan Alanların Genişletilmesi İmkanları ve Suya Göre Üretim Planlaması Üzerine Bir Çalışma

Öz

Bu çalışmada, Uluırmak sulamasında mevcut durumdaki sulama yönetimi ve performans değerlerinin tespiti ile şebeke içinde fiilen sulanan alanların genişletilme imkanlarının araştırılması ve tarım işletmelerinin optimum üretim desenlerinin hesaplanması amaçlanmıştır. Çalışma 1995 yılında yapılmış olup, o dönemde yapılan çalışmanın sonuçları ile günümüz (2020) gerçekleşme verileri karşılaştırmalı olarak da incelenmiştir. Araştırmada kullanılan veriler bölgede yer alan, tabakalı örnekleme yöntemiyle belirlenen, toplam 72 adet işletme ile yüz yüze görüşme yöntemiyle uygulanan anketlerden elde edilen birincil verilerden oluşmuştur. Sulama havzasında mevcut durum ve sulanan alanların genişletilmesi durumlarına göre optimum üretim desenlerinin belirlenmesinde ise doğrusal programlama yöntemi kullanılmıştır. Bölgede ortalama işletme arazisi genişliği 74.42 da olup, bunun 47.75 da sulu tarım

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alanından oluşmaktadır. İncelenen işletmelerde mevcut şartlara göre yapılan planlama sonrasında suluda en fazla 20.92 dekar ile buğday plana gelirken bunu sırasıyla şekerpancarı (9.87 da), ayçiçeği (5.89 da), fasulye (4.78 da), yonca (2.78 da), sebze (2.89 da) ve arpa (1.12 da) izlemektedir. Ayrıca, planlı üretimde işletme başına 2.29 süt ineği (kültür melezi) ve 18.95 koyun plana gelmesi ile işletmenin toplam brüt karı % 51.33 artarak 445,4 TL'ye ulaşmaktadır. Sulama şebekesi içinde eksik yatırımların tamamlanarak fiilen sulanan arazilerin genişlemesi durumunda yapılan planlama ile sulanan araziler, %33.33 oranında artabilecek ve brüt kar mevcut duruma göre % 60.48 oranında artarak 472,4 TL'ye yükselecektir. Yapılan araştırmanın önemli sonuçlarından birisi de 47.75 da olan ortalama sulu tarla arazisi sulanan arazilerin genişlemesi ve planlı su kullanımı ile 64.20 da (% 34.45) yükselmiştir.

Anahtar Kelimeler: Üretim Planlaması, optimizasyon, sulama İşletmeciliği

INTRODUCTION

Improving and using efficiently soil and water resources have become more of an issue in order to meet the basic needs of the population that increase rapidly in the World and also Turkey and to increase the contribution of the agricultural sector to the national economy. While drought and water scarcity-related pressure overproduction has been increasing in recent years, 2050 and 2100 projections have shown that negative effects of water scarcity and drought on production will increase dramatically. Therefore, it is very important to plan production by water asset, to use water as credit, and to produce products consuming less water and having high earning value. To this end it is necessary to review immediately the political, administrative and technical structure about irrigation management and to take essential precautions.

An increase in water demand due to increase in population while water resources are stable causes a raise in the need for water day by day. The useable water amount has been decreasing due to climate change in the World caused by the rapid increase in population and industrialization (Selek and Arslan, 2019). As one examines the studies realized about water and water management, it is seen that most of the studies are about increasing water, which is a scarce resource, with the help of effective and productive use of water and by measuring irrigation performances. In the study realized by Cin and Çakmak (2017), the irrigation performance of Irrigation Cooperative in Ankara Beypazarı Başören ,where irrigation is realized by groundwater, has been assessed. For this purpose, performance indicators for determining water usage effectiveness, agricultural effectiveness and social, and economic effectiveness in the research area have been stated. However, there is a study realized by Uçar and Kara (2016) aiming to determine the effects of land consolidation on water transmission and distribution at the secondary canal level within Isparta-Atabey irrigation network. In addition, there is another study done by Demir (2010) which aims firstly to examine the existing situation of irrigation management, and secondly to detect the main problems of irrigation facilities in Daphan Lowland.

On the other hand, another issue examined by the studies about improving soil and water resources is increasing irrigated areas with irrigation investment constructions. Approximately 6.7 million hectares of total 8.5 million hectares irrigable areas having an economic value have been opened for irrigation in our country. Also, another issue that should be taken into consideration on development of soil and water resources is to ensure effective and productive management of existing irrigation facilities as well as to enlarge irrigated agricultural areas. Regardless of how perfectly an irrigation facility has been built if it is not managed properly and maintenance and repair are not done timely and completely, it is not possible to realize the expected utility from such a facility. Today in our country irrigation facilities are either run by the public institutions or transferred to Irrigation Association, Irrigation Cooperative, Municipality, or Local Authority of Village.

Irrigation plays an important role in the diversification of production patterns and increases in production and income by the transition from dry farming to irrigated farming. Especially in areas such as Central Anatolia where there is arid/semi-arid climate, it becomes very important to manage irrigation facilities effectively, increase irrigation effectiveness and produce products that can be cultivated on irrigated areas and that provide high economic income to producers. Areas, that are not irrigated while there is an opportunity to get irrigated, should be considered as loss of national wealth. In this context, although there has been an irrigation facility opened in 1965 in Aksaray Uluırmak Basin with the capacity to irrigate 204.400 da it has been detected that there was an irrigation demand for approximately 150.000 da and there was no irrigation demand for 50.000-60.000 da according to data of General Directorate of State Hydraulic Works; therefore the need has emerged to make a research on performance assessment, determination of reasons behind areas that cannot be irrigated and development of solution offers to these reasons. With this study, it is targeted to determine existing irrigation management and performance values of Uluırmak irrigation, search for opportunities to enlarge actually irrigated areas, and calculate optimum production patterns of agricultural enterprises in other words determine optimum production pattern according to water and reveal effects of enlarging irrigated areas of agricultural enterprises on optimum production patterns. However, it is also targeted to review comparatively production planning results in 1995 and today's data.

MATERIAL AND METHOD

The main material of research has been primary data obtained by questionnaires realized in 1995 with agricultural enterprises existing in Uluırmak irrigation basin. Besides, results of the study carried out in 1995 have been examined comparatively with data in 2020 (comparison of different periods). While realizing economic analysis of agricultural enterprises, coefficients stated in related literature (Açıl and Demirci, 1984; Erkuş et.al., 1995) have been used in specifying workforce potential and stating it as Male Labor Unit. While calculation gross production value of enterprises, sale prices of main and by-product of farmers have been taken into consideration; while calculating gross production value, brut profit and gross revenue that are used to evaluate success levels of enterprises following ways have been used: Gross production value (GPV) has been calculated by multiplying the amount of plant and animal products obtained as the result of agricultural activity with prices obtained by producer and adding the productive increase in plant and animal capital to this amount. Brut profit (BP) has been calculated by deducting changing expenditures from gross production value and Gross Revenue (GR) has been calculated by deducting enterprise expenditures from gross product (Açıl and Demirci, 1984). Also, data of investing institutions such as Irrigation Associations, State Hydraulic Works, and abolished General Directorate of Village Services (GDVS) that are responsible for water management and water distribution services have been utilized.

The main mass in the study has composed of 586 agricultural enterprises selected from the city center of Aksaray Province (8 neighborhoods), 5 towns, and 15 residential areas with village status that were within the right-coast and left-coast irrigation network of Uluırmak irrigation basin in the year when this study was conducted (1995). Stratified sampling has been applied, questionnaires with 72 enterprises selected as samples have been realized, data has been collected and analyzed.

Unirrigated areas in the network and reasons behind it have been detected together with SHW technical experts by fieldwork; solutions have been offered after detecting planning, project, construction, and managing problems about canal, valve, outlet, field gates, culvert, etc. that block water transfer and also farmer related failing and insufficiencies.

Linear Programming Method has been used to determine optimum management organizations in the current situation and after enlarging actually irrigated areas by completing missing irrigation investments. Linear programming basically ensures to allocate scarce sources between competing activities in the most appropriate way in line with a determined aim. A linear programming model is composed of three main elements: 1. An aim function to be maximized or minimized 2. Restrictor cluster 3. Condition of decision variables not less than zero (Uzunkaya and Gül, 2017)

RESULTS AND DISCUSSION

Mamasın Dam which locates at the north east of Aksaray Province (20 km) is the source of Uluırmak irrigation. Water taken from this dam is brought to a regulator built right outside Aksaray Province (3 km). Water brought to this regulator is divided into right and left coast main canals. The right-coast main canal is 38,255 meters

Table 1. Information on Uluırmak Irrigation
Çizelge 1. *Uluırmak Sulamasına Ait Bilgiler*

Characteristics	1995	2020
Managing Organization	1.Right Coast Irrigation Assoc. 2.Left Coast Irrigation Assoc.	Uluırmak Irrigation Assoc. (Left coast+ right coast)
Irrigation Area (da)	204.220	200.000
Actually Irrigated Area (da)	133.691	142.245
Service Areas	Total 25 Settlements (village, neighborhood), 5 of which are municipalities	1 Municipality, 4 Town, 14 Villages, 6 Neighborhoods
Network Feature -Right Coast Main canal	- 38 255 m main canal, - 12 m3sec^{-1} capacity - 12 spare canal	Water users from whom declaration were collected 1702 Number of water users 2607 Rate of declaration collection 83%
-Left Coast Main Canal	- 14.255 m main canal - 6 m^3sec^{-1} capacity - 5 spare canal	

Resource: Anonymous,1995 and Irrigation Association Documents

and has 12 m^3sn^{-1} capacity; the left-coast main canal is 14,255 meters and has 6 m^3 sn^{-1} capacity (Anonymous, 1984). Mamasın dam is an irrigation dam and it is projected to provide 138.56*106 m^3 irrigation water annually (Anonymous, 1984). Irrigation on the field is realized mostly through auxiliary canals and outlets built on tertiary. Aksaray is a province letting in immigrants and growing rapidly since it is at the intersection of East, South, and Central Anatolia. Due to irregular migration and growing, misuse of productive soils within the network has been increasing day by day; therefore, it is necessary to take irrigation project areas under protection and prevent misuse of areas. Data on irrigation network is stated in Table 1.

Current Structural Features of Enterprises

Most of the agricultural enterprises dealing with irrigated farming on Uluırmak irrigation basin are enterprises that realize farming on their private property. Also, type and distribution of lands belonging to examined enterprises are stated in Table 2. The average land size of enterprises is 74.42 da and 95.36% (70.97) of these lands are field land (irrigated + dry). Furthermore, even if a little, there are vegetable gardens, vineyards, and orchards.

Lands are scattered and fragmented. The numbers of fragments change between 2 and 11 and the average number is 6.53. Although

Table 2. Land Distribution on Farms (1995)
Çizelge 2. *İncelenen İşletmelerde Arazi Dağılımı (1995)*

Type of Lands of Enterprises	Da	%
Field Land	70.97	95.36
Irrigated	47.15	
Dry	23.82	
Vegetable	0.60	0.81
Fruit	0.13	0.17
Vineyard	0.51	0.69
Woodland	0.49	0.66
Other (*)	1.72	2.31
Average of Enterprises	74.42	100.00

(*) Lands with problems such as high groundwater and salinity

land consolidation has been realized in some parts of the network, fragmentation has been continuing because of the Law of Inheritance. The average population in the examined enterprises is 6.36 persons and the main labor force is the population between ages 15 and 49. The labor force of an enterprise has been calculated as Male Labor Unit (MLU) by age and gender and it is 4.28 MLU. Also, the literacy rate in the area is 87.90% and the rate of people who cannot read and write is 11.60%.

Examined enterprises have been classified according to capital functions. Accordingly, active capital in enterprises is 2293.5 TL, and farm capital has constituted the most active capital. Furthermore, in consideration of all enterprises, 64.79% of active capital is farm capital and 35.21% of it is working capital.

Economic Analysis of Enterprises

In the research area, results of activities such as gross production value, production value, brut profit, gross revenue, and agricultural income of enterprises have been analyzed. The rate of plant production value in total gross production value is calculated as 69.49%, and ; rate of animal production value is calculated as 30.52%.

Industrial plants have taken the first rank in plant production value with the rate of 60.13%. Cereals have followed industrial plants with the rate of 28.14% in plant production value and legumes have taken the third place with the rate of 4.89%.

