Bangladesh J. Bot. **45**(3): 541-546, 2016 (September)

INVESTIGATION OF IRRIGATION MANAGEMENT ON SOIL SALINITY DEVELOPMENT BY ELECTROMAGNETIC TECHNIQUE

HARUN KAMAN*, MAHMUT ÇETIN[1] AND CEVAT KIRDA[1]

Akdeniz University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, 07058 Antalya, Turkey

Key words: EM38, Irrigation, Drainage, Soil salinity, Soil sodicity

Abstract

EM38 device of electromagnetic induction technique was utilized for soil salinity assessment in Akarsu and Yemisli irrigation districts having different quality and quantity irrigation sources. Calibration equations of EM38 readings (ECa) versus standard soil salinity (ECe) for the districts were found statistically representative. Salinity increased with the soil depth in Akarsu and Yemisli. Fresh water resource and excess irrigation water use prevented soil salinity development in Akarsu. Poor quality water use, on the other hand, caused to increase soil salinity in Yemisli.

Introduction

Soil salinity has been a major risk for sustainable farming. The salt deposition in the root zone is closely related to the irrigation method (Tuzcu *et al.* 1988). Excess irrigation leads to an increase in the level of groundwater and thereby increases soil salinity (Cetin and Kirda 2003). The losses in farming lands have been increasing because of salinity. Agricultural lands suffering from salinity problem in our country, Turkey, have already reached up to 20% (Konak *et al.* 1999).

Portable electromagnetic induction (EMI) device, referred to as EM38 (Geonics Ltd., Canada), has been designed to measure the soil salinity in agricultural lands by measuring apparent electrical conductivity (ECa) of the soil. ECa values need relating to the standard soil salinity values obtained from saturation extract (ECe). After the calibration of EM38 device readings, it is possible to measure the soil salinity in a quick and safe way through EMI technique. *In situ* soil salinity level within the 0 - 1 m and 0 - 2 m depth can be determined in a horizontal (EM-h) or vertical (EM-v) position of the EM device.

The work was aimed to show the usefulness of a hand-held EM38 sensor to assess quickly soil salinity in two large-scale irrigation projects located in the Mediterranean landscapes to evaluate the impact of irrigation water quality on salinity development.

Materials and Methods

This study was carried out in two different irrigation districts, which are irrigated with fresh and inferior quality water located in the Mediterranean region of Turkey.

The first one is Akarsu Irrigation District (Akarsu ID, 9495 ha). Farmers of this area generally prefer surface irrigation methods that are considered to be poor regarding irrigation efficiency. Excess irrigation water use in agriculture has been an addict, resulting poor irrigation efficiencies and leaching out of nutrients with drainage water.

The farmers of the Yemisli ID, having no access to good quality of water of Seyhan River, must divert irrigation water from drainage channels of EC over 1.5 dS/m.

*Author for correspondence: <hkaman@akdeniz.edu.tr>. [1]Cukurova University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, 01330 Adana, Turkey.

The survey site contains alluvial materials deposited within the holes of the delta bed. The weak soil permeability of the land is the biggest restriction experienced in the site. Most of the farmers in the area use the low quality water for irrigation purpose along the drainage channel and the branches of the irrigation channel.

The study was carried out in February, April, July, September and October in 2008. Vertical and horizontal soil salinity were measured by using EM38 device in the pre-determined points in Akarsu and Yemisli IDs. Meanwhile, with the help of a GPS device, the coordinates of the EM38 reading points were determined in the field. Standard soil salinity values (ECe, dS/m) of the soil saturation extract were measured at the 25 °C in the laboratory. Calibration curves for soil apparent electrical conductivity of ECa-h and ECa-v which were measured by EM38 device were separately developed for Akarsu ID and Yemisli ID. All vertical and horizontal ECa lectures of EM38 device were converted into standard ECe values using the calibration curves. Salinity maps were prepared with the use of GIS for sampling periods.

Results and Discussion

In the Akarsu ID, EM38 measurements (ECa-h for 0-1 m and ECa-v for 0-2 m soil profile) were calibrated using the standard soil saturation salinity (ECe) values - collected from a total of 23 evenly distributed calibration sites. The ECa (dS/m) and ECe (dS/m) calibration curve for 0 - 1 m soil depth was given in Fig. 1. As shown in Fig. 1, the data scattered more or less along a straight line, implying that ECa versus ECe is associated with a linear curve. Therefore, ANOVA results of linear regression analysis indicated that the ECa - ECe calibration equation in Fig. 1 was highly significant (p = 1.2E-07), with R^2 value of 0.74. Additionally, the linear regression coefficient a = 0.4217 and the intercept b = 0.1196 values in Fig. 1 were found statistically significant (α = 0.05). These results show that the calibration equation is representative to determine immediately soil salinity from EM38 lectures for Akarsu ID.

