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Evaluation of the different soil management effects on salinity control in maize cropping by HYDRUS-2D

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Abstract

Continuous irrigation causes soil salinity and decreases soil fertility. The purpose of this study is to find methods that can prevent soil salinity. Thus, a soil column with 15 cm stack height, under maize cultivation and tape irrigation has been simulated by HYDRUS–2D. In order to assess the effects of different scenarios including tape location (stack/ditch), stack height (in drip and surface irrigation), using mulch and irrigation water salinity on salinity accumulation in root zone in different time frames. The results show placing tapes on ditch will increase soil primarily salinity (0.65 dS m^{-1}) 8%, 8% and 10% lower than placing it on the stack after 1, 5 and 10 years. Also, height stack is not very effective for controlling salinity in both drip and surface irrigation. Because, assessing soil columns with 0, 10, 15 and 20 cm stack height showed neglectable difference between salinity both in short term and long–term scenarios (according to variance analysis test). Using mulch is an effective way to control salinity because it can decrease evaporation. After 1, 5 and 10 years of irrigation in mulch presence, salinity increased 34.5%, 42.8% and 50% lower than without mulch scenario. Also, irrigating soil by water of different salinities including 0.7, 1.7 and 2.7 dS m^{-1} showed 77.5%, 83.5% and 84.2% increase in salinity after 10 years ago.

1. Introduction

Water and soil are two important contents in agriculture. But unlike water, soil has get less attention. Irrigation causes salt accumulation in fertile lands which consequently makes the soil saline and destroys its structure. Neglecting salt balance in soil can be a serious thread for sustainable agriculture. Modern irrigation systems designers try to postpone this event by considering leaching requirement in their designs. But in most of the implemented irrigation systems leaching programs are not very operational and enforceable due to the lack of drainage systems and water resources limitation. Not only lack of drainage systems led to neglect leaching requirement at field but also water resources limitation has same results. It is just limited to calculations. The importance of leaching is even more in modern irrigation systems including drip and sprinkle irrigation. Because the lack of deep percolation which fasten the soil destruction. While, due to the shortage of fresh water specially in arid and semiarid areas, all recommendations end with more use of modern irrigation systems. Thus, assessing these irrigation systems, controlling the quality of soil and performing leaching programs on time are of high importance. The main purpose of this study is to assess different scenarios and find ways to control salinity accumulation. These scenarios including the effect of tape location, irrigation stack height (in both drip and surface irrigation), using mulch and irrigation water salinity in tape irrigation on salt accumulation. Also, all the scenarios have been done for 1, 5 and 10 years. For this purpose, HYDRUS-2D software has been used. Models are actually an attempt to predict conditions and events that are likely to occur in the future. It is hoped that based on models' results, more appropriate decisions will be made for optimal and sustainable use of resources (water and soil). Also, doing field experiments are both time-consuming and costly. Thus, using computer models as a suitable alternative has been extended in recent years.

Mirzayi and Nazemi (2011), in their research assessed salinity movement in the soil and the effect of soil primarily moisture on salinity distribution by means of HYDRUS software. Results showed that, model has the ability to simulate salinity movement accurately. Taqavi et al. (2012), used HYDRUS-2D software for simulating soil moisture in subsurface pressurized irrigation systems. The results showed that the model has the ability to simulate moisture distribution. Also, they stated that as time goes, the soil moisture will become steady more, because of the moisture redistribution. Thus, after 72 hour from irrigation, model can simulate moisture distribution more accurate. Also,

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Soltani et al. (2017) used HYDRUS-2D software for simulating dry drainage systems. They assessed the model ability for estimating soil hydraulic and solute transport parameters by means of inverted solution and concluded that the model has the ability to estimate these parameters accurately. But it's more accurate in terms of simulating soil hydraulic parameters. Provenzano (2007), used HYDRUS model for assessing the volume of moist soil in subsurface drip irrigation and the results showed that HYDRUS can simulate the soil moisture properly. Feyzi (2002), while emphasizing that in most arid and semi-arid regions of Iran, the irrigation water is not of good quality and is associated with high levels of salinity, and it is necessary to use salinity-resistant and semi-resistant plants, in his research assessed the effect of saline irrigation water on wheat yield. The results showed that, irrigation water salinity has a significant effect on seed yield, seed weight, stem height and spike length. Wheat has been irrigated by water of three different salinity levels in three different scenarios and results showed that as the irrigation water salinity increases, the wheat yield decreases. Feyzi and Saadat (2015) assessed the effect of saline water on product's yield and soil salinity. They tried water of three different salinity levels and different management for irrigating wheat, sugar beet and sunflower. Results showed that although, using different managements can increase the crops' yield but soil salinity is unavoidable.

Wei et al. (2019), in their research assessed the effect of irrigation water salinity on soil features, N_2O emission and spring maize yield under drip irrigation. They used water of different salinity levels and the results showed that using more saline water for irrigation causes more soil salinity and decreases soil water content. Also, as salinity increases spring maize yield decreases which consequently increases N_2O emission in soil. Yuan et al. (2018) assessed the effect of irrigation water salinity on salinity distribution in soil, soil physical features and maize yield in northwest of China. Results showed that using saline water for irrigation specially, in long term can cause salinity accumulation and consequently will increase salinity distribution in soil. Saline irrigation water can increase soil volume density, decrease soil porosity and soil saturated hydraulic conductivity. Also, irrigating maize with saline water will decrease stem height, leaf surface index and crop yield. Farhadi Machekposhti et al. (2017), in their research assessed the effect of irrigating near shore lands with a mixture of fresh water and saline sea water. Results showed as the seawater share increases and makes the water more saline, soil will become more saline too. Also, in a sunflower farm, as the irrigation water salinity increases, crop yield decreases.

The main purpose of this research is to assess the effect of different managements including the location of tape, stack height, using mulch and irrigation water salinity on salinity control in the soil under maize cultivation by means of HYDRUS-2D. In this way, it is possible to determine ideal managements and scenarios which help to control salinity expansion in the soil. Also, mostly researchers have been assessed the effect of irrigation water salinity on wheat. Although, some researches have considered maize in their studies but using HYDRUS-2D for simulating soil under maize cultivation and also, simulating all the different scenarios including the effect of tape location (stack or ditch), stack height in tape and furrow irrigation, role of mulch and irrigation water salinity in salinity accumulation with HYDRUS-2D are the difference between this study and others.

2. Materials and Methods

2.1. Study area

The available data is the result of a research conducted on the maize under tape irrigation in the research farm of water department, Imam Khomeini International University located in Qazvin province, Iran, during a period of 105 days from 2018/4/11 to 2018/7/23. Qazvin province with an area of 15623 km^2 has been located in the Iran central plateau between longitudes 48°44″ to 50°51″ E and latitudes 35°36″ to 36°48″ N.

2.2. Hydrological and Climatical characteristics of area

Qazvin city's average height from the sea is between 1135 to 1145 m. The average annual temperature and precipitation and evapotranspiration are 13.4□ and 320 mm and 1060 mm respectively. Also, according to De Martonne classification the study area has been determined as dry and semi-cold.

2.3. Soil characteristics

Soil characteristics of the area has been reported in Table 1.

