Impact of Using Desalinated Brackish Water on Chemical and Physical Characteristics of Saline Soil

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Introduction and background

- In Palestine, the problem of water shortage is coming mainly from the high water uptake by Israeli occupants, climate change and over-pumping by the agricultural sector

- Jericho District suffers from the phenomenon of salinization. The Eastern Aquifer Basin (EAB), which is the main source of water supply for irrigation in the Jericho District, comprises a layer of salt water covered with lenses of fresh water.

Introduction and background

- To overcome water shortage, Ministry of Agriculture recently installed a desalination unit on a low water quality agriculture well in Marj Na'aja in order to cope with water shortage and decreasing water quality (increasing salinity level and sodium concentration)
- The impact of using desalinated water on soil properties is still under investigation around the world. Most of the studies have focused on the economic feasibility of using desalinated water as alternative water resource in different locations and conditions over the world

Introduction and background

- In addition, a few studies have focused on the impact of using desalinated water on soil fertility on sandy soils, and studied nutrient deficiency in relation to plants irrigated with desalinated water.
- No studies have been conducted so far on the impact of using desalinated water to irrigate the saline clay loam soils of the Jordan rift valley.

Study objectives

- The overall objective of this research is **to assess the impact of irrigating saline soils with desalinated water and with a blend of desalinated water and raw brackish water on the soil physical and chemical properties that influence soil water content**.
- More specifically, the study focused on the following properties:
  - Soil Sodium Adsorption Ratio (SAR) at different depths
  - Soil structure
  - Water movement in the saline soil profile
- With the aim of determining the best mixing ratio to avoid deterioration of the soil properties

Hypothesis

- *Irrigating saline soil with desalinated water hampers soil quality that could be overcome by blending desalinated water with raw brackish water.*

Study location

- The research was conducted in Marj Na’aja village which is located to the Northern part of the Jordan in the north to Jericho, and lays 270 m below sea level.
- According to the soil analysis and land observation the soil is classified as saline soil with high content of sodium and SAR (8.25 in the top 15 cm to 6 in the lower layer 60 cm)
- This is the result of using low quality water with high TDS reaches 4500 ppm.

Methodology

Four types of water, based on TDS content were considered, namely:

- T1 Desalinized water with TDS of 200 ppm.
- T2 blended water with a final TDS of 750 ppm.
- T3 blended water with a final TDS of 1600 ppm.
- T4 Raw brackish water with TDS of 4500 ppm.

- Irrigation water quality was analysed for pH, EC, soluble cations (Ca, K, Na, and Mg), and Cl, four times during the crop growing period from the initial irrigation time to crop completion, with 45 days intervals.

Methodology con.

- In the experiment, plant tomato Izabella variety was used to introduce the root effect on the investigated depths and to grow long planting period as irrigation extend to 7 months. Plant spacing 80 cm, drip irrigation system was used with emitter spacing of 80 cm.
- The emitter discharge is 4 L/h. The irrigation system is not supplied with fertilizer injector to avoid any addition of salts that may affect the results
- . The quantity of applied water (31 cubic meter) was calculated for the actual crop water requirements according to FAO Penman – Montieth equation using CROPWAT software, utilizing the local climatic data with total amount of irrigation water

Methodology cont.

- Soil sampling was conducted for four depths of 0-15, 15-30, 30-45, and 45-60 cm.
- For calculate SAR, soil sampling were conducted twice, before the crop season and after the crop season, for all treatments with 80 soil samples.
- For soil moisture content four times (after third irrigation, after one month of the planting date, 2 months after planting date and after crop completion) for treatment 1 and treatment 4, with 12 samples at each depth with 10 cm distance between sequent in the X-Y direction with total 400 soil samples (see next slide).
- Additional soil physical properties, like soil texture and soil structure, were determined to understand the water and salt movement and proper soil and irrigation management.

