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Rehabilitation of Salt Affected Soils with Chemical Geo-Textile in Northeast Thailand

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Abstract: Salt accumulation occurred due to capillary water rise from salt groundwater is one of the major problems in Northeast Thailand. The salt accumulation is causing a serious farming problem. So, this study dealt with the rehabilitation strategy on salt affected soils for sustainable agriculture in Phra Yun, Northeast Thailand. Application of chemical geo-textile was investigated in the laboratory experiment using the soil column. The results indicated that chemical geo-textile could intercept the capillary water rise in the laboratory experiment. Based on the results of soil column experiment, chemical geo-textile was installed in the salt affected fields of Phra Yun. The field experimental results showed that $EC_{1:5}$ values in surface soils of the ridges installed the chemical geo-textile did not decrease, as sodium components existing in surface soils could not be washed out by leaching with rainfall. Therefore, leaching experiment was conducted to discuss the effective leaching measures. Through the leaching experiment, it became clear that soil permeability improvement is indispensable for washing sodium components out. Also, the experimental results showed that $EC_{1:5}$ values were reduced far below the expected crop tolerance level if applying enough volume of water as same in water height as surface soil depth. In addition, the higher mixing ratio with gravel in surface soils showed the higher effectiveness for reducing $EC_{1:5}$ values with leaching.

Keywords: Chemical geo-textile, Leaching, Salt accumulation

1. Introduction

Salt accumulation occurred due to capillary water rise from salt groundwater is causing a serious farming problem in Northeast Thailand (**Fig. 1**). There are many studies concerning salt accumulation and suggestion for suitable strategies to be taken to overcome the problems. Dissataporn *et al.* (2002) suggested that the groundwater level should be managed below 1.5 m deep from soil surface to reduce salt accumulation. Also, Kanazawa *et al.* (2006) reported that the groundwater level in Nong Thung Mon village of Phra Yun was 0.51 m deep from soil surface in August 2003 of rainy season. Anase *et al.* (1997) reported that the sub-soil drainage system in addition to the banking was effective for keeping groundwater level lower. Also, Endo and Hara (2000) reported that the stone layer in soils was suitable measures to intercept the capillary rise of saline water. However, there are no studies concerning the application of geo-textiles to intercept capillary water rise from salt groundwater in this area. Therefore, the objectives of this study are to evaluate the application of chemical geo-textile for intercepting the capillary water rise from salt groundwater and to discuss the effective leaching measures.

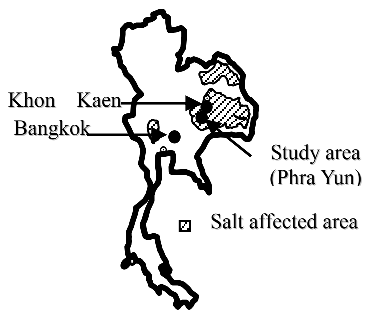

Fig. 1. Salt affected area in Thailand.

2. Research site and Methods

2.1. Experiment on intercepting capillary water rise with chemical geo-textile

The effects of chemical geo-textile on intercepting capillary water rise were investigated using the soil column. The soil column was filled with silica sand (**Table 1**) or Phra Yun soil (**Table 2**). Chemical geo-textile was installed at 23 cm deep from soil surface in the soil column of 50 cm high, and sodium chloride (NaCl) solution at 6,740-6,820 μS/cm was supplied from the bottom of soil column for 96 hours.

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Soils were sampled above and below the chemical geo-textile in the soil column, also water content and electric conductivity ($EC_{1:5}$) were measured at 24, 48, 72 and 96 hours passed. **Figure 2** shows the cross section of experimental soil column.

Table 1. Physical properties of silica sand.

	Specific gravity	Particle size distribution (%)					
		0.21 mm	0.149 mm	0.105 mm	0.074 mm	0.053 mm	under 0.053 mm
Silica sand	2.62	0.1	0.1	13.7	56.8	23.7	5.6

Table 2. Physical properties of soils in Phra Yun, Northeast Thailand (rainy season).

