Report of effects of EM treatments on Salinity problem (2018-2019, Iran)

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Introduction

Salinity is one of the main problems threatening food security and agricultural production in Iran. Salinity is one of the main abiotic stressors which negatively affects crop productivity. Ion toxicity caused by salinity will destruct various physiological processes in plants such as photosynthesis. Plant stress metabolites like lipid peroxidation, hydrogen peroxide content, electrolyte leakage and Na+ level were increased in response to salinity. Different ways to deal with salinity are investigated by applying genetic diversity of plant resistance and modification substrates and soil conditions. previous researches show that EM technology can increase soil organic substance content, improve soil porosity and permeability and raise soil available nutrients. Our aim is to use EM solution and to investigate the role of that in salinity reduction and soil improvement. We donated the EM product to farmers in different parts of Fars province and did the necessary soil sampling. Soil salinity tests were conducted during 2018-2019 and soil calcium content was measured in 2019.

Definition of Conductivity, TDS, Resistivity and Salinity

Electrical Conductivity is the ability of a solution to conduct an electrical current. Current flow in liquids carried by ions is different from metals, where is carried by free electrons. Because of the history of conductivity, micromho/cm and millimho/cm is commonly translated to microsiemens/cm and millisiemens/cm because they correspond one-to-one. The unit of measurement commonly used is one millionth of a Siemens per centimeter (micro-Siemens per centimeter or μS/cm).

When measuring more concentrated solutions, the units are expressed as milli-Siemens/cm (mS/cm). For ease of expression, 1000 μS/cm are equal to 1 mS/cm. Often times conductivity is expressed simply as either micro or milli Siemens. to 100 mS/cm are equal to 1 dS/cm.

Total dissolved solids (TDS) is a gravimetric measurement, but because the solids in a solution are predominately present in ionic form, they can be approximated with conductivity. The TDS scale uses 2 μS/cm = 1 ppm (part per million as $CaCO_3$), expressed as 1 mg/L TDS. The method of measurement is the same, the conductivity meters make the conversion and express the results of a measurement in TDS units.

For low and very low ionic concentration, the measured conductivity becomes difficult and not accurate. Therefore, the resistivity scale is used to express the results as opposed to fractions. The numbers are exactly the inverse of each other. The reciprocal of 0.10 μS/cm or $1/(0.10 \times 10^{-6}$ S/cm)] is then 10×10^{6} ohms x cm (10 MΩ x cm). This is also commonly referred to as "mega-ohms". Either unit of measurement can be used to state exactly the same value.

Salinity is a measurement without the unit corresponding to the weight of dissolved salts in seawater. The salinity is calculated from an empirical relationship between the conductivity and the salinity of a seawater sample. Oceanographic Tables and Standards endorsed by UNESCO/SCOR/ICES/ IAPSO are used for the calculation.

Salinity measurements are performed with no direct temperature correction. The salinity range is calibrated using a standard sea water solution.

Temperature effect

Conductivity is temperature sensitive as ionic activity increases with increasing temperature. Commonly, conductivity is referred to 25°C such as in the reference temperature of some standards.

Solution	µS/cm	mS/cm	ppm	MΩ x cm
Pure water	0.055			18.18
Typical DI water	0.1			10
Distilled water	0.5			2
Rain water	50-100		25-50	0.02 - 0.01
Drinking water	500-800	0.5-0.8	250-400	2.0-1.25 [KΩ x cm]
Potable water (max)	1 055	1.055	528	0.95 [KΩ x cm]
Sea water	56 000	56	28 000	
1 mol/L NaCl	85 000	85	42.5 [ppt]	
1 mol/L HCl	332 000	332	166 [ppt]	

Table 1. Aqueous conductivity/TDS/Resistivity ranges

Soil Salinity and Crop salt tolerance

Soil samples (saturated paste extract) are classified as saline when EC values exceed 4 dS/m while water is considered brackish between 0.7-2.0 dS/m and saline at levels above 2 dS/m. Rain or distilled water has a conductivity of 0.02-0.05 dS/m whereas seawater, at the other extreme, averages between 45-60 dS/m (table 2). Salinity in water is also measured by the weight of its inorganic particulates or total dissolved solids (TDS), expressed as parts per million (ppm) or milligrams per liter (mg/l): less than 1,000 ppm is considered fresh or potable, greater than 4,000 ppm saline, and between 35,000-45,000 ppm the standard for seawater. When comparing EC and TDS measurements, note that 1 dS/m is roughly equal to 650-700 ppm, and closer to 800 ppm at relatively higher levels of salinity.

Water class	EC (in dS/m)	in mg Cl^-/l	
Non-saline	< 0.7	< 150	Drinking and irrigation water
Slightly saline	0.7 - 2	150 - 480	Irrigation water
Moderately saline	2 - 10	480 - 2940	
Highly saline	10 - 25	2940 - 8250	
Very highly saline	25 - 45	8250 - 15970	
Brine	> 45	> 15970	Seawater=55 dS/m or 19,000 mg Cl^-/l

Table 2. Classification of saline water based on EC (ds/m) and equivalent chloride concentration of water

It is well known that salts can influence the soil structure of clay soils to a great extends. The replacement of especially calcium, bound to the clay fraction, by sodium may cause poor soil structure and waterlogging.
These (indirect) effects of salinity on crop growth in salt affected clay soils should be considered under actual field conditions. A well-known soil salinity classification that is often used as a general guideline in relation to crop growth is presented in table 3.

Soil salinity class	EC (in dS/m)	Effect on crop plants
Non-saline	0 - 2	Salinity effects negligible
Slightly saline	2 - 4	Yields of sensitive crops may be restricted
Moderately saline	4 - 8	Yields of many crops are restricted
Strongly saline	8 - 16	Only tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very tolerant crops yield satisfactorily

Table 3. Soil salinity classes and crop growth

Salinity thresholds are generally defined as the maximum amount of salt that a plant can tolerate in its root zone without impacting growth. Other important thresholds indicate the highest level of plant salt-tolerance associated with a decline in yield or biomass. The salt tolerance of a crop can best be described by plotting its relative yield as a continuous function of soil salinity. In general, domesticated plants classified as salt-sensitive have salinity thresholds of 1-3 dS/m and zero yields at 8-16 dS/m (or less) while the 'moderately' salt-tolerant have thresholds of 5-10 dS/m and zero yields at 16-24 dS/m (figure 1).

relative yield (*Yr*) can be estimated with the following equation:

$$Yr = 100 - b\,(ECe - a)$$

where a = the salinity threshold expressed in dS/m; b = the slope expressed in percent per dS/m; and EC_e = the mean electrical conductivity of a saturated paste taken from the rootzone.

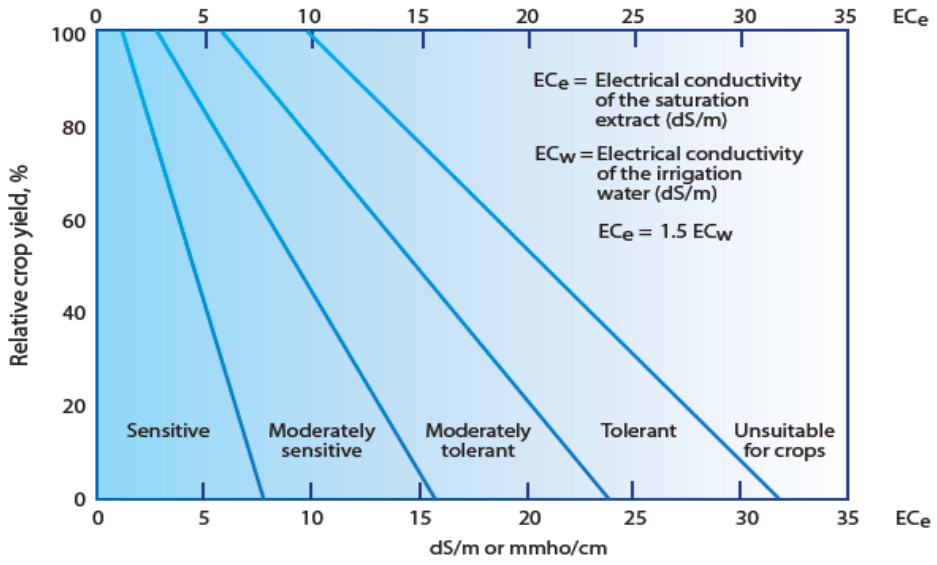


Figure 1. Relative crop yield as a function of average root zone salinity (ECe, ds/m) grouped according relative tolerance or sensitivity to salinity.

The threshold and slope concept have greatest value in providing general salt tolerance guidelines for crop management decisions. Farmers need to know the soil salinity levels that begin to reduce yield and how much yield will be reduced at levels above the threshold. Regarding theses parameters plants could be classification in range of sensitive to tolerant (table 4).