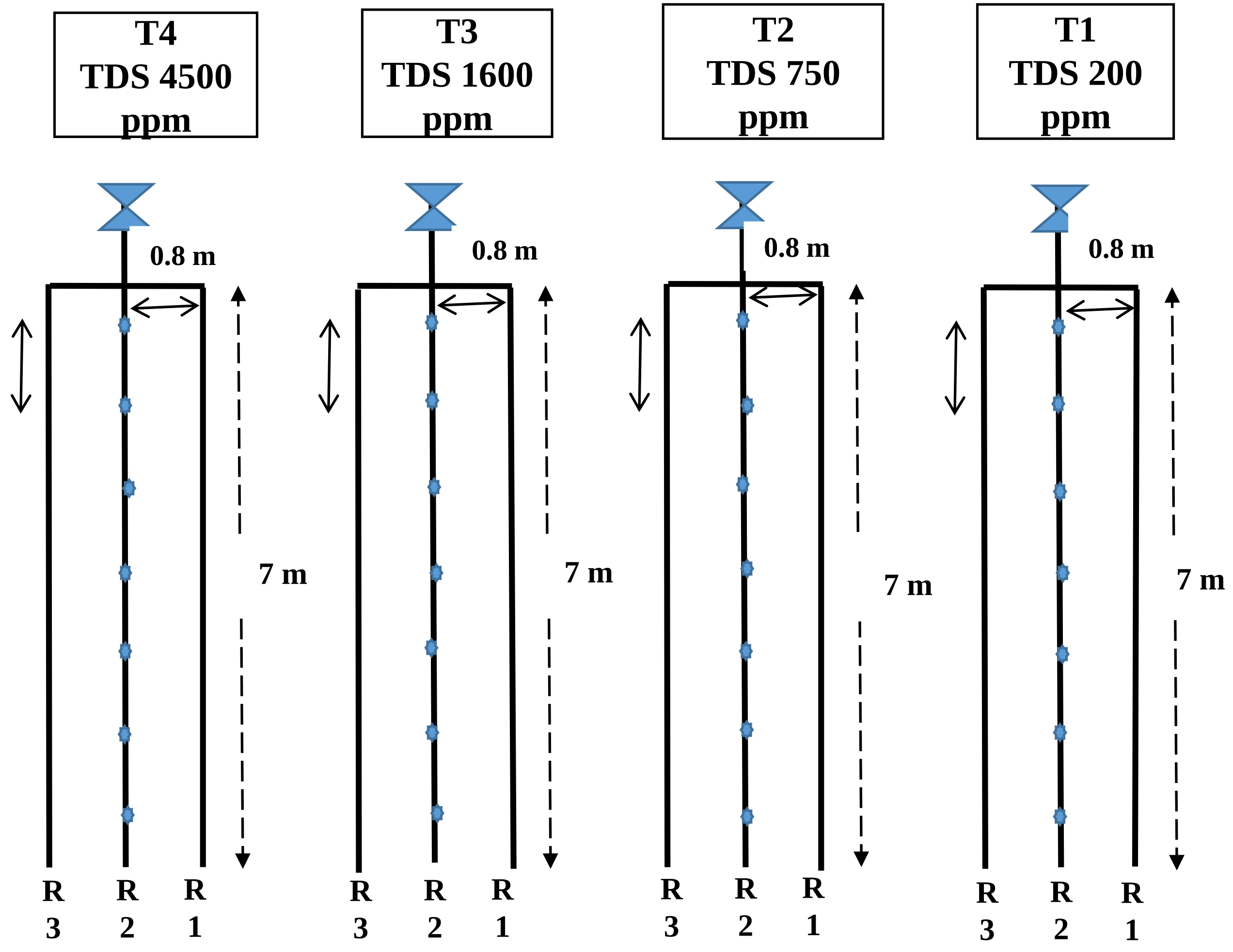
Methodology con.

- The soil and water samples were analysed following ICARDA procedure for soil and water samples analysis (ICRDA, 2013).
- The USDA soil triangle was used to define the soil texture classes as described in ICARDA (2013).


T4


Experiment layout

- The allocated experiment layout was covered with a green houses, 10 meter length and 7.35 meter width. The lot was divided into four trains. Each line contained 3 rows of plants with 7 plants for each line. The space between rows and between plants was 80 cm to avoid overlapping of irrigation water from emitters to the plants.



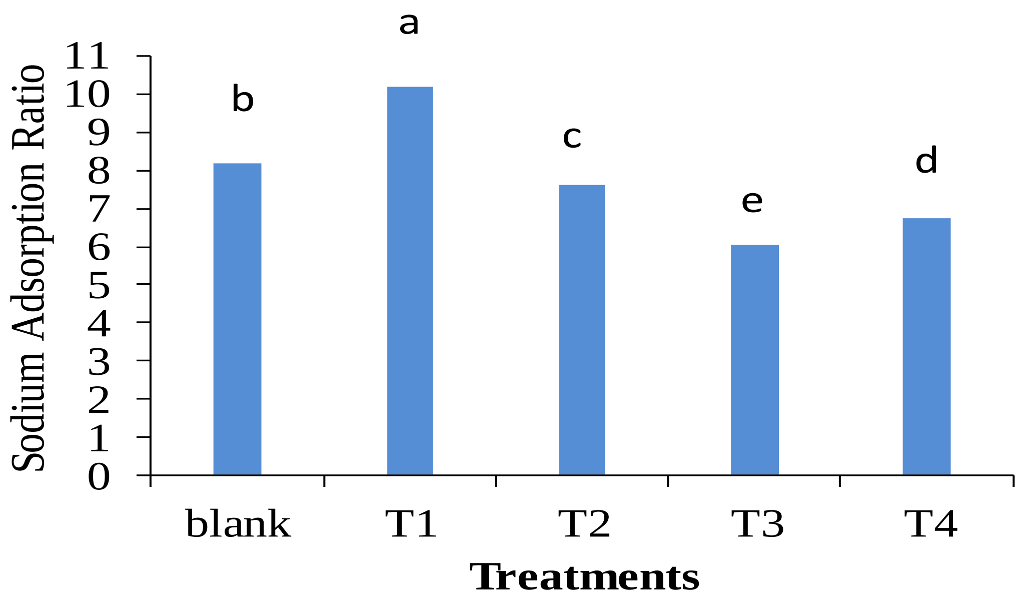
Statistical analysis

- The results were statistically tested using SPSS software 20. The soil data were analysed by analysis of variance (ANOVA) to study the effect of water quality on sodium adsorption ratio (SAR) and moisture content. All values were evaluated at a 95.0 % confident level with Scheffe analysis.

