Irrigation Water Quality Assessment for Water Resources used in Irrigation of Agricultural Fields in Mezitli Town of Mersin Province

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Abstract— *This study was conducted for irrigation water quality assessment of water resources used in irrigation of agricultural fields in Mezitli town of Mersin province. Water samples were taken from 20 sampling points of surface water resources used for irrigations in irrigated farming lands of Mezitli town in 4 sampling periods (July – October). Samples were analyzed for pH, EC, water-soluble cations (Ca, Mg, Na, K) and anions (CO_3, HCO_3, Cl and SO_4), boron, %Na, SAR and RSC. Sample pH values varied between 7,05 - 8,26 and EC values varied between 292 - 1103 µmhos/cm. According to US Salinity Lab Classification System, irrigation waters were classified as C_2S_1 and C_3S_1 (moderately and highly saline waters). Boron concentrations of all samples were below the threshold value of 0,67 ppm. Significant differences were not observed in water quality parameters throughout the irrigation season.*

Keywords— Irrigation, irrigation water quality, saline irrigation water, boron.

I. INTRODUCTION

Electrical conductivity (EC) is the most significant indicator of irrigation water quality. It is a measure of salinity with great impacts on crop productivity. Waters with high EC values reduce crop yields through reducing plant competition for water with the ions of soil solution. The greater the EC is, the less the water available for plants despite moist appearance of the soil [1].

Besides irrigation water quantity, irrigation timing and irrigation methods, irrigation water quality is also a significant parameter in modern irrigation systems [2]. When the sufficient quantity and quality irrigation water is not available, improper water resources are used in irrigations. Such waters then alleviate salinity problem. In a previous study, water samples were taken from 10 irrigation ponds in June, July, August and September to assess water quality of the ponds used for irrigation water supply in Hakkari province of Turkey. Samples were analyzed for EC, pH, anion and cations (Ca^{+2}, Mg^{+2}, K^+, Na^+, SO_4^{-2}, NO_3^{-2}, CO_3^{-2}, HCO_3^- and Cl^-). Resultant values were used to calculate sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and percent sodium (% Na) values. Research findings revealed that pH, EC, SAR, RSC and % Na values of irrigation ponds did not exceed threshold values, but Mg^{+2} and K^+ values of the pond waters in Akçalı Village – Kanatlı locality and K^+ values in Kırıkdağ Village - Şişer locality exceeded threshold values [2].

Total salt quantity of irrigation waters is expressed as electrical conductivity (EC x 10^6) in µmhos/cm (1000µmhos/cm=1mmhos/cm=1dS/m). Majority of waters used successfully in irrigated farming has a total salt concentration of less than 2250 µmhos/cm. In terms only of total salt concentration, electrical conductivity of irrigation waters should be less than 750 µmhos/cm. However, irrigation waters with electrical conductivity of between 750 - 2250 µmhos/cm are largely used. Such waters may offer sufficient yield levels under proper drainage and operational conditions, but salinity problem may emerge if the sufficient leaching was not provided under improper drainage conditions [3].

Yeter and Yurtseven [4] investigated the effects of different quality irrigation waters on alfalfa plants and reported recessed growth, reduced yield and quality in alfalfa plant irrigated with saline waters. On the other hand, it was indicated that when sufficient leaching was provided and excess salt was removed from the rootzone, plant growth and development returned to normal levels. Researchers finally concluded that for high yield levels in alfalfa farming, irrigation water salinity should be less than 1.5 dSm^{-1}.

Salinity and alkalinity problems are largely encountered in irrigated farming lands of arid and semi-arid regions of the world. Low precipitation levels, poor-quality irrigation waters and high evaporation rates aggravate salinity and alkalinity problems of these regions. Such problems also destruct structural characteristics of the soils [5-6].

Gürcan [7] conducted a study to assess the water quality in irrigation district of Ankara Haymana Soğulca Village irrigation cooperative and classified irrigation water samples as C_3 (highly saline) and indicated that these waters could not be used in fields with limited drainage facilities. It was also indicated that despite salinity problems in water resources of the irrigation district, salinity was not encountered in agricultural fields irrigated with these waters. However, it was recommended that closed or open drainage facilities should be constructed to prevent potential salinity problems in the future.