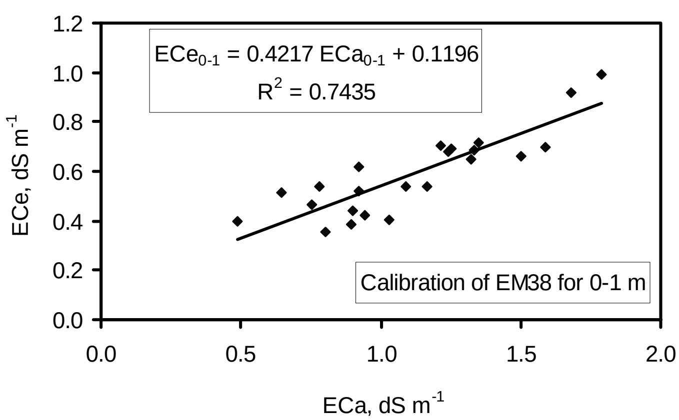

Fig. 1. Association between apparent soil salinity (ECa) readings with EM38 and standard soil salinity (ECe) in 0 - 1 m soil depth in Akarsu ID.

The descriptive statistics of soil salinity demonstrated that a maximum salinity values within 1 m soil profile was found to be less than 1.4 dS/m in February. Average soil salinity was found as 0.6 dS/m. Though salinity is not an important issue in Akarsu ID, it was found that soil salinity levels tended to increase with the soil depth. Monitoring data revealed that maximum spatial soil salinity value within the 2 m soil depth was less than 0.8 dS/m.

Furthermore, soil salinity maps, not given here, revealed that Akarsu ID had no problem in terms of soil salinity. Our observations suggested that existing irrigation water efficiency in Akarsu ID was poor, resulting in washing out of the salts from the root zone. Soil sodicity was also assessed for 0 - 0.3 m and 0 - 0.9 m soil profiles in Akarsu ID, and areal coverage with different SAR values were determined (Table 1). As seen in Table 1, there is no sodicity problem in Akarsu ID.

Table 1. Areal coverage (%) with different SAR values of soils in Akarsu ID.

Depth (m)	Areal mean SAR with standard deviation	Soil SAR ranges			
		<1	1-3	3-5	5-7
		Areal coverage (%)			
0 - 0.3	1.24 ± 0.59	39.8	58.1	2.1	0.0
0 - 0.9	1.66 ± 1.01	27.7	62.5	8.2	1.6

In Akarsu ID, mean soil SAR values was found less than 2.0. As emphasized clearly above, the peak irrigation season is July in the region. Similarly, a study carried out by Demir and Antepli (2004) claimed that the highest irrigation demand in Çukurova Region - in which Akarsu ID has been located - realized in July. Even though excess irrigation water usage was a problem in the region, this undesirable practice hindered salinity and sodicity development in the root zone.

In Yemisli ID, EM38 measurements in 0 - 1 and 0 - 2 m soil depths were done by following the procedures used in Akarsu ID. EM38 measurements were converted into standard ECe values using vertical and horizontal calibration equations (Fig. 2) developed for the District - through utilizing 20 soils sampling sites - following the same procedure applied in Akarsu ID. Standard ECe values were processed in GIS media and soil salinity maps were prepared for all sampling periods for horizontal and vertical readings.

As seen in Table 2, areal mean soil salinity increases with the soil depth, indicating both salinity accumulations below the root zone and normal salinity profile which is good and also desirable for salinity control in irrigation districts. Areal mean soil salinity in the root zone was the lowest (3.5 dS/m in Table 2) in July which was the peak irrigation season, indicating that irrigation practice helped to wash out the salts from the root zone. However, saline areas (ECe>4 dS/m in the plant root zone) covered 31% of study area in July. With the beginning of irrigation season in April, non saline areas (ECe < 4 dS/m) starts to increase gradually, and reached 69% at the peak irrigation season (July). It is important to emphasize that 61% of the area has salinity problems in 0 - 2 m depth in rainy period, indicating that winter rains are not effective to wash out salts from the soil profile due to the fact that the area is suffering from high water table conditions of poor quality for drainage is not provided accordingly.

Spatial distribution of salinity in the root zone in July (figure not given here) shows clearly that non-saline soils are mostly distributed in the villages of Oymaklı and Helvacı because farmers living around those villages are supplied with fresh water. However, irrigation return flows are being used in other parts of Yemisli ID. Non-saline areas accounted for 43.5% of the total land in July. Results lead us to suggest that drainage pumping station should be operated accordingly to prevent the salinization risk of the non-saline areas.