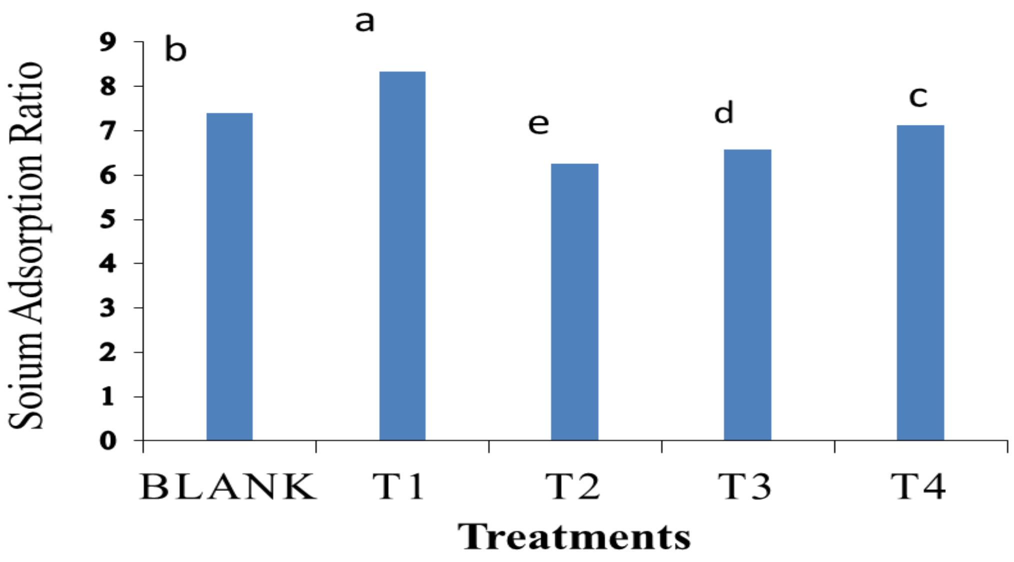
Results and discussion

SAR

Comparing between treatments



SAR at D1 (15 cm) for all treatments comparing with blank

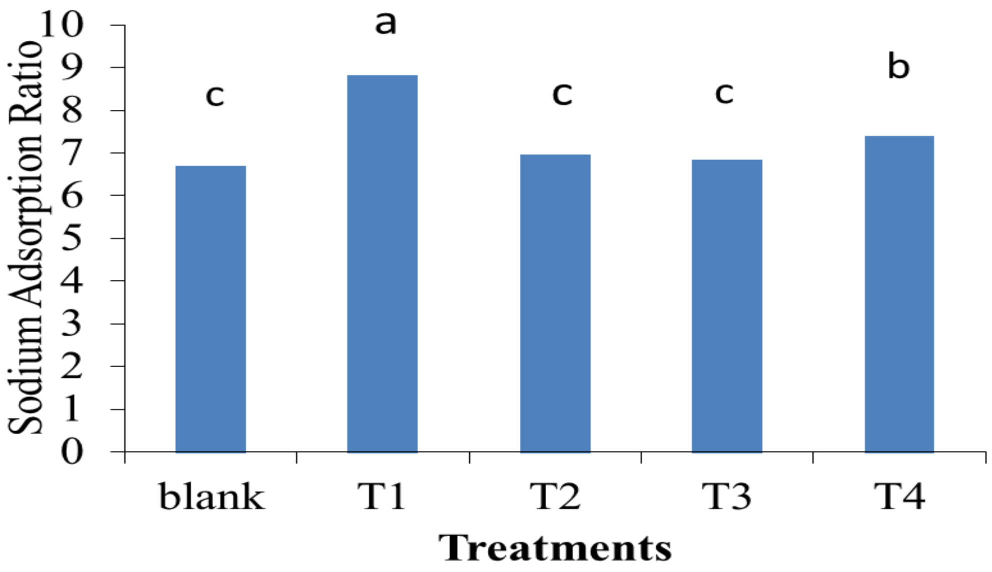


SAR at D2 (30 cm) for all treatments comparing with blank

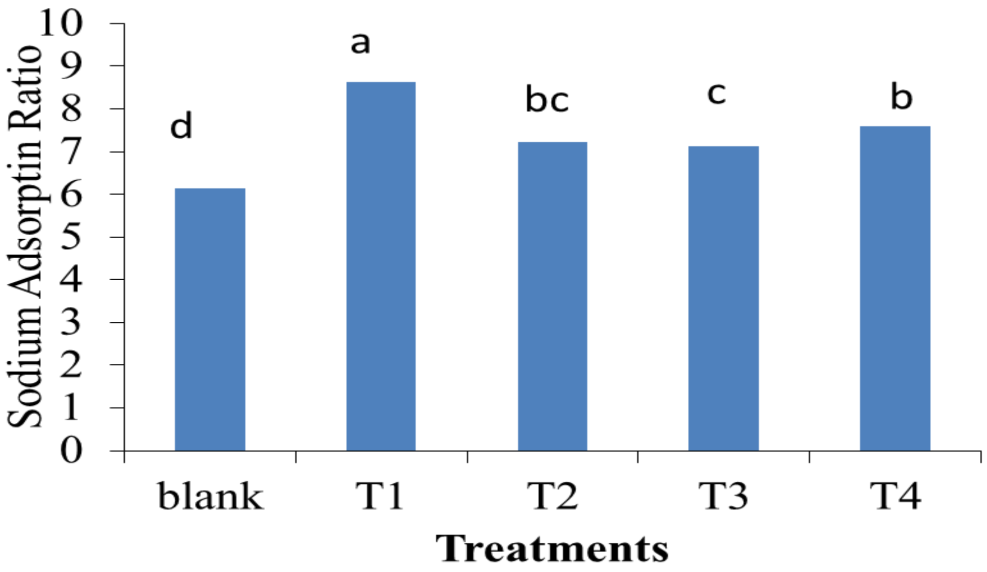
Letters represent statistical groups (a, b, c, d,e) a = the highest value, e = is the lowest