Depth from the soil surface (cm)	Horizon	Specific gravity	Dry density (g/cm³)	Particle size distribution (%) *					Soil texture	Saturated permeability ($\times10^{-5}$) cm/s	Ignition loss (%)
				Gravel	Coarse sand	Fine sand	Silt	Clay			
0-2	Horizon of soil deposit	2.62	—	0	23.6	70.9	3.6	1.9	S	—	0.70
3-14	A1	2.64	1.69	0	21.3	67.3	8	3.4	LS	0.25	0.88
15-20	A2	2.65	1.75	0	23.6	57	11.9	7.5	SL	2.51	1.25
21-30	A3	2.63	1.77	0	25.5	56.5	9.8	8.2	SL	1.62	1.79
31-42	Horizon of transitional	2.64	1.80	0	22.8	59	10.4	7.8	SL	0.35	1.19
43-75	B1	2.65	1.66	0	25.2	57.3	8.8	8.7	SL	0.15	1.31
76-95	B2	2.66	1.64	0	23.2	55.7	11.4	11.4	SL	0.25	1.48

* ISSS method

Table 3. Chemical properties of soils in Phra Yun, Northeast Thailand (rainy season).

Depth from the soil surface (cm)	Horizon	Sodium concentration ($\times10^{-5}$kg/kg)	Calcium concentration ($\times10^{-5}$kg/kg)	Electric conductivity (μS/cm)	Total nitrogen ($\times10^{-5}$kg/kg)	Total Phosphorus ($\times10^{-5}$kg/kg)
0-2	Horizon of soil deposit	7.56	0.632	35.3	22.60	0.71
3-14	A1	4.72	0.298	53.3	15.90	0.57
15-20	A2	31.20	0.392	395.0	19.65	1.05
21-30	A3	60.70	0.651	522.0	27.50	0.47
31-42	Horizon of transitional	69.30	1.288	629.0	14.71	0.72
43-75	B1	76.10	0.812	695.0	12.57	0.58
76-95	B2	81.40	0.483	683.0	11.70	0.27

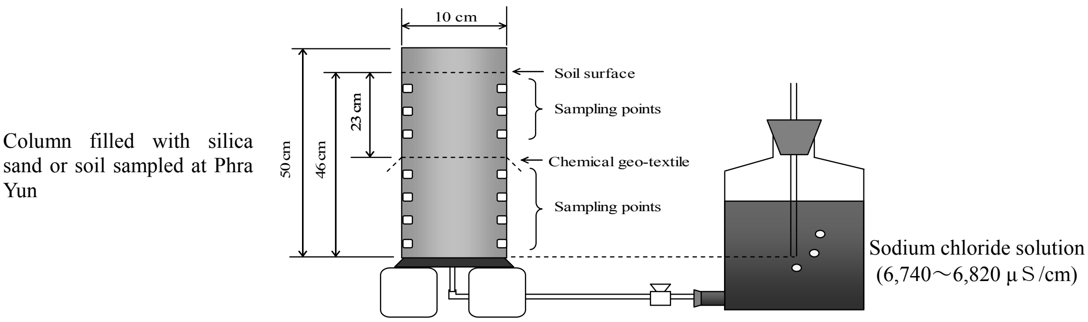

Fig. 2. Cross sectional view of experimental soil column.

2.2. Field experiment with chemical geo-textile

Salt accumulation is causing severe farming problems in Phra Yun. In August 2002, rainy season, soil profile survey was conducted in salt affected area of Phra Yun to analyze the soil physical and chemical properties as shown in **Tables 2** and **3**. There was a tendency that EC values and sodium concentration increased with depth. Also, soil permeability was low ranging from 0.1×10^{-5} to 2.6×10^{-5} cm/s.

In salt affected area of Phra Yun, chemical geo-textile was installed at 20 cm deep from soil surface in the ridge of 40 cm high in December 2002. Soils were sampled above and below the chemical geo-textile in March 2004 to analyze water content and $EC_{1:5}$ values. **Figure 3** shows the cross section of the ridge with chemical geo-textile in salt affected area of Phra Yun.

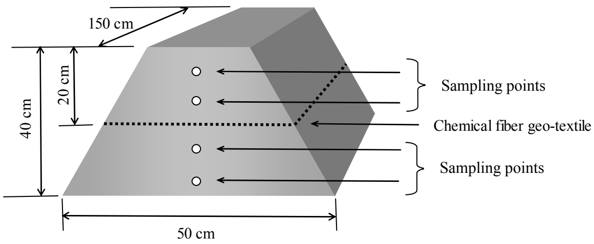

Fig. 3. Cross sectional view of ridge with chemical geo-textile.

