Research article

Plant Diversity on Slightly Saline Soils in Chi River Basin of Northeast Thailand

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Abstract This research is aimed to documenting the diversity of plant species that are found on slightly saline soils in the Chi river basin of Northeast Thailand. Both in the dry and the rainy seasons of 2013, plant surveys were conducted at selected sites in three provinces (Chaiyaphum, Khon Kaen, and Kalasin) by using a quadrat sampling technique. Soils under the dominant plant species were collected for physical and chemical analyses. From the study, a total of 155 plant species belonging to the 72 families were recorded. Five of those were classified as halophytes, and included *Azima sarmentosa*, *Maytenus diversifolia*, *Synostema bacciformis*, *Pluchea indica* and *Gisekia pharnaceoides*. The dominant species in the selected sites of three provinces were *Cynodon dactylon*, *Heliotropium indicum*, *Melochia corchorifolia*, *Ageratum conyzoides*, *Coldenia procumben*, *Glinus oppositifolius* and *Panicum repens*, respectively. In the dry season, the average soil electrical conductivity under the dominant plant species at Chaiyaphum, Khon Kaen and Kalasin provinces were 2.52, 0.7 and 0.54 dS/m, respectively. In the rainy season, the averaged soil electrical conductivity under the dominant plant species were decreased to 0.61, 0.37 and 0.14 dS/m in Chaiyaphum, Khon Kaen and Kalasin provinces, respectively. In all studied areas during in both seasons, the amounts of exchangeable sodium were in the same direction as the values of electrical conductivity. Soil pH values at all studied areas in both seasons were in an acidic condition. However, the pH values were lower in the dry season than in the rainy season. Soil moisture under the dominant plant species was higher in the rainy season than that in the dry season.

Keywords plant diversity, saline soil, halophytes

INTRODUCTION

The northeast region of Thailand, known as Isan, covers an area of 170,226 sq. km or one third of the entire country. The region situates on Korat plateau which is distinctly raised from the Central region. The plateau tilts downward from the Phetchabun mountain range in the west of the region towards to Mekong River. The plateau consists of two plains: the southern Khorat plain, which is drained by the Mun and Chi rivers, and the northern Sakon Nakhon plain which is drained by the Loei and Songkhram rivers. The two plains are separated by the Phu Phan mountain range. The soil is mostly sandy, with substantial salt deposits. Soils in Northeast Thailand are salt-affected due to

salt bearing rocks (Department of Land Development, 1991), particularly in Nakhon Ratchasima, Khon Kaen, Roi Et, Chaiyaphum and Mahasarakham provinces (Department of Mineral Resources, 1982). Saline soils currently occupy an area of approximately 17% of the region and that area is increasing annually. A rather large part of the arable land in this region is salt-affected to varying degrees. Generally, narrow areas, which are strongly salt-affected, are scattered from the western hilly areas to the undulating regions, and the relatively weakly salt-affected wide areas are spread throughout the low-lying flat regions, especially along the big rivers. The degree of soil salinity in the salt affected areas can be classified into three categories: 1) Severe salt affected soil is the area which more than 50% of the soil exhibits surface salt patches. Soil salinity ranges from high to very high. This area known as deteriorated land, covers about 0.2 million hectares and cannot be used for any agricultural activity. 2) Moderate salt affected soil is the area which 10-50% of the soil surface is covered with salt patches. The area is about 0.6 million hectares and the land is used as rice paddies, but the yield is very low. 3). Slightly salt affected soil is the area which salt patches on the soil surface occur in less than 10% of the area. There are about 2 million hectares, and most of the area is comprised of rice fields with low yields (Arunin, 1984) (Fig. 1). Soil salinity has become one of the major determinants of crop productivity in the Northeast Thailand and has an adverse impact on the physical, chemical and biological properties of soil, as well as on plant growth and yield (Marschner, 1995). To grow crops successfully, these soils must be improved. Investigations carried out at various research locations in the world have shown that salt-affected soils can be improved by the planting of salt tolerant plant species. In an effort to identify and dominant the salt tolerant plant species present on naturally occurring saline soils, it is therefore, necessary to study the soil properties and vegetation cover that are found on saline soil. The gains from this study will be valuable, and the dominant species, that have been observed, will deserve further attention as potential candidates for restoring the salt affected areas. In addition, the presence or absence of certain plants can give valuable clues to indicate the degree of soil salinity.

a) b) c)

Fig. 1 Categories of salt affected areas: a) severe, b) moderate and c) slightly

METHODOLOGY

This study has aimed to documenting the diversity of plant species and investigating the soil properties under the dominant species on slightly saline soils in the Chi river basin of Northeast, Thailand. Plant surveys were conducted on 9 selected sites in 3 provinces (Chaiyaphum, Khon Kaen and Kalasin) during both the dry season (April) and the rainy season (October) of 2013 by using a quadrat sampling technique (Fig. 2). Plant specimens were collected and identified from within 108 sample plots (1x1 m). The dominant species were analyzed by totally averaging each of the plant covers.