Table 1
Soil characteristics in the study area

Depth 30–60 cm	Depth 0–30 cm	
8	10	Clay (%)
24.5	33	Silt (%)
67.5	57	Sand (%)
SL	SL	Soil texture
22	23	Weighted moisture at FC (%)
13.5	14	Weighted moisture at PWP (%)

Maize has been cultivated in 15 plots where the area of each plot was 9 m^2 and the dimensions were 3*3 meters. In each plot, the distance between the rows of cultivation and between the maize seeds were 75 cm and 30 cm respectively.

2.4. HYDRUS-2D model

The model has the ability to simulate water, solute, heat transport, and root water uptake in steady and non-steady states in one, two, and three-dimensional ways and is developed by Simunek et al. at USSL in 2006. This model consists of two different parts including computational part and graphical part. The Richard's equations and convection-dispersion equations (CDE) are applied in HYDRUS to simulate water flow and solute/heat transport, respectively. Also, this model has the ability to estimate soil hydraulic and solute transport parameters by means of inverse solution at both saturated and unsaturated zones (Sejna et al., 2011). Galerkin linear finite elements method and Levenberg-Marquardt algorithm are applied in model to do numerical solution and parameter optimization, respectively (Abbasi and Tajik, 2007).

2.5. Procedure

At first, the model has been calibrated and validated. All the process and input data are in the appendix available at ....tu damy link do strony, na której będzie znajdował się załacznik ....

2.6. Scenario 1) effect of tape location (stack or ditch) on salinity accumulation in root development zone in soil under tape irrigation

In order to assess and determine the best location for tape strips, simulation has been done twice. First by putting irrigation strips on a stack with a height of 15 cm (the standard stack height in research area) and then by putting these strips on ditch. The location of tape strips in these two scenarios have been shown in Figure 1. Soil surface has been defined as atmospheric boundary condition. The bottom boundary has been defined as free drainage. The vertical nodes on left and right sides of the control volume have been determined as no flux. Tape strip has located on the left side on the ridge (for tape on the stack scenario) and on the right side on the ridge (for tape on the ditch scenario) which has been defined as variable flux and it's 1 cm according to dripper's radius. Also, the width of stacks is 75 cm but as the data collection was done on one side of the stack, assuming the soil is homogeneous in the horizontal direction and in order to reduce the amount of model calculation, simulation has been done based on half of the stack width (37.5 cm). In all the scenarios the land is under the maize cultivation and simulating has been done for different time frames including 1, 5 and 10 years. Figure 1 shows the boundary condition of the control volumes and Figure 2 shows salinity degrees in the different parts of the soil column. The primarily salinity in the root development zone is 0.65 dS m^{-1}.

2.6.1. Leaching

Irrigation water contains more or less soluble salts. Due to evaporation, these salts may accumulate in crop's root development zone and make growth difficult. In these situations, leaching is necessary in order to washing out useless solutes. It is especially important in drip irrigation where the amount of water used is low and as a result water and dissolved solutes move towards the depth of the soil. Maize can tolerate salinity till 1.7 dS m^{-1} and categorizes in semi-sensitive crops. Another purpose in this scenario is to assess the effect of tape strip location on leaching requirements. Leaching requirement has been calculated by means of equation 4. In this equation ECw is the irrigation water salinity (dS m^{-1}), ECe is the saturated extract salinity (dS m^{-1}) and LR is the leaching requirement fraction (–).

$$LR = \frac{EC_w}{2 * EC_e}$$

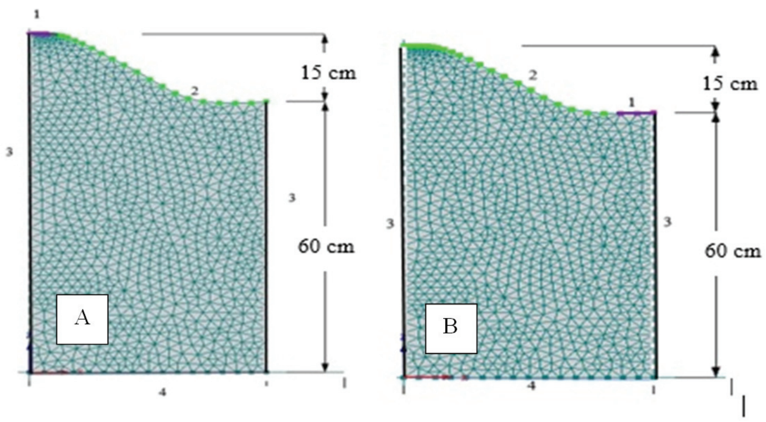
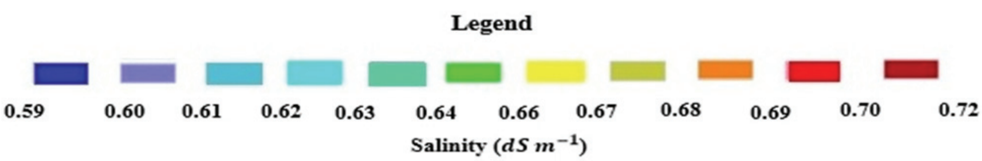


Fig. 1. control volumes' boundary conditions (A: tape on stack and B: tape on ditch) (1: variable flux, 2: atmospheric, 3: no flux, 4: free drainage)



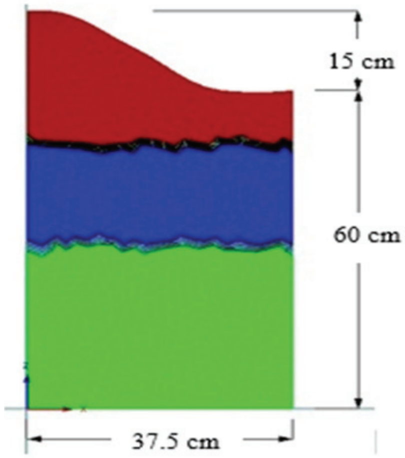


Fig. 2. Soil column's primarily salinity

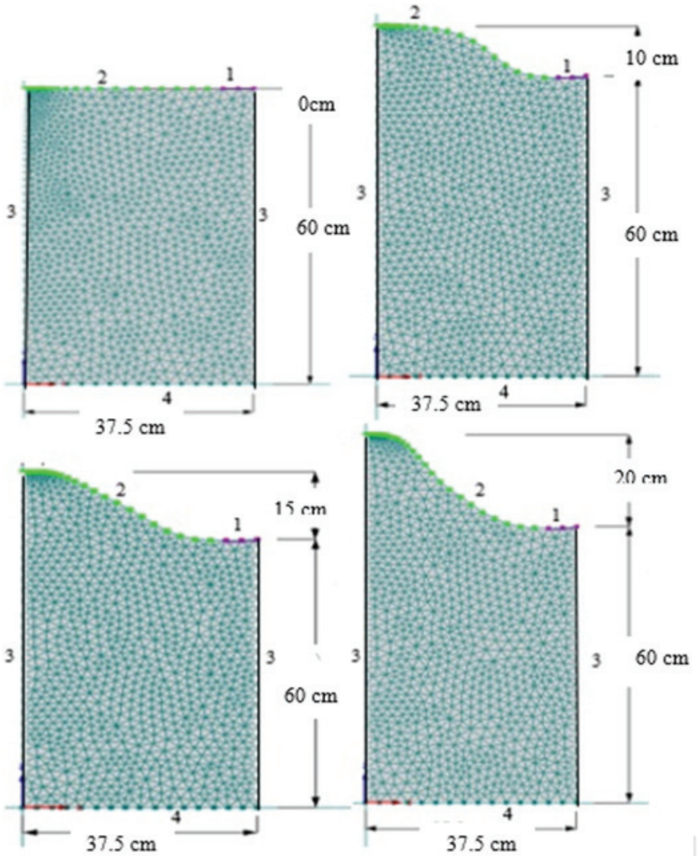


Fig. 3. Control volumes with different stack heights' boundary conditions (1: variable flux, 2: atmospheric, 3: no flux, 4: free drainage) (under tape irrigation)