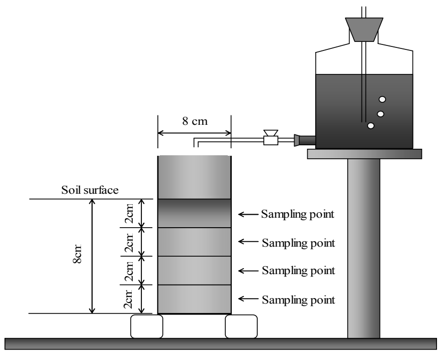

Fig. 4. Cross sectional view of column for leaching experiment.

2.3. Experiment on effective leaching measures

Salt affected soil sampled from 0 to 10 cm deep at a same point in Phra Yun during dry season of 2004 was used for investigating the effective leaching measures. Although soil texture was sandy, the soil showed low permeability as shown in Table 2. Only $EC_{1:5}$ value of 6,710 μS/cm was higher than that in rainy season in Table 3. For improving soil permeability, the soil was mixed with the gravel in which diameter was larger than 1 cm at the various ratios of soil : gravel at 7:1, 3:1 and 1:1. The column of 8 cm diameter and 20 cm high, 402 cm^3 in volume, was filled with well mixed soil and gravel.

Total volume of 100.5, 201 and 402 ml of distilled water was supplied to the column at supplying rate of 5, 10 and 20 mm/h. The volume of 100.5, 201 and 402 ml was equal to quarter height of water comparing to surface soil depth, half of water height comparing to surface soil depth and same height of water as surface soil depth. Soils were sampled from 4 layers at 0 to 2 cm, 2 to 4 cm, 4 to 6 cm and 6 to 8 cm deep from soil surface, and then water content and $EC_{1:5}$ values were measured. **Figure 4** shows the cross section of the column for leaching experiment.

3. Results and Discussion

3.1 Effects of chemical geo-textile on intercepting capillary water rise

The results of soil column experiment with and without chemical geo-textile were summarized in **Figure 5**. In the experiment, chemical geo-textile was installed at 23 cm deep from soil surface in the soil column of 50 cm high, and sodium chloride (NaCl) solution at 6,740-6,820 μS/cm was supplied from the bottom of soil column for 96 hours. Water content and $EC_{1:5}$ values above the geo-textile in silica sand column were significantly smaller than that without the geo-textile at 99% confidence level. It was considered that chemical geo-textile worked well for intercepting capillary water rise.

Although water content above the geo-textile in the column filled with soil sampled at Phra Yun was remarkably smaller than that below the geo-textile, the difference in $EC_{1:5}$ values between above and below the geo-textile was comparatively small.