SAR

Comparing between treatments



SAR at D3 (45 cm) for all treatments comparing with blank

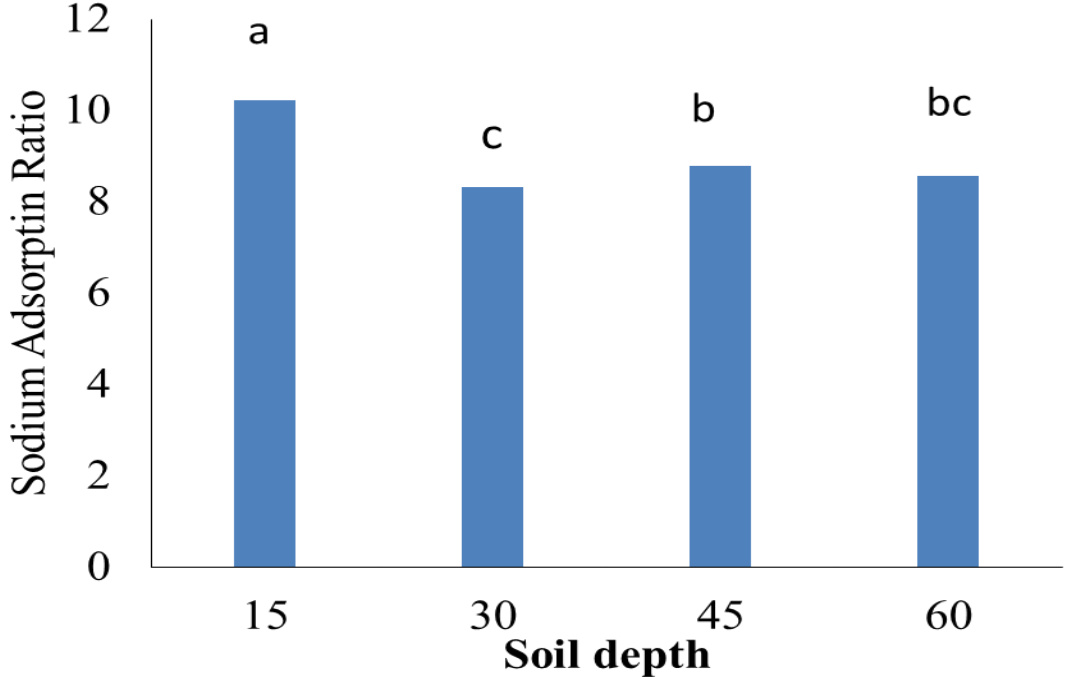


SAR at D4 (60 cm) for all treatments comparing with blank

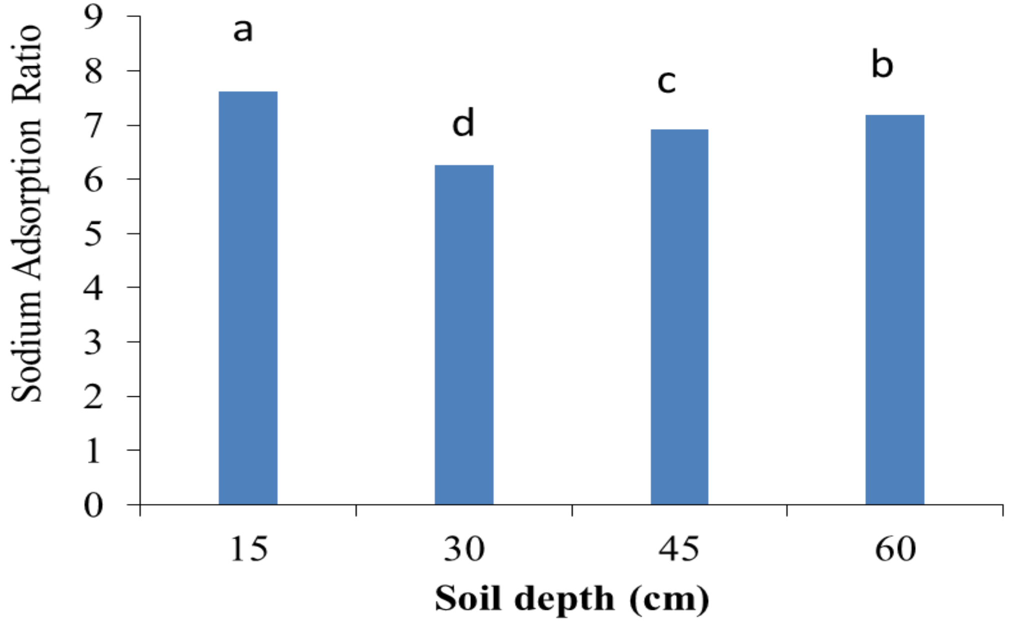
Letters represent statistical groups (a, b, c, d) a = the highest value, e = is the lowest