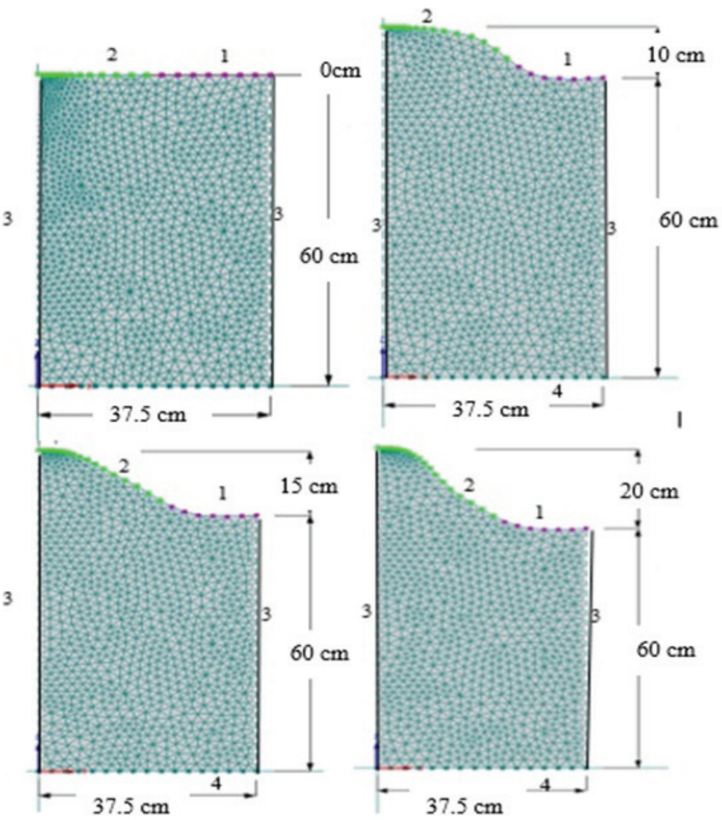


Fig. 4. Control volumes with different stack heights' boundary conditions (1: variable flux, 2: atmospheric, 3: no flux, 4: free drainage)(under furrow irrigation)

2.7. Scenario 2) effect of stack height on salinity accumulation in soil under tape irrigation

The purpose of this scenario is to assess the effect of stack height on salinity accumulation in soil under tape irrigation in different time frames. The standard stack height in the study region is 15 cm. Stacks with a height of 0 cm, 10 cm, 15 cm and 20 cm have been simulated in order to consider standard stack height and heights above and under the standard height. The soil column height is 60 cm thus the total height of the columns considering the stack's height will be 60 cm, 70 cm, 75 cm and 80 cm. Also, the width of stacks is 75 cm but as the data collection was done on one side of the stack, assuming the soil is homogeneous in the horizontal direction and in order to reduce the amount of model calculation, simulation has been done based on half of the stack width (37.5 cm). Figure 3 illustrates soil columns geometry and different stacks heights. Tape strip has located on the ditch. Which has been defined as variable flux and its 1 cm according to dripper's radius. In all the scenarios the land is under maize cultivation and simulation has been done for different time frames including 1, 5 and 10 years.

2.8. Scenario 3) effect of stack height on salinity accumulation in soil under furrow irrigation

The purpose of this scenario is to assess the effect of stack height on salinity accumulation in soil under furrow irrigation in different time frames. The standard stack height in the study region is 15 cm. Stacks with a height of 0 cm (basin), 10 cm, 15 cm and 20 cm have been simulated in order to consider standard stack height and heights above and under the standard height. The soil column height is 60 cm thus the total height of the columns considering the stack's height will be 60 cm, 70 cm, 75 cm and 80. Also, the width of stacks are 75 cm but as the data collection was done on one side of the stack, assuming the soil is homogeneous in the horizontal direction and in order to reduce the amount of model calculation, simulation has been done based on half of the stack width (37.5 cm). Figure 4 illustrates soil columns geometry and different stacks heights. In all the scenarios the land is under maize cultivation and simulation has been done for different time frames including 1, 5 and 10 years.

2.9. Scenario 4) effect of using mulch on salinity accumulation in root development zone

Decreasing evaporation loss by means of mulch, in addition to being a significant help in water conservation can control soil salinity. The purpose of this scenario is to evaluate the effect of using mulch on controlling salinity in root development zone. Control volume for this scenario has been illustrated in Figure 5. Beyrami and Rezayi (2021) in their research concluded that using mulch (water-passing layer, gravel and manure) on soil surface

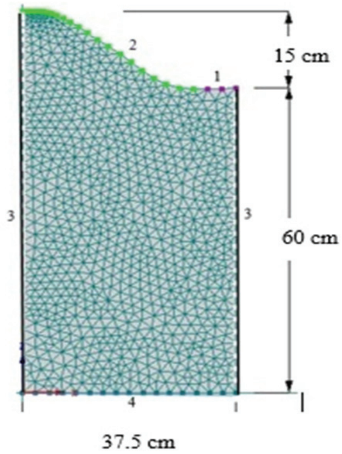


Fig. 5. Control volume's boundary conditions (1: variable flux, 2: atmospheric, 3: no flux, 4: free drainage)

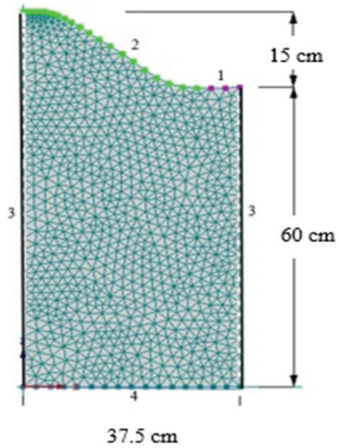


Fig. 6. Control volume's boundary conditions (1: variable flux, 2: atmospheric, 3: no flux, 4: free drainage)

can decrease surface evaporation which is different in different soil textures. Using mulch can decrease surface evaporation 59.8%, 58.2% and 61.4% in sandy loam, loam and clay loam respectively. In this study soil texture is sandy loam thus using mulch can decrease surface evaporation 59.8% but 10% has been considering as safety factor and in order to assess the effect of using mulch on controlling salinity in root development zone, evaporation has been decreased 50% and simulation has been done for 1, 5 and 10 years intervals. Figure 5 shows the boundary condition for this scenario.

2.10. Scenario 5) effect of irrigation water salinity on soil accumulation under tape irrigation

The purpose of this scenario is to assess the effect of irrigation water salinity on soil accumulation under tape irrigation in different time frames. The salinity tolerance threshold in maize is 1.7 dS m^{-1}. Thus the effect of salinity has been assessed in three different scenarios while the irrigation water salinity is 0.7 dS m^{-1}, 1.7 dS m^{-1} and 2.7 dS m^{-1} which is lower than maize tolerance threshold, equal to tolerance threshold and higher than tolerance threshold respectively. All of the scenarios have been done in 1, 5 and 10 year intervals. The width of geometry is 37.5 cm due to the mentioned reasons and stack height is considered 15 cm which is the standard height for the region. Figure 6 shows the geometry and boundary condition for this scenario.