Topçu and Taş [8] conducted a study on Çanakkale Biga Plain and investigated electrical conductivity (EC), pH, potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), carbonate (CO_3), bicarbonate (HCO_3), chlorine (Cl), sulphate (SO_4), nitrate (NO_3) and boron (B) of water samples taken from 20 groundwater wells. Considering the classification system of Water Pollution Control Regulation (SKKY) and salinity parameters, 11 of 20 samples were classified as the second-class and the rest was classified as the first-class. Apart from nitrate pollution in groundwaters, a distinctive problem was not encountered in the research site overall.

Demer and Hepdeniz [9] investigated groundwater quality with the use of water samples taken from 21 groundwater wells in Isparta Plain and reported water quality class of some wells as C_3S_1 (highly saline – slightly alkaline) and the rest as C_2S_1 (moderately saline – slightly alkaline).

Dorak and Çelik [10] conducted a study to determine the effects of domestic and industrial wastewater effluents on Nilüfer Creek and took water samples from treated wastewater effluents of 5 treatment facilities and from the creeks to which treated wastewater effluents were discharged at 4 different sampling periods between August 2013 – May 2014. It was reported that water quality of Nilufer Creek and treatment facilities varied with the sampling periods, quality classes of water samples based on EC and SAR were identified as between C_2S_1 - C_4S_4 and discharged effluents negatively influenced especially pH, EC, ammonium, sulphate, boron and chlorine values of Nilfer Creek.

Akaroğlu and Seferoğlu [11] conducted a study in Sultanhisar town of Aydın province to assess irrigation water quality and reported that water quality classes varied between C_2S_1 - C_3S_1, canal water quality influenced fruit quality and boron content of plants irrigated with these waters was greater than the boron content of control plants.

Aregahegn and Zerihun [12] took water samples from 17 sampling sites along the Awash River in four different sampling periods to assess the water quality of Awash River and tributaries. General water quality and suitability for irrigation were assessed with the use of several water quality parameters including pH, EC, SAR, RSC, Na^+, K^+, Ca^{++} + Mg^{++}, CO_3^{2-}, HCO_3^- and Cl^-. It was reported that entire quality parameters in Beseka Lake exceeded maximum allowable limits for irrigation, physicochemical characteristics of Awash River varied with the sampling sites and water quality parameters, pH and SAR values only of Beseka Lake and Meteka hot spring waters exceeded the allowable limits, Mojo, Wonji, Beseka, Melkasedi, Werer, Ambash, Meteka and Meteka hot spring waters had moderate-high salinity (EC) levels and very high RSC levels. It was recommended that industrial wastewater treatment facilities should be constructed to improve water quality of Awash River and tributaries.

II. MATERIALS AND METHODS

Mezitli with wonderful natural beauties is located on the cost of Mediterranean Sea. Total surface area of the town is 515.79 km^2 and average altitude is 3-5 m. About ¾ of Mezitli soils are composed of mountains, plateaus and undulated topography.

The coastline between the mountain and the sea contracts toward the west. Taurus Mountains set a barrier in front of northernly winds and result in dominant Mediterranean climate in the region.

Mezitli is among the towns with the greatest sunshine durations. About 300 days of a year is shinny. Daily average sunshine duration is 7.4 hours and such duration is between 8 – 10 hours in summer months. Average relative humidity is 72% and monthly relative humidity is quite close to each other. Average monthly relative humidity varies between 65–75%. Annual average temperature is 18.4 °C. Average temperatures of summer months vary between 25 – 33 °C and average temperatures of winter months vary between 9–15 °C. Average sea water temperature is 20 °C. Sea water temperature reaches to 28 °C in summer months and such a temperature is maintained for a long time, thus prolong tourism season.

Annual average precipitation is 618.6 mm with the greatest precipitation in December and the least in August. There are no plains in the town and Gemrik, Garkın, Kalegediği, Gelin Kayası, Eyüp Kayası, Hazmur, Karagedik, Gicik Kayası, Hürükızları Kepez, Manıt, Saladağ, Kuşkayası, Durnaz, Peynir, Koca Ellez Mountains are located on the north of the town. There are Kandak, Tece and Mezitli creeks in the town center.

