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Effect of fertigation with different pH and EC levels on selected physical soil properties

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ABSTRACT

In this study, the effects of fertigation with different pH and EC level on soil physical properties such as aggregate formation (AF), aggregate stability (AS) and available water content (AWC) of soil were investigated. In the study, single crop tomato (*Solanum lycopersicum*, Anıt F1) was grown under cover for two consecutive years. A total of six fertigation applications (F_1: pH 7.2/EC 2.0; F_2: pH 7.2/EC 3.5; F_3: pH 6.5/EC 2.0; F_4: pH 6.5/EC 3.5; F_5: pH 5.0/EC 2.0 and F_6: pH 5.0/EC 3.5) were created, two different EC levels and three different pH levels. Fertigation applications were applied to the soil in three replications and the study was carried out in 18 plots in total. Based on our results, the effect of fertigation applications on the AF of the soil and the AWC during the year was not significant. On the contrary, the effect of fertigation on AS has occurred at different levels and degrees of importance in terms of the effect between years. Fertigation F_5, which has a pH 5.0/EC 2.0 levels, caused a significant increase in the stability of 2-1 mm aggregates.

1. Introduction

The most important condition for obtaining high yield from the soil is to know the soil properties well and to utilize it according to its capabilities and sustainability. A fertile soil has high organic matter and biological activity, friable stable aggregates, and a porous medium in which plant roots and water can move easily (Lewandowski and Zumwinkle 1999). On the other hand, the ability of the plant to develop well in the soil is significantly related to the physical properties of the soil environment in which it grows. Physical soil quality reflects the compatibility of the physical properties of the soil with plant productivity and environmental quality (Lal 1998). The most important physical soil quality parameters are the percentage of aggregation, the mean weighted diameter of the aggregates, the pore size distribution, and the water–holding characteristics of the soil (Subbian et al. 2000). Effective fertilizer management is important in improving the physical quality of the soil (Lal 1997).

Soil aggregates are generally examined in two categories as macro (>250 µm) and micro (<250 µm). Macroaggregates are formed by the combination of microaggregates (Golchin et al. 1994). Microaggregates are more resistant to external disruptive forces than macro aggregates (Christensen 2001).

The formation of aggregates in the soil and their size distribution are very important in terms of the movement of water and air in the soil, the development of plant roots and the balance of air and water in the soil. With the dispersion of aggregates, the disappearance of the pores in the soil, a decrease in the amount of aeration and infiltration capacity, an increase in the level of surface flow and erosion, and an increase in exposure to plant water stress and its frequency occur. It has been reported in various studies that the crop production system and fertilizer applications affect aggregation and mean weighted diameters of aggregates (Tripathi et al. 2014; Peng et al. 2015; Guo et al. 2019). As a result of the significant increases in root biomass provided by farm manure and inorganic fertilizer applications, high organic matter formation occurs in the soil. Thanks to the cementing effect, soil organic matter provides significant increases in the mean weighted diameters of aggregates (Benbi and Senapati 2009).

Aggregate stability is an expression of the resistance of the soil to the mechanical forces disrupting the soils and the degree of aggregate stability of the soils is accepted as an indicator of soil quality (Six et al. 2000). Aggregate stability often depends on soil properties such as organic matter, clay and oxide content (Zhang and Horn 2001; Převost 2004). Organic carbon and sesquioxides have a very important role in the aggregate formation of red soils (Yao et al. 1990). According to Mahimairaja et al. (1986) aggregate stability in humid regimes differs depending on fertilization and nutrient management. Many studies have been conducted on the effectiveness of fertilization on aggregate stability and different opinions have been reported (Bronick and Lal 2005; Yin et al. 2016; Xin et al. 2016).

