

Salt-Tolerant Plants of the Inland Region of Northeastern Thailand

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ABSTRACT

Generally, most vascular plants are physiologically unable to grow on salt-affected soil. Such soil is widely distributed in the Khon Kaen region of northeastern Thailand. This region can be divided into two areas, depending upon the type of vegetation. One area is affected by crystalline salt and hard dry soil under the severe climatic condition only in the dry season. In this area, there are many halophyte species which are tolerant of high salinity and extremely dry conditions, but these halophytes have mingled with some coastal halophyte plants. This means that heavy rainfall in the rainy season dissolves salt in the soil and enables some adapted coastal halophytes to grow. This phenomenon occurs in rice fields and around brackish water ponds. In the other area, where the natural forest is dry deciduous forest, many species grow which are resistant to salinity. These forests are composed of plants which are somewhat adapted physiologically and morphologically to the extremely dry conditions.

A dry climate is a condition for physical dryness of the plant, while high salinity is a condition for physiological dryness. Both conditions have the same effects on plants. While salination is advanced in the soil during the dry season, plants in the dry forest can avoid the period of hard soils by reducing their physiological function (fall of leaves). These plants in dry forest, which are characterized by thorny trunks, hairy leaves, fleshy leaves, corpulence of root system etc. can therefore be classified as salt-tolerant plants adapted to the dry conditions.

According to this result, it may be concluded that a system of managing saline land can be established by artificial vegetation, consisting of several indicator species. Further, the practical application of the system will prevent the erosion of soil and sand in the region.

INTRODUCTION

Around 1950, as population increased, native dry deciduous forests began to be felled to develop farmland, housing, roads and other facilities in the northeastern part of Thailand. The gradual disappearance of the vegetation was followed by an unexpected phenomenon — salt began to rise from the underlying rock salt layer to the surface and accumulated on the ground, resulting in the salination of the soil. Once soil becomes salt-affected, most vascular plants are physiologically unable to grow and land becomes increasingly degraded. Primary vegetation cannot be restored or its recovery is greatly delayed.

This region has a distinct wet and dry season. Whereas the salinity of soil is reduced by flooding and water saturation in the rainy season, it is significantly raised by evaporation in the severe dry season, which is also extremely unfavorable to the growth of plants. Since soil salinity is variable throughout the year and soil moisture fluctuates significantly, various types of vegetation have

developed. A few dry deciduous forests, the original primary vegetation of this region, still remain in some districts.

In central and southern coastal areas, where soil salinity is generally high and soil humidity does not change as extremely as in the northeastern part, the halophytes communities including mangroves, *Suaeda maritima* and *Sesuvium portulacastrum* communities, have developed. These communities of coastal halophytes are not found in Khon Kaen, in northeastern Thailand, where salinity is almost at the same level. This is probably due, as stated previously, to extreme variation in the salinity and climate of the latter.

METHODS

Selecting sites in the Khon Kaen region for survey and vegetation plots, to carry out a survey on soil salinity.

The Khon Kaen district in northeastern Thailand is about 400 km northeast of Bangkok, the national