To study soil properties, soil samples under each of the dominant species found in the study area were collected separately at the depth of 0-15 cm and were brought back to the laboratory for physical and chemical analyses in both the dry season and the rainy season. The moist soil samples were analyzed for the moisture content, pH (1:2.5 soil: water), ECe (saturation extract), organic matter and exchangeable Na^+. A good indicator of potential salinity problems is the depth and quality of the groundwater table. If groundwater table are both saline and shallow or rising, there is the potential for salinity problems to occur in the future (Kohyama et al., 1993). Therefore, in this

study, the depth of water table has been measured in the middle of both the rainy and dry seasons by using a piezometer. In addition, water samples were collected to determine the salinity in order to determine the quality of the groundwater.

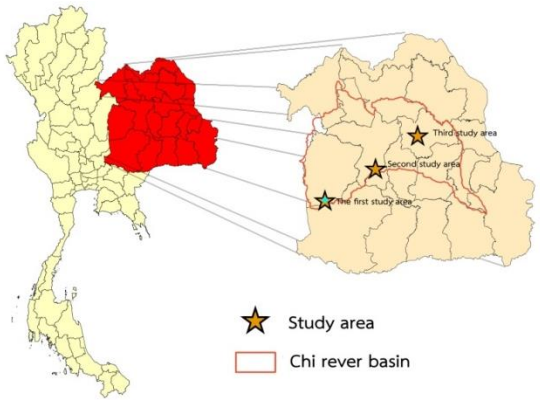


Fig. 2 The study area in 3 provinces (Chaiyaphum, Khon Kaen, and Kalasin) of Northeastern Thailand

RESULTS AND DISCUSSION

For soil properties on slightly saline soil in the dry season, the average soil electrical conductivity under the dominant plant species at Chaiyaphum, Khon Kaen and Kalasin were 2.52, 0.7 and 0.54 dS/m, respectively. In the rainy season, the average soil electrical conductivity under the dominant plant species decreased to 0.61, 0.37 and 0.14 dS/m in Chaiyaphum, Khon Kaen and Kalasin, respectively. The amounts of exchangeable sodium were in the same direction at electrical conductivity values for all areas studied in both seasons. Soil pH at all studied areas in both seasons were in an acidic condition. However, soil pH values were lower in the dry season as compared to the rainy season as found by Topark-ngarm (1990). Soil moisture under the dominant plant species was higher in the rainy season than in the dry season (Table 1).

Table 1 Soil properties in the dry season and the rainy season in the study areas (Mean±SD)

Soil properties	Chaiyaphum Province		Khon Kaen Province		Kalasin Province	
	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season
pH (1: 2.5 H_2O)	5.30 ± 0.19	5.93 ± 0.48	4.31 ± 0.39	4.56 ± 0.26	4.13 ± 0.15	4.41 ± 0.17
ECe (dS/m)	2.52 ± 0.94	0.61 ± 0.57	0.70 ± 0.20	0.37 ± 0.27	0.54 ± 0.34	0.14 ± 0.05
OM (%)	0.83 ± 0.14	0.82 ± 0.22	0.74 ± 0.16	0.85 ± 0.13	0.68 ± 0.01	0.66 ± 0.10
Exchangeable Na^+ (ppm)	12.86 ± 1.90	2.82 ± 2.28	3.00 ± 1.28	1.33 ± 0.96	1.57 ± 0.69	0.31 ± 0.16
Soil moisture content (%)	4.61 ± 0.92	20.24 ± 4.11	5.35 ± 0.63	13.14 ± 5.57	3.30 ± 0.61	11.65 ± 2.38

The water table at the Chaiyaphum site is more shallow than at the other sites. In addition, the groundwater salinity is also higher, and that makes the soil salinity at Chaiyaphum site higher than at the other sites (Table 2).