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For a given soil, soil aggregation can be altered by fertilization and management strategies which can impact on the biotic and abiotic cementing agents (Noellemeyer et al. 2008; Sodhi et al. 2009). On the other hand, soil aggregate stability is predominately influenced by the following factors: soil organic carbon (SOC) content, texture, temperature, water content, freeze–thaw conditions, wetting–drying cycles, differences in soil management (e.g., tillage and crop rotation and residue management), acidity levels and calcium carbonate (CaCO3) concentrations, root mass, root length and microbial richness (Are et al. 2018).

Soil moisture is the most important factor that directly affects both soil formation and development and the growth and development of plants. Global climate changes cause significant drought problems in the world and this situation makes the methods to be applied in the protection of soil moisture important. The soil moisture regime affects the nutrient status of the soil under different agricultural production systems, as well as the distribution of plant roots to the soil and water use efficiency (Lata et al. 2020). Soil water retention is seen as a function of plant production systems and fertilization levels as well as the basic properties of the soil (Subbian et al. 2000). The physical, chemical and biological properties of the soil, the differences in meteorology and the pattern of the grown crops, and the changes in soil moisture in the surface and root zone are defined temporally and spatially (Monti and Zatta 2009).

Thanks to the aggregating and stabilizing functions of the materials applied in order to improve the aggregate formation in the surface soil, the rate of water entry into the soil and the amount of water retained in the soil are affected. In many studies, it is reported that balanced inorganic or organic fertilizer applications improve the physical properties of the soil by increasing the nutrient content and increase the productivity of the soil (Chen et al. 2009; Sun and Huang 2011). It has been reported by different researchers that crop production systems and fertilizer applications affect the water–holding capacity of the soil (Walsh et al. 1996; Bassouny and Chen 2016). The water–holding capacity of the soil also largely determines the mechanical resistance to root penetration. The penetration resistance of the soil can control plant growth by reducing the rate of root growth (Fasinmirin and Reichert 2011). The water–holding capacity of the soil in the plant production season is a basic feature that affects plant development, transport and transformation of plant nutrients, and the water and energy budget in the soil–plant system (Kahlon et al. 2013).

The aim of this study is to determine the effects of fertigation with different pH and EC values on physical soil properties such as aggregate formation, aggregate stability and available water content.

2. Materials and Methods

2.1. Study area and experimental methods

This study was carried out on *Lithic Rhodoxeralf* (Soil Survey Staff 2014) soil with a high lime content and clay loam texture. The study area (36° 53’ N, 30° 38’ E) is located in the Akdeniz University Faculty of Agriculture Research and Application area (Antalya, Turkey). The research was carried out as two–season single–crop tomato cultivation under greenhouse conditions. The trials were designed and conducted in a factorial experiment with 3 repetitions according to the randomized blocks experimental design.

Fertigation applications applied in the research include F_1: pH 7.2 / EC 2.0 dSm^{-1}, F_2: pH 7.2 / EC 3.5 dSm^{-1}, F_3: pH 6.5 / EC 2.0 dSm^{-1}, F_4: pH 6.5 / EC 3.5 dSm^{-1}, F_5: pH 5.0 / EC 2.0 dSm^{-1} and F_6: pH 5.0 / EC 3.5 dSm^{-1}. During the production season, in order to create 2.0 dSm^{-1} and 3.5 dSm^{-1} salinity levels, Ammonium Nitrate (NH_4NO_3), Mono Ammonium Phosphate (MAP), Mono Potassium Phosphate (MKP), Potassium Nitrate (KNO_3), Calcium Nitrate ($CaNO_3$), Magnesium Nitrate ($MgNO_3$) and Magnesium Sulphate ($MgSO_4$) were applied. Also micro element fertilizer containing iron, manganese, zinc and copper was used. In order to establish the salinity levels determined during the production season, the fertilization programme was carried out by using the pure substance amounts given in Table 1.