3 Results and discussion

3.1. Scenario 1) effect of tape location (stack or ditch) on salinity accumulation in root development zone in soil under tape irrigation

According to Figure 7, placing tape strips on stack can increase salinity accumulation in root development zone and other parts in the soil column both in short term and long term. By placing tape on the ditch, after 1, 5 and 10 years of irrigation, the initial salinity of the soil (0.65 dS m^{-1}) has been increased by 50%, 60.3% and 60.4% respectively and has been reached to 1.3, 1.63 and 1.65 dS m^{-1}. while, placing them on stacks after 1, 5 and 10 years can increase primarily salinity 58.7%, 68% and 70% and reach it to 1.58, 2.04 and 2.16 dS m^{-1}.

The graphical results of assessing the effect of tape location (stack/ditch) have shown in Figure 8. As it is obvious from the graphical results placing tape on ditch has caused a lower salinity increase in the root zone in all time periods and it's better to place tapes on the ditch. The salinity tolerance threshold of maize is 1.7 dS m^{-1}. Thus, according to results, when tape is on the ditch, the salinity in the root zone is lower than maize's tolerance threshold in all time intervals and there is no need for leaching. No need for leaching saves water. While by placing the tapes on stack, salinity in root zone has became more than tolerance threshold. Although there's no need for leaching after 1 year irrigation. But after 5 and 10 years irrigation, leaching

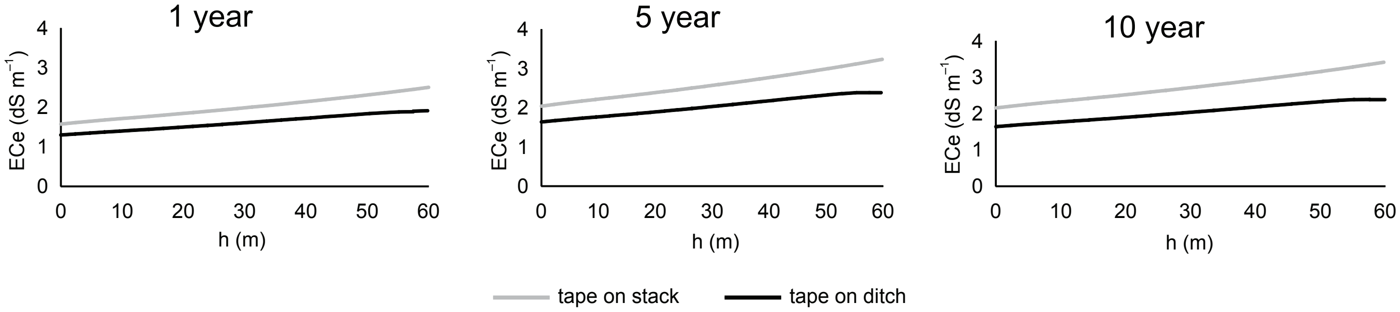


Fig. 7. The effect of tape location (stack or ditch) on salinity accumulation in root development zone

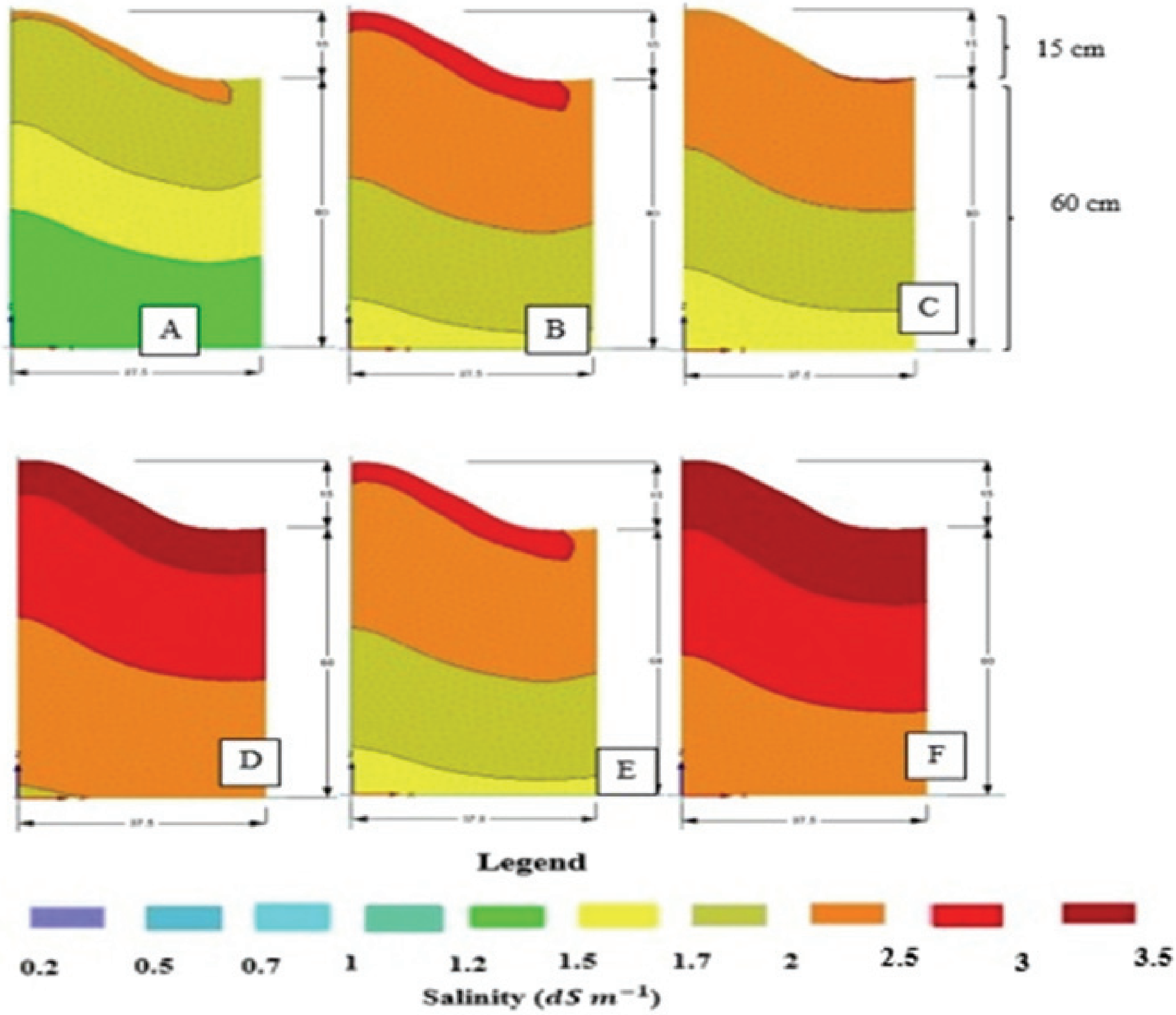


Fig. 8. The effect of tape location (stack or ditch) on salinity in soil column (A: tape on stack-1 year, B: tape on the ditch-1 year, C: tape on stack-5 years, D: tape on ditch-5 years, E: tape on stack-10 years, F: tape on ditch-10 years)

is unavoidable. The amount of LR for root development zone is equal to 1.734 and 1.836 after 5 and 10 years irrigation which have been calculated by using equation 4.

