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Relationship between Soil Moisture Content and Salinity Degree in the Salt-Affected Soils in Khon Kaen, Northeast Thailand

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ABSTRACT

The research was set up in the salt-affected area in Ban Phai and Non Sila district, Khon Kaen Thailand during 2017-2018. The aims were to study on the variation of a salt-affected soil properties as ECe and SAR and explanation the relationship between soil moisture content and salinity degree in the salt-affected soil. The study site was classified in four classes by map of distribution of salt crust on soil surface, created by LDD, there are the class 1(salt crust>50%), class 2(salt crust10-50%), class 3 (salt crust1-10%), and class 4 (salt crust<1%). Soil samples were collected monthly at 0-30 cm depth for analyze Electrical Conductivity of the saturated extract (ECe), Sodium Adsorption Ratio (SAR), Soil Moisture Content (SMC), Permanent Wilting Point (PWP), and Field Capacity (FC) at LDD5 laboratory. The results showed that variation of ECe and SAR is high (CV >35%) at 0-30 cm soil depth. ECe and SAR in class 1 (salt crust >50%) ranged from moderately to very severely salinity and sodic in a dry season. But it was varied from slightly to very severely salinity and non-sodic to sodic in a wet season. While, class 2, 3 and 4 (soil crust <50%),the ECe value pointed out that salinity degree varied from normal to very severely salinity in both a dry season and a wet season. Also, SAR showed range from non-sodic to sodic. According to ECe and SAR, a salinity was higher variability in a wet season than in a dry season. The correlation showed that ECe and SAR is positive relation to SMC in a dry season. Whereas, the relation of salinity properties like as ECe and SAR showed a negative trend with SMC in a wet season. Also, a soil moisture content at PWP and FC had a negative correlation with ECe and SAR in both a wet season and a dry season. Meanwhile, the relation of ECe and SAR with SMC under different soil texture had a positive correlation in a dry season, especially, in a fine-textured soil. But a relation is not clarified in a wet season.

Keywords: salt-affected soils; Electrical Conductivity, SAR, soil moisture content; Northeast Thailand

INTRODUCTION

Salt-affected soils, which is the one significant problem for soil resource that impact on an agricultural system. Soil salinization is the key limiting factors for agricultural development. Due to it has high the saline ion and exchangeable Na in soil solution, that effect on growth and yield of crop. Salt-affected soil is classified into three types including saline soil, sodic soil, and saline-sodic soil. The salinity degree is considered by Electrical conductivity of the saturated extract (ECe), Sodium Adsorption Ratio (SAR), and Exchangeable Sodium Percentage (ESP). Saline soils can be defined as soils have a high enough salt concentration to start affecting plant growth will have an EC greater than 4.0 dS m^{-1}. These soils will have high concentration of several salts (e.g., Ca^{2+}, Mg^{2+}, Cl^{-} , HCO^{3-} , etc.). The sodic soil is dominated by the salt Na^{+} that SAR above 13(1). In generally, the salt-affected soils are in tropical zone and subtropical zone that an evapotranspiration is higher than a precipitation (2).

The agricultural area in Thailand is affected by the salt, where found in Northeast1.84 million ha. Due to is influenced from rock salt is baseline in underground. The central part was flooded and deposited by the sea water that is 8,743 ha. Moreover, the coastal saline soil is found in the coastal where the sea is reached that is about 304,000 ha (3).

Salt-affected soil is influenced by factors that the primary factors are climate, precipitation, and parent material. Also, the secondary factors are manmade, climate change, landform, and rainfall pattern, there can stimulate the higher salinity (4). For a changing of salinity degree is related to many factors. However, the salinity degree is a temporary changing especially 0-30 cm soil depth because it is impacted from a climate such as precipitation, temperature, and drought period (5).

This project aim to study on the variation of a salt-affected soil properties as ECe and SAR and explanation the relationship between soil moisture content and salinity degree in the salt-affected soil.