SAR

Comparing between depths



Soil SAR for all depths in T1 (200 ppm)

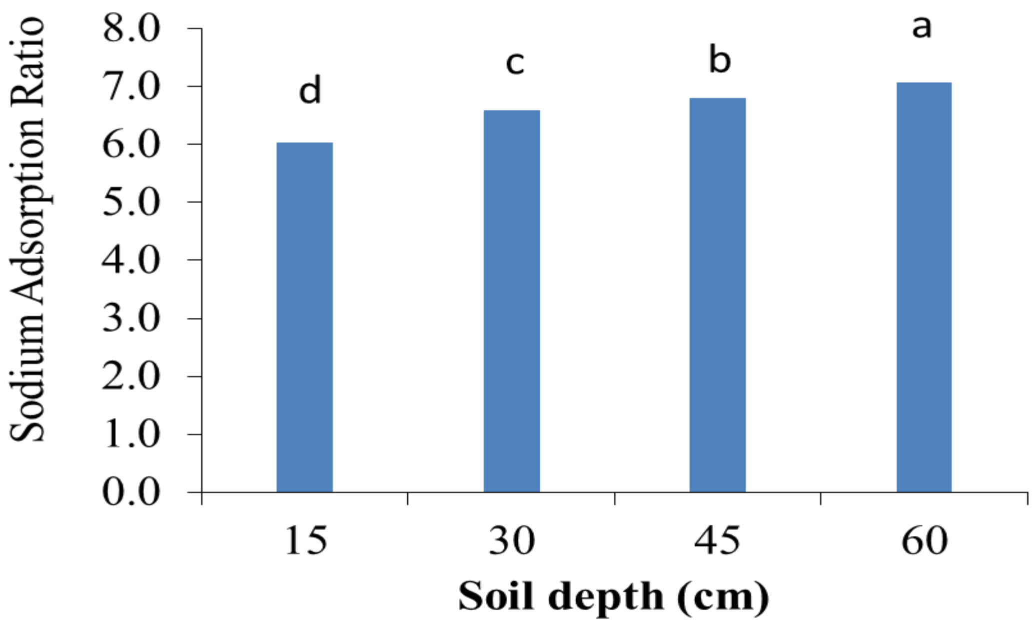


Soil SAR for all depths in T2 (750 ppm)

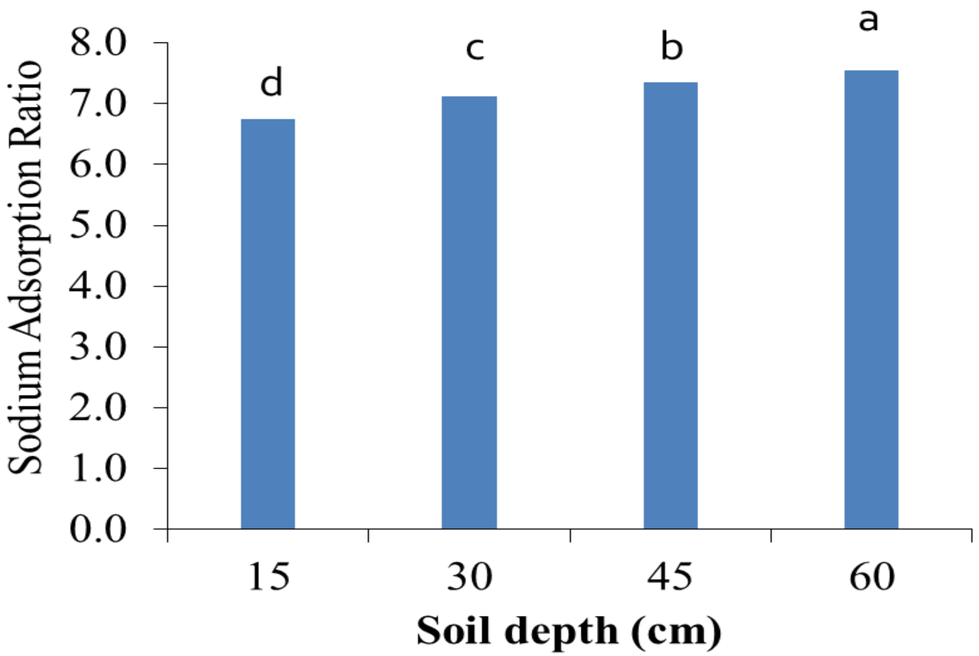
Letters represent statistical groups (a, b, c, d) a = the highest value, e = is the lowest

SAR

Comparing between depths



Soil SAR for all depths in T3 (1600 ppm)



Soil SAR for all depths in T4 (4500)

Letters represent statistical groups (a, b, c, d) a = the highest value, e = is the lowest

Soil moisture content

Soil moisture content in T1 (200 ppm) at all soil depths for all horizontal distances after third irrigation / Stage 1

Soil depth	Horizontal distance from the emitter (cm)								
	10			20			30		
D1: 15 cm	A+	a*	30.14	A+	b*	25.69	A+	b*	24.48
D2: 30 cm	B	a	25.53	B	b	22.80	B	b	21.52
D3: 45 cm	C	a	21.91	C	b	20.12	C	b	19.01
D4: 60 cm	D	a	18.83	C	ab	17.88	D	b	16.39

Soil moisture content in T4 (4500 ppm) at all soil depths for all horizontal distances after third irrigation / Stage 1

Soil depth	Horizontal distance from the emitter (cm)								
	10			20			30		
D1: 15 cm	A*	a*	29.97	A*	b*	26.19	A*	b*	25.56
D2: 30 cm	B	a	26.47	B	b	23.91	B	b	23.47
D3: 45 cm	C	a	23.05	C	b	21.29	C	b	20.52
D4: 60 cm	D	a	19.51	D	a	18.80	D	b	17.40

+Capital Letters represent statistical groups (A, B, C, D) A = the highest value, D = is the lowest.