Maquis, encountered at altitudes of 500 – 600 m, is the dominant ever-green typical plant cover of the Mediterranean region. Laurel, wild olive, carob, myrtle, rose laurel, banyan, blackberry and rosehip naturally grown in this zone. Forests start after maquis. Oak trees grow at altitudes of between 100 - 1000 m, Calabrian pine between 100 - 1200 m, black pine at 1500 m, cedar and juniper at 2000 m. Shrubs and pastures are encountered after 2500 m. Nomads (Yuruks) generally live on these high altitudes [13]. Location of the research site is presented in Figure 1.

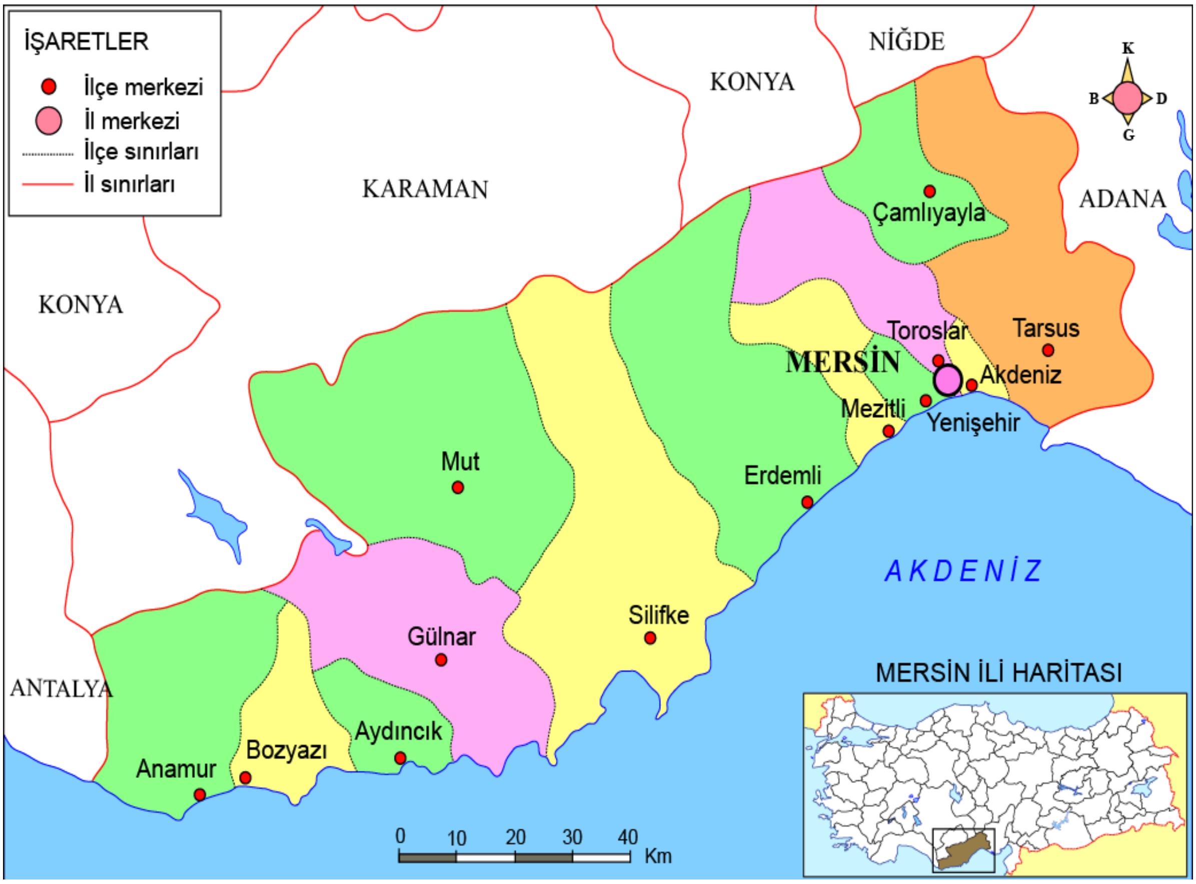

FIGURE 1: Location of the research site

Water samples were taken from 20 sampling points of surface water resources used for irrigations in irrigated farming lands of Mezitli town in 4 sampling periods (July – October). Sample pH and EC readings were performed in each month. Water samples taken in August were also subjected to water-soluble cations (Ca, Mg, Na, K) and anions (CO_3, HCO_3, Cl and SO_4) and boron analyses. With the use of these analysis results, %Na, SAR and RSC values were calculated and irrigation water quality classes were determined.