1.METHODOLOGY

1.1 Study Area

The project was set up in the salt-affected area in Ban Phai and Non Sila district, Khon Kaen, Thailand during 2017-2018. The study site covered four classes, based on the map percentage of salt crust on soil surface (6), shown in Table. 1. The main land use is a rain-fed paddy rice. The annual precipitation is 1,451.97 mm and 1,192.97 mm in 2017 and 2018, respectively (Fig.1 and Fig.2).

TABLE 1 Classification of salinity degree by map percentage of salt crust on soil surface

Class	Description
1: very severely salinity	soil surface covered by salt crust > 50 %
2: severely salinity	soil surface covered by salt crust 10-50%
3: moderately salinity	soil surface covered by salt crust 1-10%
4: slightly salinity	soil surface covered by salt crust <1%

1.2 Soil sampling and analysis

The soil samples were taken monthly at 0-30 cm depth in 4 classes of a salt crust on soil surface based on map percentage of salt crust on soil surface. For class1 and class4, 10 samples for each class were collected. While soil samples in class2 and class3 were gathered 15 samples for each class. Totally 1,200 soil samples were collected (Table 2).

The samples were air-dried naturally indoor and then all soil samples were passed through a 2 mm sieve. Next, soil samples were determined using saturated paste extract, which were prepared by adding deionized water until it reached a condition of complete saturation. The extracts were analyzed for Electrical conductivity of the saturated extract (ECe), and Sodium Adsorption Ratio (SAR). And, soil samples were analyzed for Soil Moisture Content (SMC), Permanent Wilting Point (PWP), and Field Capacity (FC) at Land Development Department Regional 5 (LDD5) laboratory.

1.3 Statistical analysis

The descriptive statistics including mean, minimum, maximum, and coefficient of variation (CV)were determined for each class separately. The CV was classified as little (CV <15%), moderate (CV =15-35%), and high (CV >35%) variability (7). Also, the linear regression was analyzed.

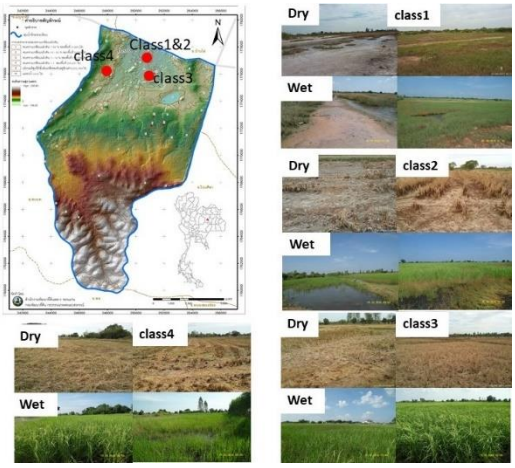


Fig.1. Study area

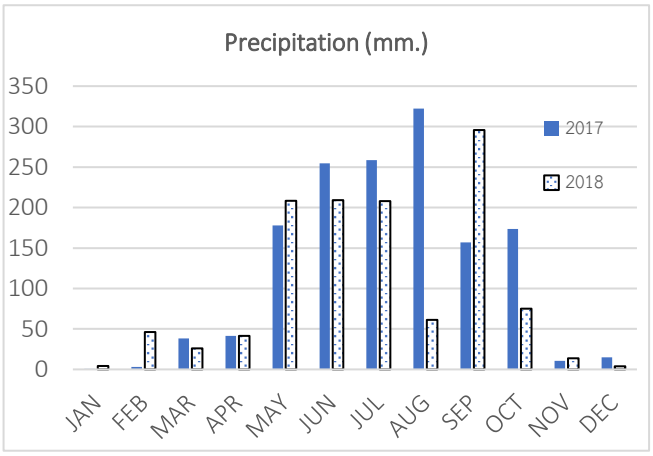


Fig.2. Precipitation in 2017 and 2018

TABLE 2 Classes, soil texture, and Number of soil samples

class	Soil texture	Number of soil samples
1: very severely salinity	Sandy loam, loam, silt loam	240
2: severely salinity	Loam, sandy loam	360
3: moderately salinity	Sandy loam, clay loam, sandy clay loam	360
4: slightly salinity	Sandy loam, loamy sand, clay loam, sandy clay loam	240