In the study, tomato plant (Solanum lycopersicum) was grown and Anıt F1 variety was used as a tomato variety in order to determine the effects of applications on yield and quality parameters in plant production. Tomato seedlings were planted in a double row (40 x 90 cm planting distance) in plots with a length of 10 m. A total of 50 seedlings were used, 25 tomato seedlings in each plot. Seedling planting was carried out on 17.10.2015 in the first year of the study and on 20.10.2016 in the second year (Fig. 1). Fertigation and other cultural processes (hoeing, tying, plant protection measures, etc.) after planting the seedlings were carried out regularly in the trials, which were carried out for approximately 8 months in both years. Fertilizer applications were made with drip irrigation. During the growing season, considering the climate and plant needs, irrigation was done at least 3 to 8 days apart.

2.2. Soil analysis methods

Soil samples were taken from 0–30 cm depth in order to determine the soil properties before and after fertigation. After the soil samples were air–dried, they were sieved through a 2 mm sieve and some physicochemical soil properties were determined.

Table 1. The amounts of nutrients used to reach the determined EC values in fertigation

EC ($dS\ m^{-1}$)	Fertigation components ($kg\ da^{-1}$)					
	First season					
	N	P_2O_5	K_2O	CaO	MgO	Micro-nutrients (Fe, Mn, Zn and Cu)
2.0	48.92	42.36	60.18	12.32	6.59	0.40
3.5	85.56	74.13	105.31	21.55	11.53	0.70
	Second season					
2.0	46.68	40.49	57.19	11.66	6.31	0.40
3.5	81.69	70.86	100.01	20.41	11.04	0.70

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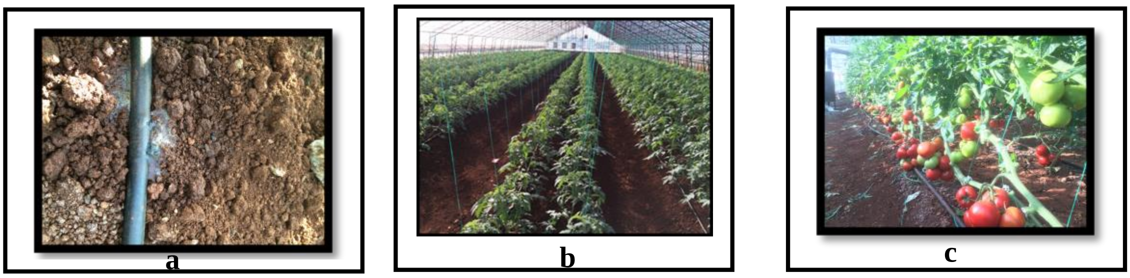

Figure 1. Fertigation (a) and tomato production (b, c) in the study area.

The texture was determined using the hydrometer method (Bouyoucos 1953). Soil pH values (Jackson 1967) and electrical conductivity (EC) were measured in a mixture of soil and water (ratio of soil to water 1: 2.5) by a digital pH meter and conductivity meter (Rhoades 1982). The carbonate ($CaCO_3$) content of soil was measured with a Scheibler calcimeter (Allison and Moodie 1965). The soil's total organic carbon content was determined using the modified Walkey–Black method (Black 1965). The organic matter content of soil was calculated by multiplying the organic carbon value by Van Bemmelen factor (1.724) (Nelson and Sommer 1982). Total nitrogen was determined using the modified Kjeldahl method (Kacar 1995). Available P (with $NaHCO_3$) was determined using the Olsen method (Olsen and Sommer 1982). The concentrations of DTPA-extractable Fe^{2+}, Zn^{2+}, Mn^{2+} and Cu^{2+} of soil were measured according to Lindsay and Norwell (1978). The exchangeable K^{+}, Ca^{2+}, Mg^{2+} and Na^{+} of soil samples were extracted by 1 N ammonium acetate (CH_3COONH_4), and determined by using an ICP–OES (PE–Optima7000DV) device (U.S. Salinity Laboratory Staff 1954).