Rating	Definition
tolerant	leaves uninjured when the soil's salinity, as indicated by EC_e, is 8 to 10 dS/m
moderately tolerant	leaves uninjured with EC_e of 6 to 8 dS/m
moderately sensitive	leaves sustain minimal to recognizable injuries when the soil's EC_e reaches 3 to 6 dS/m
sensitive	leaves sustain minimal, if any, recognizable injuries with EC_e of less than 3 dS/m

Crop			Salt Tolerance Parameters			
Common name	**Botanical name**	**Tolerance based on**	**Threshold (*ECe*)**	**Slope**	**Rating**	**References**
			dS/m	**% per dS/m**		
Fibre, grain and special crops						
Alfalfa	*Medicago sativa* L.	Shoot DW	2.0	7.3	MS	Bernstein & Francois, 1973
Barley[#]	*Hordeum vulgare* L.	Grain yield	8.0	5.0	T	Ayers *et al.*, 1952; Hassan *et al.*, 1970
Canola or rapeseed	*Brassica campestris* L. [syn. *B. rapa* L.]	Seed yield	9.7	14	T	Francois, 1994
Quinoa	*chenopodium quinoa* L.	Seed yield	6	12	T	Bahrami *et al*, 2018
Sugar beet[##]	*Beta vulgaris* L.	Storage root	7.0	5.9	T	Bower *et al.*, 1954
Corn[‡‡]	*Zea mays* L.	Ear FW	1.7	12	MS	Bernstein & Ayars, 1949; Kaddah & Ghowail, 1964
Tomato	*Lycopersicon lycopersicum* (L.)	Fruit yield	2.5	9.9	MS	Shalhevet & Yaron, 1973
Fig	*Ficus carica* L.	Plant DW	-	-	MT	Patil & Patil, 1983;
Pistachio	*Pistacia vera* L.	Shoot growth	4.5	-	MT	Sepaskhah & Maftoun, 1988; Picchioni *et al.*, 1990

Table 4. Salt tolerance of plants and trees

Source: FAO website (http://www.fao.org/3/y4263e/y4263e0e.htm)

Drought and salinity problem in Iran agriculture

Recent reports of salinity problem of agricultural land show at least 50% of total area under irrigation in Iran (estimated 4.1 million ha.) is highly salt-affected (figure 2). Southern and central provinces of Iran have the highest percentage of salt-affected surface (Qadir *et al*., 2007). Over the past several years, because of droughts in the southern regions of Iran, water salinity and water quality were lost due to global warming crisis effects like evaporation, heat and lack of rainfall (figure 3). Current trends and future projections suggest that we need to monitor soil salinity and take proper measures to ameliorate affected soils.

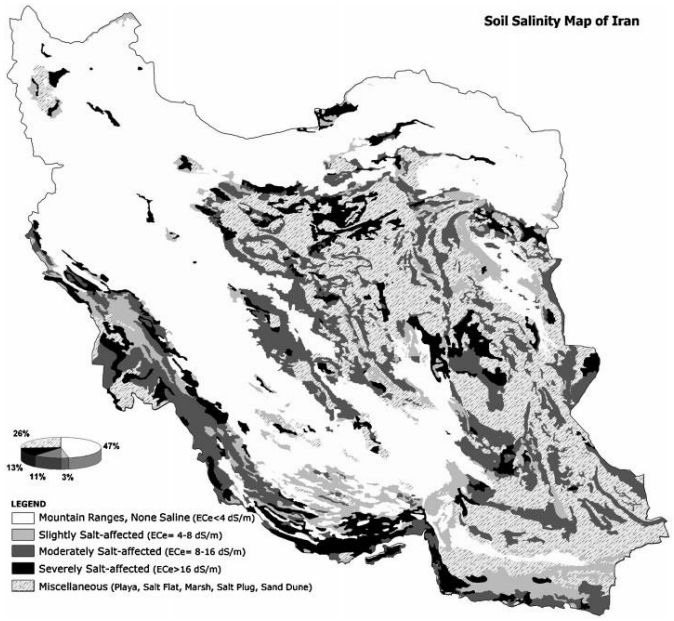


Figure 2. Soil Map of Iran indicating area under salt-affected soils and other types of landscape. from Qadir *et al*., 2007.

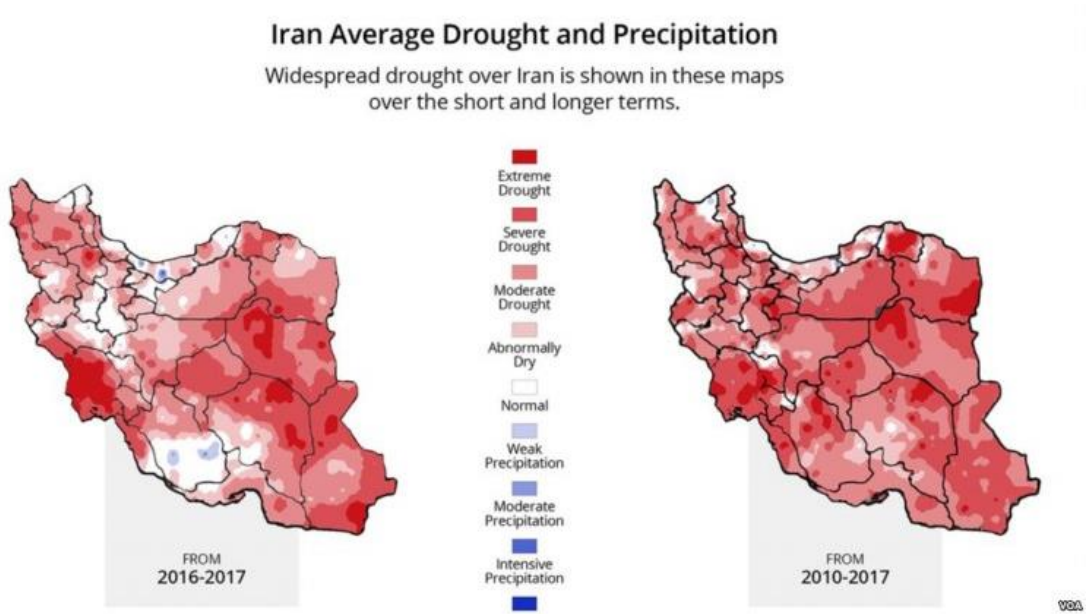


Figure 3. Drought zoning map of Iran in the recent short- and long-term period

Effect of EM product on Saline soils- Iran cases

Given the problem of salinity that threatens the country's agriculture and food security, the government and researchers in this field have been working to catch up with this problem. EMKANPAZIR company also strives to move forward in the direction of local needs and EMRO company goals for solving the problems. So, we have used EM technology at different locations in Fars province during 2018-2019 to improve salinity problem in the soil and help our farmer to adapt their agricultural practices and check the results. Salinity tests using EM were carried out in different parts of Fars province (south of Iran) during 2018-2019.

Onion farm-Baladeh, Kazeroon county (Mr. Mohammad-zade)

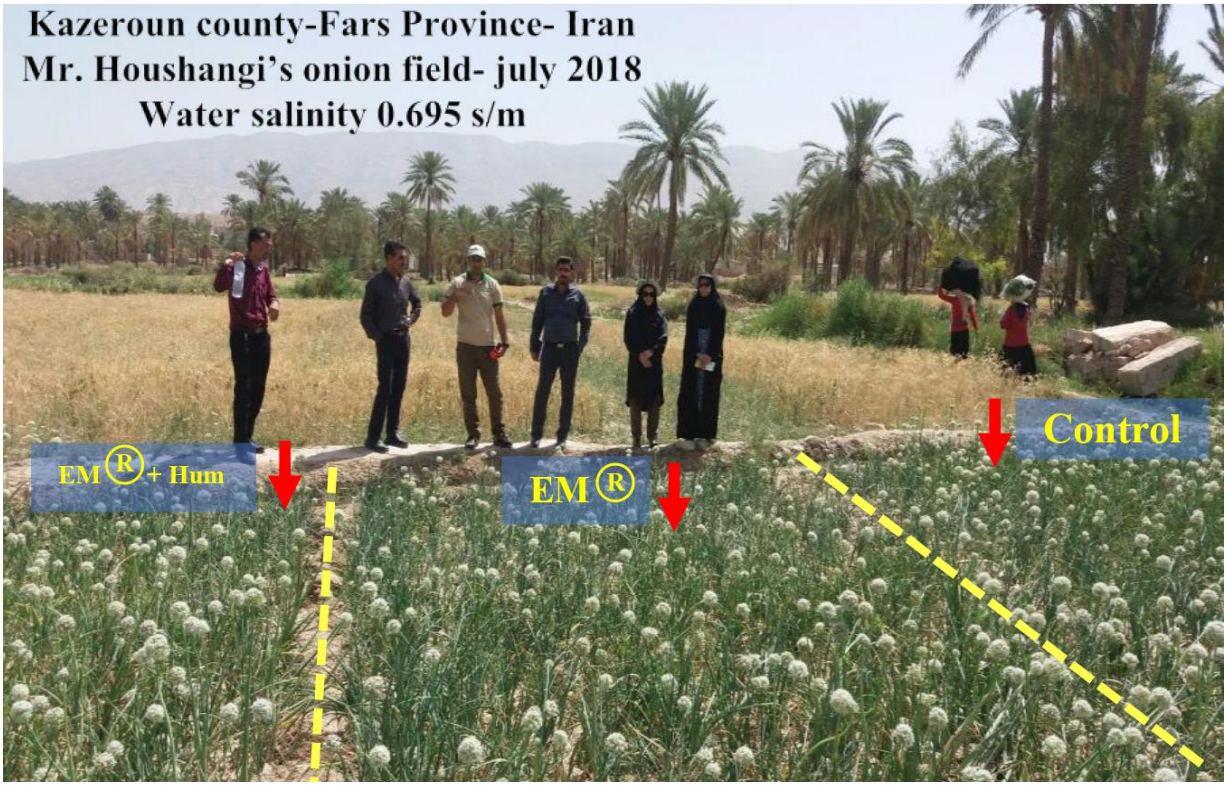
Mr. Mohammad-zade onion farm irrigates with low quality and saline water. We suggested him using EM and organic matter (humic acids) to ameliorate salinity of the soil. He applied EM and EM+Humic acid in two neighbour lanes according to our recommendations. EM was applied with 40 L/ha dosage and Humic acid was applied in 2 Kg/ha rate. EM and EM+Humic acid treatments were diluted and irrigated three time during the season. Salinity factors (EC+TDS+Salinity) of the soil were assessed and a continuous decline specially in treatment beside humic acid (Lane3) was observed. The results were showed in the table 5.