2.RESULT AND DISCUSSION

2.1 Variation of ECe and SAR

As seen in Table 3, ECe and SAR were highly varying in area of every class. Regarding to the coefficients of variation, soil ECe and SAR of every class were higher than 35 % that there is high variability. Thus, salinity degree in class 1 was ranged from moderately to very severely salinity and sodic in a dry season. But it was varied from slightly to very severely salinity and non-sodic to sodic in a wet season. While, in class 2and class 3, the ECe value pointed out that salinity degree is ranged from normal to very severely salinity in both dry and wet. Also, SAR showed range from non-sodic to sodic. As class4, ECe indicated that soil is normal to moderately salinity in a dry season. But it was normal to severely salinity in a wet season in 2017. While, in 2018, soil ECe was normal to very severely salinity. SAR variation was ranging from normal to sodic in consideration area. Moreover, the data presented that ECe and SAR are higher variability in a wet season than in a dry season. And, SAR in class4 was the highest variation, compared to others.

The results revealed that salinity degree at 0-30 cm depth are highly variability. Also, the salinity variability in rainy season was higher than in dry season. Similarly, coefficients of variation of the ECe and SAR values was higher than 35% (8). Due to the salinity level changing was related to the water movement through a soil profile. The water upward was moved by capillary force from a subsoil to surface. Meanwhile, the water from a surface soil to a subsoil was moved by a permeability that depends on the hydraulic conductivity (9). During the dry season, there is a lot of groundwater move up to the soil surface. While there is little rainfall, it is not enough to leach the salt into the subsoil. In contrast to the rainy season, although the movement of groundwater to the surface but there is rainfall that can leach salt back into the subsoil outside the root zone. And soil moisture content reduced the movement of groundwater caused by capillary force, which is the pulling force of water in small channels. Therefore, the soil salinity was more changing in the topsoil (10). In addition, salinity level and sodium level were also reported to be spatial and vertical variations. which is a temporary change, especially, at a soil depth of 0-30 cm, that is influenced by rainfall, climate changing, and changing of the seasons (rain/drought) in the year such as length of the dry season. These factors affect soil salinity excess both salt accumulation and salt leaching from the root zone (11). Moreover, the salt leaching was easy in a sand texture and a deep ground water table, resulting in the salt in a 0-30 cm soil depth is leached. However, the salt leaching method may induce the future problem, especially, the area had a ground

water table near a surface. Due to the leaching water moved downward to add a groundwater level and water was move to a surface and evaporated (12,13). Comparing the results of the two periods, which soils at 0-30 cm depth in a wet season were affected by rice cultivation resulting in variability of salinity degree. Due to land management such as tillage and fertilizer could alter physical and chemical properties of soil for example bulk density, increased water permeability, and pH, etc. of top soil. But at some depth below the top soil a hard layer was developed, which is characterized by high bulk density and low infiltration rate (14).