Aggregate size distribution was determined by sieving 750 g of soil through sieves of <0.05, 0.05–0.25, 0.25–0.5, 0.5–1.0, 1–2, 2–4 and >4mm with a 75-stroke frequency/for 5 min in the rotary sieve machine (Chepil 1962). Macro– and micro–aggregate stability was determined by wet sieving each aggregate fraction (0.25 mm and 1–2 mm), which was obtained by dry sieving, for 5 min at 1.3 cm stroke length and 34 cycle/min (Yoder 1936). Aggregate stability percentage was calculated with Kemper's aggregate stability formula* (Kemper and Koch 1966). A sieve with 100 µm mesh aperture was used to correct the sand fraction weights.

*: Aggregate Stability (%) = $100 \times [(P1 - P2) / (P - P2)]$. (1)

P: Oven dry weight of soil (g)
P1: Stable aggregate + sand fraction weight (g)
P2: Sand fraction weight (g).

The water–holding characteristics of soil were calculated with a pressure plate extractor, corresponding to the field capacity (%) and the permanent wilting point (%), respectively. The soil's field capacity was determined using the undisturbed soil samples taken by a steel cylinder which the stainless-steel cores were 50 mm in height and 50 mm in diameter (98.125 cm^3 inner volumes), and the wilting point of soil was determined using disturbed soil samples (Richards 1947). The principal physical and chemical properties of the soils are represented in Table 2.

Table 2. Some physical and chemical analysis results of the research soil

Soil properties	Value
Sand (%)	22.12
Silt (%)	40.00
Clay (%)	37.88
Texture	Clay loam
pH (1: 2.5)	7.42
$CaCO_3$ (%)	17.20
Electrical conductivity-EC (dS m^{-1})	0.42
Organic matter (%)	2.43
Total N (%)	0.15
Available P (mg kg^{-1})	236
Exchangeable K (cmol kg^{-1})	0.67
Exchangeable Mg (cmol kg^{-1})	3.88
Exchangeable Ca (cmol kg^{-1})	31.36
Available Fe (mg kg^{-1})	4.73
Available Mn (mg kg^{-1})	10.70
Available Zn (mg kg^{-1})	9.24
Available Cu (mg kg^{-1})	6.80

2.3. Statistical analysis methods

All data were analyzed by the DUNCAN multiple comparison test ($P \leq 0.05$). All results presented in the text are expressed as mean values (n= 3). Statistical analyses were performed using MINITAP 16.1.1 (Minitab 2010).

3. Results and Discussion

3.1. Aggregate formation

The effect of six different fertigation cycles carried out in both years of the study on aggregate formation (AF) was not found to be statistically significant in any aggregate size. However, when the difference of the effect of fertigation on AF between years was examined, there were statistically significant differences in some aggregate sizes. F6 provided a significant increase ($P<0.05$) in the amount of aggregates with 2–1 mm size in the second year of the study compared to the first year. On the contrary, all fertigation applications except F_3 and F_4 in aggregate size of 0.5–0.25 mm, and F_1 in size <0.050 mm caused a decrease in the amount of aggregate in the soil in the second year of the study (Table 3). In particular, the increase in the amount of 2–1 mm aggregate obtained with low pH and high EC fertigation may be related to the increase in the amount of free Ca^{+2} ions. In other words, it is thought that both the dissociation of calcium

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Table 3. The effect of fertigation with different pH and EC levels on aggregate formation (%) [1]

Fertigation	>4 1. Year	>4 2. Year	LSD_Y [3] (%5)	4–2 1. Year	4–2 2. Year	LSD_Y [3] (%5)	2–1 1. Year	2–1 2. Year	LSD_Y [3] (%5)
F_1	26.60	23.41	n.s	18.44	18.94	n.s	17.52	19.95	n.s
F_2	25.56	19.96	n.s	18.73	19.77	n.s	18.21	20.39	n.s
F_3	24.77	24.45	n.s	18.33	22.45	n.s	17.84	20.81	n.s
F_4	20.87	23.03	n.s	16.12	18.68	n.s	18.50	20.92	n.s
F_5	22.90	19.94	n.s	19.73	17.93	n.s	18.81	21.05	n.s
F_6	26.07	19.42	n.s	16.61	17.88	n.s	17.25**B**[2]	21.49**A**	*
Mean	**24.46**	**21.70**		**17.99**	**19.28**		**18.02**	**20.77**	
LSD_F (%5)[3]	n.s	n.s		n.s	n.s		n.s	n.s	