	Water	Lane 1: control	Lane 2: EM 1st	Lane 2: EM 2nd	Lane 3: EM+Hum 2nd	Lane 2: EM 3rd	Lane 3: EM+Hum 3rd
EC	0.648 s/m	1.41 s/m	570.5 ms/m	308. 5 ms/m	378 ms/m	391.5 ms/m	353 ms/m
SAL	0.35%	0.75%	0.3%	0.15%	0.2%	0.2%	0.15%
TDS	3.55 g/l	7.55 g/l	3.06 g/l	1.64 g/l	2.04 g/l	2.09 g/l	1.89 g/l
Res.	1.54 Ω.m	0.71 Ω.m	1.74 Ω.m	3.22 Ω.m	2.6 Ω.m	2.53 Ω.m	2.80 Ω.m
Temp.	27.8°c	26.5 °c	26.4 °c	26.7 °c	26.3 °c	26.2 °c	26.5 °c

Table 5. Salinity parameters of Mr. Mohammad-zade's onion field.
(1st: after first use of EM, 2nd: after second use of EM, EM+Hum: use EM and humic acids)

Onion farm-Baladeh, Kazeroon county (Mr. Houshangi)

His onion farm irrigates with low quality water. We suggested him using EM and organic matter to decrease salinity of the soil. He applied EM and EM+Humic acid in two lanes according to our recommendations. EM was applied with 40 L/ha dosage and Humic acid was applied in 2 Kg/ha rate. EM and EM+Humic acid treatments were diluted and irrigated three time during the season. Salinity factors (EC+TDS+Salinity) of the soil were assessed and a significant decline was not observed. The results were showed in the table 6.



	Water	Lane 3: control	Lane 4,5: 1st	Lane 4: EM 2nd	Lane 5: EM+Hum 2nd	Lane 4: EM 3rd	Lane 5: EM+Hum 3rd
EC	0.695 s/m	440 ms/m	259 ms/m	436 ms/m	392.5 ms/m	596 ms/m	351.5 ms/m
SAL	0.38%	0.2%	0.15%	0.2%	0.2%	0.3%	0.2%
TDS	3.81 g/l	2.36 g/l	1.415 g/l	2.33 g/l	2.105 g/l	3.19 g/l	1.98 g/l
Res.	1.43 Ω.m	2.25 Ω.m	3.78 Ω.m	2.28 Ω.m	2.53 Ω.m	1.67 Ω.m	2.62 Ω.m
Temp.	27.6°c	29.3 °c	26.1 °c	26.2 °c	26.2 °c	26.5 °c	26.6 °c

Table 6. Salinity parameters of Mr. Houshangi's onion field.
(1st: after first use of EM, 2nd: after second use of EM, EM+Hum: use EM and humic acids)

Fig garden- Kafdahak, Kherameh county (Mr. Sadeghi)

Mr. Sadeghi was worried about the cultivation and growth of fig trees due to the high salinity problem in the village of Kafdahak, Kherameh county. His previous soil salinity analysis showed it could be difficult to grow healthy fig trees in long-term period (Table 7 and 8). EMKANPAZIR Company Expert performed a re-sampling of the garden sections. Mr. Sadeghi mostly buys fresh water to irrigate the trees. we also asked him to use an EM product in irrigating and spraying some trees. Sampling was done in April (2018) from 0-30 centi-meter depth of soil. The EM product from the company was donated to Mr. Sadeghi to use in specified treatments and repetitions plots.

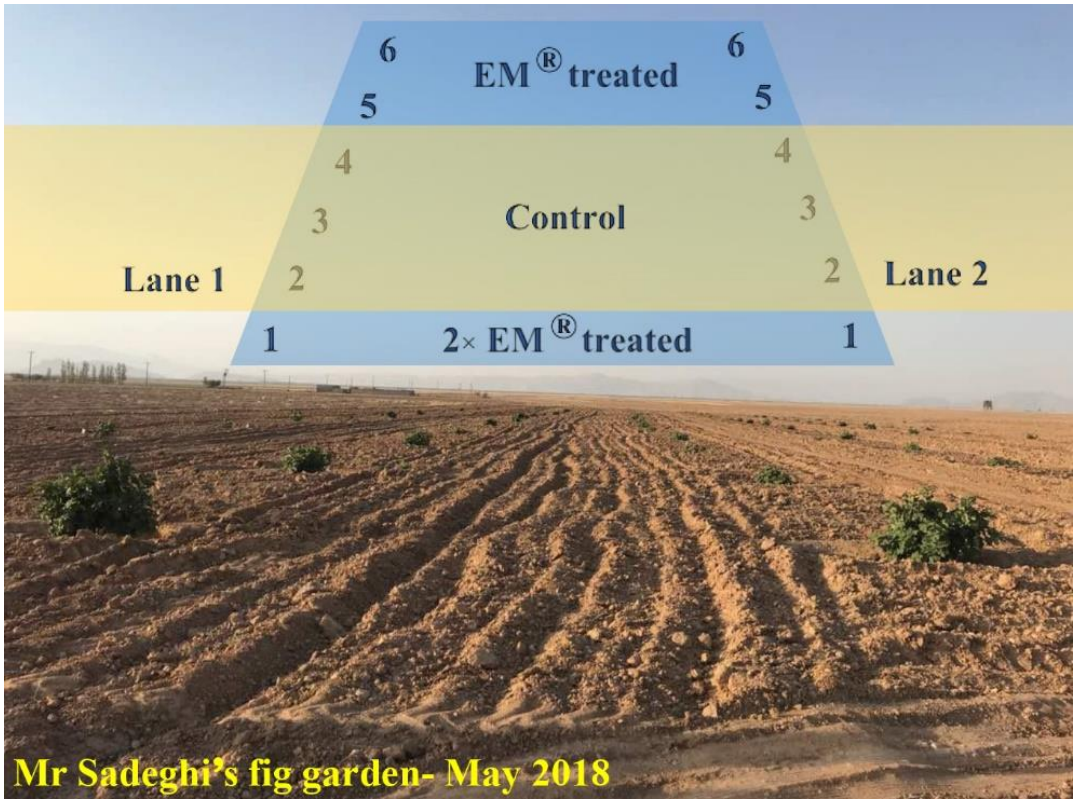
After using EM, second time of sampling was done in May (2018). After EM treatment, no significant change in soil salinity was observed (Table 9). However, the gardener was very satisfied with the results of the crop growth. It should be mentioned that the use of diluted EM solution at 5% dose showed excellent effect on germination and vegetative growth of branch meristem.

Parameter	
Depth	0-30 cm
EC ms/cm	5.18
pH of paste	7.48
T.N.V	43.68
O.C (%)	1.12
OM (%)	1.93
T.N (%)	0.11
P.ava (ppm)	5.90
K.ava (ppm)	287.67
Clay (%)	20.40
Silt (%)	36.60
Sand (%)	43.00
Texture	-
Cu ava. (ppm)	0.90
Mn ava. (ppm)	5.60
Fe ava. (ppm)	2.72
Zn ava. (ppm)	0.94
B ava. (ppm)	-

Table 7. Soil nutrient analysis of Mr. Sadeghi's fig garden in February 2016 (was done by himself).

Parameter	
Depth	0-30 cm
EC ms/cm	1.70
pH of paste	7.96
T.N.V	57.00
O.C (%)	0.57
OM (%)	0.98
T.N (%)	0.06
P.ava (ppm)	0.02
K.ava (ppm)	305.00
Clay (%)	-
Silt (%)	-
Sand (%)	-
Texture	-
Cu ava. (ppm)	0.62
Mn ava. (ppm)	5.40
Fe ava. (ppm)	3.60
Zn ava. (ppm)	0.76
B ava. (ppm)	0.976

Table 8. Soil nutrient analysis of Mr. Sadeghi's fig garden in February 2019 (was done by himself).



	Before EM application				After EM application			
Sample	Lane 1: 2,3,4	Lane 2: 2,3,4	Lane 1: 5,6	Lane 2: 5,6	Lane 1: 2,3,4	Lane 2: 2,3,4	Lane 1: 5,6	Lane 2: 5,6
EC	112.5 ms/m	124.5 ms/m	110 ms/m	930 ms/m	143 ms/m	158.5 ms/m	149 ms/m	163 ms/m
SAL	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
TDS	615 mg/L	670 mg/L	610 mg/L	510 mg/L	760 mg/L	840 mg/L	790 mg/L	870 mg/L
Res.	8.68 Ω.m	7.96 Ω.m	8.72 Ω.m	10.4 Ω.m	6.98 Ω.m	6.76 Ω.m	6.36 Ω.m	6.12 Ω.m
Temp.	26.6 °c	26.2 °c	26.6 °c	26.5 °c	26.6 °c	26.7 °c	27 °c	26.9 °c

Table 9. Salinity parameters of Mr. Sadeghi's fig garden.
(Lane1: 2,3,4 and Lane2: 2,3,4: control parts (without EM))

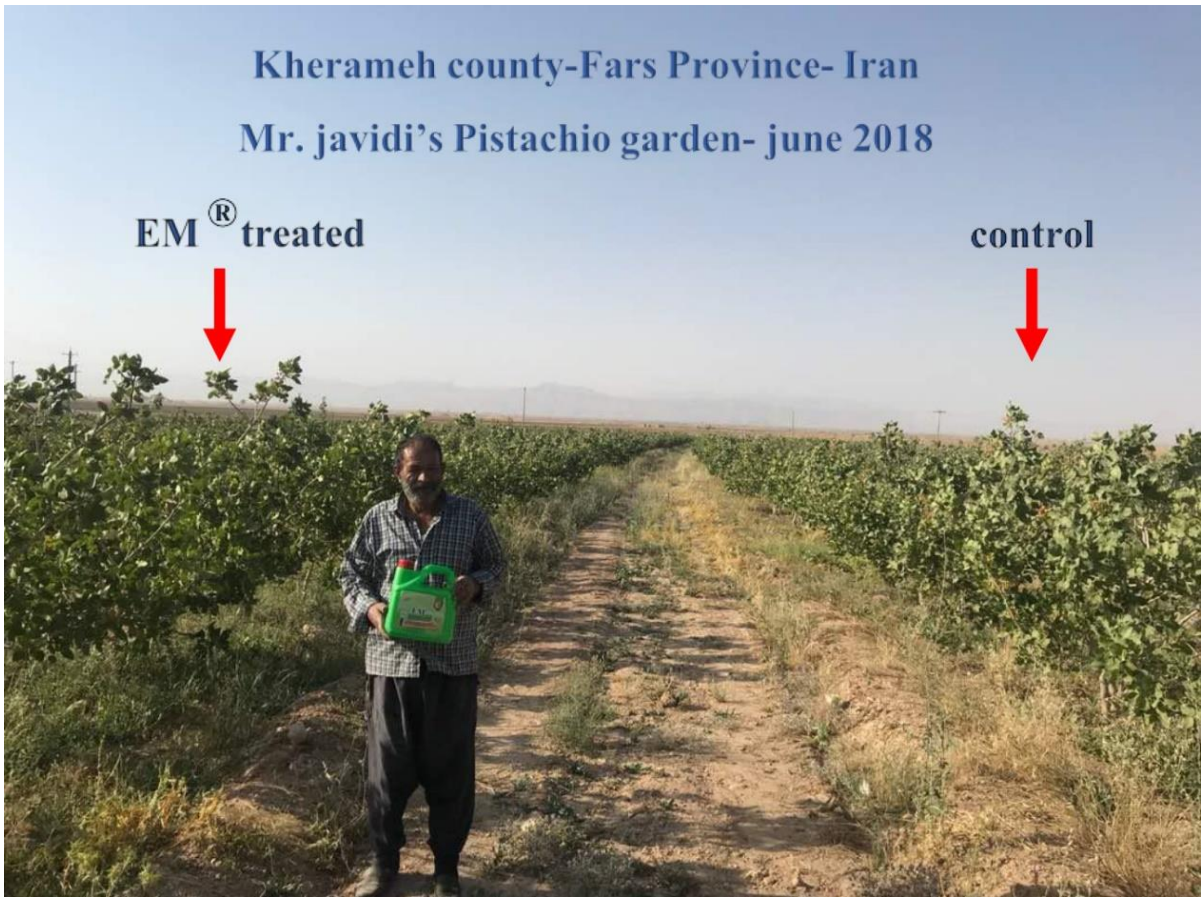
Pistachio Garden- Abshour, Kherameh county (Mr. Javidi)