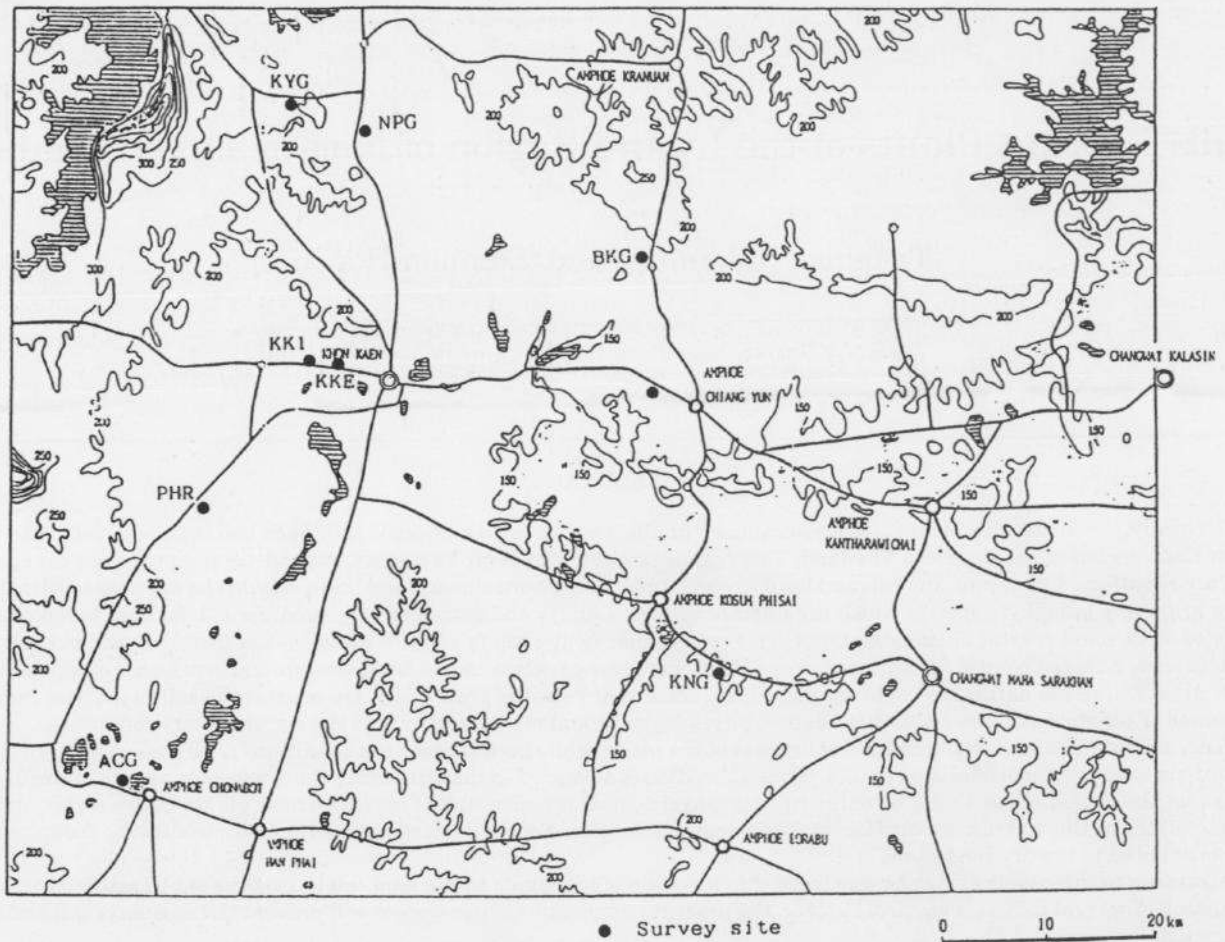


Fig. 1. Map of Khon Kaen area and the survey sites.

capital and is only about 150 m above sea level. Ponds occur in lower places and gentle undulations constitute higher places. There are mountains called Phu Kraddon and Phu Keou about 100 km west of the city of Khon Kaen and large and small mountains north and east of the city, surrounding the Khon Kaen Plain.

Many of the mountains surrounding the plain are rocky. Forests extend in places covered with soil, while shrubs or grasslands occupy other places. No salt was detected in the soil of these mountains regardless of the type of vegetation.

In contrast with the mountainous area, the flat area showed some salinity. Whereas salinity is low in the soil where forests remain, it is somewhat high in shrub land or grassland and very high in grassland and bare land.

Thus, bare land, grassland and shrub land will provide appropriate sites for studying vegetation to clarify the pattern of succession in saline areas. We selected a total of 9 sites for survey (3 on bare land, 4 on grassland and 2 in shrub land). We also selected

a total of 23 plots and set up quadrats with a specified area in each site.

To measure soil salinity, we sampled soil with sampling tubes at three places within each quadrat. These samples were dried and mixed with distilled water, and their electric conductivity was measured with an EC meter at the Pedological Laboratory of Khon Kaen University. Although the results of the measurement should be converted into salinity values, we substituted mean EC values for salinity.

Figure 1 illustrates a conceptual plan of the Khon Kaen district, including the sites surveyed.

Vegetation surveying method and listing of constituent species.

At the above-mentioned 9 sites, we used Braun-Blanquet's estimation method based on sociability and coverage. This method estimates the type of a community by selecting 3–5 plots as quadrats with a certain area in each site, studying constituent species within each quadrat and measuring the sociability and coverage of each species.

Although this survey was initially designed to understand the types of the community and their succession process in the Khon Kaen district, we were also able to determine the frequency of occurrence of species within each of several quadrats by listing species which occurred in each plot.

Through the Braun-Blanquet method for studying vegetation in this study we were thus able to understand the frequency of occurrence of plant species, as well as soil salinity.

We classified and identified plant samples collected in this survey. The staff of the Herbarium of

Kasetsart University, as well as the Herbarium of the Royal Forest Department, Thailand, helped and instructed us in comparing our samples with their specimens.