3.2. Scenario 2) effect of stack height on salinity accumulation in soil under tape irrigation

Initial salinity in the root developmental zone is equal to 0.65 dS m^{-1}. According to graphs in Figure 9 after one year of irrigation with water (salinity: 0.25 to 1 dS m^{-1}), soil salinity has increased approximately 50% in all soil columns with different stack heights and has been reached to 1.3 dS m^{-1}. After 5 years of irrigation, salinity has increased 59.8%, 60.2%, 60.3% and 60.5% in soil columns with 0, 10, 15 and 20 cm stack height and has been reached to 1.61, 1.63, 1.64 and 1.65 dS m^{-1}. After 10 years, soil primarily salinity has increased 59.9%, 60.3%, 60.4% and 60.6% and has been reached to 1.62, 1.64, 1.645 and 1.655 dS m^{-1} in soil columns with 0, 10, 15 and 20 cm stack height respectively. As the difference between salinity increases in soil columns with different stack heights is not very significant, thus stack height does not have an effective role in changing and controlling salinity in root development zone under tape (drip) irrigation. A variance analysis test has been done on data in order to show the insignificant effect of stack height on salinity accumulation both in tape and furrow irrigation. P-value is the output of this statistical test which should be compared to significance level. The first hypothesis is that the average salinity in the root zone is the same in scenarios with different stack heights. If the p-value is smaller than the significant level that has been considered for the test, the firs hypothesis is rejected and it seems that the average of at least one group of data (salinity) is different from the rest. But, if the p-value is bigger than considered significant level, there is no reason to reject the first hypothesis and it has been confirmed. The significant level value usually assumed to be 0.05. in the soil under the tape irrigation after 1, 5 and 10 years of irrigation the p-value is equal to 0.26, 0.27 and 0.62 which means that, stack height doesn't have a significant effect in controlling salinity in root zone and the average salinity in stacks with different heights were the same.

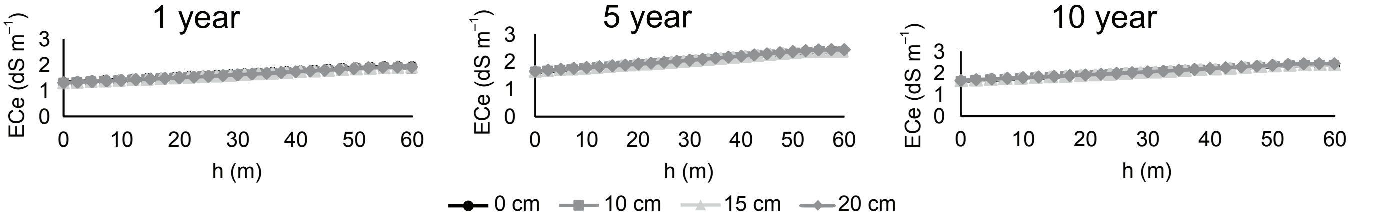


Fig. 9. The effect of stack height on salinity accumulation in root development zone (in a soil column under tape irrigation)

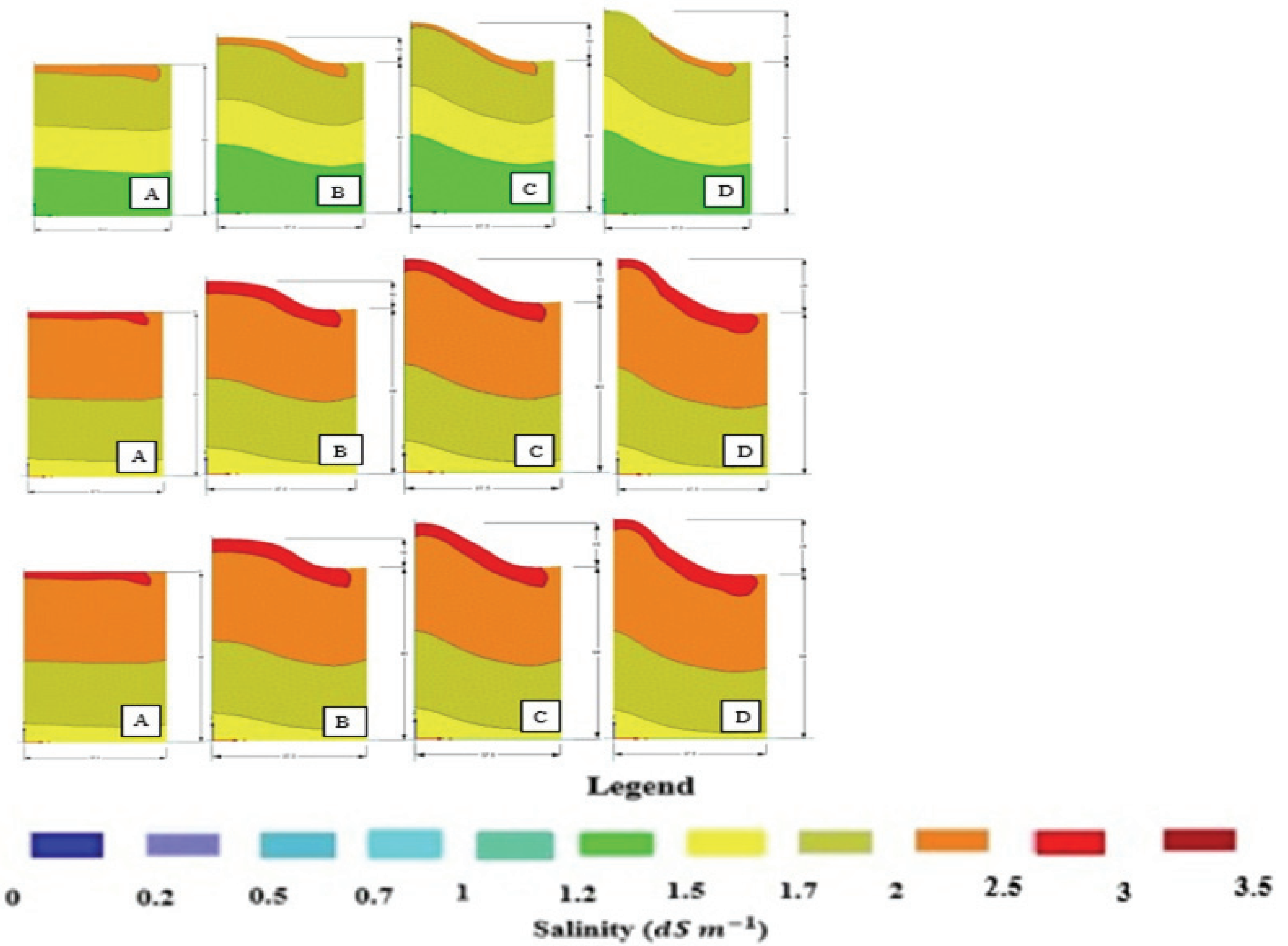


Fig. 10. The effect of stack height (A: 0 cm, B: 10 cm, C: 15 cm, D: 20 cm) on salinity accumulation in root development zone after 1,5 and 10 years irrigation (in a soil column under tape irrigation)

Also, Figure 10 show the graphical results of assessing the effect of stack height on salinity accumulation in the root zone after 1, 5 and 10 years irrigation respectively.