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Values followed by the same alphabetical letter in each column do not differ significantly from each other using LSD.

Soil moisture content

Soil moisture content at T1 (200 ppm) at all soil depths for all horizontal distances after one month of planting/Stage2

Soil depth	Horizontal distance from the emitter (cm)								
			10			10			30
D1: 15 cm	A+	a*	32.08	A	b	29.88	A	c	27.33
D2: 30 cm	B	a	28.58	B	b	26.11	B	b	24.73
D3: 45 cm	C	a	23.99	C	ab	22.96	C	b	21.78
D4: 60 cm	D	a	21.19	D	ab	20.48	D	b	19.36

Soil moisture content at T4 (4500 ppm) for all soil depths and all horizontal distances after one month of planting/Stage 2

Soil depth	Horizontal distance from the emitter (cm)								
			10			20			30
D1:15 cm	A*	a*	31.82	A*	b*	28.43	A*	b*	27.59
D2: 30 cm	B	a	29.38	A	b	26.74	B	b	25.95
D3:45 cm	C	a	25.55	B	ab	24.41	C	b	23.02
D4: 60 cm	C	a	23.55	C	ab	22.01	D	b	20.85

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Soil moisture content

Soil moisture content at T1 (200 ppm) for all soil depths and all horizontal distances after two month of planting/Stage3

Soil depth	Horizontal distance from the emitter (cm)								
			10			20			30
D1: 15 cm	A+	a*	33.64	A	ab*	31.63	A	b*	29.33
D2: 30 cm	B	a	30.51	B	ab	28.52	B	b	26.97
D3: 45 m	C	a	25.99	C	b	24.33	C	c	23.27
D4: 60 cm	D	a	23.16	C	a	22.65	D	b	21.12

Soil moisture content at T4 (4500) for all soil depths and all horizontal distances after two months of planting/Stage 3

Soil depth	Horizontal distance from the emitter (cm)								
			10			20			30
D1: 15 cm	A+	a*	34.10	A	b	32.86	A	c	28.33
D2: 30 cm	B	a	32.33	A	a	31.27	A	b	27.14
D3: 45 cm	C	a	28.91	B	a	26.96	B	b	24.94
D4: 60 cm	D	a	25.96	C	b	24.88	C	c	22.53

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Values followed by the same alphabetical letter in each column do not differ significantly from each other using LSD.

Soil moisture content

Soil moisture content at T1 (200 ppm) for all soil depths and all horizontal distances after crop completion/Stage 4

Soil depth	Horizontal distance from the emitter (cm)								
			10			20			30
D1: 15 cm	A+	a*	35.99	A	b	33.87	A	c	31.67
D2: 30 cm	B	a	32.54	B	b	29.06	B	b	29.18
D3: 45 cm	C	a	26.70	C	a	25.40	C	a	24.78
D4: 60 cm	C	a	24.01	C	ab	23.46	D	b	22.03

Moisture content at T4 (4500 ppm) for all soil depths and all horizontal distances after crop completion/Stage 4

Soil depth	Horizontal distance from the emitter (cm)								
			10			20			30
D1: 15 cm	A+	a	33.81	A	a	33.49	A	b	30.14
D2: 30 cm	B	a	32.08	B	ab	31.49	AB	b	29.07
D3: 45 cm	C	a	29.85	C	a	28.35	BC	b	26.26
D4: 60 cm	D	a	27.15	D	a	25.83	C	b	24.42