TABLE 3 Showing variation of ECe and SAR in 4 study sites using basic statistics

Dry									
value		class1		class2		class3		class4	
		2017	2018	2017	2018	2017	2018	2017	2018
ECe ($dS\ m^{-1}$)	Min	6.48	5.57	1.00	0.75	0.92	1.07	0.33	0.33
	Max	121.05	165.50	36.41	53.90	16.46	21.10	4.54	7.04
	Mean	41.73	67.94	8.74	12.43	4.90	6.11	1.10	1.31
	CV(%)	65.24	78.16	78.81	105.99	74.39	72.85	66.09	103.95
SAR	Min	18.66	16.64	8.39	3.76	1.22	2.08	0.46	0.38
	Max	196.31	244.57	68.41	103.22	80.98	80.16	10.74	28.47
	Mean	81.17	108.51	28.19	29.39	21.73	19.29	3.98	3.82
	CV(%)	51.99	67.92	51.05	79.15	79.93	76.23	69.76	126.76
TYPES		saline-sodic	saline-sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic
Wet									
value		class1		class2		class3		class4	
		2017	2018	2017	2018	2017	2018	2017	2018
ECe ($dS\ m^{-1}$)	Min	3.56	3.17	0.58	0.69	0.54	0.50	0.30	0.23
	Max	136.35	157.00	60.95	113.80	35.80	25.73	10.74	28.47
	Mean	42.14	59.61	7.30	11.02	3.83	5.36	3.98	3.82
	CV(%)	84.31	83.44	168.29	165.00	117.21	97.44	69.76	126.76
SAR	Min	11.72	10.42	5.28	3.29	0.48	1.14	0.24	0.25
	Max	195.09	289.09	99.95	169.92	78.65	77.40	14.78	47.26
	Mean	81.69	100.43	21.53	27.48	16.77	18.71	3.37	5.76
	CV(%)	61.57	73.22	90.31	96.93	94.58	73.69	96.18	157.92
TYPES		slightly saline, saline-sodic	slightly saline, saline-sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic	normal, saline, saline-sodic, sodic

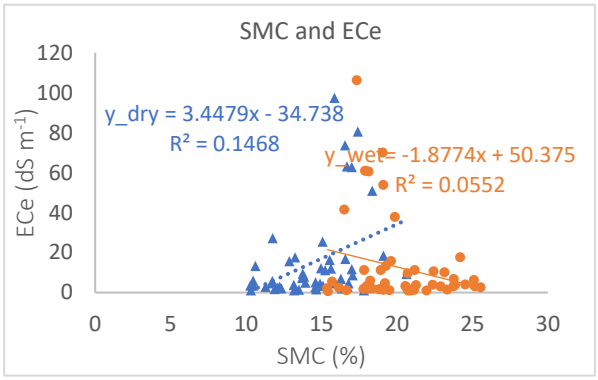
2.2 Relation ECe and SAR with soil moisture content

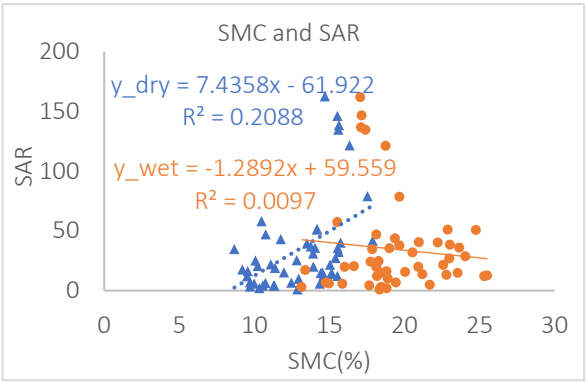
The relation between ECe and SAR to SMC, PWP, and FC were presented in Fig.2. and Fig.3. The results showed that ECe and SAR is positive correlation to SMC in a dry season. While, the relation of salinity properties like as ECe and SAR showed a negative trend with SMC in a wet season. Likewise, a soil moisture content at PWP and FC indicated that it is a negative relation with ECe and SAR in both a wet season and a dry season. Moreover, the relation of ECe and SAR with SMC under a different soil texture pointed out that it is a positive correlation in a dry season, especially, in a fine-textured soil with R^2 value 0.5892 for ECe and 0.7019 for SAR. While, in a wet season is not clarified for both salinity as ECe and SAR, as shown in Fig.5 and Fig.6.