Fertigation	1–0.5 1. Year	1–0.5 2. Year	LSD_y [3] (%5)	0.5–0.25 1. Year	0.5–0.25 2. Year	LSD_y [3] (%5)	0.25–0.050 1. Year	0.25–0.050 2. Year	LSD_y [3] (%5)	<0.050 1. Year	<0.050 2. Year	LSD_y [3] (%5)
F_1	14.79	17.44	n.s	11.18	10.38	n.s	9.40	8.39	n.s	2.00	1.19	n.s
F_2	14.77	17.70	n.s	10.85	11.57	n.s	9.61	9.05	n.s	2.16**A**	1.26**B**	**
F_3	15.07	15.93	n.s	11.53**A**	8.46**B**	*	10.02	6.61	n.s	2.25**A**	1.00**B**	*
F_4	17.62	17.97	n.s	13.84**A**	10.34**B**	*	10.85	7.77	n.s	2.04**A**	1.04**B**	*
F_5	15.52	18.82	n.s	11.35	11.59	n.s	9.50	9.08	n.s	2.02**A**	1.27**B**	**
F_6	15.45	19.25	n.s	12.12	11.46	n.s	10.23	8.84	n.s	2.11**A**	1.36**B**	**
Mean	**15.54**	**17.85**		**11.81**	**10.63**		**9.94**	**8.29**		**2.10**	**1.19**	
LSD_F (%5)	n.s	n.s		n.s	n.s		n.s	n.s		n.s	n.s	

1: Values of n= 3, 2: The difference between values not shown with the same letter are significant at $P<0.05$ level. Capital letters indicate the differences between the years, 3: Significance: *significant at $P<0.05$; **significant at $P<0.01$; n.s: not significant.

carbonate in the soil by fertigation with low pH and the Ca^{+2} ion originating from the CaO used in fertigation play a role in this event. Soil aggregation results from the rearrangement, flocculation and cementation of particles. It is mediated by soil organic carbon, biota, ionic bridging, and clay and carbonates (Bronick and Lal 2005). The increases in Ca^{+2} cations from the dissociation of $CaCO_3$ lead to coagulation of organic and mineral colloids from soil, promoting their flocculation (Gliński et al. 2011). Muneer and Oades (1989) report that the predominance of Ca^{2+} in the soil exchange complex acts as a physical stabilizer of soil organic matter as it allows better particle aggregation. Ca^{+2} acts as a binding agent between the organic and mineral fraction of soil, favoring the association and strengthening the links between mineral and organic particles, favoring the aggregates formation (Gliński et al. 2011; Briedis et al. 2012). The increase in Ca^{+2} and Mg^{+2} in the soil as a result of fertilization play an important role in forming aggregates through flocculation of clay particles (Rengasamy and Marchuk 2011).

Fertigation and crop rotation regulate C cycle dynamics and C storage, as they increase the biological activity in the soil and affect the amount and quality of residues returned to the soil (Aune and Lal 1997). The balanced use of organic and inorganic fertilisers is the most accepted strategy for maintaining agricultural productivity and increasing soil fertility (Sharma and Subehia 2003; Manna et al. 2007). In various studies, it has been reported that the total mean weighted diameter (MWD) of the soil significantly increased with different NPK levels and farm manure applications (Brar et al. 2015; Zhang et al. 2016). It has been reported by some researchers that the MWD of the aggregates increase, especially with nitrogen fertilizer applications (Subbian et al. 2000).