Mr. Javidi's pistachio garden is located in the village of Abshour, Kherameh county. Due to the salty water of the village's aqueducts, they have named the village 'Ab: water' and 'shour: saline'. In May 2018, the company expert checked the previous soil analysis was done by the farmer (Table 10) and selected test plot and was given a 20 litre EM gallon for use in one of the garden rows. After one month in June 2018, second sampling was taken from 0-30 centi-meter soil depth. The results showed no significant change in soil salinity (Table 11).

However, the gardener acknowledged that at least few weeks the leaves of the trees looked greener and more succulent after consuming EM. He had used some of the EM in the nearby alfalfa farm and was very surprised by the growth stimulation of EM product in alfalfa plants.

Test	Depth 0 – 40 cm	Depth 40 – 80 cm	critical level
EC (ds/m)	6.24	4.46	<8
pH	7.78	7.82	6.5-7.5
Ca (meq/l)	18.0	14.0	
Mg (meq/l)	16.0	9.5	
Na (meq/l)	27.0	18.5	
SAR	6.5	5.4	<13
K (mg/kg)	238	269	250
P (mg/kg)	11.6	9.7	25
Clay (%)	23	33	
Silt (%)	44	36	
Sand (%)	33	31	
Ca/Mg	1.13	1.47	

Table 10. Soil nutrient analysis of Mr. Javidi's Pistachio garden in December 2017 (was done by himself).



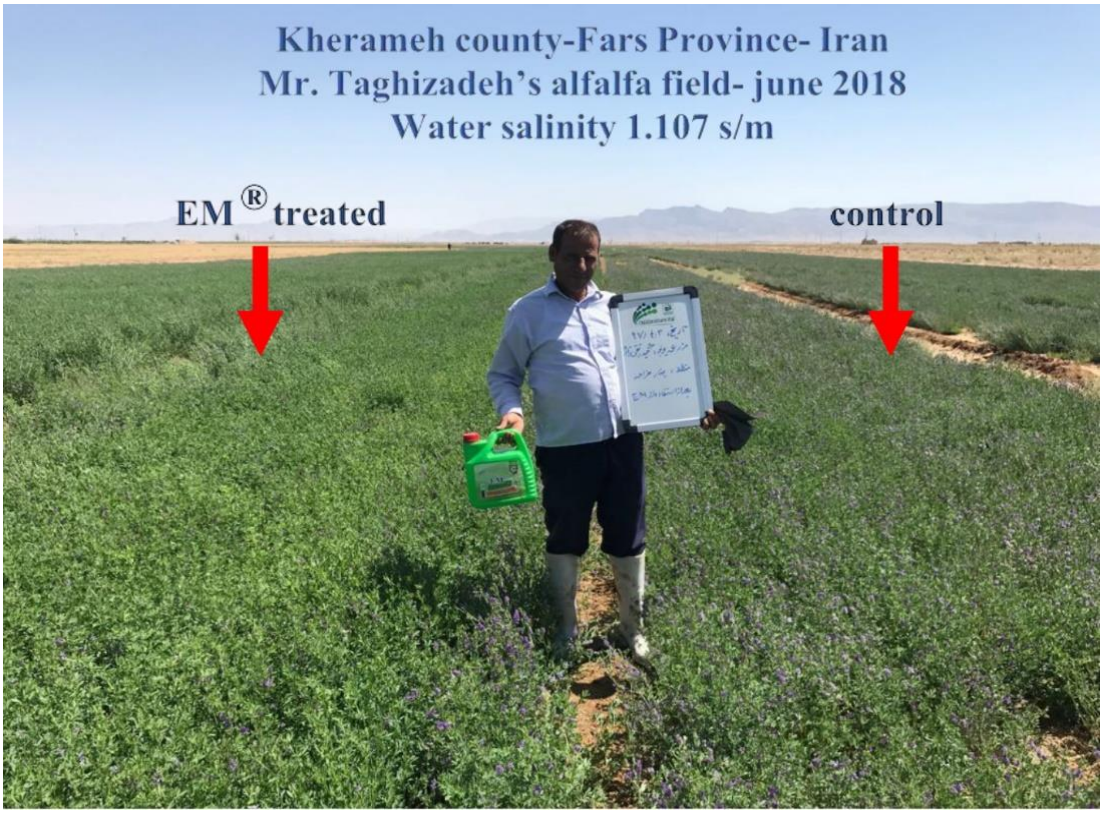
	Before EM application	After EM application
Sample	Lane 1	Lane 1
EC	181 ms/m	306 ms/m
SAL	0.1%	0.15%
TDS	975 mg/l	1.62 g/L
Res.	5.46 Ω.m	3.26 Ω.m
Temp.	28.9 °c	26.6 °c

Table 11. Salinity parameters of Mr. Javidi's pistachio garden.

Alfalfa farm- Chenar, Kherameh county (Mr. Taghizadeh)

Mr. Taghizadeh, a leading farmer in the Chenar area of Kherameh city and the owner of the alfalfa farm, faced severe salinity problems in all his 6 hectares field. Water sampling revealed surprisingly high saline water (EC_w: 1.107 s/m) was using for irrigation of the farm. The accumulation of salt in the soil showed that in some areas, the plants density was decreased and in some patches it was completely empty. The company expert donated 40 litres of EM per hectare to the farmer to be used in two replicates of 20 litres on two occasions. The first soil sampling was done in May 2018, from farm soil and the second sampling was done after EM application in June 2018.

The results of soil tests showed that salinity in the farm soil intensely decreased to an acceptable level (Table 12). It should be noted that the farmer observed an increase in EM-treated foliage growth of about 30 cm compared to the control. Alfalfa bushes in control plot had low density, low growth that make mechanized harvesting impossible and the bushes flower immerged much sooner than 20 days. Whereas in the EM-treated plot the plant density was much higher, the bushes flowered on-time and more Forage was harvested.