Sugar beet (53.97%) and sunflower (45.76%) are industrial plants in plant production value. Mostly wheat (68.10%) and barley (30.63%) have been planted as cereals. Dairy farming has taken first place in animal production value with the rate of 11.42% and inventory value increase has followed this with 10.20% and sheep breeding has come behind with 8.44%.

Gross revenue of examined enterprises that indicates the success of enterprises has been calculated as 173.7 TL and agricultural income, another success indicator, has been detected as 211.4 TL.

Irrigation Results and Performance Evaluation of Uluırmak Irrigation

The distribution of plants irrigated in the irrigation area in some selected years has been indicated in Table 3. While in the period of research the most important plants cultivated with irrigation were cereals, sunflower, and sugar beet, in the following years' cereals have protected their importance in the area and also in times of drought cultivation rate of cereals had increased, but then it has seen that important changes in production pattern had emerged later. With the increase in income obtained from sunflower, its production area has increased dramatically and the production area of sugar beet has decreased due to the quota applied by the government. Change in production pattern has led to change in water consumption and irrigation water demand.

Table 3. Distribution of Plants Irrigated by Uluırmak Irrigation
Çizelge 3. *Uluırmak Sulaması Sulanan Bitkilerin Dağılımı (%)*

Irrigated Plants	1995	2000	2005	2010	2015	2020
Cereals	45	48	64	47	40	50
Sugar beet	17	17	9	6	4	2
Sunflower	24	27	17	35	40	31
Legumes	3	0	0	0	0	0
Maize	0	0	4	3	5	6
Fodder Crop	5	2	4	6	7	8
Water-melon	2	0	0	1	0	0
Fruit	2	1	1	1	1	1
Vegetable	2	0	1	1	1	1
Other (onion, garlic)	0	5	0	0	2	1
Total	100	100	100	100	100	100

On the other hand, Uluırmak irrigation network is open canal irrigation and most of the farmers realize surface irrigation, they pay the cost of irrigation according to plant variety and land size irrigated, so the cost of irrigation changes with the size of enterprises. Rate of cost of irrigation under total enterprise costs changes between 2.61% and 3.27%.

The productivity of irrigation networks has been measured by performance evaluation. To this end, criteria such as irrigation rate, irrigation efficiency, plant pattern, irrigation price, realization and collection rates are utilized. Irrigation results and performance indicators in Uluırmak irrigation area (left-coast and right-coast) in 1995 and 2000 have been indicated in Table 4.

As indicated in Table 4 although the amount of water per hectare has decreased irrigation rate has been 63% and the irrigation efficiency rate has been 65% in 2000 while the irrigation rate was 65% and the irrigation efficiency rate was 45% in 1995. One of the most important factors behind this increase in rates has been the use of sprinkler and drip irrigation systems which are types of pressurized irrigation systems by the farmers in recent years. Reasons for not irrigating have been stated in Table 5.

Management and maintenance and repair services of Uluırmak irrigation have been transferred to Right Coast Irrigation Association and Left Coast Irrigation Association in

Table 4. Uluırmak Irrigation Performance Indicators for 1995 and 2020 Period
Çizelge 4. *Uluırmak Sulaması 1995 ve 2020 Dönemi Performans Göstergeleri*

Indicators	1995	2020
Irrigation Project Area (da)	204.220	200.000
Area for which irrigation demanded (da)	150.191	150.000
Actually Irrigated Area (da) (% 89.5)	133.691	126.220
Irrigation Rate (%)	65	63
Water Amount within the Network (hm^3year^{-1})	105.581	63.460
Amount of Water per Hectare (hm^3year^{-1})	7.897	4.922
Need for Irrigation Water (hm^3year^{-1})	3.529	3.198
Irrigation Efficiency (%)	45	65
Efficiency to-be (%)	54	54
Realization/Collection Rate (%)	61	62

Table 5. Reasons for Not Irrigating Fields in Uluırmak Irrigation
Çizelge 5. *Uluırmak Sulamasında Alanların Sulanamama Nedenleri*

Reasons	1995		2020
	Right Coast IA	Left Coast IA	Uluırmak IA
Sufficient Rain	12.540	1.291	0
Insufficient Canal	44.000	6.000	50.000
Insufficiency in Outlets, Settings	500	0	0
Neighbor Conflicts	500	100	200
Irrigation with Private Opportunities	2500	300	10.260
Total	60.040	7.691	60.460

1994. However, network insufficiencies and deficiencies in maintenance and repair services have decreased irrigation performance. Irrigated area has decreased due to the inability to serve to the total area planned to be irrigated by the network because of lack of investments. Thus, according to data of irrigation associations (according to water demand receipts) in 1995, irrigation demand for 150.191 da of total 204.420 da network area and 133.691 da (65.45%) of irrigation area could be irrigated. In 2020 126.220 da of 150.000 da for which irrigation demand has been realized have been irrigated. Although 25 years have passed, 82.3% of unirrigated areas cannot be irrigated because of insufficient canals.

On the other hand, considering the cost of water and irrigation, there are no water measurement facilities in Uluırmak irrigation area and charging of irrigation water has still be realized according to product and decare. Irrigation charges have been taken according to the area ($TLda^{-1}$) taking the water budget and expenditures of the Association into consideration. Water demand bills have been collected before irrigation season and water distribution plans have been prepared and applied according to water reserve. Also, some sanctions have been imposed on persons damaging the facility and realizing transactions inconsistent with irrigation orders. Actions such as causing material damage to the irrigation system, not using irrigation system appropriately, causing pollution, preventing the flow of water, not obeying water limitations determined by Association officers, not obeying restricted product, restricted area, restricted day and hour implementations, not signing Irrigation Contract (declaration form) until 15th of March in every year are subject to sanctions. Also, it has been accepted and put into force to impose penalty to persons who don’t pay debts to Irrigation Association on time according to the Law of Obligations.

Expansion Possibilities of Irrigated Areas and Developments Obtained

In this part, it has been aimed to compare developments in 2020 with activities that need to be done in order to ensure irrigation of unirrigated areas in irrigation area determined in research date. Developments in both periods and the comparison of these developments have been indicated in Table 6.

As indicated in Table 6 investments necessary to expand irrigated areas have not been realized yet. In addition to this, it has been decided and included in the program to transform some part of the irrigation network to a closed system, but could not be initialized due to insufficient allocation. In this context, it is very important to transform the system to closed irrigation system, to train and raise awareness of farmers about irrigation, to ensure maintenance and repair, not to cultivate plants consuming too much water, and to use water in a controlled way.

Results of Planning

In this part results of comparison between existing production pattern of enterprises dealing with irrigated farming in Uluırmak irrigation basin and optimum enterprise organization determined through linear programming method in case of continuation of the current situation and in case of expanding irrigated areas by completing investments have been stated.

The most cultivated product in the research area has been wheat with 16.26 da cultivation area on irrigated areas; sunflower has taken the second place with 14.71 da cultivation area and then sugar beet with 7.91 da and barley 7.36 da have followed them. Total brut profit of enterprises has been determined as 294.342.502 TL. According to planning realized under current conditions for examined enterprises on irrigated land, wheat has taken the first rank with 20,92 da; sugar beet with 9.87 da, sunflower with 5.89 da, bean with 4.78 da, alfalfa with 2.78 da, vegetable with 2.89 da, and barley with 1.12 da have followed wheat. Also, after planning each enterprise has had 2.29 dairy cattle (cultured crossbreed) and 18.95 sheep and the total brut profit of an enterprise have increased to 445.4 TL with an increase of 51.33%.

After planning in case of expanding irrigated areas by completing investments within the irrigation network, irrigated areas would increase at the rate of 33.33% and brut profit would increase to 472.4 TL with an increase of 60.48%.

Another important result of this research is that 16.49 da (90.43%) of the average 18.59 da dry farming area within the network can be irrigated economically after investment. Thus, 47.75 da

Table 6. Identified Deficiencies in Uluırmak Irrigation and Current Situation
Çizelge 6. *Uluırmak Sulamasında Belirlenen Eksiklikler ve Mevcut Durum*

Years	
1995	2020
Increasing capacity of right coast main canal (increase from 12 m^3sec^{-1} to 16 m^3sec^{-1} 18 km)	Cannot be realized
Constructing soil tertiary canal (Tavşancıl canal /1.150 m) on Spare-1 as concrete canal (3500 da)	Cannot be realized
Constructing 1 km soil canal following Spare-1 canal as concrete canal (1000 m)	Cannot be realized
Increasing Spare-2A canal capacity (2200 m)	Cannot be realized
Opening a new spare canal between Spare-7 and Spare-8 (3500 da)	Cannot be realized
Opening a spare canal between Spre-4 and Spare-5	Cannot be realized
Repair and restoration of outlets and settings	Outlets and settings are repaired every year.
Updating enterprise map	No updated map

which is the average irrigated agricultural land within network would increase to 64.20 da (34.45%).

The size of the area where cereals are cultivated and which is 22.04 da of the irrigated area under planning in the current situation will increase to 30.61 da of the irrigated area with an increase of 8.57 da in planning in case of expanding irrigated area. The size of the area where industrial plants are cultivated and which is 15.76 da in the current situation will increase to 21.18 da under planning in case of expanding irrigated area. Furthermore, size of the area where the vegetable is cultivated will increase from 2.39 to 3.21 da with increase in irrigated area.

Considering the animal production, dairy cattle breeding (2.29 Production Unit) and sheep breeding (18.95) have been planned in accordance with barn and fold capacity. Since barn and fold capacity have been used fully under the current situation, there has been no change in terms of animal assets under planning after investment.

Consequently, 52.10% of the irrigated area after expanding is utilized for cultivating cereals, 32.94% for industrial plants, 9.97% for legumes, and 4.98% for vegetable growing.

CONCLUSIONS

It is seen that most of the deficiencies in relation to the subject of this research have not been completed when the period of research (1995) is compared to the recent situation. However, measures taken against structural problems of enterprises (heritage, fragmentation, etc) have partial positive effects. In this context, in order to utilize soil and water resources in the research area more effectively and productively, it becomes necessary in the service area of irrigation network to solve structural problems about irrigation network like increasing canal capacity when needed, to transform soil canals to concrete covered or piped canals, build new spare canals when needed, meet deficiencies in water receiving structures such as settings and outlets and drainage deficiencies.

At the same time, it would be beneficial for the region to make some arrangements about cooperation between the public, irrigation associations and farmers, and especially to ensure participation of farmers more actively in management and maintenance and repair services. Also, training of staff of irrigation association and farmers for efficiency of irrigation and agricultural activity and completing in-field development services such as drainage, levelling and land improvement needed within irrigation network become more of an issue.

Water loss is high in the region because of open and old canals of irrigation network. Systematically extending the use of modern irrigation systems ensuring water savings, extreme increase in input prices, difficulty in accessing credit, and an increase in expenditures cause increase in irrigation costs.

Fodder crop growing level is below where it needs to be even on irrigated areas. It would be beneficial to encourage fodder crop growing in the region especially for improving animal breeding.

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Studies on the Conformity of Three-Nutrient and Micronutrient Fertilisers in Drip Irrigation System

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Abstract

As a result of the changes in climatic conditions, especially in precipitation, the water usage methods of the producers have changed in parallel and drip irrigation systems started to be used widely. A very small amount of drip irrigation fertilizers is produced by the Turkish fertilizer industry, and therefore they are mostly imported from abroad. In this study, fertilizers produced by large fertilizer companies and imported by these companies are examined. The main purpose of this study is to determine the conformity of the compound three-nutrients and micronutrient fertilizers used in drip irrigation system, in accordance to the "Regulation on the Surveillance and Inspection of Fertilizers on the Market" (EC fertilizers) of the Ministry of Agriculture and Forestry dated 29.03.2014, number 28956. Some physical and chemical properties as well as heavy metal contents of the fertilizers supplied from the market and fertilizer factories in their original packaging were investigated. As a result of the examination of 56 three-nutrient and 13 micro-nutrient-containing fertilizers according to the relevant regulation, it was seen that 35 of the three-nutrient fertilizers and 5 of the fertilizers containing micro-nutrients were determined to be out of the tolerance values of the regulation, so they were not suitable for the fertigation system. Therefore, it was determined that 40 out of 69 fertilizers were not in compliance with the regulation. If the heavy metal contents are examined on the basis of the tolerance values applied by China and Japan, it can be said that 10 (5xHg, 4xCd and 1xHg) fertilizers do not conform to drip irrigation system. Fertilizers were examined in terms of radioactivity and ^{238}U and ^{232}Th were not found to be threatening for human health. It is believed that the samples do not contain ^{40}K and the defined values are natural. The results of this current study will be useful in making fertigation and fertilization programs to be prepared based on soil and water analyses or whether to use those fertilizers.