3.2. Aggregate stability

The effect of fertigation with different pH and EC levels on the stability of 2–1 mm aggregate in both years of the study was found to be statistically significant at $P<0.001$ and $P<0.01$ levels, respectively (Table 4). F4, F5 and F6 provided an increase in aggregate stability (AS) and the highest increase in stability was obtained from F5 application in both years (17.04% and 21.26%). This effect reveals the effect of both a decrease in pH and an increase in EC level on stability. In addition, fertigation shows that the decrease in pH level is more effective on stability than the increase in EC level. Tang at al. (2020) stated that the ratio of water–stable macro aggregates (0.25–2 mm) in silt loam and silty clay textured soils increased depending on the increase in soil EC level. It is thought that fertigation with a low pH level may cause the dissociation of $CaCO_3$ in the research soil with high lime content and thus increase the amount of free Ca^{+2} ions. In fact, it has been reported by researchers that calcium ion is an important cementing agent in many soils and increases aggregate stability. On the other hand, it is stated in various studies that with the increase in the EC level of the soil, the cation concentration of the soil increases and that there also may be significant increases in stability due to cation bridges. The role of carbonates, as a source of $Ca+^2$, in promoting mineral bonds and mineral-SOM interactions mediated by cation bridges has been described as being responsible for microaggregate formation and stability in several studies (Muneer and Oades 1989; Baldock and Skjemstad 2000).

The effect of fertigation on the stability of 0.25–0.050 mm aggregates was not found to be significant in both years of the study. However, considering the difference between years, there was no significant difference in the stability of 2–1 mm aggregate with fertigation, but F2 created a significant ($P<0.01$) difference in 0.25–0.050 mm aggregates. The effect of F2 on AS was greater in the second year than in the first year of the study (Table 4). Especially with fertilizer applications made in the greenhouse

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production system, significant increases in aggregate stability are obtained, but the effect of inorganic applications are less than organic applications (Herencia et al. 2011). On the contrary, it has been reported in some studies that especially nitrogen fertilizer applications disrupt the soil aggregate system and cause a decrease in stability (Fonte et al. 2009; Brtnicky et al. 2017).

3.3. Available water content

The effect of fertigation with different pH and EC levels on the available water content (AWC) of the soil was not found to be significant in both of the research years (Table 5). However, considering the difference between years, the effect of F4 application on soil AWC was found to be significant (*P*<0.05) and it provided a higher increase in soil AWC in the second year (8.23%) compared to the first year (6.23%) of the study (Table 5).In the second year of the study, fertilization with low pH and high EC levels increased the amount of aggregates, especially in 2–1 and 1–0.5 mm sizes. This is an indication that the macro and medium dimensional pore volume of the soil has increased. It can be said that due to the positive development provided in the pore structure of the soil, the amount of available water in the soil has also been improved. Guber et al. (2003) reported that aggregate size distribution parameters can be useful in estimating soil water retention parameters especially that the content of medium–sized aggregates affects the water content at -33 and -1500 kPa.

Bassouny and Chen (2016) reported that after 14 years of organic and inorganic (NPK) fertilizer applications, inorganic fertilizer applications increased the amount of water content at 0–10 and 10–20 cm soil depth at all tensions in the 0–1500 kPa range. On the other hand, Herencia et al. (2011) reported that there is no significant difference between organic and inorganic fertilization in terms of the available water capacity of the soil in greenhouse or open field production. Lata et al. (2020) stated that three different nitrogen fertilizer applications in four different production systems did not make a significant difference in the moisture characteristics of the soil, and the water–holding characteristics of the soil were strongly affected by texture and physical conditions.