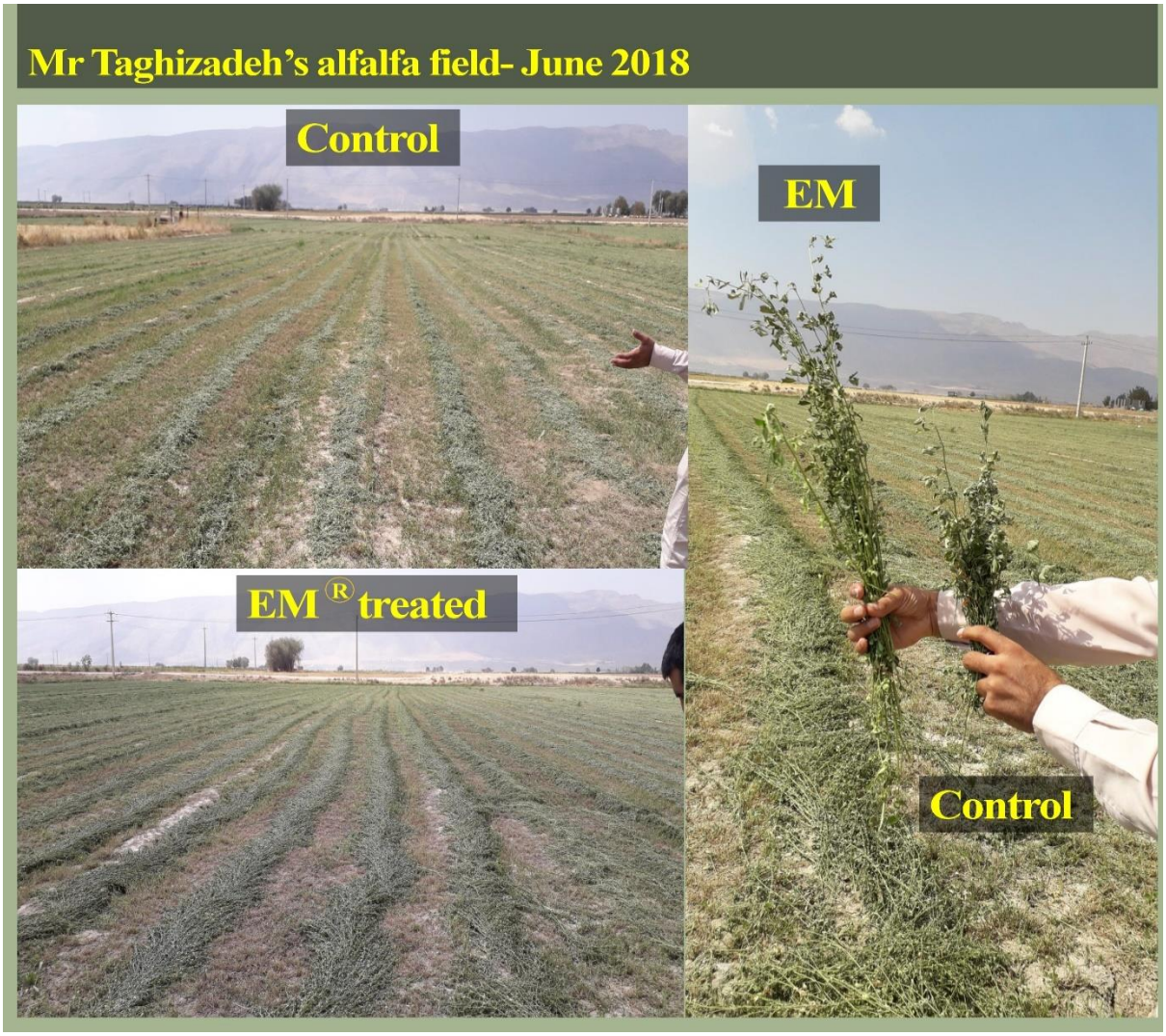


		Before EM application		After EM application	
Sample	Water	Lane 1: control	Lane 2: before EM	Lane 1: control	Lane 2: after EM
EC	1.107 s/m	1.31 s/m	1.075 s/m	772 ms/m	596.5 ms/m
SAL	0.64%	0.7%	0.55%	0.4%	0.3%
TDS	6.39 g/l	7.35 g/l	5.8 g/l	4.155 g/l	3.2 g/l
Res.	0.87 Ω.m	0.734 Ω.m	0.926 Ω.m	1.28 Ω.m	1.66 Ω.m
Temp.	25.2°c	28 °c	29.3 °c	26.7 °c	26.6 °c

Table 12. Salinity parameters of Mr. Taghizadeh's alfalfa field.

Alfalfa farm- Moezabad, Kherameh county (Mr. Taghizadeh)

Another alfalfa farm in the adjacent village that had less salinity and water EC_w parameter was about 340 ms / m (microsimens / meter). Increase in vegetative growth was also observed in alfalfa farm and comparison of soil test results showed that salinity decrease was acceptable (Table 13). The extremely intense effect of EM on alfalfa growth could be due to the fact that EM increases the rhizobium population of alfalfa rhizosphere and biological mobility of soil intensifies alfalfa growth and high tolerance of plants to salinity stress.



	Before EM application		After EM application	
Sample	Lane 1: control	Lane 2: before EM	Lane 1: control	Lane 2: after EM
EC	684 ms/m	713.5 ms/m	702 ms/m	595.5 ms/m
SAL	0.35%	0.35%	0.35%	0.3%
TDS	3.67 g/l	3.875 g/l	3.78 g/l	3.19 g/l
Res.	1.45 Ω.m	1.36 Ω.m	1.39 Ω.m	1.66 Ω.m
Temp.	29 °c	29.4 °c	26.7 °c	26.6 °c

Table 13. Salinity parameters of Mr. Taghizadeh's alfalfa field.

Sugar-beet farm- Majd-abad, Marvdasht county (Mr. Estakhri)

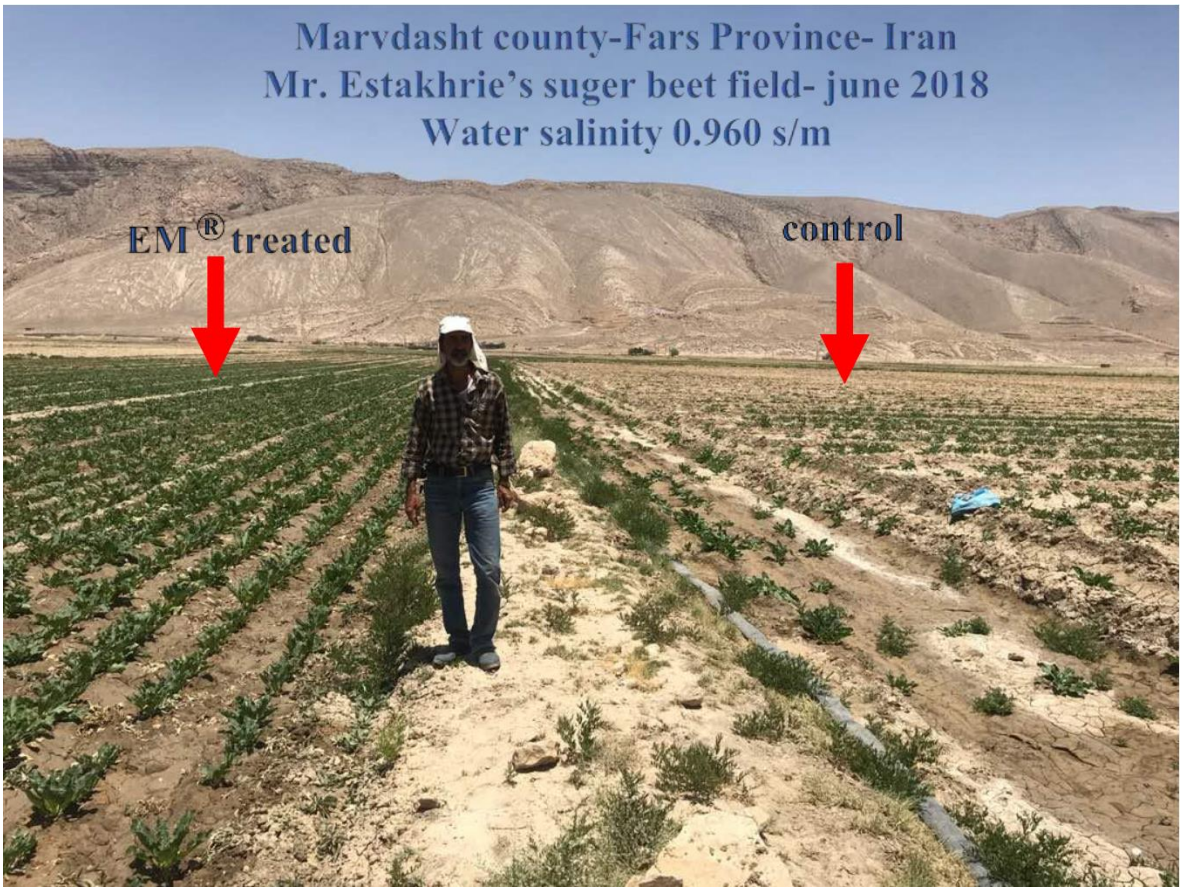
Mr Estakhri had rented a 7 hectares plot of land for sugar beet cultivation in the village of Majd-abad in Marvdasht county in 2018. After sowing the seeds, he found that in addition to the water salinity problem (EC: 0.925 s/m, SAL: 0.54%), the soil also had high salinity (Table 14 and 15). Inside that 7-hectare farm, no significant seedlings were grown, and only at the border margins, due to salt uptake, the density of seedlings were further. Mr. Estakhri was forced to replant the seeds in the farm, so he was introduced to the EM product technical expert and was recommended utilizing EM product for remaining 4 acres. The EM was applied in two replications of 20 litres with a week interval to the irrigation system. Soil sample analysis performed in June 2018, and the EM-treated and control plots were compared. The results were extremely promising (Mr. Estakhri farm picture). Comparison of soil salinity analysis showed that the use of EM solution not drastically reduced soil salinity but had a significant effect on the growth of sugar-beet bushes (Table 16). The use of EM in the irrigation system helped to overcome salinity stress in sugar beet. After the tuber began to form, the farmer was able to provide a better source of water with less salinity, and the second time sampling showed that the EM-treated patch had a better condition until harvest. Overall, due to the high salinity, the farmer was able to harvest sugar-beet from his farm, although yields were less than about one-third the ideal farms irrigated with salt-free water

Parameter	
Depth	0-30 cm
EC*10^3	7.28
pH	8.32
T.N.V (%)	59
O.C (%)	2.9
T.N (%)	0.26
P.ava (ppm)	6.6
K.ava (ppm)	328
Clay (%)	34.6
Silt (%)	38.8
Sand (%)	26.6
Texture	Clay loam
Cu ava. (ppm)	-
Mn ava. (ppm)	-
Fe ava. (ppm)	-
Zn ava. (ppm)	-

Table 14. Soil nutrient analysis of Mr. Estakhri's Sugar-beet farm in April 2018. (was done by himself).

Parameter		
EC*10^6		9250
TDS mg/L		7770
pH		7.32
$^{-}CO_3^{2}$	meq/l	0
$^{-}HCO_3^{2}$	meq/l	1.9
^{-}cl	meq/l	76
$^{-}SO_4^{2}$	meq/l	21.5
Sum Anion	meq/l	99.4
$+Ca^{2}$	meq/l	16.8
$+Mg^{2}$	meq/l	20.4
^{+}Na	meq/l	63
^{+}K	meq/l	0.3
Sum Cation	meq/l	100.5
S.S.P %		63
S.A.R		14.6
Total hardness		1860

Table 15. Water analysis of Mr. Estakhri's Sugar-beet farm in April 2018 (was done by himself).