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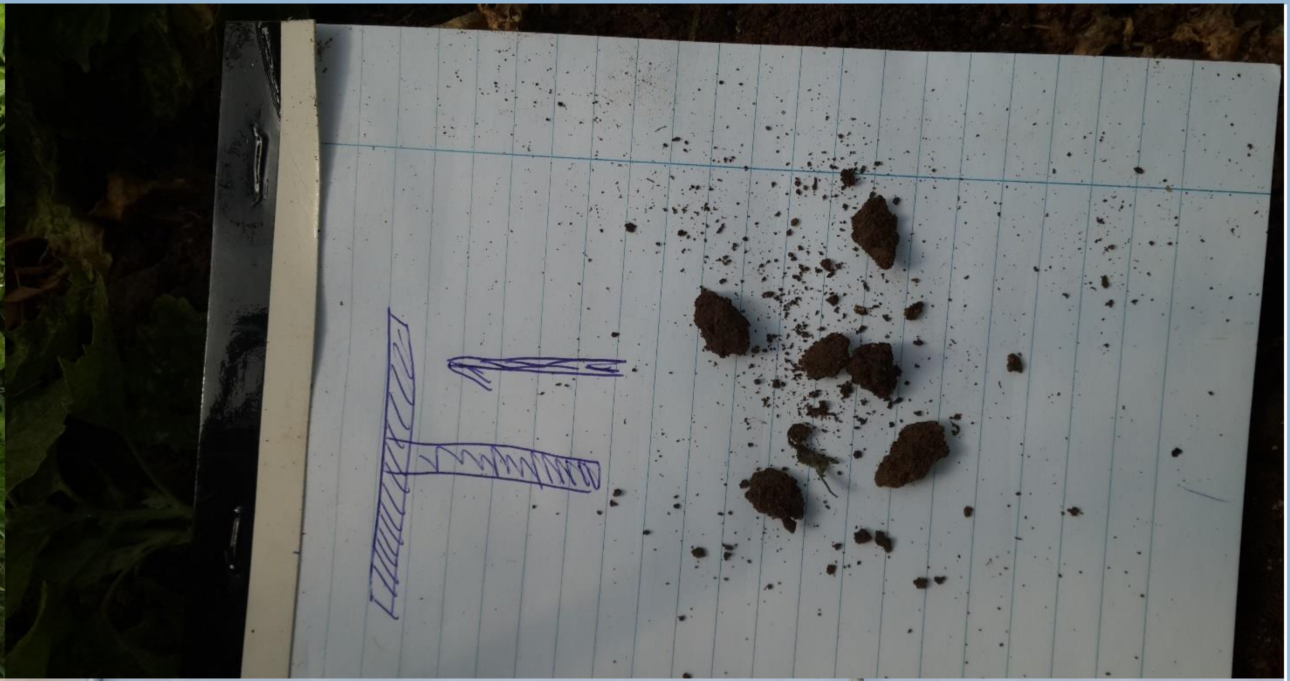
Soil structure

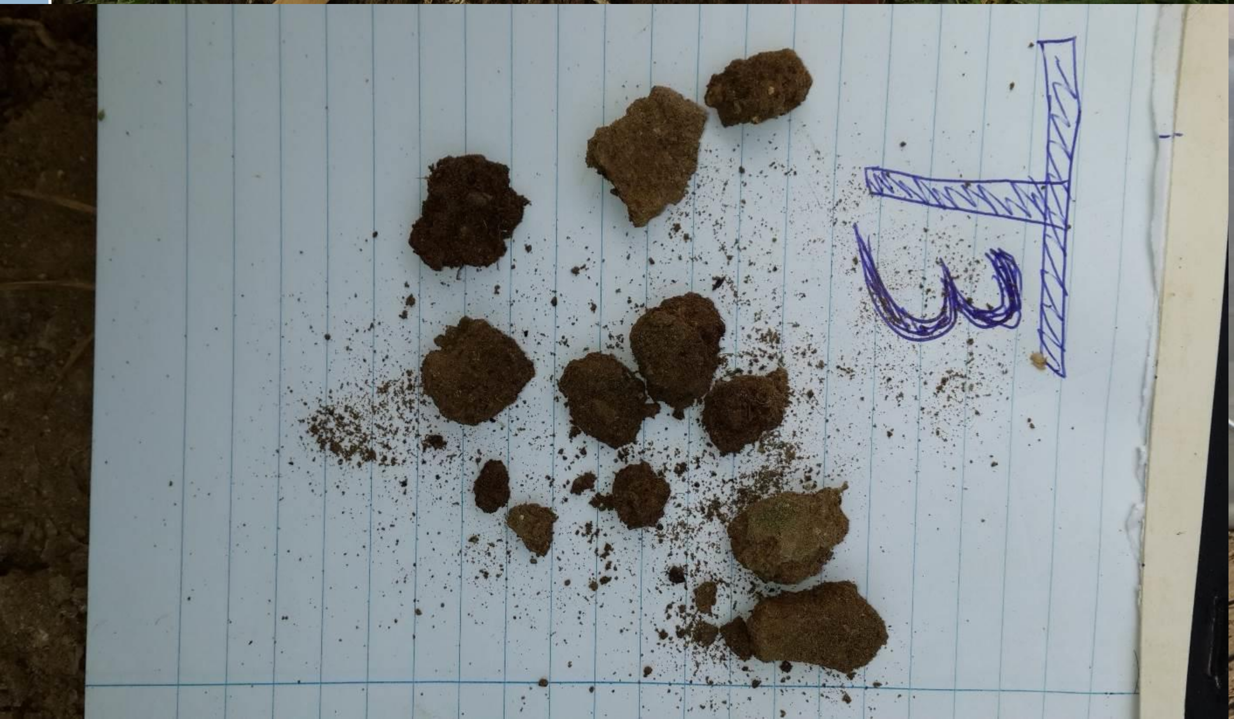
- According to the FAO, (2006) Soil structure can be defined as "arrangement of soil particles into separated soil units or small aggregates, separated from each other by pores or voids. These aggregate are characterised primarily on basis of its dominant shape" spheroidal (granular, crumb), platy, prism (columnar- top of the prisms are rounded and prismatic- top of the prisms are level) and blocky (angular blocky and sub angular blocky). Besides the structure type, also grade and size of aggregates are recorded".