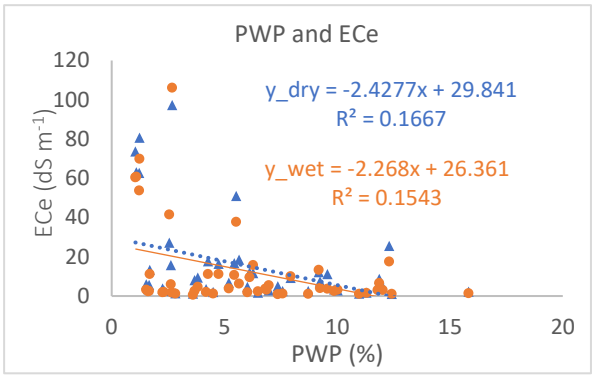
As the correlation result, it explained that quantity of moisture content in soil and soil texture are impact on a salinity alteration. Thus, SMC in a wet season was higher than SMC at saturated condition, resulting in more water can wash a salt into a subsoil. Also, SMC at FC point could leach a salt due to soil moisture content at FC almost reach to a saturated moisture content. Meanwhile, SMC at PWP point was too dry that can not carry a salt into a root zone (0-30 cm). In contrast, SMC in a dry

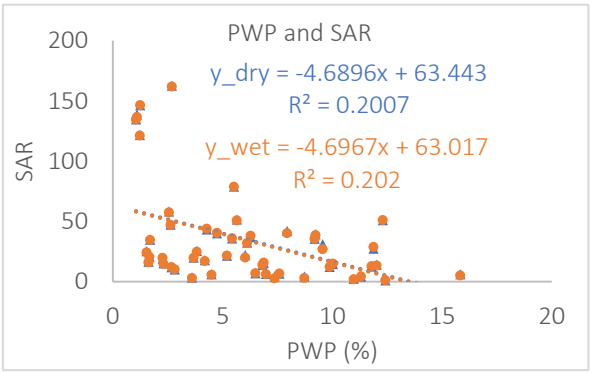
season was between PWP and FC, thus soil has enough soil moisture can move up a salt to an upper soil horizon. Additionally, the fine-textured soils showed a significant relation in a dry season. Due to salinity was affected by rainfall, soil moisture, and soil texture, which influencing salt deposition in the soil cross-section. Due to soil texture was related to hydraulic conductivity and soil pore. In generally, soil was more different texture between each soil horizon. Which, different soil texture and their distributions influence the water conductivity and solute distribution in the face (15). Additionally, a water absorbed in the hardpan layer, it may be a source of water for plants or may increase the risk of saline soil formation (16). Moreover, soil profile complicated by the discontinuity of the soil texture. That, it was a very important factor in the permeability of saturated soil and the water permeability in the unsaturated soil water retention and air pressure values which related to salt accumulation (17).

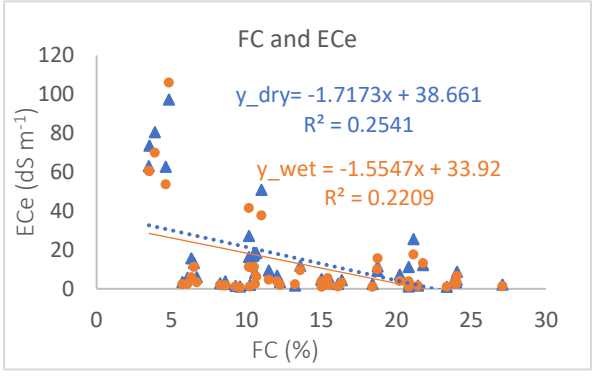
The salt leaching process was more affected by soil structure fractures, and scattering of small soil particles resulted in fragmentation, especially, in saline soils with high clay particles such as montmorillonite (18). Which, the amount of salt accumulation in the root zone was depended on the leaching process and the process of upward movement of groundwater by capillary force which is in the opposite direction (19). The moist soil would have the expansion of the soil ped, resulting in a macro pore being compressed, causing the hydraulic conductivity decreased. It has been shown that saline soil was affected by both water conductivity and soil water retention (20, 21).