The extent and severity of the soil sodicity/alkalinity in Yemisli ID were also investigated in this study. As known very well, sodium adsorption ratio (SAR) is a good indication of soil sodicity. Therefore, soil SAR maps were prepared for 0 - 0.3 m and 0 - 0.9 m depth. SAR map for

0 - 0.9 m soil profile indicated that there was a significantly severe sodicity problem in the area. The saline regions with ECe>4 dS/m were also found to have sodicity problem in the root zone. As seen in Fig. 3, as soil depth increases, soil sodicity also increases. Within the 0 - 0.3 m soil layer which is considered to be the seeding bed, the SAR values higher than 13 covers almost 40% of the total land. Besides, the potential sodic areas in 0.3 m sail layer where SAR values vary between 6 and 13 cover 26% of the total area. Within the 0 - 0.9 m layer of the soil profile, the SAR value with 13 - which is the threshold value for SAR assessment - demonstrates that 43% of the total land suffers from severe sodicity problem. This may hinder germination in the area. The sodality problem may have resulted from inadequate leaching due to the poor drainage conditions in the area.

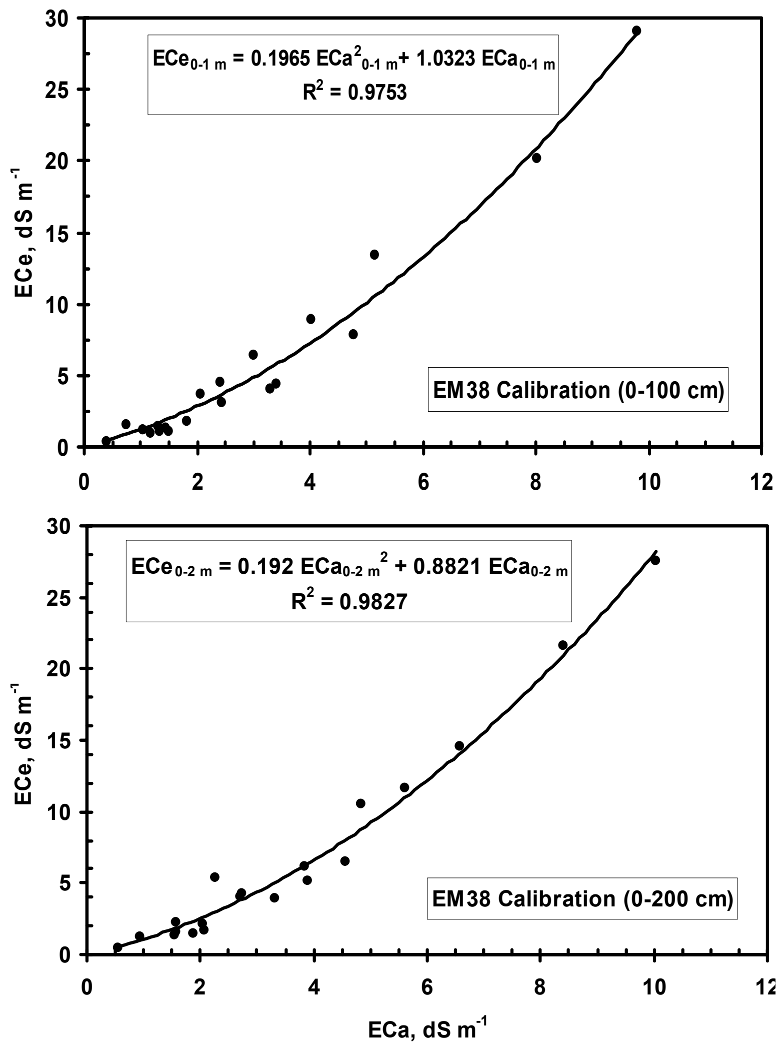

Fig. 2. Association between EM38 readings (ECa) and soil saturation extract salinity (ECe) in Yemisli ID.

Yemisli ID still lacks of irrigation and drainage facilities whereas it has been irrigated for 40 years. There is not sufficient knowledge about irrigation, groundwater depth and groundwater salinity. In this region, irrigation efficiency is very poor. To overcome the drainage problems appearing as a consequence of excess irrigation applications, the adopted surface irrigation methods in the area need to be improved (Cetin and Diker 2003). Additionally, a shift of irrigation system from open channels to closed ones, i.e., pressurized irrigation system, might be a remedy to overcome the problems highlighted in the study areas.

Table 2. Areal coverage with different soil salinity (ECe, dS/m) values in Yemisli ID.