The ideal soil EC value in plant production is 2-4 dS m^{-1}. Soils with an EC value above 4 dS m^{-1} are considered saline soils (Qadir et al. 2007). Above this value, many plants are adversely affected. The EC levels of the majority of greenhouse soils in Antalya, where greenhouse production is carried out intensively, are above 4 dS m^{-1} (Sönmez et al. 2004). High EC increases the osmotic pressure of the soil environment, making it difficult for the plant to absorb water and nutrients (Ding et al. 2018). In our study, the EC level, which is the upper limit for plant production, was not exceeded. In addition, although it was statistically insignificant, especially in the second year of the study, an increase in the amount of aggregates with a size of 2–1 mm was achieved also with other applications other than F6. This effect shows the importance of the effect of fertigation on the AWC due to the improvement in soil structure.

Table 4. The effect of fertigation with different pH and EC levels on aggregate stability (%) [1]

Fertigation	Aggregate Size (mm)					
	2–1			0.25–0.050		
	1. Year	2. Year	LSD_Y (%5)[3]	1. Year	2. Year	LSD_Y (%5)[3]
F_1	2.97**c**[2]	3.48**d**	n.s	97.23	96.18	n.s
F_2	3.64**c**	3.84**d**	n.s	96.29**B**	98.41**A**	**
F_3	3.25**c**	3.41**d**	n.s	96.56	97.06	n.s
F_4	8.96**b**	9.37**c**	n.s	97.39	95.68	n.s
F_5	17.04**a**	21.26**a**	n.s	96.72	95.44	n.s
F_6	9.57**b**	10.42**b**	n.s	96.99	97.12	n.s
Mean	**7.57**	**8.63**		**96.86**	**96.64**	
LSD_F (%5)[3]	***	**		n.s	n.s	

1: Values of n= 3, 2: The difference between values not shown with the same letter are significant at *P*<0.05 level. Small letters indicate the differences within the year, and capital letters indicate the differences between the years, 3: Significance: **significant at *P*<0.01; ***significant at *P*<0.001; n.s: not significant.

Table 5. The effect of fertigation with different pH and EC levels on available water content (AWC) of soil (%) [1]

Fertigation	Available Water Content (AWC) (%)		LSD_Y (%5)[3]
	1. Year	2. Year	
F_1	6.73	6.29	n.s
F_2	6.30	6.49	n.s
F_3	6.47	5.88	n.s
F_4	6.23**B**[2]	8.23**A**	*
F_5	6.73	5.97	n.s
F_6	6.20	7.91	n.s
Mean	**6.44**	**6.79**	
LSD_F (%5)[3]	n.s	n.s	

1: Values of n= 3, 2: The difference between values not shown with the same letter are significant at *P*<0.05 level. Capital letters indicate the differences between the years, 3: Significance: *significant at *P*<0.05; n.s: not significant.

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4. Conclusions

In our study, the effect of fertigation with different pH and EC values on selected physical properties of the soil occurred at different levels and directions. It can be seen that fertigation with high EC and low pH levels can be important especially in macro–scale aggregation. With high EC value fertigation, cation increase will be provided in the soil, and due to the cation bridges that will be formed between the colloids as a result of this increase, an improvement in aggregation will be achieved. In addition, with low pH level fertigation, the lime in the trial soil with high lime content will be partially dissolved and a significant amount of free Ca^{2+} ions will be released. In this way, it is thought that promoting cation bridges between colloidal surfaces may be important.

The highest aggregate stability values were obtained especially at low pH levels. It is thought that the possible high Ca^{2+} concentration in the soil solution due to low pH fertigation and $CaNO_3$ fertilizer application s are important in this effect. In addition, as a result of fertigation with low pH and high EC values, there was an increase in the amount of available water in the soil, especially with the increase in the amount and stability of aggregates with macro size. As a result, it is understood that fertigation with high EC and low pH values will make important contributions to the improvement of the physical properties of calcareous soils with high pH values. However, considering the negative effects of high EC level in plant production, it was predicted that fertigation with low pH and medium EC level would be more suitable in terms of productivity, especially in soils with high lime content.

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