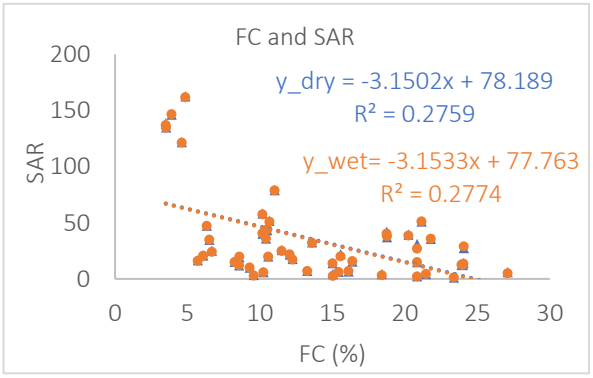
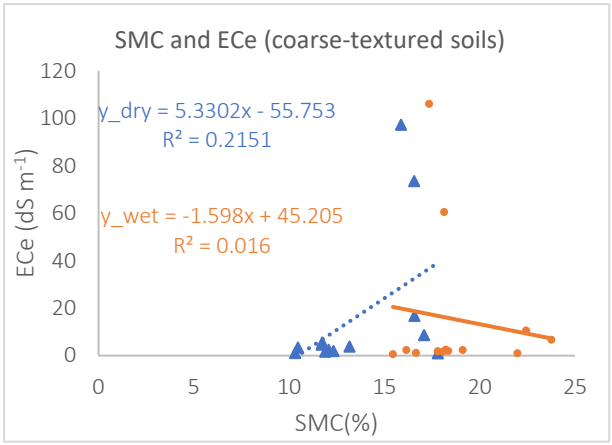
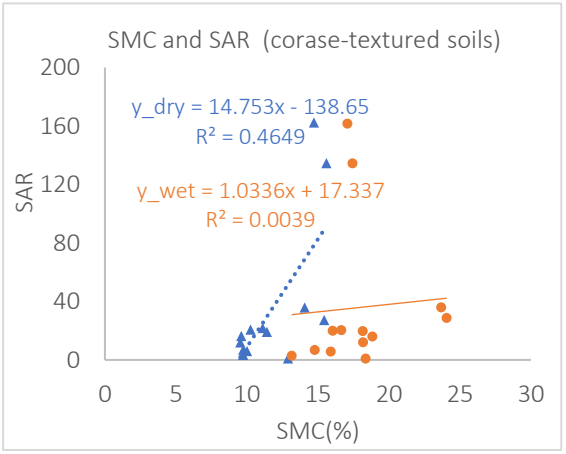
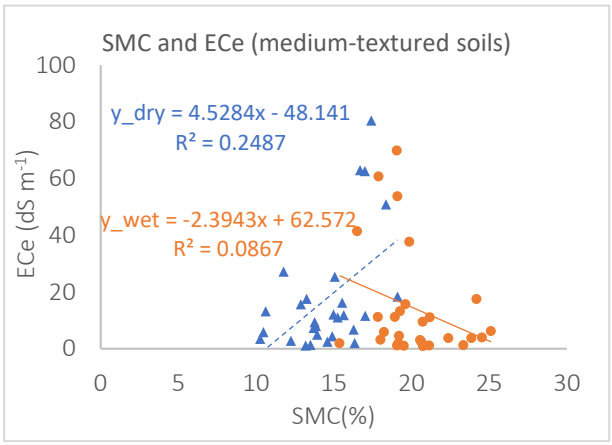