Keywords: Fertilizer, physical property, chemical property, drip irrigation.

Üç Besinli ve Mikrobesinli Gübrelerin Damla Sulama Sistemine Uygunluğu Üzerinde Çalışmalar

Öz

İklim şartlarında ve özellikle yağış durumlarında meydana gelen değişiklikler nedeni ile üreticilerin su kullanım yöntemlerindeki değişikliklere paralel olarak, damla sulama sistemleri yaygın kullanılmaya başlanmıştır. Damla sulama gübrelerinin çok az bir miktarı ülkemiz gübre sektörü tarafından üretilmekte, genelde ülkemiz dışından ithal edilmektedir. Bu çalışmada, büyük gübre firmaları tarafından üretilen gübreler ile bu firmalar tarafından ithal edilen gübreler incelenmiştir. Çalışmanın ana amacı, damla

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sulama sisteminde kullanılan, üç besinli ve mikro besin elementi içeren gübrelerin Tarım ve Orman Bakanlığının 29.03.2014 tarih ve 28956 sayılı "Gübrelerin Piyasaya Gözetimi ve Denetimi Yönetmeliği" göre (EC fertilizers) değerlendirilerek uygunluk durumlarının belirlenmesidir. Piyasadan ve gübre fabrikalarından orijinal ambalajda sağlanan gübre örneklerinin bazı fiziksel, kimyasal özellikleri yanında ağır metal içerikleri de incelenmiştir. Bulgularımız, analizi yapılan 56 adet üç besinli ve 13 adet mikro besin elementi içeren gübrenin ilgili yönetmeliğe göre incelenmesi sonucunda, üç besinli gübrelerin 35 adedinin ve mikro besin elementi içeren gübrelerin 5 adedinin yönetmeliğin tolerans değerleri dışında saptanması nedeni ile fertigasyon sistemine uygun olmadığını göstermiştir. Dolayısıyla, toplam 69 adet gübreden 40 adedinin yönetmeliğe uygun olmadığı belirlenmiştir. Ağır metal içerikleri Çin ve Japonya'nın uyguladığı tolerans değerlerine göre incelendiğinde, 10 adet (5xHg, 4xCd ve 1xHg) gübrenin de damla sulama sistemine uygun olmadığı ifade edilebilir. Gübreler, radyoaktivite açısından irdelendiğinde, ^{238}U ve ^{232}Th'un insan sağlığı bakımından tehlike oluşturacak seviyede bulunmadığı, örneklerin ^{40}K içermediği ve belirlenen bu değerlerin de doğal olduğu düşünülmektedir. Çalışmanın sonuçları, toprak ve su analizlerine bağlı olarak hazırlanacak fertigasyon ile gübreleme programlarının yapılmasında veya o gübrelerin kullanılıp kullanılmaması konusunda yarar sağlayacaktır.

Anahtar Kelimeler: Gübre, fiziksel özellik, kimyasal özellik, damla sulama

INTRODUCTION

Global warming in the recent years significantly changed the precipitation regime of countries. In this regard, the water consumed in cities, industry and agriculture must be used efficiently and in the most economical way. In agricultural production, water harvesting is important, this water is used for irrigation. Studies in this context have shown that drip irrigation is the best method.

Many researchers pointed out that drip irrigation is a very efficient way of irrigation and the fertilizers delivered via this system (fertigation) results in higher quality and high yield, (Bar-Yosef, 1977; Levis et al., 1979).

Fertilization by drip irrigation provides the uptake of nutrients via the roots efficiently (Çolakoğlu, 1990). When chemical fertilizers dissolve in water, they gain an electrical charge and may act as a chemical salt. Producers can check whether they are fertilizing correctly by measuring the EC value of the fertigation system. Therefore, Na^+ and Cl^- are not preferred to be included in fertigation fertilizers since they increase salinity. It is desirable that the fertilizers used with the drip irrigation system do not contain additives, have a high solubility in water and do not cause clogging pipes.

The objective of this study was to determine the compliance of 56 macro-nutrient (N, P, K compound fertilizers) and 13 micro-nutrient (B, Co, Cu, Fe, Mn, Mo, Zn,) drip irrigation fertilizers with the Regulations. The other objective was to find some of their heavy metals (As, Cd, Cr, Hg, Ni, Pb) and natural radioactivity (^{40}K, ^{238}U and ^{232}Th) contents.

MATERIAL AND METHODS

In this study, 56 NPK compound fertilizers (Table 1) and 13 single/multi micronutrient fertilizers (Table 2), in total 69 drip fertilizers which are either produced in our country or imported from abroad were the materials that were examined.

Table 1. Formulation and number of three nutrient fertilizers
Çizelge 1. *Üç besinli gübrelerin formulasyon ve adedi*

Fertilizer Formulation	Number	Fertilizer Formulation	Number
10.5.40	1	15.30.15	6
28.14.25	1	18.18.18	10
20.8.20	1	20.20.20	8
16.8.24	2	15.5.30	5
3.5.40	1	18.6.24	1
20.10.20	1	12.5.40	1
12.5.41	2	12.40.10	1
14.8.30	1	14.7.17	2
16.10.17	1	15.15.15	1
13.40.13	1	14.6.26	1
5.5.40	1	12.7.40	1
14.40.5	1	16.6.31	1
23.5.5	1	10.30.10	1
15.5.35	1	16.16.16	1

Table 2. Formulation and number of microelement fertilizers
Çizelge 2. *Mikroelementli gübrelerin formülasyon ve adedi*

Fertilizer Formulation	Number
13.2% Fe EDTA	1
6% Fe EDDHA	1
14% Zn EDTA	1
3% B 0.4% Cu EDTA 6.5% Fe EDTA 5% Mn EDTA 0.2% Mo 5% Zn EDTA	1
24% $MnSO_4 4H_2O$ Mn	1
22% $ZnSO_4 7H_2O$ Zn	3
0.2% B 0.5% Cu 6% Fe 4% Mn 5% Zn	1
0.6% B 1% Cu 5% Fe 3.5% Mn 0.3% Mo 2.4% Zn	1
1.5% B 0.6% Cu 4% Fe 3% Mn 0.05% Mo 4% Zn	1
0.5% B 1% Cu 6% Fe 4% Mn 8% Zn	1
1% Cu 4% Fe 2% Mn 3% Zn	1

After the preliminary preparations were completed in the examination of the fertilizer samples taken from the market and fertilizer factories, for the evaluations the regulation (EC fertilizers 29.03.2014/28956) and AOAC analysis methods were used.

Radionuclide contents of the fertiliser samples were measured by Gamma spectroscopy method (Yaprak,1995).

RESULTS AND DISCUSSION

1. pH, EC and insoluble matter

The pH values of the N, P, K compound fertilizers examined in the study were found between 3.22 and 6.69; EC between 0.81 and 1.78 mS cm^{-1}, humidity between 0.07 and 6.13% and the insoluble matter percentage between 0.01 to 5.62. The pH of the 13 micronutrient fertilizers changed from 3.32 to 8.64; EC values from 0.21 to 1.20 mS cm^{-1}; humidity from 0.13 to 2.46% and the insolubility from 0.10 to 2.24%.

The EC values of the 20.20.20 and 15.5.30 grade fertilizers were found to be low. Likewise, the EC values of the chelated fertilizers containing micronutrients were also found to be low. It is considered normal to have lower EC values than fertilizers in the form of mineral salts, since micronutrients bind to chelates such as EDTA or EDDHA and do not generate electrical charge when dissolved in water. The EC values of micro element fertilizers in the form of mineral salts are higher than those in the form of chelate (0.47-1.19 mS cm^{-1}). Fertilizers produced with mineral salts sometimes show low levels of EC as those in the form of chelate most probably due to lower nutrient elements than stated on the label. In chelated microelement fertilizers, theoretically, the EC value may be very low or not at all, as in urea fertilizer.

However, when EDTA group is used as the chelating material, EC value can be measured even less

The high moisture content of the three-nutrient compound fertilizer (6.13%) may be due to incorrect packaging or unsuitable storage conditions, as well as the use of chemicals containing crystal water (such as $MgSO_4$) in the production of the fertilizer.

The moisture contents of 8 of the microelements containing fertilizers were determined above the level specified in the relevant regulation (1.50%). Two of these 8 fertilizers are in chelate form. Their moisture contents were found 1.64% and 2.46%, in other words, above the limits, might be caused by inappropriate storage conditions or packaging or low (10%) chelate content. In 6 of the others, the moisture content was between 1.58-1.89% i.e above 1.50%. High humidity in these samples may be due to unsuitable storage conditions. Of the other 2, the moisture content varied between 2.15-9.01%. In the production of the compounds, most probably crystalline water ($CuSO_4$, $FeSO_4$, $ZnSO_4$ and $MnSO_4$) is used.

In 12 of the three-nutrient fertilizers, the rate of insoluble matter in water was more than 1%. The insoluble matter in 8 of these 12 fertilizers was below 2% and at higher levels in the other

4 fertilizers. It is not appropriate to use fertilizers with a high number of water-insoluble matter in fertigation, as this will cause clogging of drip irrigation pipes.

Four of the micronutrient fertilizers were in the form of chelate and their water-insoluble matter was found more than 1%. Of the fertilizers containing micronutrients in mineral form, 4 of them are mono-nutrient and 3 had water-insoluble matter above 1%. Other 5 multi-micronutrient fertilizers can be used in drip irrigation since their water-insoluble matter was found less than 1.1%. Findings of this study indicated that the amount of water-insoluble matter is almost non-existent most of the time.

2. N, P_2O_5 K_2O, (%) Contents of Three-Nutrient Drip Fertilizers

It has been observed that 19 of the 56 drip irrigation fertiliser samples were outside the nitrogen (N) fertilizer tolerance threshold set forth in the "Regulation on Chemical Fertilisers Used in Agriculture" (Figure 1).

Fifty-six fertiliser samples were analysed in terms of their N contents (%). Ten of them had N more than the data on their labels while 27 of them were within the tolerance limits (Figure 1).

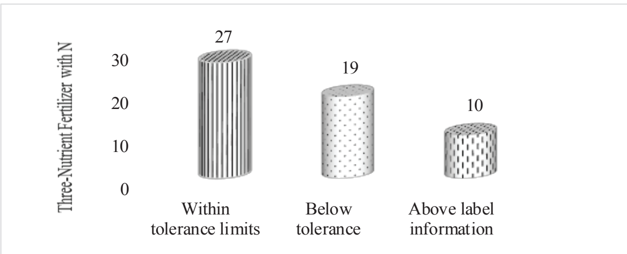

Figure 1. Tolerance of three nutrient fertilizers with respect to their N % content
Şekil 1. *Üç besinli gübrelerin % N miktarlarının toleransa uygunluğu*

Results were examined according to their nitrogen forms and found that NH_2-N ratio of the total N in 4 fertilizer samples was higher than other N fertilizer types. Such three-nutrient fertilizers are also used in soilless culture technique and in this regard may create a problem in terms of N uptake. Urea-N does not turn into NH_4 and NO_3-N in soilless environment and since the plant cannot take N in the form of NH_2-N, it is recommended that special care should be taken in the use of such fertilizers.

When the P_2O_5 contents of 56 drip fertilizers were examined, 5 of the fertilizers were below the tolerance limits of 1.1(%) specified in the relevant regulation. It was determined that 24 fertilizers were within the tolerance limits, and 27 contained more P_2O_5 (%) than the label data (Figure 2).