III. RESULTS AND DISCUSSIONS

Water samples were taken for 4 months throughout the irrigation season (July, August, September, October) from the water resources (groundwater wells) used in irrigation of agricultural fields.

The pH and EC values of irrigation water samples taken in July, September and October are provided in Table 1. Irrigation water pH values varied between 7,07 - 8,11 in July, between 7,14 - 8,15 in September and between 7,05 - 8,02 in October. Irrigation water EC values varied between 343 - 1045 µmhos/cm in July, between 308-1103 µmhos/cm in September and between 344-1056 µmhos/cm in October.

In July, the greatest salinity values were observed in samples 16 and 17, EC values of samples 15 and 20 were greater than allowable limit value (750 µmhos/cm) and the rest was below the allowable limit (750 µmhos/cm), thus considered to be used in irrigation of agricultural fields without generating a salinity problem. In September, the greatest irrigation water salinity values were obtained from the samples 14, 15, 16 and 17, which were greater than the threshold salinity level (750 µmhos/cm) and the rest was below the threshold salinity level of 750 µmhos/cm, which was considered to be used in irrigations. In October, the greatest salinity values were seen in the samples 14, 15, 16 and 17, which were greater than the threshold salinity level (750 µmhos/cm), but the rest was below the threshold value of 750 µmhos/cm, which was considered to be used in irrigation of agricultural fields.

TABLE 1
EC AND pH VALUES OF IRRIGATION WATER SAMPLES TAKEN IN JULY, SEPTEMBER AND OCTOBER

Sample No	July		September		October	
	pH	EC x 10^6 µmhos/cm 25 ^oC	pH	EC x 10^6 µmhos/cm 25 ^oC	pH	EC x 10^6 µmhos/cm 25 ^oC
1	8,11	549	7,93	551	7,86	548
2	7,72	553	7,88	547	7,98	556
3	7,60	452	8,11	525	8,02	498
4	7,65	435	8,15	516	8,01	502
5	7,40	452	8,08	519	7,88	503
6	7,09	585	7,20	554	7,15	576
7	7,08	582	7,23	570	7,05	565
8	7,60	351	7,82	311	7,88	346
9	7,56	351	7,90	308	7,75	344
10	7,30	343	7,44	353	7,50	349
11	7,31	349	7,50	351	7,66	359
12	7,90	715	7,48	724	7,60	710
13	7,80	717	7,39	730	7,48	720
14	7,11	724	7,15	1015	7,05	935
15	7,09	752	7,14	1040	7,11	1005
16	7,39	1045	7,56	1103	7,45	1018
17	7,31	1045	7,60	1094	7,55	1056
18	7,31	562	7,30	424	7,85	496
19	7,68	569	7,46	416	7,68	511
20	7,07	752	7,22	624	7,26	703