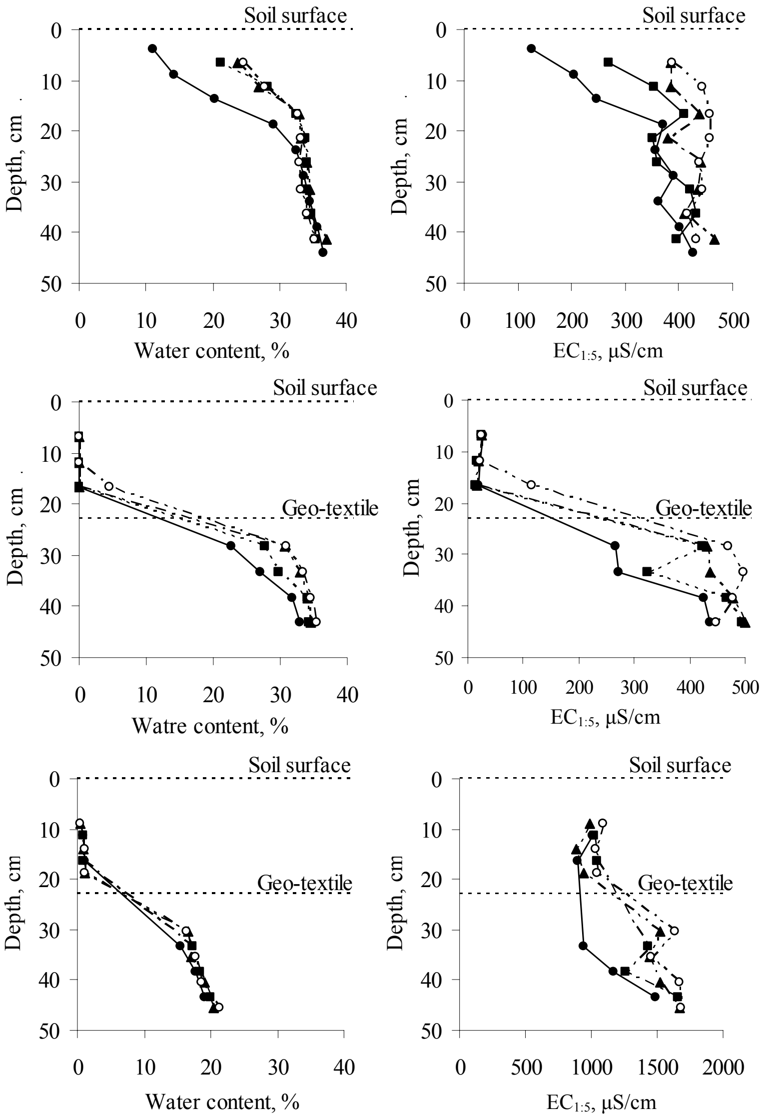

Fig. 5. Changes in water content and $EC_{1:5}$ values in soil column.
(1st and 2nd rows: silica sand, 3rd row: Phra Yun soil)

3.2 Effects of chemical geo-textile on reducing salt accumulation in fields

In salt affected area of Phra Yun, chemical geo-textile was installed at 20 cm deep from soil surface in the ridge of 40 cm high in December 2002, and then soils were sampled above and below the geo-textile in March 2004 to analyze water content and $EC_{1:5}$ values. As shown in **Figure 6**, water content above the geo-textile was lower than that below the geo-textile, however $EC_{1:5}$ values above the geo-textile were higher than that below the geo-textile.

In addition, there was a tendency for $EC_{1:5}$ values in the upper parts of the ridges above the geo-textile to be higher than that without the geo-textile. It meant that rainfall events from January 2003 to February 2004 did not contribute well for leaching sodium components out from top layer of the ridges. Although soil texture was sandy in salt affected area of Phra Yun, the soil showed low permeability as shown in Table 2. It was considered that soil permeability improvement is indispensable for leaching sodium components effectively.

3.3 Effective leaching measures

For improving soil permeability, the soil sampled at Phra Yun in dry season of 2004 was mixed with the gravel in which diameter was larger than 1 cm at the various ratios. The column of 8 cm diameter and 20 cm high, 402 cm^3 in volume, was filled with well mixed soil and gravel.

The changes in water content and $EC_{1:5}$ values under different leaching measures were summarized in **Figures 7**, **8** and **9**. The experimental results showed that $EC_{1:5}$ values were reduced far below the expected crop tolerance level if applying enough volume of water as same in water height as surface soil depth. In addition, the higher mixing ratio with gravel in surface soils showed the higher effective for reducing $EC_{1:5}$ values due to leaching. However, there was no certain tendency for the effects of supplying rate on reducing $EC_{1:5}$ values.

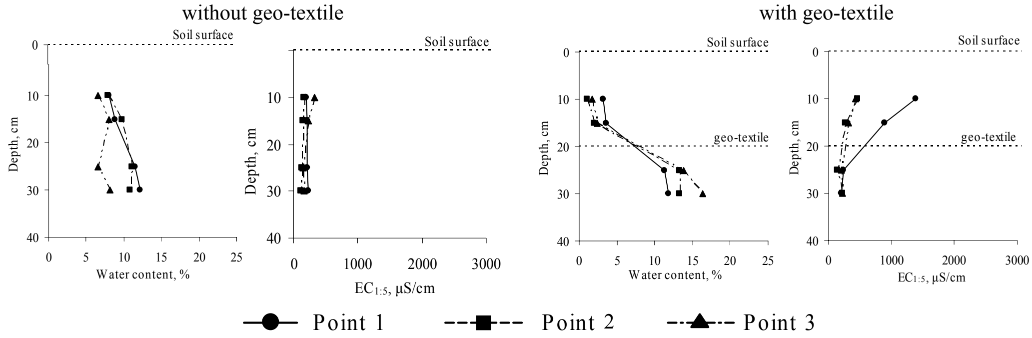

Fig. 6. Water content and $EC_{1:5}$ values in ridges of Phra Yun.