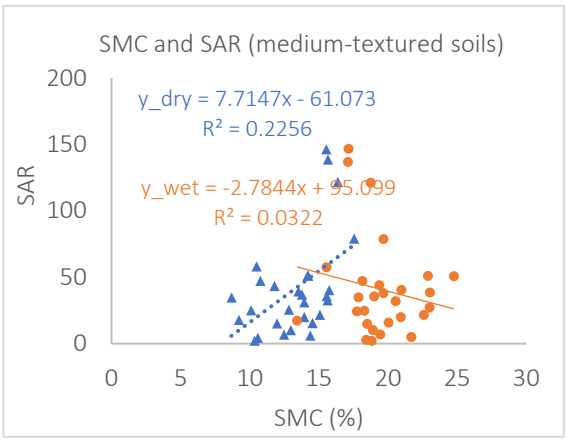
Fig. 3. Relation soil moisture content and ECe

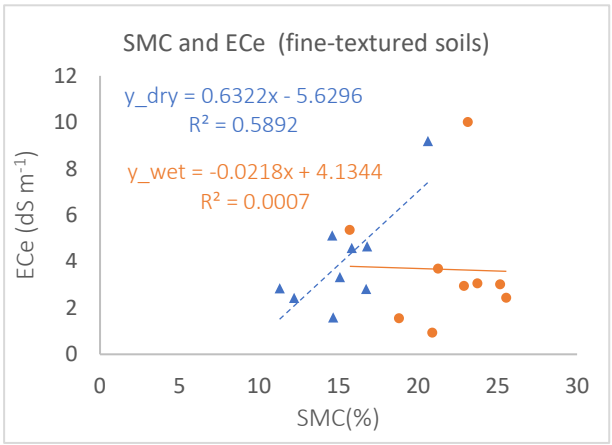
Fig. 4. Relation soil moisture content and SAR











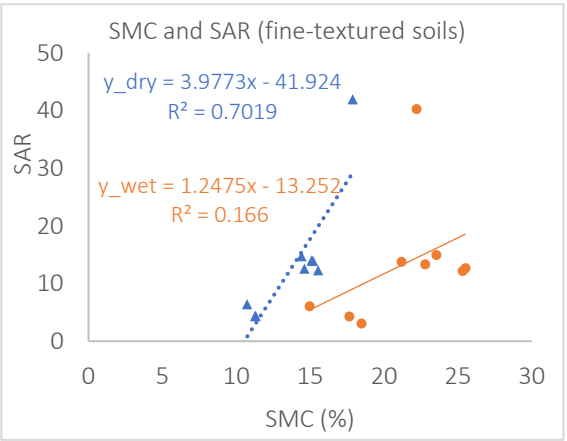


Fig.5. Relation soil moisture content and ECe

Fig.6. Relation soil moisture content and SAR

3. SUMMARY

The research results showed that variation of ECe and SAR is high (C.V >35%) at 0-30 cm. soil depth. Soil ECe and SAR in class 1 (salt crust on surface >50%) was ranged from moderately to very severely salinity and sodic in dry season. But it was varied from slightly to very severely salinity and non-sodic to sodic in wet season. While, in class 2,3 and 4 (salt crust on surface <50%), thus, ECe data pointed out that salinity degree is ranged from normal to very severely salinity in both dry and wet. Also, SAR variation was ranging from non-sodic to sodic for every class in consideration area. Moreover, the data presented that ECe and SAR are higher variability in wet season than dry season. The correlation showed that ECe and SAR is positive relation to SMC in a dry season. While, the relation of salinity properties like as ECe and SAR showed a negative trend with SMC in a wet season. Likewise, a soil moisture content at PWP and FC showed a negative correlation with ECe and SAR in both a wet season and a dry season. Moreover, the results pointed out that it is a positive correlation between a salinity and soil moisture

content under different soil texture in a dry season, especially, in a fine-textured soil. While, in a wet season was not clarified for both salinity as ECe and SAR.

In future research, the long-term continuing study will provide a better understanding of salt variation in the soil profile. Thus, it is significant to understand changes and spatial responses, climate, and the water cycle. Also, the irrigation research will be more study to expose how much of suit water for crop and leaching salt from the root zone and how to manage a salt-affected soil under the climate change situation.

4. ACKNOWLEDGMENTS

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