Table 2 The water table depth and groundwater salinity

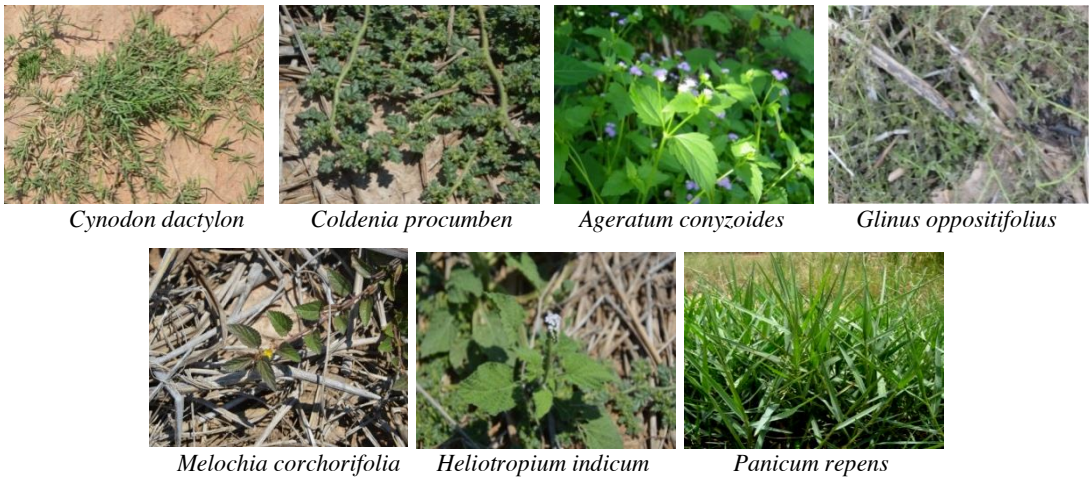
Site	Water table (cm)		Groundwater salinity (dS/m)	
	Dry season	Rain season	Dry season	Rain season
Chaiyaphum Province	194	42	2.82	1.20
Khon Kaen Province	> 200	105	2.16	1.52
Kalasin Province	> 200	116	1.78	0.76

In the plant study, a total of 155 plant species belonging to the 72 families have been recorded. Five of those were classified as halophytes: *Azima sarmentosa*, *Maytenus diversifolia*, *Synostema bacciformis*, *Pluchea indica* and *Gisekia pharnaceoides* (Fig. 3). The dominant species in the selected sites of the three provinces were *Cynodon dactylon*, *Coldenia procumbent*, *Ageratum conyzoides*, *Glinus oppositifolius*, *Melochia corchorifolia*, *Heliotropium indicum* and *Panicum repens*, respectively (Fig. 4). In the rainy season, the number of plant species at every study site was higher due to a decrease in soil salinity as compared to the dry season.

Azima sarmentosa *Maytenus diversifolia* *Synostema bacciformis* *Pluchea indica* *Gisekia pharnaceoides*

Fig. 3 The halophytes found in the study area

The dominant species found on the slightly saline soils were quite different from those found on high saline soils and moderate saline soils. *Azima sarmentosa*, *Maytenus diversifolia*, and *Pluchea indica* were the dominant species found in areas of high salinity (Kulna et al., 2012). *Combretum quadrangulare*, *Imperata cylindrical*, *Cynodon dactylon*, *Panicum repens*, *Sphaeranthus afraricanus*, *Glinus oppositifolius* and *Fimbristylis disticha* were the dominant species dicovered growing in moderate salinity (Chason et al., 2014). Also, *Cynodon dactylon*, *Coldenia procumben*, *Ageratum conyzoides*, *Glinus oppositifolius*, *Melochia corchorifolia*, *Heliotropium indicum* and *Panicum repens* were the dominant species found growing in slightly salinity.



Cynodon dactylon *Coldenia procumben* *Ageratum conyzoides* *Glinus oppositifolius*

Melochia corchorifolia *Heliotropium indicum* *Panicum repens*

Fig. 4 The dominant species found in the study area in the dry season

Table 3 Cover areas and soil electrical conductivity of dominant species in the study area in the dry season

Plant Name	Cover areas (%)	ECe (dS/m)
Cynodon dactylon	16.53	0.87±0.97
Coldenia procumben	14.58	0.86±0.93
Ageratum conyzoides	13.33	0.74±0.80
Glinus oppositifolius	12.92	0.32±0.11
Melochia corchorifolia	12.50	1.03±1.26
Heliotropium indicum	10.83	1.34±1.10
Panicum repens etc.	8.33	0.88±0.85