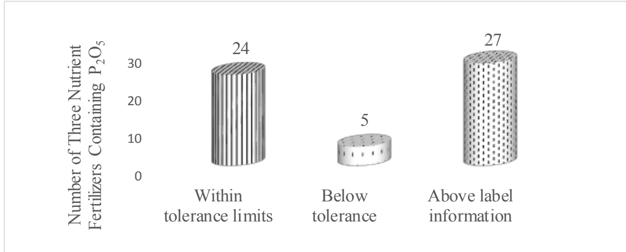

Figure 2. Tolerance of three nutrient fertilizers with respect to their P_2O_5% contents
Şekil 1. *Üç besinli gübrelerin % P_2O_5 miktarlarının toleransa uygunluğu*

Figure 3. . Tolerance of three nutrient fertilizers with respect to their K_2O % contents
Şekil 3. *Üç besinli gübrelerin % K_2O miktarlarının toleransa uygunluğu*

Regulation-compliance status and K_2O (%) ranges of the fertilizers are given in Fig.3. According to the tolerance value (1.1%) for K_2O, 23 of the fertilizers were determined to be suitable, 18 of them were out of the tolerance and 15 contained more K_2O than the amount specified on the label.

The results of the compliance status of 56 fertilizers with three nutrients are given in Table 1 shows that 35 fertilizer samples do not comply with the tolerance values of the regulation. Among the fertilizer samples that are not within the tolerances of the relevant regulation, there is only 1 fertilizer that is not suitable for all three plant nutrients. Five of the two nutrient compound fertilizers (NP, NK and PK) are not within the appropriate tolerance values. The number of fertilizers with inappropriate N (%) content was 14, the number of P_2O_5 (%) unsuitable fertilizer was 2, and the K_2O (%) unsuitable fertilizer was 12. It was determined that only 22 fertilizer samples were in compliance with the tolerance limits (1.9).

Therefore, it can be said that the non-compliance with the tolerance values in the chemical fertilizer inspection regulation in NPK fertilizers is mostly caused by N and K_2O as plant nutrients.

Table 3 shows that 14 of the three-nutrient ($N+P_2O_5+K_2O$) fertilizers that do not comply with the tolerance limits are not suitable in terms of N and 13 of them in terms of K_2O. One reason for this inconvenience might be the N in the three nutrient compound fertilizers. In these fertilizers, a large part of N (13 of them) are in the form of NH_2-N (3.0-11.5% of total N). In terms of K, might be related to the K source. If the Na, Ca and Mg results of three-nutrient fertilizers are examined, it was determined that the sum of these three elements was between 0.27-0.68%.

Table 3. Number of fertilizers that exceed the tolerance limits
Çizelge 3. *Damla sulama sistemi gübrelerinin tolerans sınırları dışındaki örnek sayıları*

Plant nutrients	Number of fertilizers out of limits
N, %	14
P_2O_5, %	2
K_2O, %	13
$N+P_2O_5$, %	1
$N+K_2O$, %	3
$P_2O_5+K_2O$, %	1
$N+P_2O_5+K_2O$, %	1

Most probably Na, Ca and Mg presence, in addition to the N, P_2O_5, K_2O, in the three- nutrient fertiliser could have led these fertilizers to go beyond the tolerance limits.

3. Micronutrient containing drip fertilizers

Thirteen of the fertilizers (B, Cu, Co, Fe, Mn, Mo, Se and Zn) containing micronutrients and used in the drip irrigation system were examined and analysed. Four of these fertilizers are in the form of chelates (EDTA and EDDHA) and the other 9 are mineral salts.

Chelates were determined in 4 micronutrient fertilizers, which are reported as "chelated" on the label. It is found that these fertilizers contained SO_4 which shows that they are produced from mineral salts, such as $FeSO_4$, $MnSO_4$, $ZnSO_4$ (Table 4). So, 2 of the 4 fertilizers stated to be chelated are not in compliance with the relevant regulation.

Table 4. Chelate and micro elements in the fertilizers (%)
Çizelge 4. *Şelatlı mikro element gübrelerinin içerikleri (%)*

Elements	13.2% Fe EDTA	6% Fe EDDHA	14% Zn EDTA	3% B, 0.4% Cu EDTA, 6.5% Fe EDTA, 5% Mn EDTA, 0.2% Mo, 5% Zn EDTA
Ca %	-	-	0.74	0.22
Mg %	-	-	-	-
S %	0.56	-	-	16.90
Na %	4.41	9.42	8.04	0.33
B %	-	0.02	-	0.05
Cu %	0.01	0.14	0.02	0.57
Fe %	13.18	6.04	-	4.84
Mn %	-	0.01	-	8.01
Zn %	-	-	15.59	5.59
Se %	-	0.04	-	0.03
Co %	-	-	-	-
Mo %	-	-	-	0.12
Şelat %	95.42	100.00	60.90	10.00

(-): Unidentified

Table 5 shows the results of 9 micronutrient fertilizers which are in the form of mineral salts according to their label. Results indicated that 3 of the 4 fertilizers containing single microelement comply with the relevant regulation, and 3 of the 5 fertilizers containing multiple micronutrients do not comply with the tolerance values specified in the relevant regulation in terms of total micronutrient elements.

Findings in relation to 56 fertilizers containing three nutrients and 13 micronutrients showed that 35 of the three-nutrient fertilizers and 5 of the fertilizers containing micronutrients were out of the tolerance limits of the relevant regulation. Therefore, it has been determined that these fertilizers are not suitable for the fertigation system. It is seen that 39 of the 69 fertilizers are not in compliance with the regulation and contain nutrients other than the label information.

Table 5. Micro element fertilizers in mineral salt form (%)
Çizelge 5. *Mineral tuz formundaki mikro element gübrelerinin içerikleri (%)*

Sample	Fertilization Formulation (Label Information)	Ca %	Mg %	S %	Na %	B %	Cu %	Fe %	Mn %	Zn %	Se %	Co %	Mo %
1	24% Mn $MnSO_4.4H_2O$	0.17	-	18.89	0.17	0.01	0.01	-	30.33	-	0.09	-	-
2	22% Zn $ZnSO_4.7H_2O$	-	-	22.72	0.15	-	0.01	-	-	24.03	0.01	-	-
3	22% Zn $ZnSO_4.7H_2O$	0.16	-	11.64	1.06	0.01	0.02	-	-	22.09	-	-	-
4	22% Zn $ZnSO_4.7H_2O$	-	-	12.50	0.14	-	0.02	1.00	-	23.43	-	-	-
5	0.2% B, 0.5% Cu, 6% Fe,	0.10	-	18.19	0.29	0.37	0.86	8.77	4.95	6.89	0.03	-	-
6	0.6% B, 1% Cu, 5% Fe,	0.32	-	10.27	0.34	0.03	1.43	4.73	2.84	2.98	-	-	-
7	1.5% B 0.6% Cu, 4% Fe,	0.05	-	7.79	3.63	0.35	0.86	4.99	3.60	4.90	0.01	-	0.04
8	0.5% B, 1% Cu, 6% Fe,	0.60	-	19.50	0.57	0.41	1.53	9.55	6.35	11.95	0.01	-	-
9	1% Cu, 4% Fe, 2% Mn,	0.32	-	10.27	0.34	0.03	1.43	4.73	2.84	2.98	-	-	

(-): Unidentified

4. Heavy Metals

There are no heavy metal limit values determined for drip irrigation system fertilizers in Turkey. In this study, heavy metal contents in Turkish fertilizers were evaluated according to the limit values (MEP, 2002) in China and Japan.

Table 6. Heavy metal limit values in fertilizer (MEP, 2002)
Çizelge 6. *Gübre ağır metal sınır değerleri (MEP, 2002)*

Heavy metal	Limit values
As	≤75
Cd	≤10
Cr	≤150
Hg	≤5
Pb	≤100

Table 7. 69 Minimum and maximum heavy metal contents of the 69 drip irrigation fertilizers (mg kg^{-1}).
Çizelge 7. *69 Adet damla sulama sistemi gübresine ait minimum ve maksimum ağır metal içerikleri mg kg-^{1})*

Heavy Metal	Multi-Nutrient		Micro-Nutrient	
	Min.	Max.	Min.	Max.
	mg kg^{-1}			
As	0.07	36.34	0.23	29.11
Cd	0.01	1.70	0.05	4962.68
Cr	0.05	27.00	0.21	86.00
Hg	0.01	2.96	0.36	13.75
Ni	0.08	6.77	1.43	110.68
Pb	0.01	7.55	1.62	100.22

Heavy metal contents of the fertilizers are given in Table 6, as minimum and maximum values. The data given in Table 4 have been compared with previous studies on this subject and it can be stated that 10 fertilizers out of 69 fertilizers are not particularly suitable for Hg, Cd and Hg in terms of heavy metal content. Köleli et al. (2005) stated that the Cd in the raw material for P fertilizers and P fertilizers vary between 23-179 mg kg^{-1}. According to Rui et al. (2008), the amount of Hg in fertilizers ranges between 5-10 mg kg^{-1}.

In conclusion, if the heavy metal findings in this study are compared with the tolerance values used in China and Japan, results put forth that 10 (5xHg, 4xCd and 1xHg) fertilizers are not suitable to be used in drip irrigation systems.

5- ^{238}U, ^{232}Th, ^{40}K Conditions of the Fertilizers

The levels of ^{238}U and ^{232}Th in three-nutrient drip irrigation fertilizers were found to be below ND (not measurable) and it was concluded that these fertilizers do not contain radionuclide in terms of ^{238}U and ^{232}Th. Depending on the potassium (K_2O%) levels, some radioactivity was detected due to the 40K isotope. Indeed, a high correlation (r=0.89) was found between K_2O% and ^{40}K radionuclide content. This result is important in showing that the level of ^{40}K radionuclide increases as K_2O% increases. This is due to the presence of 0.0118% of the ^{40}K isotope in the K source.

No ^{238}U, ^{232}Th and ^{40}K activities have been observed in the micronutrient fertilizers and radionuclide has been observed to be below detectable limits in all samples.

CONCLUSION

At the end of the research, it was concluded that the fertilizers did not contain radionuclide in terms of ^{238}U and ^{232}Th and did not contain ^{40}K radioactivity that would endanger human health, and that these amounts were natural.

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The Effect of Organic Waste and Synthetic Conditioner Applications on Consistency Limits

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Abstract

This study was carried out to determine the effects of wheat straw (WS), hazelnut husk (HH), humic acid (HA) and polyacrylamide (PAM) treatments on consistency limits (liquid limit (LL), plastic limit (PL), plasticity index (PI)) in two soils with sandy loam and clayey loam in texture. Soil samples used in the study were taken from two different areas of land (0-20 cm) from Samsun province's Bafra district. WS (0, 2%, 4%), HH (0, 2%, 4%), HA (0, 200 and 1000 ppm) and PAM (0, 30 and 90 ppm) were used in this study that was conducted in a split plots experimental design with three replications. According to the results; it was determined that the liquid limit, plastic limit and plasticity index values increased with the application of organic and synthetic conditioners in both soil texture, and the effect was realized as WS>HH>HA>PAM. It was observed that the highest dose application was the more effective in both soil texture, except for PAM.

Keywords: Hazelnut husk, humic acid, liquid limit, plastic limit

Organik Atık ve Sentetik Düzenleyici Uygulamalarının Kıvam Limitleri Üzerine Etkisi

Öz

Bu araştırma, kumlu tın ve killi tın tekstüre sahip iki toprakta buğday samanı (WS), fındık zurufu (HH), hümik asit (HA) ve poliakrilamid (PAM) uygulamalarının kıvam limitleri (likit limit (LL), plastik limit (PL), plastiklik indeksi (PI)) üzerine etkilerini belirlemek üzere yürütülmüştür. Çalışmada kullanılan toprak örnekleri, Samsun ili Bafra ilçesinde tarla tarımı yapılan iki farklı araziden (0-20 cm) alınmıştır. Bölünmüş parseller deneme deseninde yürütülen çalışmada buğday samanı (0, %2, %4), fındık zurufu (0, %2, %4), hümik asit (0, 200 ve 1000 ppm) ve PAM (0, 30 ve 90 ppm) topraklara üç tekerrürlü olarak uygulanmıştır. Sonuç olarak, likit limit, plastik limit ve plastiklik indeksi değerlerinin her iki toprak tekstüründe de organik ve sentetik düzenleyici uygulaması ile arttığı, etkininin WS>HH>HA>PAM şeklinde gerçekleştiği tespit edilmiştir. Her iki toprak tekstürün de PAM hariç en yüksek doz uygulamasının daha etkili olduğu görülmüştür.