3.3. Scenario 3) effect of stack height on salinity accumulation in soil under furrow irrigation

According to the graphs in Figure 11, for maize under furrow irrigation, after one year of irrigation, primarily salinity in the root development zone, 0.65 dS m^{-1} has increased 58.7%, 57.4%, 57.4% ,57% and has been reached to 1.58, 1.53, 1.53 and 1.525 dS m^{-1} for soil columns with 0, 10, 15 and 20 cm stack height respectively. After 5 years irrigation, salinity has increased 59%, 58.4%, 58.3% and 58.1% in soil columns with 0, 10, 15 and 20 cm stack height and has been reached to 1.59, 1.562, 1.557 and 1.55 dS m^{-1}. After 10 years, soil primarily salinity has increased same as the 5 years interval. In the soil under furrow irrigation after 1, 5 and 10 years of irrigation, p-value is equal to 0.57, 0.89 and 0.97 which confirms the first hypothesis. Thus, stack height does not have an effective role in changing and controlling salinity in root development zone under the furrow (surface) irrigation.

Also, Figure 12 show the graphical results of assessing the effect of stack height on salinity accumulation in the root zone after 1, 5 and 10 years irrigation respectively.

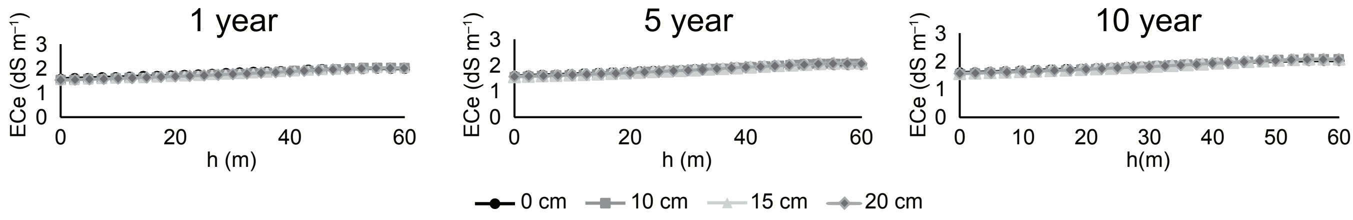


Fig. 11. The effect of stack height on salinity accumulation in root development zone after 1, 5 and 10 years irrigation (in a soil column under furrow irrigation)

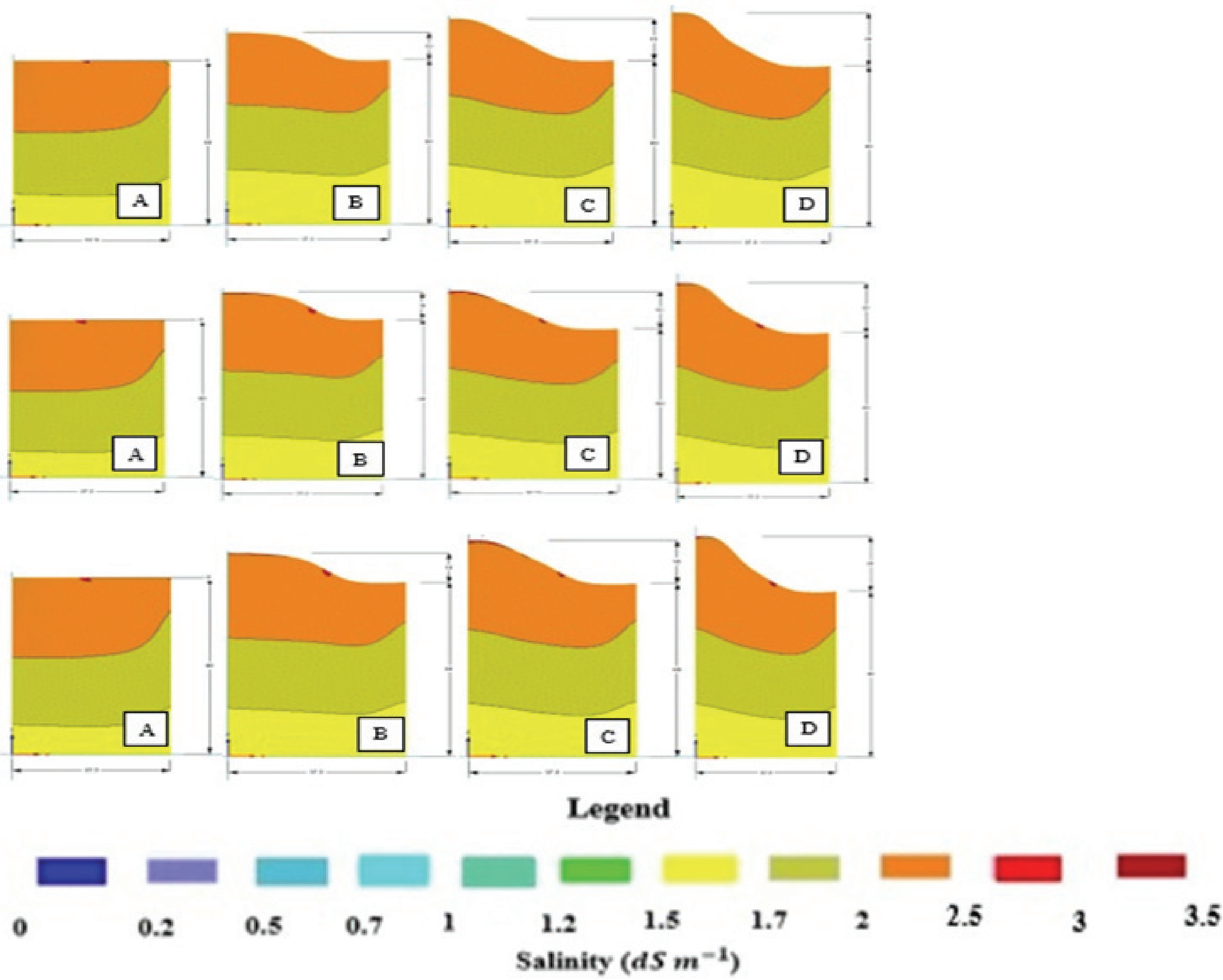


Fig. 12. The effect of stack height (A: 0 cm, B: 10 cm, C: 15 cm, D: 20 cm) on salinity accumulation in root development zone after 1,5 and 10 years irrigation (in a soil column under furrow irrigation)

3.4. Scenario 4) effect of using mulch on salinity accumulation in root development zone

Figure 13 shows salinity difference in the soil column in presence and absence of mulch scenarios. According to the graphs, in a soil column with standard stack height (15 cm) without mulch, soil primarily salinity in the root development zone, 0.65 dS m^{-1}, has been reached to 1.3 dS m^{-1} after one year irrigation. While, in with mulch scenario under the same condition, primarily salinity in the root development zone has been reached to 0.85 dS m^{-1}. Thus, in 1 year time interval using mulch on the soil surface can increase salinity in the root zone 34.3% lower than the without mulch scenario. After 5 and 10 years of irrigation, soil primarily salinity in the root development zone, 0.65 dS m^{-1}, has been reached to 1.63 and 1.65 dS m^{-1} respectively in the without mulch scenario. While, in the with mulch scenario salinity has been increased 42.8% and 50% lower than without mulch scenario and has been reached to 0.93 and 0.95 dS m^{-1}. Thus, using mulch is one of the most effective ways to controlling salinity in the root zone. This result is completely matching the results of Moniruzzaman and Shaminm (2015). They assessed the effect of mulching on soil salinity and yield of