TABLE 2
CHEMICAL ANALYSIS RESULTS OF IRRIGATION WATER SAMPLES TAKEN IN AUGUST

Samples No	pH	ECx10^6 µmos/cm 25 ^{o}C	WATER SOLUBLE										RSC	SAR	%Na	Irrigation Water Class	Boron (mg/L)
			Cations (me/l)					Anions (me/l)									
			Na^+	K^+	Ca^{+2}	Mg^{+2}	Total	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}	Total					
1	7,97	546	0,56	0,04	0,98	3,11	4,69	0,00	1,40	1,74	1,55	4,69	-	0,39	11,94	C_2S_1	<0,67
2	8,04	546	0,56	0,04	0,99	3,21	4,80	0,00	1,40	1,98	1,43	4,81	-	0,39	11,67	C_2S_1	<0,67
3	8,19	534	0,65	0,11	3,36	2,12	6,24	0,00	2,73	1,62	1,88	6,23	-	0,39	10,42	C_2S_1	<0,67
4	8,21	534	0,65	0,11	3,40	2,10	6,26	0,00	3,05	1,74	1,48	6,27	-	0,39	10,38	C_2S_1	<0,67
5	8,26	535	0,65	0,11	3,47	2,12	6,35	0,00	2,90	1,63	1,82	6,35	-	0,39	10,22	C_2S_1	<0,67
6	7,20	560	0,26	0,01	5,53	0,98	6,78	0,00	3,26	1,62	1,90	6,78	-	0,14	3,84	C_2S_1	<0,67
7	7,27	588	0,26	0,01	5,61	1,00	6,88	0,00	3,44	1,53	1,91	6,88	-	0,14	3,78	C_2S_1	<0,67
8	7,85	292	0,06	0,00	3,22	0,29	3,57	0,00	0,45	1,52	1,60	3,57	-	0,05	1,68	C_2S_1	<0,67
9	7,93	293	0,07	0,00	3,20	0,32	3,59	0,00	0,27	1,48	1,85	3,60	-	0,05	1,95	C_2S_1	<0,67
10	7,55	346	0,08	0,01	3,66	0,51	4,26	0,00	0,79	1,58	1,88	4,25	-	0,06	1,88	C_2S_1	<0,67
11	7,49	353	0,07	0,01	3,76	0,49	4,33	0,00	1,08	1,52	1,72	4,32	-	0,05	1,62	C_2S_1	<0,67
12	7,38	709	0,69	0,07	3,47	4,04	8,27	0,00	4,80	1,67	1,80	8,27	-	0,36	8,34	C_2S_1	<0,67
13	7,37	706	0,69	0,07	3,50	4,16	8,42	0,00	4,87	1,62	1,93	8,42	-	0,35	8,20	C_2S_1	<0,67
14	7,21	1082	1,64	0,05	5,24	5,43	12,36	0,00	8,80	1,84	1,73	12,37	-	0,71	13,27	C_3S_1	<0,67
15	7,16	1101	1,65	0,05	5,13	5,27	12,10	0,00	8,77	1,87	1,46	12,10	-	0,72	13,64	C_3S_1	<0,67
16	7,51	1082	5,12	0,08	1,96	4,12	11,28	0,00	7,80	1,81	1,67	11,28	1,72	2,94	45,39	C_3S_1	<0,67
17	7,55	1097	5,26	0,08	1,47	4,14	10,95	0,00	7,51	1,69	1,75	10,95	1,90	3,14	48,04	C_3S_1	<0,67
18	7,94	362	0,12	0,01	3,30	1,06	4,49	0,00	1,30	1,98	1,21	4,49	-	0,08	2,67	C_2S_1	<0,67
19	7,73	355	0,13	0,01	3,40	1,07	4,61	0,00	1,25	1,67	1,68	4,60	-	0,09	2,82	C_2S_1	<0,67
20	7,30	599	0,47	0,01	4,49	2,22	7,19	0,00	3,73	1,91	1,56	7,20	-	0,26	6,54	C_2S_1	<0,67

Chemical analysis results of irrigation water samples taken in August are provided in Table 2. Irrigation water pH values varied between 7,16 – 8,26 and EC values varied between 292 - 1101 μmhos/cm. Boron concentration of all samples was below the threshold boron level of 0,67 ppm. In terms of water-soluble anions and cations, Ca was identified as the dominant cation and HCO_3 as the dominant anion. Sodium adsorption ratios (SAR) of the samples varied between 0.05 – 3,14; % Na values varied between 1,62 - 48,04, residual sodium carbonate (RSC) values varied between 1,72 - 1,90 (in samples 16 and 17). According to US Salinity Lab Classification System, water samples taken in August were classified as C_2S_1 and C_3S_1.

EC values of irrigation water samples taken in August are presented in Figure 2. The greatest salinity values were obtained from the samples 14, 15, 16 and 17, which were greater than the threshold salinity level (750 μmhos/cm) and the rest was below the threshold level of 750 μmhos/cm, which was considered to be used in irrigations without a concern of salinity problem.