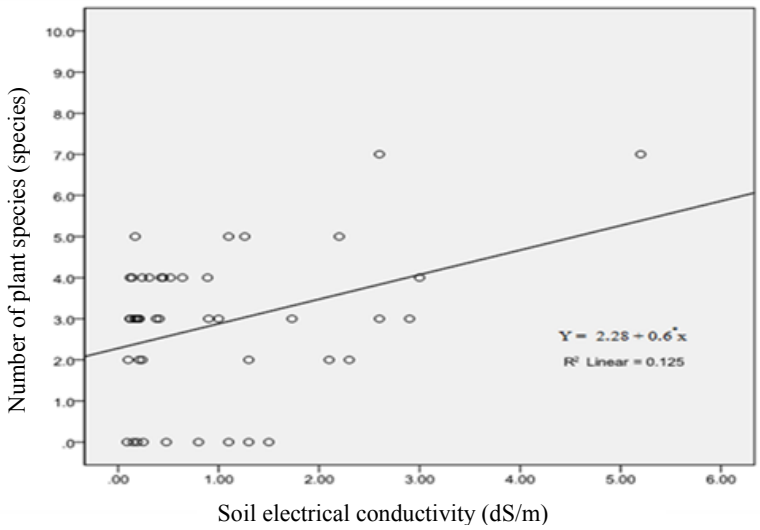


Fig. 5 The relationship between number of plant species and the average soil electrical conductivity (ECe) in the dry season (less salinity more plant species)

CONCLUSION

From the study, some native plants in Northeast Thailand have been found to have become well adapted to saline conditions, and these plants are called halophytes. The presence of some halophytes is generally indicative of a saline soil. There is a natural variation in the ability of plants to tolerate salinity. Most of plant species can grow well when soil ECe is low. On the other hand, some plant species can tolerate in the soil which have high ECe value (Fig. 5). Therefore, the presence or absence of certain plants can give valuable clues to indicate the degree of soil salinity. *Cynodon dactylon*, *Coldenia procumben*, *Ageratum conyzoides*, *Glinus oppositifolius*, *Melochia corchorifolia*, *Heliotropium indicum* and *Panicum repens* are the dominant species in areas of slightly salinity. This study has not experimentally evaluated plant species for their use in the restoration or re-vegetation of salt affected areas. However, comparable salinity levels and species found in the areas suggest that the dominant species observed in this study would be valuable and deserve further attention as potential candidates for the restoration of salt affected areas.

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REFERENCES

Arunin, S. 1984. Characteristics and management of salt-affected soils in the Northeast of Thailand. In: Ecology and Management of Problem Soils in Asia. FFTC Book Series No. 27. Food and Fertilizer Technology Center for the Asian and Pacific Region. Taipei, Taiwan, 336-351.

Chason, S., Trelo-ges, V., Topark-ngarm, B. and Homchuen, S. 2014. Study on plant species diversity with soil properties in moderate saline soil of Chi River, Northeast Thailand. Book of Abstracts. The 5th ICERD-International Conference on Environmantal and Rural Development. 18-19 January 2014. Rajamangala University of Technology Thanyaburi, Thailand.

Department of Land Development. 1991. Distribution of salt affected soils in the northeast region 1:100,000 map. Department of Land Development, Thailand.

Department of Mineral Resources. 1982. Geologic map of Thailand. Department of mineral resources, Thailand.

Kohyama, K., Wichaidit, P., Pramojanee, P., Sukchan, S. and Wada, H. 1993. Salinization in the watershed of Northeast Thailand. In: ADRC (ed.) "Research Activities of ADRC contributed to Agricultural Development in Northeast Thailand", Khon Kaen, Thailand.

Kulna, W., Trelo-ges, V., Topark-ngarm, B. and Homchuen, S. 2012. Study of relationships of some soil properties on plant species diversity in serious saline soil of Chi river basin. The 9th National Conferences of Agricultural Academic. 6-7 December 2012. Kasetsart University, Kamphaeng Sean Campus, Thailand.

Marschner, H. 1995. Mineral nutrition of higher plants. 2nd Edition. Academic Press, UK.

Topark-ngarm, B., Patcharapreecha ,P., Goto, I. and Kimura, M. 1990. Studies on saline soils in Khon Kaen Region, Northeast Thailand. II. Seasonal changes of physical and chemical properties. Soil Sci. Plant Nutr., 36, 289-298.