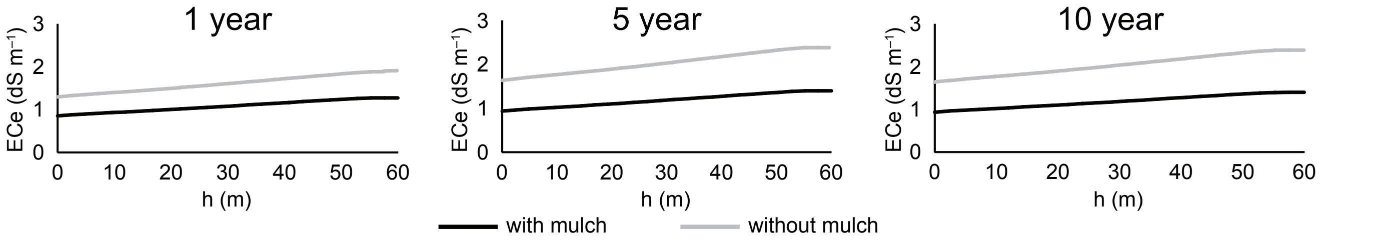


Fig. 13. The effect of presence or absence of mulch on salinity accumulation in root development zone after 1,5 and 10 years irrigation (in a soil column under tape irrigation)

sweet gourd in two scenarios including no mulch and mulch on soil surface and concluded that using mulch on soil surface not only can control and reduce salinity but also will increase crop yield too. Also, results are completely matching Abd El-mageed et al. (2016). In their study, they assessed the effect of mulching on plant water status, soil salinity and yield of squash under deficit irrigation in salt affected soil. Results showed that, all different kinds of mulching materials can effectively reduce salt accumulation in the root zone. Also, mulching treatments increased yield markedly and saved 15% irrigation water due to decrease in evaporation.

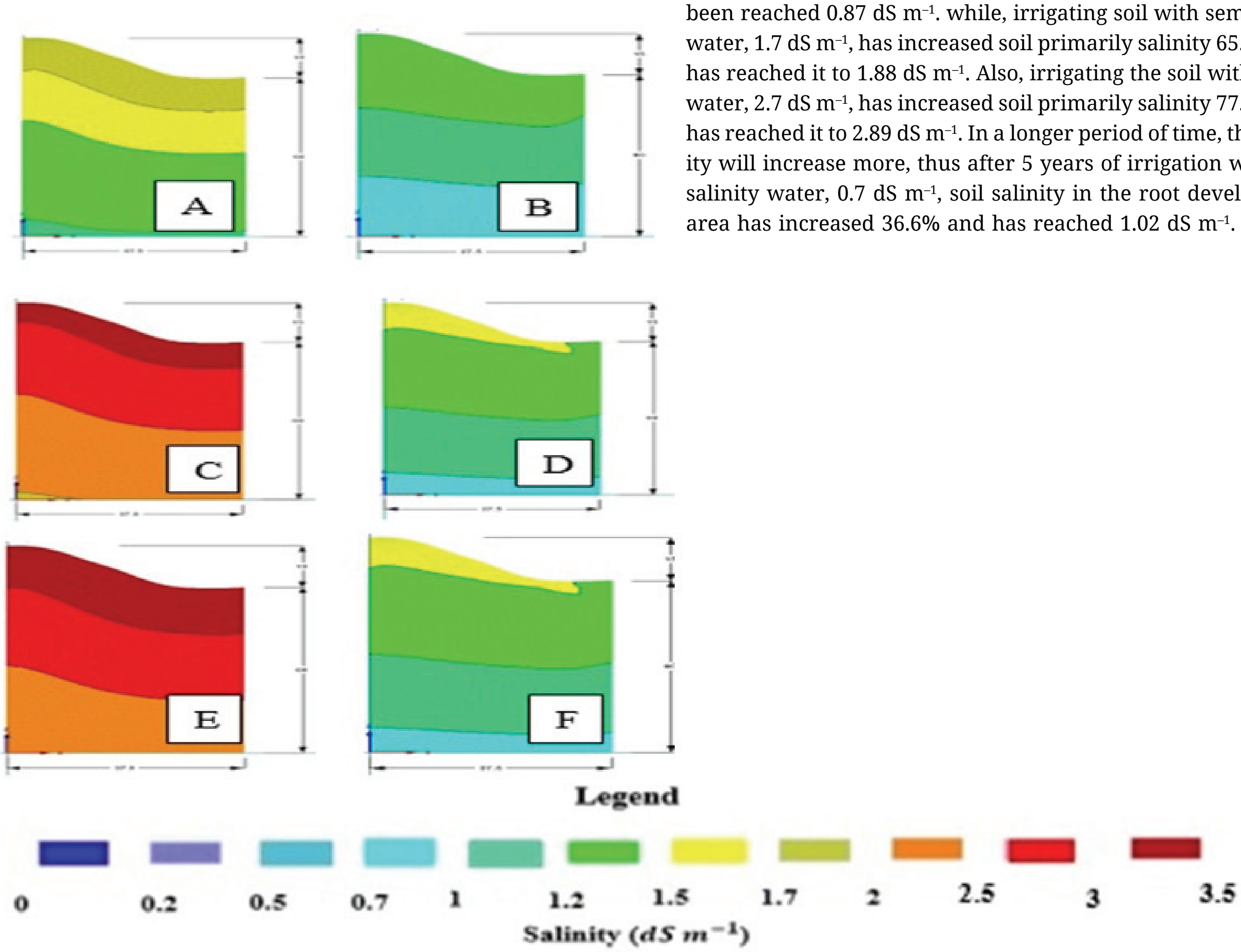


Fig. 14. The effect of presence or absence of mulch on salinity accumulation in root development zone (A: without mulch-1 year, B: with mulch-1 year, C: without mulch--5 years, D: with mulch--5 years, E: without mulch--10 years, F: with mulch--10 years)

Also, Figure 14 shows the graphical results of two scenarios (with and without mulch) in different time frames.

3.5. Scenario 5) effect of irrigation water salinity on soil accumulation under tape irrigation

According to graphs that have shown in Figure 15, Irrigation water salinity has had an effective role in salinity accumulation in the root zone in all time frames and the more the water primarily salinity, the more the salinity accumulation in the soil. After one year irrigation with low salinity water, 0.7 dS m^{-1}, primarily salinity (0.65 dS m^{-1}) has increased 25.3% and has been reached 0.87 dS m^{-1}. while, irrigating soil with semi-saline water, 1.7 dS m^{-1}, has increased soil primarily salinity 65.4% and has reached it to 1.88 dS m^{-1}. Also, irrigating the soil with saline water, 2.7 dS m^{-1}, has increased soil primarily salinity 77.5% and has reached it to 2.89 dS m^{-1}. In a longer period of time, the salinity will increase more, thus after 5 years of irrigation with low salinity water, 0.7 dS m^{-1}, soil salinity in the root development area has increased 36.6% and has reached 1.02 dS m^{-1}. also, irrigating soil with semi-saline and saline water can increase soil primarily salinity in the root development zone 74% and 83.5% and reach it to 2.49 and 3.59 dS m^{-1}. After 10 years, irrigating soil with low, medium and high salinity water salinity has increased 38%, 75% and 84.2% in comparison to soil primarily salinity in the root development zone and has reached 1.08, 2.59 and 4.19 dS m^{-1}. Which shows the more the water salinity, the more the salinity accumulation in the root zone. The results are completely matching Yuan et al. (2018). They assessed the effect of irrigation water salinity on salinity distribution in soil and concluded that irrigation with saline water, specially long-term irrigation with saline water can cause salinity accumulation and consequently will increase salinity distribution in soil. Also, the results are matching Feyzi (2002). He assessed the effect of saline irrigation water on wheat yield. The results showed that, irrigation water salinity has a significant effect on seed yield, seed weight, stem height and spike length. Furthemore, Feyzi and Saadat (2015) assessed the effect of saline water on product's yield and soil salinity. Results showed that although, using different managements can increase the crops' yield but soil salinity is unavoidable.