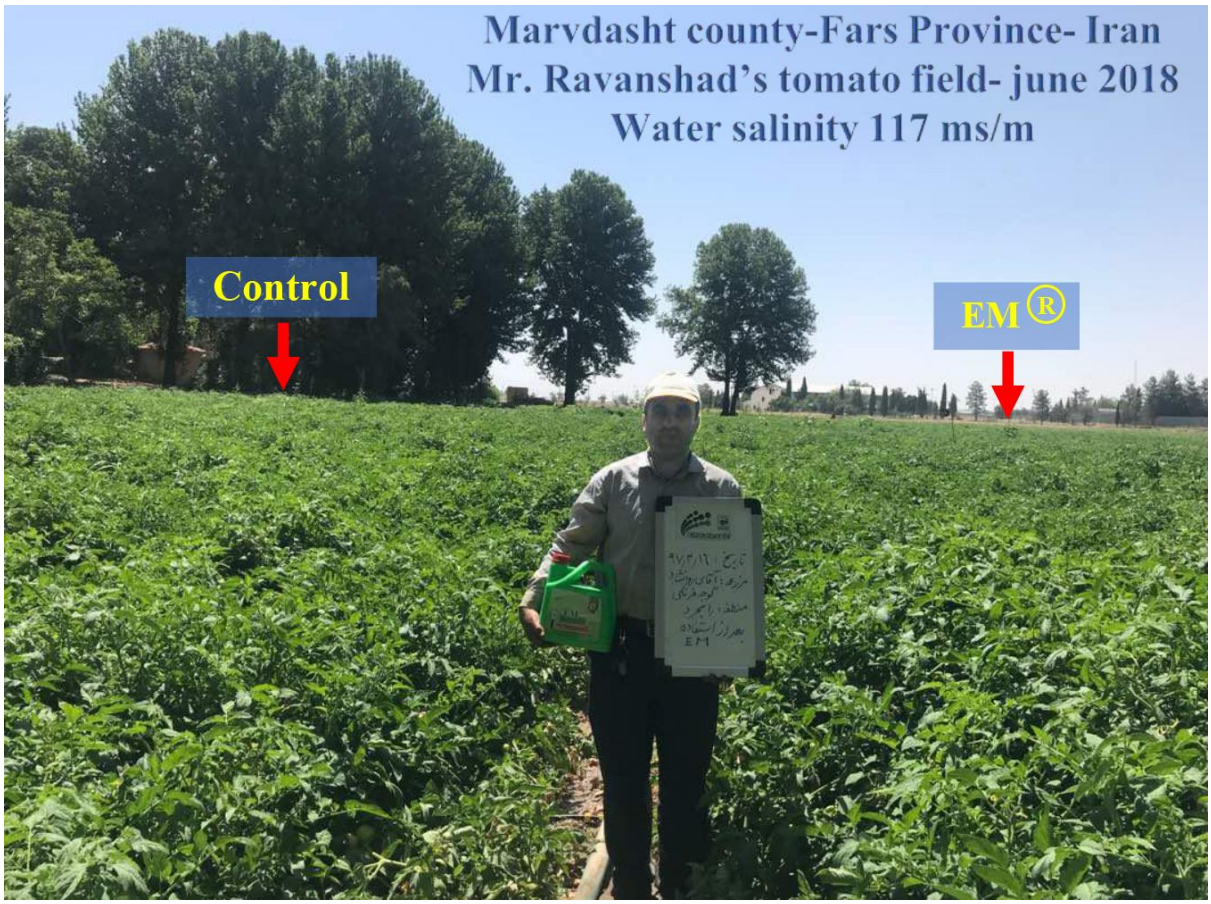


		Before EM application	After EM application		After irrigation source change	
Sample	Water	Lane 1: control	Lane 1: control	Lane 2: after EM	Lane 1: control	Lane 2: after EM
EC	0.96 s/m	407 ms/m	623 ms/m	652.5 ms/m	414.5 ms/m	236 ms/m
SAL	0.54%	0.2%	0.3%	0.35%	0.2%	0.1%
TDS	5.28 g/l	2.18 g/l	3.335 g/l	3.70 g/l	2.22 g/l	1.26 g/l
Res.	1.05 Ω.m	2.43 Ω.m	1.59 Ω.m	1.43 Ω.m	2.39 Ω.m	4.24 Ω.m
Temp.	25.9°c	26.2 °c	26.8 °c	26.5 °c	30.6 °c	30.8°c

Table 16. Salinity parameters of Mr. Estakhri's sugar-beet field.

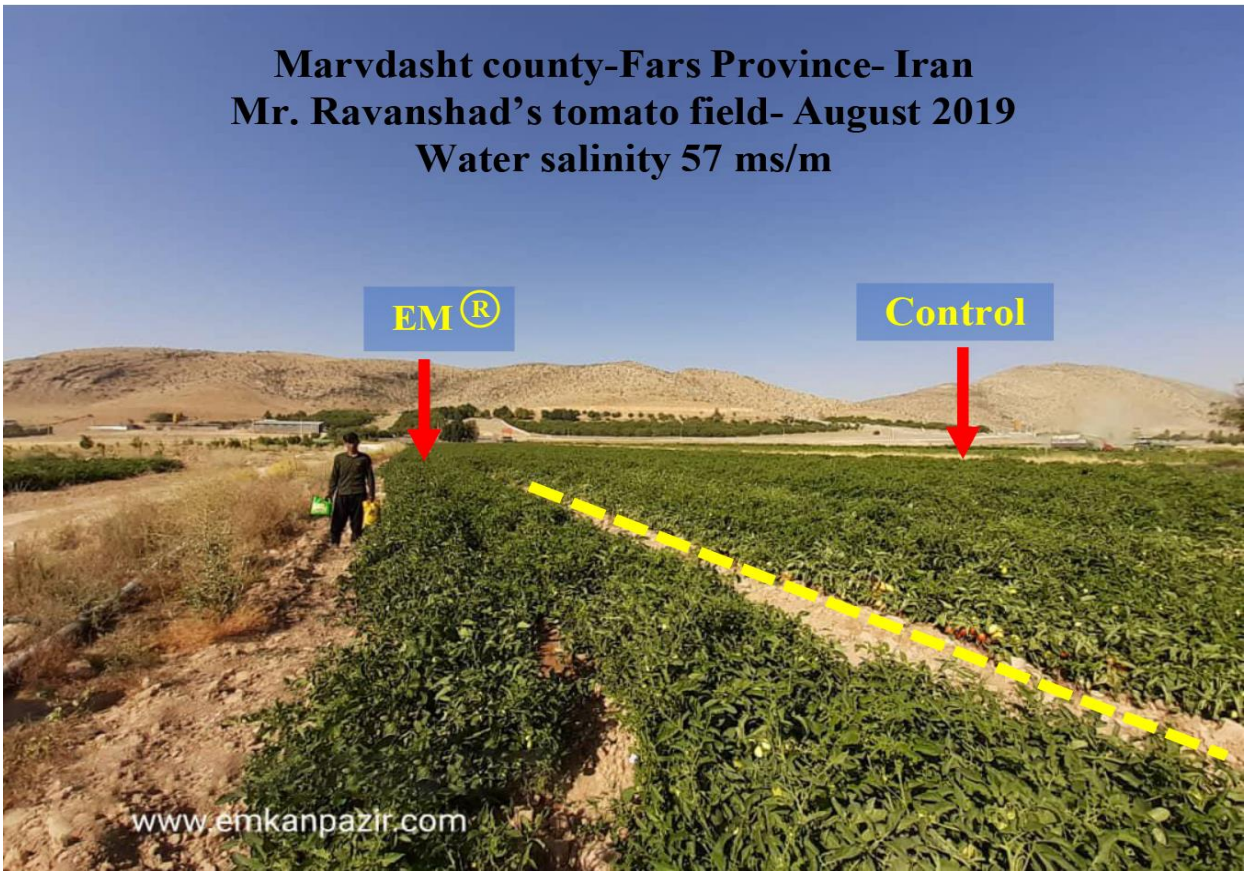
Tomato farm- Abarj, Marvdasht county (Mr. Ravanshad)

Mr. Ravanshad is a leading and experienced farmer in the field of tomato and tomato production in Fars province. Mr. Ravanshad has been acquainted with the EM product of EMKANPAZIR Co. for two years now, and has been using higher than recommended doses based on the results of the EM product. In the first year he consumed 60 litres of EM solution per hectare and in the second year he consumed 100 litres of EM per hectare. Mr. Ravanshad stated that after using EM, the Greenery and chlorophyll levels in the plants increased, the leave twisting and distortion observed -as a result of high-temperature weather, salt accumulation in the soil and impaired root uptake- was extremely improved. Comparative results for EM treatment and control plots showed no significant difference in salinity (Table 17 and 18). Since the amount of calcium in the saturated extract was also examined in the second year, the amount of calcium increased from 165 ppm to 245 ppm in the saturated extract of soil.



		Before EM application	After EM application	
Sample	Water	Lane 1 and 2: Control & before EM	Lane 1: control	Lane 2: after EM
EC	116.8 ms/m	198 ms/m	217.5 ms/m	272 ms/m
SAL	0.06%	0.1%	0.1%	0.15%
TDS	637 mg/l	1.04 g/l	1.17 g/l	1.47 g/l
Res.	8.33 Ω.m	5.14 Ω.m	4.56 Ω.m	3.62 Ω.m
Temp.	29 °c	25.7 °c	25.2 °c	25.1 °c

Table 17. Salinity parameters of Mr. Ravanshad's tomato field.