Anahtar kelimeler: Fındık zurufu, hümik asit, likit limit, plastik limit

INTRODUCTION

The liquid limit is defined as limit water content values when a dry soil flows under the influence of a small external force due to the increasing water content, while the plastic limit is defined as the water content values when the soil starts to crumble while losing its water. The numerical difference between the liquid limit and the plastic limit is called the plasticity index (Dexter and Bird, 2001; Gülser and Candemir, 2006).

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The liquid limit (LL), plastic limit (PL), and plasticity index (PI) are defined as consistency limits and are important parameters in the evaluation of some properties of soil when used for agricultural or engineering purposes. These parameters gain value depending on the dominant clay mineral type of the soil, the clay content, the type of exchangeable cations, and the amount of organic matter (Odell et al., 1960; Farrar and Coleman, 1967).

Canbolat and Öztaş (1997), in a study in which they examined the relationships between soil consistency limits and some physicochemical properties, revealed significantly positive correlations between the clay content, organic matter content, lime content, cation exchange capacity and the liquid limit and plastic limit values, and significantly negative correlations with sand content. Yakupoğlu and Özdemir (2006), as a result of the study in which they applied biosolids and tea waste to soils eroded at different levels, reported that the additions of organic material significantly increase the liquid limit (LL) and plastic limit (PL) values of the soils, and such increase depends on the increased erosion levels, the type of waste and the applied dose for the liquid limit, and the type of clay mineral, clay content, exchangeable cation type, and organic matter amount for the plastic limit. Similarly, Kara et al. (2018), as a result of the study in which they examined the effect of applying gyttja as a conditioner on clayey loam textured soil with low percentage of lime content on the liquid limit (LL) and plastic limit (PL) values of the soils; they found that the organic matter (OM), liquid limit (LL) and plastic limit (PL) values of the soil increased depending on the application dose of gyttja. This study was carried out to examine the effects of organic waste and synthetic conditioner applications on consistency limits in two soil texture with sandy loam and clayey loam in texture.

MATERIALS AND METHODS

Material

This study was carried out on soil samples taken from the Bafra application area of Samsun Ondokuz Mayıs University and the Black Sea Agricultural Research Institute's Bafra experimental field and its surface (0-20 cm). In the study, wheat straw (WS) and hazelnut husk (HH) were used as organic waste, while humic acid (HA) and polyacrylamide (PAM) were used as synthetic conditioners. Organic wastes were used by passing through a 2 diameter sieve. These wastes and conditioners were obtained from different institutions and organizations. The wheat straw used in the study has 53.46% organic C and 0.65% total N content, and its C/N value is 82.25. The pH and P contents of wheat straw were determined as 5.69 and 2055.00 ppm, respectively. Hazelnut husk has 46.93% organic C, 1.86% total N content, and its C/N ratio is 25.23. The pH and P contents of the hazelnut husk are 6.16 and 6291.52 ppm, respectively. The applied PAM is of technical quality, and HA is a commercially available material containing 15% active substance.

In the study carried out under greenhouse conditions as a pot experiment and in a split plots experimental design, organic residues (0, 2% and 4%); humic acid (0, 200 and 1000 ppm) as a synthetic conditioner; and PAM (0, 30 and 90 ppm) were used with three replications. During the experiment, the air temperature was kept between 25-30 ^{0}C with the air conditioner and irrigation was done when fifty percent of the available moisture in the pots was exhausted. Soil samples were incubated for five months and wheat plants were grown in pots after the incubation period. After the wheat plant was harvested (3 months), the relevant analyses were made on the soil samples.

Methods

The particle size distributions of soils were determined by the Bouyoucos hydrometer method (Gee et al., 1986); the soil reaction (pH) in a 1:2.5 soil-water suspension with a pH meter (Rowell, 1996); the electrical conductivity in soil-water suspension with a glass-electrode electrical conductivity meter (Bayraklı, 1987); the lime content of soils by measuring the volume of CO_2 gas released due to hydrochloric acid treated with $CaCO_3$ using Scheibler calcimeter (Kacar, 1994); and the organic matter contents were determined by the Walkley-Black method (Nelson and Sommers, 1983) based on the oxidation of organic carbon.

The LL value of the soils was determined using the "Casagranda" instrument (Sowers, 1965). The PL value was determined according to the amount of moisture the soil had when it was formed into 3 mm filaments and started to disperse (Sowers, 1965). The PI value was found by subtracting the PL value from the LL value (Casagranda, 1932).

The statistical evaluation of the data obtained as a result of the research was performed using the Minitab computer package program. The Duncan test was used in multiple comparisons (Minitab, 2013).

RESULTS AND DISCUSSION

Soil Properties

Some physical and chemical properties of the soils studied are given in Table 1. As can be seen from the examination of this chart, the research soils have clayey loam and sandy loam texture. The lime content of clayey loam soil is 7.24%, organic matter content is 2.09%; the lime content of soil with sandy loam texture was determined as 17.92% and organic matter content as 1.06%. Liquid limit, plastic limit and plasticity index are measured as 36.49%, 24.71% and 11.78% for clayey loam soil and as 22.76%, 16.35% and 6.41% for sandy loam soil, respectively.

Table 1. Some characteristics of the soils used in the research
Çizelge 1. *Araştırmada kullanılan toprakların bazı özellikleri*

	Soils	
	OMU	BSARI
Sand, %	59.42	23.86
Silt, %	29.88	42.30
Clay, %	10.70	33.82
Texture Class	SL	CL
pH (1:2.5)	7.96	7.59
EC dS m^{-1} (1:2.5)	0.418	0.425
$CaCO_3$,%	17.92	7.24
OM, %	1.06	2.09
Consistency limits (Pw)		
Liquid limit (LL), %	22.76	36.49
Plastic limit (PL), %	16.35	24.71
Plasticity index (PI), %	6.41	11.78

$CaCO_3$: lime content, OM: organic matter content, EC: electrical conductivity, Pw: Percentage weight OMU: Ondokuz Mayıs University's Bafra Experimental Field, BSARI: Black Sea Agricultural Research Institute's Bafra Experimental Field

Consistency Limits

Liquid Limit (LL)

In the study carried out under greenhouse conditions, the changes in the liquid limit values were determined after harvest in soils that were mixed and incubated with the different doses of conditioners (WS, HH, HA and PAM) and where wheat plants were grown are shown in Figure 1. As can be seen from this Figure, except for PAM applications in sandy loam textured soil, the applied conditioners provided significant improvements in liquid limit values. These increases were higher in Black Sea Agricultural Research Institute's Bafra Experimental Field with high clay (33.82%) and organic matter content (2.09%) and low lime content (7.24%). The liquid limit (LL) values of the soil samples ranged from 22.76% to 44.81%, and the lowest LL value was determined in the sample with sandy loam texture in the second dose application of the PAM conditioner, and the highest LL value was determined in the soil with clayey loam texture and in the second dose application of wheat straw.

Soils with an LL value of less than 30% are considered to have "low" plasticity, while those with an LL value between 30-50% are considered to have "medium" plasticity and those with more than 50% are considered to have "high" plasticity (Demiralay and Güresinli, 1979). Accordingly, it can be stated that Ondokuz Mayıs University's Bafra Experimental Field with sandy loam texture (LL values lower than 30%) have low plasticity; Black Sea Agricultural Research Institute's Bafra Experimental Field with clayey loam texture (LL values between 30-50%) have moderate plasticity.

It is determined that there are significantly negative correlations between the liquid limit values, the lime content (-0.964**) and pH (-0.549**) of soils, while significantly positive correlations were established between and organic matter content (0.714**) at the level of 1%.

Deng et al. (2017) determined in their study that there are significant positive correlations

Table 2. Some chemical properties of organic wastes used in the study
Çizelge 2. *Çalışmada kullanılan organik atıkların bazı kimyasal özellikleri*

Organic waste	pH (1:10)	EC (1:10), dS m^{-1}	OC, %	Total N, %	C/N	Ash, %	P, %
WS	5.69	2.848	53.46	0.65	82.25	7.84	0.205
HH	6.16	2.058	46.93	1.86	25.23	19.09	0.629

WS: wheat straw, HH: hazelnut husk, OC: organic carbon between organic carbon and LL and PL values. Similarly, many researchers have found that there are statistically significant positive correlations between the liquid limit and plastic limit values of soils and their clay contents (Aksakal et al., 2013; Spagnoli et al., 2018) and organic matter contents (Canpolat and Öztaş, 1997; Gülser and Candemir, 2006).

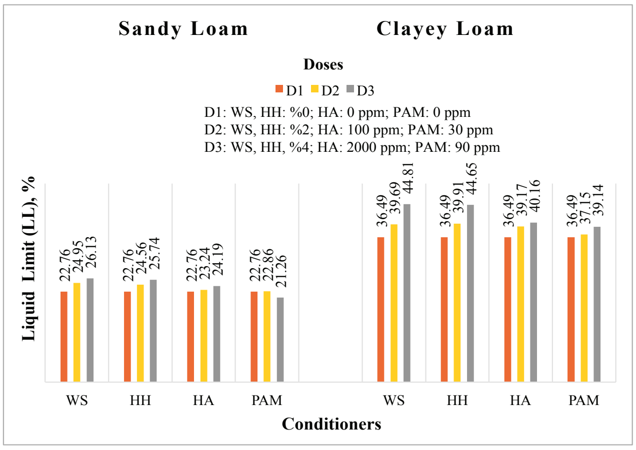

Figure 1. Changes in the liquid limit values due to applications compared to control (WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide)
Şekil 1. *Uygulamaların likit limit değerlerinde kontrole göre meydana getirdiği değişimler*

According to the results of variance analysis, the effect of the mean squares of soils, conditioner types and application doses on the change in the liquid limit values of the study soils ($p<0.01$) was found to be significant. The Duncan multiple comparison test results, which were conducted to examine the conditioner types and the effectiveness of the applied doses, are given in Table 3.

As can be understood from the examination of these data, the effectiveness of hazelnut husk and wheat straw on the LL value of the soils is the highest, and the effectiveness of the PAM conditioner is the least; and it was determined that the LL values increased with the higher dose levels.

Plastic limit (PL)

In the study carried out under greenhouse conditions, the changes in the plastic limit values determined after harvest in soils that were mixed and incubated with different doses of conditioners (WS, HH, HA, and PAM) and where wheat plants were grown are shown in Figure 2. As can be seen from this Figure, except for PAM applications in sandy loam textured soil, the applied conditioners provided significant improvements in plastic limit values. These increases were higher in the samples from Ondokuz Mayıs University's Bafra Experimental Field with high sand (59.41%) and lime content (17.92%) and low organic matter content (1.06%). PL values ranged between 15.01-30.19%, with the lowest PL value recorded in the soil with sandy loam texture and in the second dose application of the PAM conditioner, and the highest PL value recorded in the second dose application of hazelnut husk in the soil with clayey loam texture.