Graphical results of the effect of irrigation water salinity on salinity accumulation in the soil has been shown in Figure 16.

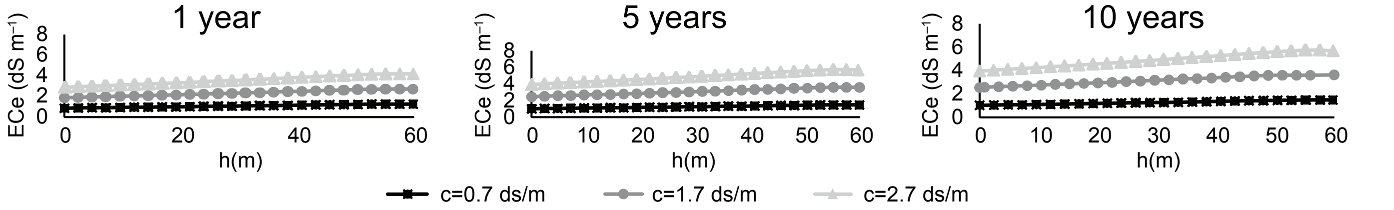


Fig. 15. The effect of irrigation water salinity on salinity accumulation in root development zone after 1,5 and 10 years irrigation (in a soil column under tape irrigation)

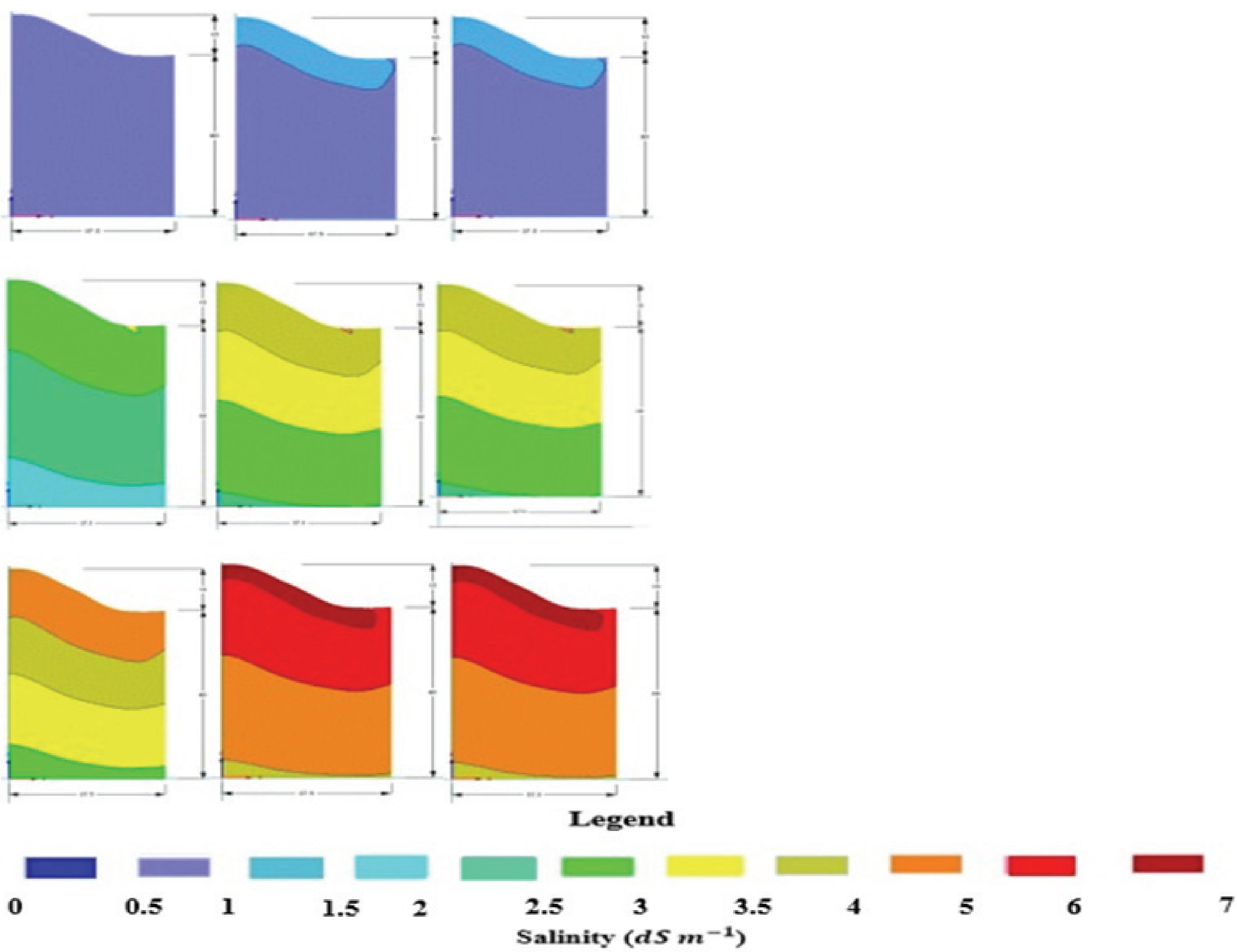


Fig. 16. The effect of irrigation water salinity on salinity accumulation in root development zone after 1, 5 and 10 years irrigation from left to right (irrigation water salinity: 0.7, 1.7 and 2.7 dS m^{-1} from up to down)

4. Conclusions

The purpose of this article is to find ways that can control salinity in root developmental zone. According to scenario 1, location of irrigation tape has a significant effect on controlling salinity in the root development zone. Placing tape in the ditch helps to wash the root development area and in addition to controlling salinity, it also reduces the need for leaching. While, placing tape on the stack increases salinity in root development zone and increases the need for leaching. Also, according to scenario 2 and 3, stack height both in drip irrigation (tape) and surface irrigation (furrow) does not have much effect on salinity control in the root development zone, either in the short term or in the long term. According to scenario 4, using mulch on soil surface can be one of the most useful methods in controlling and reducing the speed of salinity increase in root zone and in the entire column. Moreover, according to scenario 5, irrigation water salinity has a significant effect on the solute accumulation in the soil. The higher the salinity of the irrigation water, the more the salts accumulation in the soil, either in short term and long term. While, the lower the irrigation water salinity, the less the solute accumulation in the soil. Thus, placing tapes on ditch, using mulch on soil surface and irrigating lands with low saline water are some effective methods to control soil salinity specially in root development zone.

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