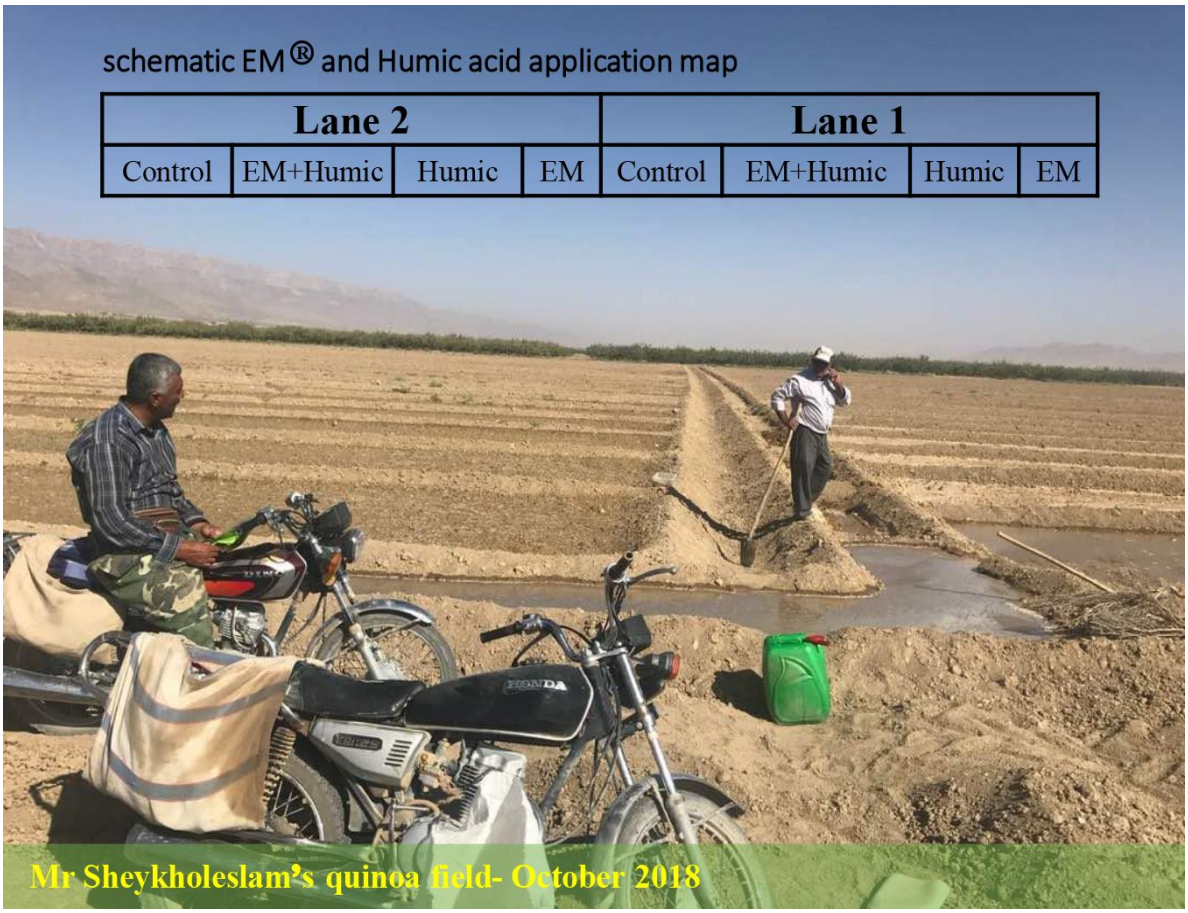


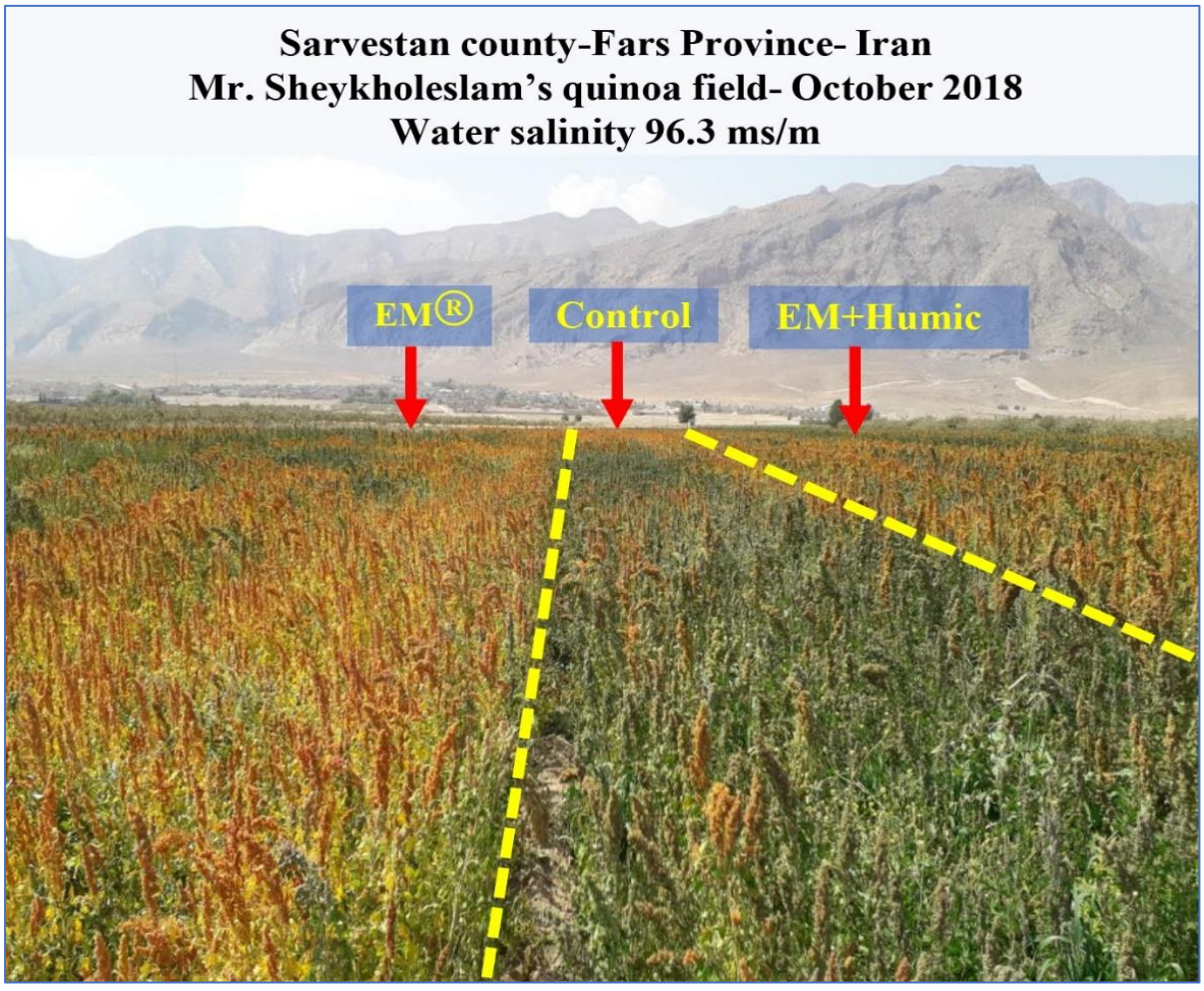
		Before EM application	After EM application
Sample	Water	Lane 1	Lane 1
EC	57 ms/m	135.5 ms/m	171.5 ms/m
SAL	0.03%	0.05%	0.1%
TDS	310 mg/l	725 mg/l	925 mg/l
Res.	17.13 Ω.m	7.38 Ω.m	5.76 Ω.m
Temp.	28.9°c	26.8 °c	26.4 °c
Ca	54 ppm	165 ppm	245 ppm

Table 18. Salinity parameters of Mr. Ravanshad's tomato field.

Quinoa farm- Kouhenjan, Sarvestan county (Mr. Sheikholeslam)

Sarvestan County is one of the eastern provinces of Fars province which has led most of the farmers to pistachio cultivation due to the decrease of water quality and increasing salinity. One of the crops recently recommended by the Ministry of Agriculture of Fars province to cope with the salinity problem is quinoa. In an effort conducted by EMKANPAZIR Company expert, EM and organic matter treatments with two replications were performed in Mr. Sheikholeslam's farm. Soil test results showed no significant change in soil salinity (Table 19). However, at field visit, in terms of seed ripening and plant maturation, the EM and EM plus humic acids plots were better than the control.


schematic EM® and Humic acid application map
Lane 2
Control
EM+Humic
Humic
EM
Lane 1
Control
EM+Humic
Humic
EM
Mr Sheykholeslam's quinoa field- October 2018

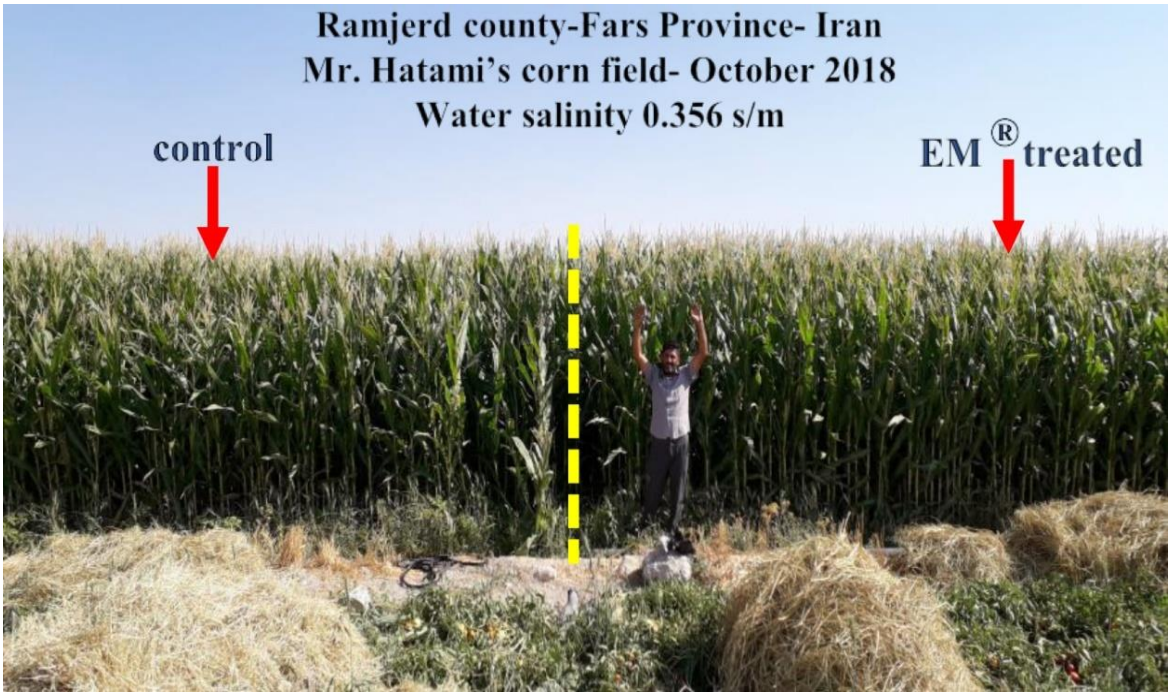

Sarvestan county-Fars Province- Iran
Mr. Sheykholeslam's quinoa field- October 2018
Water salinity 96.3 ms/m
EM®
Control
EM+Humic