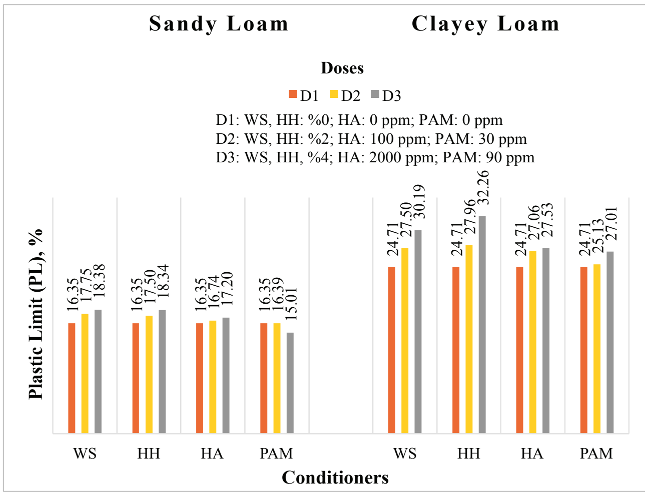

Figure 2. Changes in the plastic limit values due to applications compared to control (WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide)
Şekil 2. *Uygulamaların plastic limit değerlerinde kontrole göre meydana getirdiği değişimler*

Table 3. Duncan test results on the effects of soils mixed with different doses of conditioners on liquid limit values
Çizelge 3. *Farklı dozlarda düzenleyici karıştırılan toprakların likit limit değerleri üzerine etkilerine ilişkin Duncan testi sonuçları*

Conditioners	WS	HH	HA	PAM
Liquid Limit (LL), %	32.47[a]	32.17[a]	31.00[b]	29.95[c]
Doses	D1	D2	D3	
Liquid Limit (LL), %	29.63[c]	31.44[b]	33.26[a]	

(WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide (D1: WS, HH: 0%; HA: 0 ppm; PAM: 0 ppm, D2: WS, HH: 2%; HA: 100 ppm; PAM: 30 ppm, D3: WS, HH, 4; HA: 2000 ppm; PAM: 90 ppm))

Table 4. Duncan test results on the effects of soils mixed with different doses of conditioners on plastic limit values
Çizelge 4. *Farklı dozlarda düzenleyici karıştırılan toprakların plastik limit değerleri üzerine etkilerine ilişkin Duncan testi sonuçları*

Conditioners	WS	HH	HA	PAM
Plastic limit (PL), %	22.48^{b}	22.86^{a}	21.60^{c}	20.77^{d}
Doses	D1	D2	D3	
Plastic limit (PL), %	20.53^{c}	22.00^{b}	23.24^{a}	

(WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide (D1: WS, HH: 0%; HA: 0 ppm; PAM: 0 ppm, D2: WS, HH: 2%; HA: 100 ppm; PAM: 30 ppm, D3: WS, HH, 4; HA: 2000 ppm; PAM: 90 ppm))

Significantly negative correlations were detected at the level of 1% between PL values and lime content (-0.947**) and pH (-0.528**) values of soils, while significantly positive correlations were found at the level of 1% between the organic matter content (0.734**) and PL values.

According to a study, Qu et al. (2014) stated that there was a statistically significant increase in plastic limit values with the application of different doses of rice husk ash to the soil, while Stanchi et al. (2015) stated that the plastic limit values in the upper soil horizons were higher than the lower horizons, and this situation was related to the organic matter content in the surface layer.

According to the results of variance analysis, the effect of the mean squares of soils, conditioner types, and application doses on the change in the PL value of the study soils ($p<0.01$) was found to be significant. The Duncan multiple comparison test results, which were conducted to examine the conditioner types and the effectiveness of the applied doses, are given in Table 4.

As can be understood from the examination of these data, the effectiveness of HH on the PL value of the soils is the highest, and the effectiveness of the PAM conditioner is the least; and it was determined that the PL values increased with the higher dose levels.

Plasticity index (PI)

In the study carried out under greenhouse conditions, the changes in the PI values determined after harvest in soils that were mixed and incubated with different doses of conditioner (WS, HH, HA and PAM) and where wheat plants were grown are shown in Figure 3. As can be understood from this Figure, except for PAM applications in sandy loam textured soil, the applied conditioners provided significant improvements in PI values. Such increases were higher in the samples from Black Sea Agricultural Research Institute's Bafra Experimental Field with high sand (33.82%) and organic matter content (2.09%) and low lime content (7.24%). PI values ranged between 6.25and 14.48%, with the lowest PI value seen in the soil with sandy loam texture and in the second dose application of the PAM conditioner, and the highest PI value seen in the second dose application of wheat straw in the soil with clayey loam texture.

The PI index value is used as a parameter in the evaluation of tillage time. A high PI value indicates that the risk of sludge formation will increase when the soils are cultivated (Demiralay and Güresinli, 1979; Mueller et al., 2003). Gülser and Candemir (2006) examined the PI values of the soil series in the Ondokuz Mayıs University Campus, and found that the PI values increased with the order of Aksu < Kurupelit < Müzmüllü < Oyumca < İncesu; they stated that the risk of sludge formation during tillage is higher in the İncesu and Oyumca series than in the other series. In light of such findings and considering the PI values of the soils in this study, it can be stated that the risk of sludge formation during tillage is higher in Black Sea Agricultural Research Institute's Bafra Experimental Field with high clay content than in Ondokuz Mayıs University's Bafra Experimental Field with high sand content.

Significantly negative correlations were detected at the level of 1% between PI values and lime content (-0.973**) and pH (-0.575**) values of soils, while significantly positive correlations were found at the level of 1% between such values and the organic matter content (0.657**). Considering relevant studies, Rezaee et al. (2019) examined swelling shrinkage characteristics and plasticity indices in paddy fields, and stated that clay content, cation exchange capacity, organic carbon and saturated water content have significant effects on the value of Atterberg limits in cultivated soils.

Demir et al. (2012) found significant positive relationships between liquid limit, plastic limit and plasticity index and clay content, organic matter and lime content in the study they carried out to examine the relationship between soil consistency limits and some soil properties depending on land use in the Uğrak Basin, and stated that there was no significant relationship with silt, sand, pH and EC values.

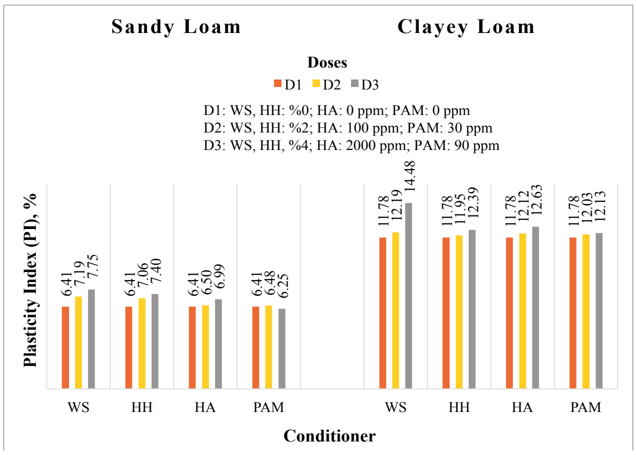

Figure 3. Changes in the plasticity index values due to applications compared to control (WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide)
Şekil 3. *Uygulamaların plastiklik indeksi değerlerinde kontrole göre meydana getirdiği değişimler*

According to the results of variance analysis, the effect of the mean squares of soils, conditioner types and application doses on the change in the plasticity index value of the study soils ($p<0.01$) was found to be significant. The Duncan multiple comparison test results, which were conducted to examine the conditioner types and the effectiveness of the applied doses, are given in Table 5.

As can be seen from the examination of these findings, the effectiveness of WS on the plasticity index value of the soils is the highest, and the effectiveness of the PAM conditioner is the least; and it was determined that the PI values increased with the higher dose levels.

CONCLUSIONS

In this study, in which changes in the consistency limits were examined with the addition of WS, HH, HA and PAM in clayey loam and sandy loam textured soil samples; it has been observed that the aforementioned conditioners added to the soils cause increases in the LL, PL and PI values, but the effect of the PAM conditioner on the consistency limits of the sandy loam in texture soils remained low level. This is probably related to the nature of PAM, the effect of soil texture and the incubation and cultivation process. It has been determined that the effectiveness of organic and synthetic conditioners used on the consistency limits are listed as WS > HH > HA > PAM. It is seen that organic wastes are more effective than synthetic conditioners on consistency limits. This is probably associated with the chemical structure of hazelnut husk and wheat straw and disintegration time (C/N ratio). And the fact that the conditioners were more effective in clay textured soils is probably due to the length of the process (incubation and cultivation) and the decelerated texture disintegration and aeration process. On the other hand, statistically significant positive correlations were found between soil consistency limits and organic matter content, while significant negative correlations were established with lime and pH values. It was determined that the effectiveness of conditioners depends on their own characteristics, and the texture, lime and organic matter content of soils, as well as on the application dose.

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Table 5. Duncan test results on the effects of soils mixed with different doses of conditioners on plasticity index values
Çizelge 5. *Farklı dozlarda düzenleyici karıştırılan toprakların plastiklik indeksi üzerine etkilerine ilişkin Duncan testi sonuçları*

Conditioners	WS	HH	HA	PAM
Plasticity index (PI), %	9.97[a]	9.50[b]	9.40[b]	9.18[c]
Doses	D1	D2	D3	
Plasticity index (PI), %	9.10[c]	9.44[b]	10.00[a]	

(WS: wheat straw, HH: hazelnut husk, HA: humic acid, PAM: polyacrylamide (D1: WS, HH: 0%; HA: 0 ppm; PAM: 0 ppm, D2: WS, HH: 2%; HA: 100 ppm; PAM: 30 ppm, D3: WS, HH, 4; HA: 2000 ppm; PAM: 90 ppm))

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Assessing Growth Performance and Yields of Spinach (*Spinacia Oleracea* L.) Irrigated with Sea Water

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Abstract

This study was carried out to determine the utilization possibility of sea water in spinach plant cultivation, and to evaluate the effect on yield and growth parameters of spinach irrigated with sea water diluted at different rates. The experiment consists of 5 different irrigation water salinity. The tap water was taken as a control (T1; 0.33 dS/m), and 10% (T2;4 dS/m), 20% (T3; 7 dS/m), 30% (T4; 10 dS/m) and 40% (T5; 13 dS/m) rate of sea water diluted with tap water. According to results, the highest average fresh yield and dry matter values were obtained at T2 (%10) seawater treatment. Both T2 (10%) and T3 (20%) seawater treatments lead to increased fresh yields and dry matter compared to control conditions (T1). While using dilution 10% and %20 seawater for irrigation fresh yields increased approximately 27% and 8.5% respectively but when irrigated with 30% and 40% yields decreasing about 28% and 72% respectively. As with the yield results, the 4 dS/m seawater salinity level caused an increase in leaf heights and leaf number compared to the control treatment. In conclusion, this study shows that seawater can be used successfully when diluted 10% with good quality water without affecting the growth parameters and yields of spinach.

Keywords: Sea water irrigation, salt stress, spinach yield, salinity

Deniz Suyuyla Sulanan Ispanağın (*Spinacia Oleracea L.*) Büyüme Performansının ve Veriminin Değerlendirilmesi

Öz

Bu çalışma, deniz suyunun ıspanak yetiştiriciliğinde kullanılabilirliğini belirlemek ve farklı oranlarda sulandırılmış deniz suyu ile sulanan ıspanak bitkisinin verim ve büyüme parametrelerine olan etkisini değerlendirmek amacıyla yapılmıştır. Deneme 5 farklı sulama suyu tuzluluğundan oluşmaktadır. Musluk suyu kontrol olarak alınmış (T1; 0.33 dS/m), ve 10% (T2;4 dS/m), 20% (T3; 7 dS/m), 30% (T4; 10 dS/m) ve 40% (T5; 13 dS/m) oranlarında deniz suyu çeşme suyu ile seyreltilmiştir. Sonuçlara göre; en yüksek ortalama ıspanak verimi ve kuru madde değerleri T2 (%10) deniz suyu konusunda elde edilmiştir. Hem %10 hem de %20 oranlarında seyreltilmiş deniz suyu uygulanan konulardan, kontrol konusuna göre daha yüksek verim ve kuru madde elde edilmiştir. %10 ve %20 oranlarında seyreltilmiş deniz suyu kullanıldığında verim değerleri yaklaşık %27 ve %8.5 artarken, %30 ve %40 oranında sulandırıldığında verim değerleri %28 ve %72 oranında azalmıştır. Verim sonuçlarında olduğu gibi, 4 dS/m deniz suyu tuzluluk seviyesi (T2) kontrol konusuna kıyasla yaprak yüksekliklerinde ve yaprak sayısında artışa neden olmuştur. Sonuç olarak, bu çalışma, deniz suyunun iyi kalite su ile % 10 düzeyinde seyreltildiğinde ıspanağın büyüme parametrelerini ve verimlerini etkilemeden başarıyla kullanılabileceğini göstermektedir.

Anahtar kelimeler: Deniz suyu ile sulama, tuz stresi, ıspanak verimi, tuzluluk

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1. INTRODUCTION

Due to the global warming that has continued to increase in recent years, the whole world is faced with serious problems in terms of water resources. FAO estimates that by 2050, the world will need to produce sixty percent more food to feed its growing human population. In order to increase food production, a fifty percent increase in irrigated cultivation is required. However, existing water resources allow for an increase of only ten percent (FAO, 2017). For this reason, it is necessary to produce different solutions to meet insufficient water resources especially in regions located in arid and semi-arid climate zones such as our country. There is an increasing awareness among scientists and decision makers about the use of seawater (at least diluted) to reduce the supply of fresh water to be used for agricultural irrigation (Farhadi-Machekposhti et al., 2017; Ghassemi Sahebi et al., 2020; Bianciotto et al., 2021).