Soil structure

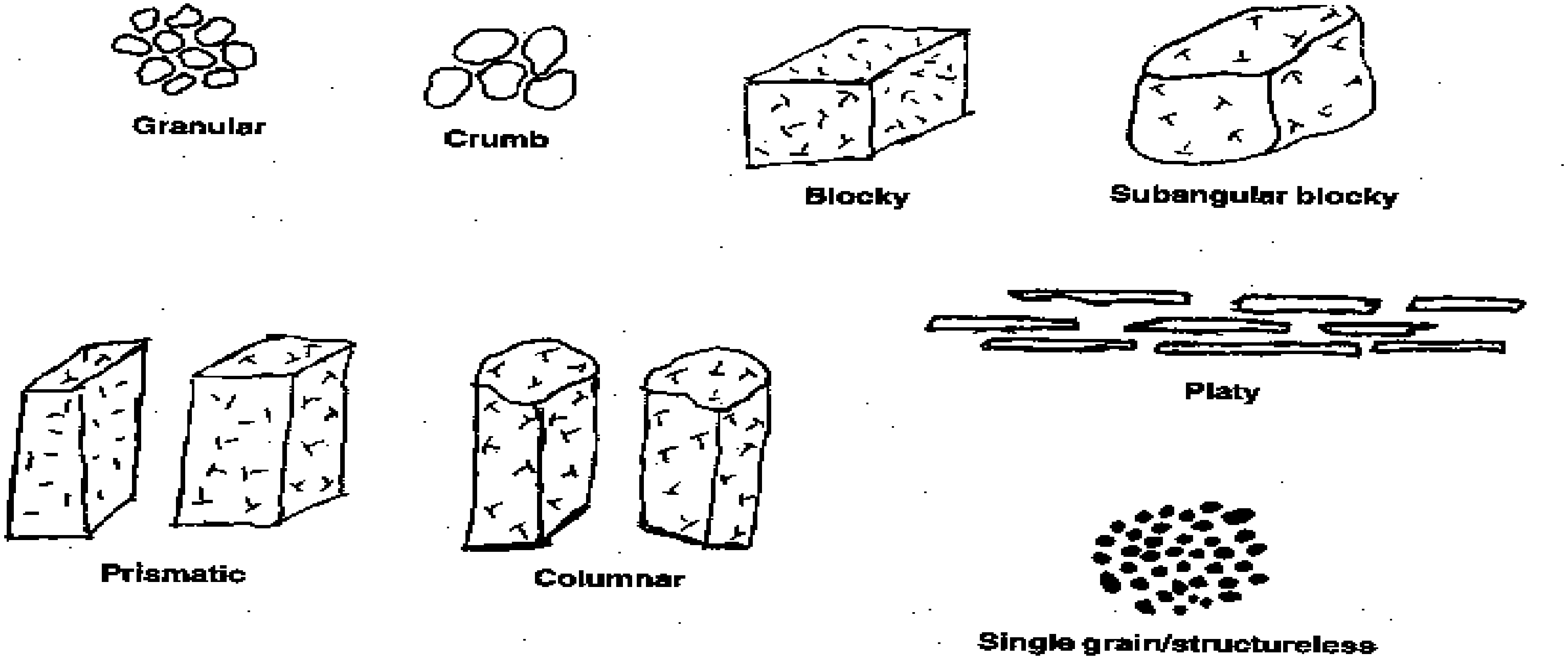
Soil structure assessed in site for all treatments in stage 1 (before planting) and stage 2 (at season completion)

Stage	Treatment	Structure		
		Type	Size	Grade
Before irrigation	T1	Granular and sub angular	Medium	moderate to
	T2	Granular and sub angular	Medium	moderate to
	T3	Granular and sub angular	Medium	moderate to
	T4	Granular and sub angular	Medium	moderate to
After irrigation	T1	Granular and crumb	Medium	moderate
	T2	Granular and sub angular	Medium	moderate to
	T3	Granular and sub angular	Medium	moderate to
	T4	Granular and sub angular	Medium	moderate to


T1


T3

Soil structure



Conclusions

- Irrigating saline soils with desalinated water increases the Sodium Adsorption Ratio (SAR), especially in first 15 cm.
- Irrigating saline soils with desalinated water negatively affected the soil structure in the surface layer (15 cm),
- Soil structure was changed from granular and sub-angular with medium size and moderate to strong grade, to granular and crumb with medium size and moderate grade.

Conclusions

- Irrigating saline soils with desalinated water increases water movement horizontally and decreases water movement vertically as compared with brackish water.

- The optimum blending ration found to avoid soil degradation is that with total dissolved salts of the irrigation water 1600 ppm because SAR values were the lower than other treatments especially in first and second soil layers.

Recommendations

- Continuous and comprehensive researches should be continued in the same conditions to overcome any expected negative results on soil properties and plant nutrition.
- Continuous and periodic monitoring for water quality.
- Applied research should be done on the brine for using as saline water resources

Recommendations

- Building capacity of the extension staff in soil and irrigation management.
- Direct supervision from the soil and irrigation experts to follow the farmers who are using desalinated water for irrigation.
- Improving soil physical properties and soil management practises to increase leaching of sodium and salinity out of the root zone.

Recommendations

- Blending desalinated with brackish water to increase calcium and magnesium content is considered as low cost strategy.
- Calcium and Magnesium sources should be added or injected with irrigation system or directly to the soil.

Thanks for your attention!