Sample	Water	Lane 1: EM	Lane 2: Hum	Lane 3: EM+Hum	Lane 4: control	Lane 5: EM	Lane 6: Hum	Lane 7: EM+Hum	Lane 8: control
EC	0.271 s/m	89.35 ms/m	88.3 ms/m	81.95 ms/m	94.15 ms/m	101 ms/m	94.3 ms/m	100.5 ms/m	133 ms/m
SAL	0.14%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
TDS	1.44 g/L	477 mg/L	471.5 mg/L	453.5 mg/L	505 mg/L	555 mg/L	510 mg/L	550 mg/L	710 mg/L
Res.	3.68 Ω.m	11.12 Ω.m	11.28 Ω.m	11.66 Ω.m	10.52 Ω.m	9.48 Ω.m	10.26 Ω.m	9.64 Ω.m	7.48 Ω.m
Temp.	27.2 °c	27.2 °c	27.6 °c	27.4 °c	27.7 °c	28.1 °c	28.1 °c	27.9 °c	27.7 °c

Table 19. Salinity parameters of Mr. Sheykholeslam's quinoa field.
(EM: use of EM, Hum: use humic acids, EM+Hum: use EM and humic acids)

Corn and tomato farm- Falunak, Ramjerd county (Mr. Hatami)

Next field survey conducted on Mr Hatami's corn and tomato farm in Falunak village of Ramjerd County, the field appearance and salinity results of the EM treated and control plots were not significantly different (Table 20), however a slight decrease was observed in EM treated plot in compare with control at tomato field.



		Corn field		Tomato field	
Sample	Water	Lane 1: control	Lane 2: EM	Lane 1: control	Lane 2: EM
EC	0.356 s/m	302.5 ms/m	392.5 ms/m	349.5 ms/m	246.5 ms/m
SAL	0.19%	0.15%	0.2%	0.15%	0.1%
TDS	1.97 g/l	1.615 g/l	2.105 g/l	1.87 g/l	1.33 g/l
Res.	2.74 Ω.m	3.28 Ω.m	2.53 Ω.m	2.84 Ω.m	4.02 Ω.m
Temp.	29.4°c	27.8 °c	27.7 °c	27.5 °c	27.6°c

Table 20. Salinity parameters of Mr. Hatami's corn and tomato fields

Animal manure composting- Marvdasht county (Mr. Nemati)

EM products are frequently utilizing to accelerate the composting process, rapidly reducing C/N ratios and removing unpleasant odours and insects from the environment. In the farm, Mr. Nemati prepared manure compost treated with EM (EM-compost) to improve soil condition for his tomato plants. The appearance of the compost showed that the EM-treated compost was completely dark in colour compared to the control treatment and had a much lower odour. Fewer flies were apparent around this compost pile. Mr. Nemati was very pleased with the results of the EM product and praised the Japanese biological technology and stated that the achievement of Professor Higa and EMRO Japan has improved the compost quality and improved the performance of his tomato farm. The result of compost salinity comparison also shows that the salinity parameters of treated compost was much lower than the control, which indicates better humification and improved mass conditions (table 21).

Sample	Control	EM treated
EC	2.102 s/m	1.49 s/m
SAL	1.18%	0.84%
TDS	11.56 g/l	8.24 g/L
Res.	0.48 Ω.m	0.66 Ω.m
Temp.	26.5 °c	26.3 °c

Table 21. Salinity parameters of Mr. Nemati's compost pile

Compost factory- Yasuj county (Mr. Rafati)

A survey also carried out at a composting plant in Mr. Rafati's compost factory. The factory is located in Yasuj city of Kohgiluyeh and Boyer-Ahmad province. Mr. Rafati, the factory manager, provided one of the compost stacks to the company's experts and completed his 30-day composting process with the EM product donated. He used a tractor and tuner to aerate the compost mass daily. According to company experts, after applying EM to the treatment stack, anaerobic conditions were recommended to expedite the decomposition process. After two weeks pre-fermentation period, aeration was performed again. The combination of anaerobic and aerobic composting methods made the process of decomposition faster and halved the costs of mixing and turning piles.

According to comparison of nutritional analysis, nitrogen content increased from 1.5 to 3.5% and bed salinity (EC) decreased from 23.1 to 15.8 ms/cm (microsimens per cm) (Table 22). Mr. Rafati was very pleased with the smell control at the workplace, the increase in environmental health, the rapid decrease in C / N ratio and the improvement of the quality of the compost.

Parameter	Control	EM applied compost
Total Nitrogen (N)	% 1.56	% 3.49
Phosphate (P205)	% 0.89	% 1
Potash (K2O)	% 1.46	% 1.53
Iron (Fe) ppm	2780	1164
Zinc (Zn) ppm	370	540
Copper (Cu) ppm	32	40
Manganese (Mn) ppm	460	790
electrical conductivity (EC:ms/cm)	23.1	15.8
PH	7.66	7.65
Organic Matter Conten (OM%)	% 48	% 45
Sulfur (S)	-	10
Boron (B)	-	1.02
Total Organic Carbon (OC%)	% 27.84	% 14.5
Carbon:Nitrogen Ratio (C:N)	17.84	4.15

Table 22. Salinity and nutritional parameters of Mr. Rafati's compost factory

Tomato farm- beyza, Sepidan county (Mr. Mohammadi)

Fars Province is one of the major tomato-growing provinces in Iran. So, we have done a survey to explore the effect of EM solution on soil condition in tomato farm of Mr. Mohammadi for two years. The afghan farmer, Khan Mohammad Mohammadi, has been using the EM solution for two years. Afghan farmers are one of the tribes that make up the majority of the agricultural labour force in Iran and are highly skilled and experienced in their work and profession with a common cultural background. Mr. Mohammadi is a farmer who has been using the EM product for two years and has experienced the benefits of this Japanese biological product. Mr. Mohammadi pointed to EM results in the field, such as increased vegetation and chlorophyll levels, improved plant nutrient uptake, and increased plant health. Soil analysis results showed salinity factors declined in EM treated plot at two years (Table 23 and 24).

In last year, initial sampling was performed in July 2019 and subsequent to EM application, second time sampling and analysis was performed in august 2019. The calcium content of soil samples was measured in second year. Calcium content in EM treated and control plot decreased slightly in parallel.

Sample	Water	Lane 1: control	Lane 2: EM
EC	143.4 ms/m	443.1 ms/m	295.5 ms/m
SAL	0.07%	0.2%	0.15%
TDS	767 mg/l	2.385 g/l	1.570 g/l
Res.	6.95 Ω.m	2.22 Ω.m	3.39 Ω.m
Temp.	28.3°c	30 °c	27.3 °c

Table 23. Salinity parameters of Mr. Mohammadi's tomato field in first year (2018)

	Before EM application		After EM application	
Sample	Lane 1: control	Lane 2: EM	Lane 1: control	Lane 2: EM
EC	139 ms/m	267.5 ms/m	92.4 ms/m	223 ms/m
SAL	0.05%	0.15%	0.05%	0.1%
TDS	745 mg/l	1.43 g/l	498.5 mg/l	1.195 g/l
Res.	7.1 Ω.m	3.72 Ω.m	10.66 Ω.m	4.442 Ω.m
Temp.	26.2 °c	26.3 °c	26.5 °c	26.4°c
Ca	255 ppm	325 ppm	145 ppm	300 ppm

Table 24. Salinity parameters of Mr. Mohammadi's tomato field in second year (2019)

Tomato farm- Shul, Marvdasht county (Mr. Rahimi)

Mr. Sardar Rahimi is one of the leading farmers in the Shul village of Naqsh-e Rostam Marvdasht who used EM product donation from EMKANPAZIR Company in his tomato fields. Mr. Rahimi planted a 6-hectare tomato farm that used an EM solution gallon (20 litre) in a half-hectare plot and was relatively satisfied with the apparent results of plant growth. Initial sampling of soil conditions was performed in July 2019 and following applying EM, second sampling was done in August 2019. Comparison of soil salinity and calcium analysis in soil saturated extract was performed. Acceptable decrease in salinity parameters was proved following EM utilization and Ca content was diminished in EM treated plot (Table 25).

	Before EM application		After EM application	
Sample	Lane 1: control	Lane 2: EM	Lane 1: control	Lane 2: EM
EC	144.5 ms/m	159.5 ms/m	86.25 ms/m	72.75 ms/m
SAL	0.05%	0.1 %	0.05%	0.05 %
TDS	775 mg/l	860 mg/l	459.5 mg/l	392.5 mg/l
Res.	6.88 Ω.m	6.2 Ω.m	11.56 Ω.m	13.5 Ω.m
Temp.	26.5 °c	26.3 °c	26.3 °c	26.5 °c
Ca	185 ppm	220 ppm	150 ppm	150 ppm

Table 25. Salinity parameters of Mr. Rahimi's tomato field

Conclusion:

Salinity tests were conducted to evaluate EM solution effects on plant growth under salinity stress in Fars province during 2018-2019. EM efficacy through enhanced photosynthesis and soil remediation is the strongest possible mechanisms of action.

The obvious effects of EM on plants and trees showed that its application increased the vitality and chlorophyll content of the plant. Farmers were clearly referring to these symptoms. Soil salinity data showed slight difference between plots treated with EM and control. It should be noted that the differences in sampling methods and irrigation systems can affect the results and data to some extent. More detailed research is needed on the effects of EM on leaf chlorophyll levels and nutrient uptake. Controlled environment and more specific analyses of plant growth factors and their metabolites accelerate our investigation.

The results of EM application in alfalfa fields under salinity and drought stresses were much promising, confirming the supportive role of EM microorganisms for rhizosphere microbiomes. EM combined with increased soil organic matter such as humic acids showed more favourable results in saline soil amelioration. EM technology can evidently reduce amount of chemical fertilizers application, thereby improving the sustainable agriculture.

Acknowledgment

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