The high concentration of salts in seawater is the main limiting factor in the utilization of seawater for irrigation. Plants are damaged by salts due to osmotic effects and specific ion toxicity or their combination (Ayers and Westcot, 1989; Nandwal et al., 2000; El-Mahrouk et al., 2010). These factors cause adverse effects on plant growth and yield and these reductions vary according to plant species (Ayers and Wescot, 1976).

Spinach is a moderately salt-tolerant glycophyte and irrigation water salinity threshold level is 2.0 dS/m. According to some studies on spinach, 25% and 50% yield reduction occurs when irrigation water salinity (ECi) is about 3.5 dS/m and 5.7 dS/m respectively. It is determined that almost no yield can be obtained with irrigation water salinity higher than 15 dS/m (Ayers and Westcot, 1989; Hoffman et al., 1992; Grieve et al., 2012).

However, in a study by Ferreia et al. (2018), it was stated that although increasing amounts of Na and Cl accumulate in the leaves according to the physiological and genetic data of the spinach plant applied with salt water, it did not show toxicity even in irrigation water with an ECi of about 10 dS/m.

It is possible to find several scientific papers (Delfine et al., 2003; Ors and Suares, 2016; Erdem and Kale Celik, 2017; Ünlükara et al., 2017; Deveci and Tugrul, 2017; Ferreira et al.,2020; Uçgun et al., 2020) related to biochemical, physiologşical and moleculer mechanisms of spinach growing under salinity stress. Only in recent years, the effects of alternative water sources such as sea water on commercial plants have begun to be investigated. Turan et al., 2014 carried out a study to investigate the effects of irrigating lettuce (*Lactuca sativa* L. cv. Funly) with different concentrations of diluted seawater (0%, 2.5%, 5%, 10%, 15%, 20%) on the fresh yield, marketable yield and quality parameters. The results of this study demonstrated that low concentrations of seawater are suitable for lettuce production and lettuce can be grown successfully using diluted seawater at concentrations of 2.5% and 5%.

In another study, irrigation with diluted seawater improved the nutritional value and quality of cherry tomatoes (Sgherri et al., 2008). In addition, diluted seawater in the growing medium has also been shown to increase plant water use efficiency (Atzori et al., 2017).

The aim of this study determines using possibility of seawater for the cultivation of spinach and evaluate of changes that may occur in yield and growing parameters of spinach irrigated with different diluted seawater.

2. MATERIAL AND METHOD

2.1 Material

The experiment was carried out in a greenhouse located on Agricultural Research and Application Center of Isparta University of Applied Sciences

Table 2.1. Some physical and chemical properties of the experimental soil
Çizelge 2.1. *Deneme toprağının bazı fiziksel ve kimyasal özellikleri*

Parameters	Value
pH	7.15
EC (dS/cm)	0.146
Saturation (%)	45.00
Field capacity (%)	24.30
Wilting point (%)	12.86
Bulk density (g/cm^3)	1.15
Organic matter (%)	1.65
Lime (%)	26.44
Sand (%)	35.00
Clay (%)	41.00
Loam (%)	24.00
Texture	Clay Loam

Table 2.2. Chemical composition of irrigation water
Çizelge 2.2. *Sulama suyunun kimyasal içeriği*

		Soluable cations (meq/L)				Soluable anions (meq/L)				
EC (dS/m)	pH	Ca	Mg	Na	K	CO_3	Cl	SO_4	HCO_3	SAR
33 (seawater)	8.6	20.55	107.5	195	10.55	25	150	110.6	48	24.37
0.3 (tap water)	7.4	0.98	1.2	0.2	0.8	0	0.97	1.01	1.2	0.19
4	8.2	5.89	15.62	19.68	1.78	5.3	28.71	3.08	5.88	6.00
7	8.3	8.60	26.00	32.00	5.20	6.1	41.58	15.53	8.59	7.69
10	8.3	12.20	35.20	52.36	6.20	7.4	49.21	41.57	7.78	10.76
13	8.4	15.20	49.30	68.76	7.80	8.6	42.50	81.86	8.10	12.11

(37°77′ N, 30°54′ E) in Mediterranean Region of Turkey. In the experiment, plastic pots with a diameter of 17 cm and a height of 16 cm (volume 3 liter) were used and filled with 2.5 kg of soil. The experimental soil was taken from Aridisol great soil group. Soil physical and chemical properties were presented in Table 2.1. According to soil fertility analysis results for basal fertilizer, 10 ml NPK (sodium phosphorus potassium, 3.5 % NH4, 5.5 % NO_3, 10 % urea 19N-19P-19K+micro elements) was applied to the pots.

Spinach (*Spinacia Oleracea* L.) of Matador variety was used in this experiment. This variety is a fast growing, spreading, moderately upright growing variety Its leaves range from light green to dark green, and its shape is elongated oval or round. It is resistant to cold weather and moderately tolerant to salt stress. Spinach, whose leaves are eaten and has a very high nutritional value, is from the *chenopodiaoase* family. Its scientific name is *Spinacea oleracea L*. (Oraman, 1968). Three seeds were planted in each pot and irrigated to field capacity with tap water for 15 days and then they were irrigated with various levels of diluted seawater.

The seawater was obtained from Mediterranean Sea in Antalya/Turkey and diluted with tap water. Seawater salinity was measured as 33 dS/m. Portable EC meter (Hanna HI8633) used for measuring irrigation water salinity level before each application. Irrigation water quality parameters were given in Table 2.2.

2.2. Method

The experimental design was completely randomized block design with three replications. The experiment consists of 5 different irrigation water salinity. The tap water was taken as a control, and different rate of sea water diluted with tap water (Table 2.3).

Table 2.3. Salinity treatments
Çizelge 2.3. *Tuzluluk konuları*

Treatments	Dilution ratio	EC (dS/m)
T1	100% Tap water (Control)	0.3
T2	90% Tap water + 10% Sea water	4.0
T3	80% Tap water + 20% Sea water	7.0
T4	70% Tap water + 30% Sea water	10.0
T5	60% Tap water + 40% Sea water	13.0

Pots were weighed regularly and irrigated when soil moisture content decreased below the 50% field capacity. 15% leaching water were applied for all treatments. Plants were irrigated with seawater until harvesting (60 days after sowing). Spinach plant height was measured and plant leaf number were countered before harvesting.

The total weight of the plants was measured, and the total weight was divided by the number of plants to find the average plant fresh yield (gr/plant). Fresh samples were dried in an oven at 70 ºC until they reached a constant weight (approximately 48 hours), and their dry weights were measured.

MINITAB 18 computer package programs were used for statistical analysis of the results from spinach to determine its salinity responses. Three replicates were taken for each measurement and one-way ANOVA was used to identify significant differences according to Tukey's Test ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

In the study, the effects of diluted seawater salinity at different rates on plant fresh and dry weight, plant height and number of leaves were investigated.

3.1. The effect of sea water salinity on plant fresh yield and dry matter

Fresh and dry matters of spinach irrigated with diluted sea water were given in Table 3.1.

Table 3.1. Salinity treatments
Çizelge 3.1.*Tuzluluk konuları*

Treatments	Fresh yield (g/plant)	Dry matter (g/plant)
T1	45.59	3.91
T2	57.97	4.84
T3	49.44	4.24
T4	32.61	3.37
T5	12.76	1.68

There was a significant quadratic relationship between irrigation water salinity and fresh yield and dry matter (Figure 3.1). The correlation coefficient (R2) was found to be 0.98 for both fresh yield and dry matter values, respectively. According to variance analysis of average plant fresh yield and dry matter values differences in the spinach plant due to different concentrations of seawater are important with a probability of 95%. Tukey classification, which is one of the multiple comparison methods used to determine the differences between the level averages of the factors, are given on Figure 3.1 with lower case letter.

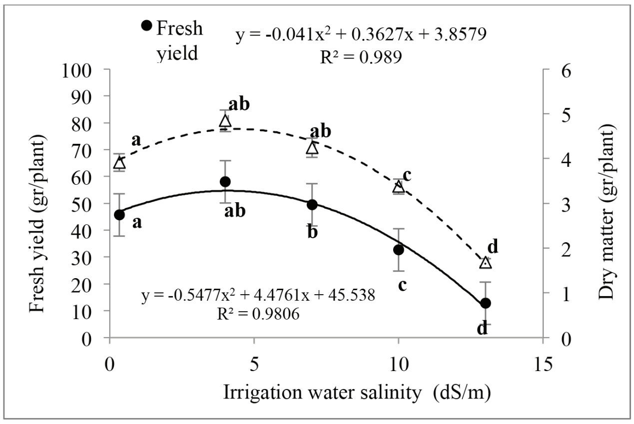

Figure 3.1. Relationships between irrigation water salinity and yield and dry matter
Şekil 3.1. *Sulama suyu tuzluluğu ile verim ve kuru madde arasındaki ilişki*

The highest average fresh yield and dry matter values were obtained at T2 (%10) seawater treatment. Both T2 (10%) and T3 (20%) seawater treatments lead to increased fresh yields and dry matter compared to control conditions (T1). Relative percentage and differences were calculated and presented Figure 3.2.

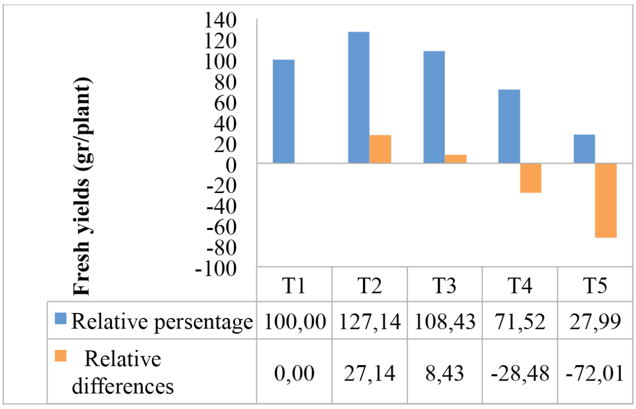

Figure 3.2. Relative percentage and differences of yield according to treatments
Şekil 3.2. *Konulara göre nispi verim ve verim farklılıkları*

While using dilution 10% and 20% seawater for irrigation fresh yields increased approximately 27% and 8.5% respectively but when irrigated with 30% and 40% yields decreasing about 28% and 72% respectively. Study results showed good agreement with other experiments conducted using diluted seawater (Caporratta et al., 2019; Ors and Suarez, 2016; Tomemori et al., 2002; Turan et al., 2014). Some scientist reported that diluted seawater becomes an essential source of micro and macro elements that may have a stimulatory effect on plant growth of spinach (Natsheh et al., 2012; Atzori et al., 2016; El-Nwehy et al., 2020).

3.2. The effect of sea water salinity on plant height

The effects of the applied seawater salinity levels on the plant height were measured and the plant heights according to the treatments were given in Table 3.2.

The increase in the concentration of sea water used as irrigation water caused a decrease in plant height. As seen in Figure 3.3, there is a negative quadratic relationship between treatments and plant height with correlation coefficient 0.86.

Table 3.2. Plant heights values of different seawater salinity levels
Çizelge 3.2. *Farklı deniz suyu tuzluluklarında bitki boyu değerleri*

Treatments	Plant Height (cm)			
	1. Replication	2. Replication	3. Replication	Average
T1	13.0	14.0	14.5	13.8
T2	15.0	16.5	12.0	14.5
T3	10.0	8.5	7.0	8.5
T4	8.5	6.0	9.0	7.8
T5	5.0	6.0	6.0	5.6

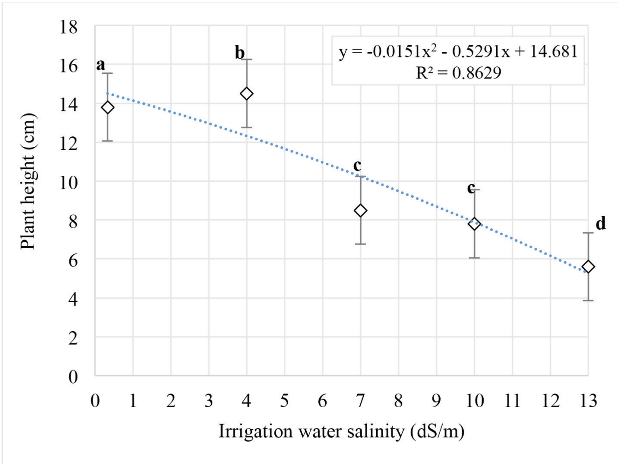

Figure 3.3. Relationships between irrigation water salinity and plant height
Şekil 3.3. *Sulama suyu tuzluluğu ile bitki boyu ilişkisi*

The results of analysis of variance of average plant heights are shown in Table 3.3.