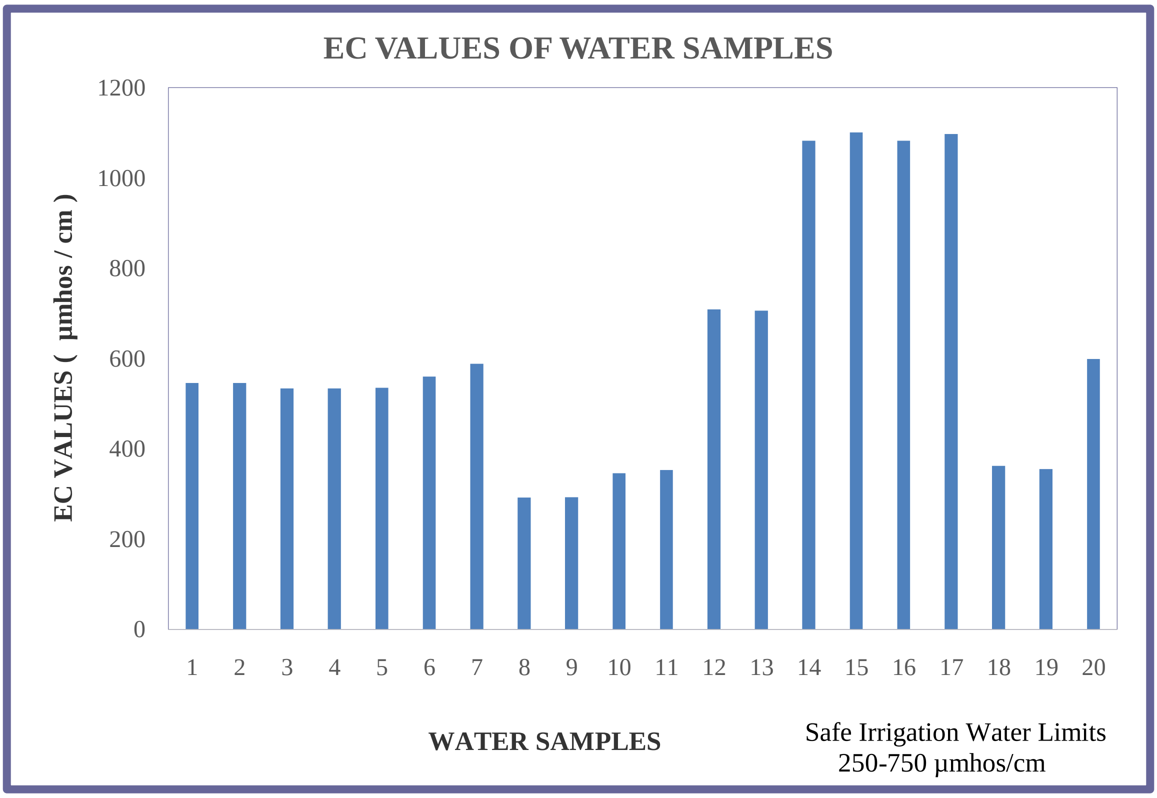

FIGURE 2: EC values of irrigation water samples taken in August

IV. CONCLUSION

Following conclusions were drawn from the present study conducted to assess irrigation water quality of water resources used in irrigation of agricultural fields of Mezitli town of Mersin province:

a) Water samples with salinity levels of lower than the threshold salinity level (750 μmhos/cm) were classified as **moderately saline (C_2)**, thus they could be used in irrigations without posing a risk of salinity in surrounding fields. Rest of the samples with salinity values greater than the threshold salinity value of 750 μmhos/cm was classified as **highly saline (C_3)**, thus salt-resistant plants should be selected or special measures should be taken for salinity control. EC values of present samples varied between 292 - 1101 μmhos/cm and pH values varied between 7,05 - 8,26. Based on these values, irrigation water quality classes were identified as C_2S_1 (moderately saline – low alkaline) and C_3S_1 (highly saline – low alkaline).

b) In terms of water-soluble anions and cations, Ca^{++} was identified as dominant cation and HCO_3^- as dominant anion. Sodium adsorption ratios (SAR) of the samples varied between 0,05 – 3,14; % Na values varied between 1,62 – 48,04 and boron concentrations of all samples was below the threshold boron level of 0,7 ppm.

V. RECOMMENDATIONS

a) Drainage facilities should be developed to prevent emergence of a salinity problem and periodical maintenance of available drainage facilities should be practiced.

b) Soils should be enriched in organic matter and soil tillage methods should precisely be selected.

c) Relevant measures should already be taken to prevent future salinity and alkalinity problems. Reclamation practices and leaching should be emphasized.

d) To prevent yield losses, irrigation water should be applied through proper irrigation methods. Considering leaching practices, sprinkler irrigation should be selected in places with insufficient water resources and ponding irrigation (especially intermittent ponding) should be selected in places with sufficient water resources.

e) Trainings on soil – plant – water relations and irrigation water quality should be provided by agricultural institutions and organizations to raise farmer's awareness on these issues.

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