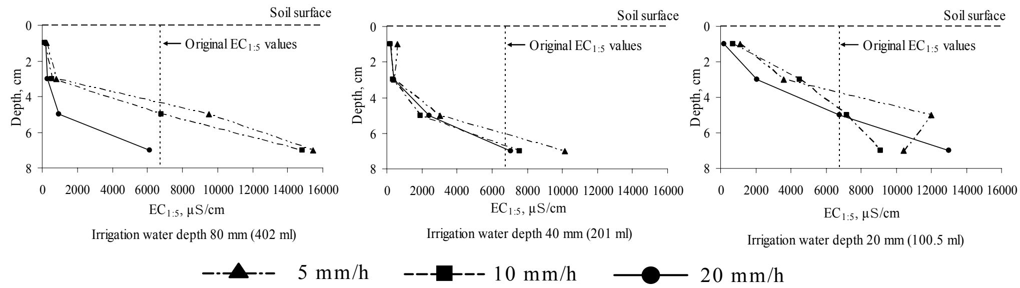

Fig. 7. Changes in $EC_{1:5}$ values due to leaching at 12.5 % gravel added.

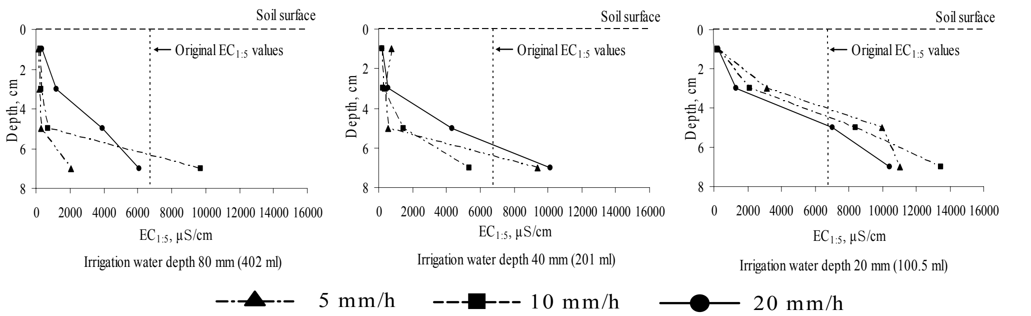

Fig. 8. Changes in $EC_{1:5}$ values due to leaching at 25 % gravel added.

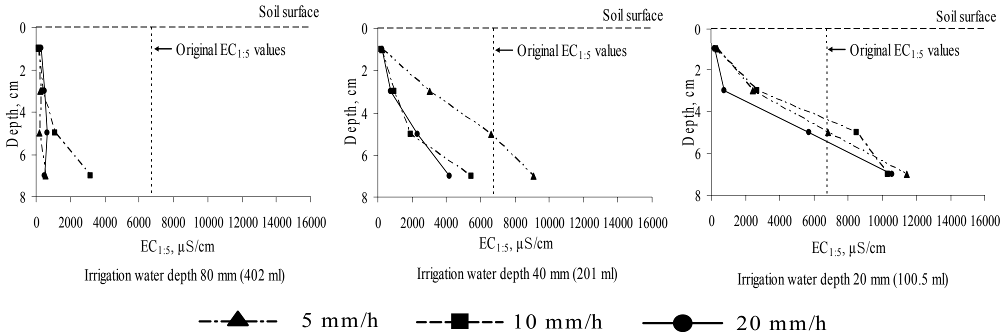

Fig. 9. Changes in $EC_{1:5}$ values due to leaching at 50% gravel added.

4. Conclusions

Salt accumulation occurred due to capillary water rise from salt groundwater is causing a serious farming problem in Northeast Thailand. This study dealt with the evaluation of chemical geo-textile application for intercepting the capillary water rise from salt groundwater and the discussion of effective leaching measures.

Chemical geo-textile could intercept the capillary water rise; however the geo-textile did not work for decreasing $EC_{1:5}$ values at field level. Sodium components existing in surface soils could not be washed out by leaching with rainfall. Therefore, leaching experiment was conducted to discuss the effective leaching measures. Through the leaching experiment, it became clear that soil permeability improvement is indispensable for washing sodium components out.

Also, the experimental results showed that $EC_{1:5}$ values were reduced far below the expected crop tolerance level if applying enough volume of water as same in water height as surface soil depth. In addition, the higher mixing ratio with gravel in surface soils showed the higher effective for reducing $EC_{1:5}$ values with leaching.

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