Table 3.3. Variance analysis table of plant height
Çizelge 3.3. *Bitki boyuna ait varyans analizi tablosu*

Source of variation	SD	SS	AS	F	Table F	
					0.05	0.01
Treatments	5	150.93	30.19	73.96*	3.86	
Error	9	18.37	2.04			
General	14	172.93				

*; significant level of 0.05, SD; Standard deviation, SS; Sum of square, AS; Average of square

According to the statistical evaluation, the effect of sea water levels at different concentrations on plant height was found to be significant at the 0.01 level.

3.3. The effect of seawater salinity on the number of leaves

For commercial purposes, leaves are the main component of spinach plant (Atzori et al., 2017; Caparrotta et al., 2019). The effects of seawater salinity levels on the number of plant leaves were evaluated and the average plant leaf numbers according to the subjects are given in Table 3.4.

Table 3.4. The number of plant leaves
Çizelge 3.4. *Bitki yaprak sayısı*

Treatments	The number of plant leaves (cm)			
	1. Replication	2. Replication	1. Replication	Average
T1	12	13	11	12
T2	14	13	12	13
T3	11	10	9	10
T4	8	9	7	8
T5	7	7	7	7

The highest average number of plant leaves was obtained in T2 treatment. The average number of plant leaves was T1 (12), T3 (10), T4 (8), and T5 (7), respectively. The variance analysis results of the average plant leaf numbers are shown in Table 3.5.

Table 3.5. The number of plant leaves variance analysis table
Çizelge 3.5. *Bitki yaprak sayısına ait varyans analizi tablosu*

Source of variation	SD	SS	AS	F	Table F	
					0.05	0.01
Treatments	5	40.93	8.19	32.13*	3.86	
Error	9	11.47	1.27			
General	14	52.93				

*; significant level of 0.05, SD; Standard deviation, SS; Sum of square, AS; Average of square

There is a significant negative relationship between seawater salinity and the number of plant leaves. This situation can be seen in Figure 3.4.

According to the obtained values, the correlation coefficient R^2 = 0.98. As the irrigation water salinity increased, there was a linear decrease in the number of plant leaves. No significant differences in leaves number were assessed among treatments at T4 and T5.

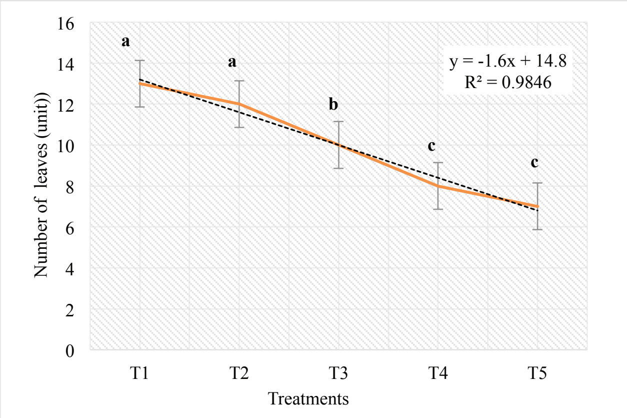

Figure 3.4. Average number of leaves and Tukey classifications
Şekil 3.4. *Ortalama yaprak sayıları ve Tukey sınıflaması*

4. CONCLUSIONS

Experiment results indicated that more than 10% diluted seawater application negatively affected of the spinach plant in terms of fresh and dry yields as compared to the control. Both 10% and 20% seawater treatments lead to increased relative yields (%27 and %8) but 30% and 40% diluted seawater treatments decreased relative yields about 28% and 72% respectively. As in yield results, significant differences in leave heights and number of leaves were observed, with 4 dS/m sea water salinity level (T2) compared to the control.

In conclusion, this study indicates that spinach can be successfully cultivated using sea water with moderate salinity (%10 diluted) without altering its growth parameters and yields.

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Makale; Türkçe başlık, Yazar(lar), Yazar adres(leri), Öz, Anahtar kelimeler, İngilizce başlık, Abstract, Keywords, Giriş, Materyal ve Yöntem, Bulgular ve Tartışma, Sonuç, Teşekkür (varsa), Kısaltmalar (varsa), Kaynaklar, Şekil ve Çizelge bölümlerinden oluşmalıdır. Makale, "Kaynaklar" bölümü dahil 18 sayfayı geçmemelidir.

Başlık: Kısa, makalenin içeriğini tam olarak yansıtacak şekilde olmalı ve 15 kelimeyi aşmamalıdır. Kelimelerin ilk harfi büyük, koyu (bold) ve 14 punto ile yazılmalıdır. İngilizce başlık Türkçe başlığı tam olarak karşılamalı ve koyu (bold) olarak 13 punto ile yazılmalıdır. Yazışmalarda sorumlu yazarın kim olduğu ve elektronik ileti adresi yazar adreslerinin altında dipnot olarak belirtilmelidir.

Kısa Başlık: Makalenin iç sayfalarında üst bilgi şeklinde verilecek olan akıcı (kısa) bir başlık (running head) da oluşturulmalıdır. Kısa başlık makale başlığını içerecek ve 8 kelimeyi geçmeyecek şekilde olmalıdır.

Öz ve Anahtar Sözcükler: Türkçe ve İngilizce özetlerin her biri 250 kelimeyi geçmemelidir. Özet kısmı çalışmanın amacını, nasıl yapıldığını, sonuçları ve sonuçlar üzerine yazar(lar)ın yaptığı değerlendirmeleri içermelidir.

Anahtar Kelimeler: Özetlerin altında 1 satır boşluktan sonra, küçük harflerle, mümkünse başlıkta kullanılmayan, çalışmayı en iyi biçimde tanımlayacak en fazla 5 anahtar sözcük alfabetik sıra ile yazılmalıdır.

Giriş: Bu bölümde; çalışma konusu, gerekçesi, konu ile ilgili doğrudan daha önceden yapılmış çalışmalar ve çalışmanın amacı verilmelidir.

Materyal ve Yöntem: Çalışmada kullanılan materyal, araştırmanın uygulanması ve istatistiksel yöntemler hakkında kısa ve öz bilgi verilmelidir. Bu bölüm, aynı konuda çalışanlara araştırmayı tekrarlama olanağı verecek nitelikte açık olmalıdır.

Bulgular ve Tartışma: Bu bölümde elde edilen bulgular verilmeli, gerekirse çizelge, şekil ve grafiklerle de desteklenerek açıklanmalıdır. Bulgular tartışılmalı, ancak gereksiz tekrarlardan kaçınılmalıdır. Bulguların başka araştırmalarla benzerlik ve farklılıkları verilmeli, nedenleri tartışılmalıdır.

Sonuçlar: Elde edilen sonuçlar, bilime ve uygulamaya katkısıyla birlikte verilmelidir. Giriş ile Bulgular ve Tartışma bölümünde verilen ifadeler, bu kısımda aynı şekilde tekrar edilmemelidir.

Teşekkür: Gerekli ise mümkün olduğunca kısa ve yapılan katkı da ifade edilerek verilmelidir.

Kısaltmalar ve Semboller: Makalede kısaltmalardan mümkün olduğunca kaçınılmalıdır. Kısaltma ve semboller metin içinde ilk kez kullanıldığında açıklanmalıdır. Uluslararası geçerliliği olan ve yerleşik kısaltmalar tercih edilmelidir. Kısaltmalar makalenin başlığında kullanılmamalıdır.

Kaynaklar: Eserde yararlanılan kaynaklara ilişkin atıf metin içinde "(Yazarın soyadı, yıl)" yöntemine göre yapılmalıdır, örnek: (Özcan, 2011), (Erşahin ve Brohi, 2006). Yazara atıf yapılırsa sadece yayının yılı parantez içine alınmalıdır, örnek: Özcan (2003)'e göre ya da Erşahin ve Brohi (2006). Üç ya da daha fazla yazar için makale içindeki atıf'ında "vd" kullanılmalıdır, örnek: (Dengiz vd., 2010) veya Lawrence vd. (2001). Aynı yazarın aynı yıl içinde birden fazla yayını varsa, yıldan sonra küçük harfler verilmelidir, örneğin, (Gürbüz vd., 2003a).

Kaynaklar bölümünde metin içinde atıfı yapılan tüm kaynaklar alfabetik olarak (yazarların soyadlarına göre) ve orijinal dilinde verilir. Dergi isimleri kısaltma yapılmadan tam adı yazılmalıdır. Sadece özeti/abstract basılmış kongre kitaplarına atıf yapılamaz. Makaledeki yanlış atıf ve kaynak gösterimlerine ait sorumluluk yazar(lar)a aittir.

Dergi:

Dengiz O (2010). Morphology, physico-chemical properties and classification of soils on terraces of the Tigris River in the South-East Anatolia Region of Turkey. Journal of Agricultural Sciences, 16 (3): 205-212.

Bayramin I, Basaran M, Erpul G, Canga M R (2008). Assessing the effects of land use changes on soil sensitivity to erosion in a highland ecosystem of semi-arid Turkey. Environmental Monitoring and Assessement, 140:249–265.

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Şekiller ve Çizelgeler: Şekil, grafik, fotoğraf ve benzerleri "Şekil", sayısal değerler ise "Çizelge" olarak belirtilmelidir. Tüm şekil ve çizelgeler makalenin sonuna yerleştirilmelidir. Şekil ve çizelgelerin boyu tek sayfa düzeninde en fazla 16x20 cm ve çift sütun düzeninde ise genişliği en fazla 8 cm olmalıdır. Şekil ve çizelgelerin boyutu baskıda çıkabilecek özellikte olmalıdır. Araştırma sonuçlarını karşılaştırmalı olarak sunma özelliğinde olmayan fotoğraf makalede yer almamalıdır. Araştırma sonuçlarını destekleyici nitelikteki resimler 600 dpi çözünürlüğünde "jpg, pdf ve tiff" formatında olmalıdır. Renkli resimler yerine gri tonlu resimler tercih edilmelidir. Çizelgelerde dikey çizgi kullanılmamalıdır. Her çizelge ve sekile metin içerisinde atıf yapılmalı ve metin içinde atıf yapıldıktan sonra verilmelidir. Tüm çizelge ve şekiller makale boyunca sırayla numaralandırılmalıdır (Çizelge 1. ve Şekil 1.). Çizelge ve şekil başlıkları ve açıklamaları kısa ve öz olmalıdır. Çizelge başlıkları çizelgenin üstünde, şekil başlıkları ise şeklin altında yer almalıdır. Çizelge ve şekillerin İngilizce başlıkları, Türkçe başlığın hemen altına İtalik olarak yazılmalıdır. Şekillerde yatay ve düşey kılavuz çizgiler ve rakamlar bulunmamalı ancak istatistiksel karşılaştırma için verilmesi durumunda küçük harfler verilebilmektedir. Çizelge ve şekillerde kısaltmalar kullanılmış ise hemen altına bu kısaltmalar açıklanmalıdır. Farklı parçalardan oluşan çizim araçları, şekiller veya resimler, gruplandırılmalıdır. Cins ve tür isimleri italik olarak yazılmalıdır.

Birimler: Tüm makalelerde SI (Systeme International d'Units) ölçüm birimleri kullanılmalıdır. Ondalık kesir olarak virgül kullanılmalıdır (1.25 yerine 1,25 gibi). Birimlerde "/" kullanılmamalı ve birimler arasında bir boşluk verilmelidir (3 m/s yerine 3 m s–1, 4 kg N ha–1 gibi)

Formüller: Formüller numaralandırılmalı ve formül numarası formülün yanına sağa dayalı olarak parantez içinde gösterilmelidir. Formüller 12 punto olacak şekilde ana karakterler ve değişkenler italik, rakamlar ve matematiksel ifadeler düz olarak verilmelidir. Metin içerisinde atıf yapılacaksa "Eşitlik 1." Seklinde verilmelidir (…ilişkin model, Eşitlik 1. de verilmiştir).