Time/ 2008	Depth (m)	Areal mean ECe with standard deviation	Soil salinity ranges, ECe (dS/m)			
			< 4	4 - 8	8 - 16	16 <
			Areal coverage (%)			
February	0 - 1	5.33 ± 4.14	51.2	27.4	19.2	2.2
	0 - 2	6.33 ± 4.38	39.0	30.7	27.4	3.0
April	0 - 1	4.36 ± 2.96	56.7	31.0	11.7	0.6
	0 - 2	5.64 ± 3.65	42.1	35.0	21.3	1.6
July	0 - 1	3.53 ± 2.43	68.9	26.4	4.3	0.4
	0 - 2	4.97 ± 3.29	46.7	38.4	14.0	0.9
Late September	0 - 1	3.64 ± 2.37	65.3	29.6	4.9	0.1
	0 - 2	4.63 ± 3.02	52.1	31.8	15.7	0.4

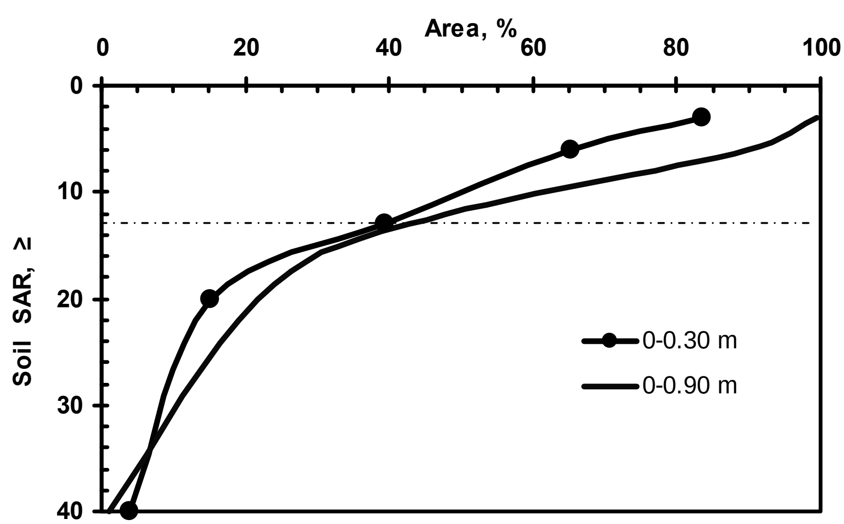

Fig. 3. The extent of sodicity in soil layers in Yemisli ID.

The calibrating equations for the two irrigation districts of different quality and quantity irrigation source led us to conclude that they are representative for the districts and can be used confidently to determine immediately soil salinity levels in the districts in any time. Furthermore, a hand-held EM induction sensor (e.g. EM38) is a breakthrough in the ability to rapidly and accurately assess soil salinity in large-scale agricultural landscapes prone to salinization in the semi-arid regions including Mediterranean landscapes. Additionally, the mapping of soil salinity is indeed a practical tool for helping both farmers and irrigation managers to take management decisions on future crops and irrigation strategies.

Soil salinity and sodicity data revealed that under existing conditions there are no salinity and sodicity problems in Akarsu ID due to the fact that leaching efficiency is as high as 52% and district irrigation efficiency is as low as 50% (data not given here). However, irrigation water use efficiency is very low.

Fresh water availability is very limited in Yemisli ID. Therefore, majority of farmers has to use irrigation return flows of inferior quality. Consequently, the extent and severity of saline and alkaline soils are inclined to increase in the Yemisli ID. The use of irrigation return flows of inferior quality and improper management of drainage system have accelerated the extent and severity of both soil salinity and alkalinity problems in the low-lying lands of the Yemisli ID.

Acknowledgments

Authors gratefully acknowledge that this work was funded by the European Union QUALIWATER project (INCO-CT-2005-015031) and partial support received from Cukurova University Research Fund (Project #: ZF2006KAP1 & ZF2009KAP1). The authors also would like to thank the Research Fund of Akdeniz University for its partial support.

References

Cetin M and Diker K 2003. Assessing drainage problem areas by GIS: a case study in the eastern mediterranean region of Turkey. Irrig. and Drain. **52**: 343-353.

Cetin M and Kirda C 2003. Spatial and temporal changes of soil salinity in a cotton field irrigated with low-quality water. J. Hydrol. **272**: 238-249.

Demir N and Antepli N 2004. Aşağı seyhan ovası sulaması taban suyu ve tuzluluk problemleri değerlendirme çalışması. (in Turkish) Sulanan Alanlarda Tuzluluk Yönetimi Sempozyumu, 20-21 Mayıs 2004, DSİ Genel Müdürlüğü, Ankara.

Konak C, Yilmaz R and Arabaci O 1999. Salt tolerance in eagean region's wheats. Tr. J. Agr. For. **23**(5): 1223-1229.

Tuzcu Ö, Çevik B, Kaplankiran M and Kirda C 1988. Influence of different irrigation methods on nutrient uptake of lemon trees. Adv. Hort. Sci. **2**: 79-83.

(Manuscript received on 6 October, 2015; revised on 1 March, 2016)