RESULTS

Occurrence of species

Of the species recorded (about 184 spp.) in all plots, those that occurred at a frequency of over 30% are listed in Table 1 according to vegetation type — bare land, grassland and shrub land.

TABLE 1

A list of plants on saline soil in Khon Kaen areas

<i>Abrus villosa</i>	(Leguminosae)	<i>Glinus oppositifolius</i>	(Aizoaceae)
<i>Abutilon indicum</i>	(Malvaceae)	<i>Hedyotis teneliflora</i>	(Rubiaceae)
<i>Alternanthera pungens</i>	(Amaranthaceae)	<i>Helicteres hirsuta</i>	(Sterculiaceae)
<i>A. sessile</i>	(Amaranthaceae)	<i>H. lanata</i>	(Sterculiaceae)
<i>Asparagus ramosus</i>	(Liliaceae)	<i>Hymenachne indica</i>	(Gramineae)
<i>Azima sarmentosa</i>	(Salvadoraceae)	<i>Hyptis suaveolens</i>	(Labiatae)
<i>Borreria articularis</i>	(Rubiaceae)	<i>Imperata cylindrica</i>	(Gramineae)
<i>Brachiaria mutica</i>	(Gramineae)	<i>Ipomoea reptans</i>	(Convolvulaceae)
<i>Chrysopogon aciculatus</i>	(Gramineae)	<i>Leptochloa chinensis</i>	(Gramineae)
<i>Chloris barbata</i>	(Gramineae)	<i>Leucaena leucocephala</i>	(Leguminosae)
<i>Combretum quadrangulare</i>	(Combretaceae)	<i>Lindernia antipoda</i>	(Scrophulaceae)
<i>Crotalaria pallida</i>	(Leguminosae)	<i>L. crustacea</i>	(Scrophulaceae)
<i>Cyanotis axillaris</i>	(Commelinaceae)	<i>Lipocarpa microcephala</i>	(Cyperaceae)
<i>Cynodon dactylon</i>	(Gramineae)	<i>Lippia nodiflora</i>	(Verbenaceae)
<i>Cyperus aestivilis</i>	(Cyperaceae)	<i>Massia trisetia</i>	(Gramineae)
<i>C. compressus</i>	(Cyperaceae)	<i>Maytenus mekongensis</i>	(Celastraceae)
<i>C. grossus</i>	(Cyperaceae)	<i>Melastoma villosum</i>	(Melastomaceae)
<i>C. haspan</i>	(Cyperaceae)	<i>Nimosa pudica</i>	(Leguminosae)
<i>C. iria</i>	(Cyperaceae)	<i>Murdannia nudiflora</i>	(Commerinaceae)
<i>C. pulcherrimus</i>	(Cyperaceae)	<i>Panicum cambodiense</i>	(Gramineae)
<i>C. rotundus</i>	(Cyperaceae)	<i>P. repens</i>	(Gramineae)
<i>Dactyloctenium aegyptiacum</i>	(Gramineae)	<i>Paspalum orbiculare</i>	(Gramineae)
<i>Desmodium heterophyllum</i>	(Leguminosae)	<i>Pluchea indica</i>	(Compositae)
<i>Digitaria adscendens</i>	(Gramineae)	<i>Phyllanthus collinsae</i>	(Euphorbiaceae)
<i>D. sanguinalis</i>	(Gramineae)	<i>P. virgatus</i>	(Euphorbiaceae)
<i>Dioscorea gibbiflora</i>	(Dioscoreaceae)	<i>Polygala glomerata</i>	(Polygalaceae)
<i>Echinochloa colomum</i>	(Gramineae)	<i>Randia tomentosa</i>	(Rubiaceae)
<i>Eichhornia crassipes</i>	(Pontederiaceae)	<i>Rhynchelytrum repens</i>	(Cyperaceae)
<i>Eragrostis browii</i>	(Gramineae)	<i>Sesbania bispinosa</i>	(Leguminosae)
<i>Eupatorium odoratum</i>	(Compositae)	<i>Sida retusa</i>	(Malvaceae)
<i>Euphorbia heterophylla</i>	(Euphorbiaceae)	<i>Stachytarpheta indica</i>	(Verbenaceae)
<i>Fimbristylis aestivalis</i>	(Cyperaceae)	<i>Synostemon bacciformis</i>	(Euphorbiaceae)
<i>F. dichotoma</i>	(Cyperaceae)	<i>Tridax procumbens</i>	(Compositae)
<i>F. miliacea</i>	(Cyperaceae)		
<i>Gisekia pharnacioides</i>	(Aizoaceae)		

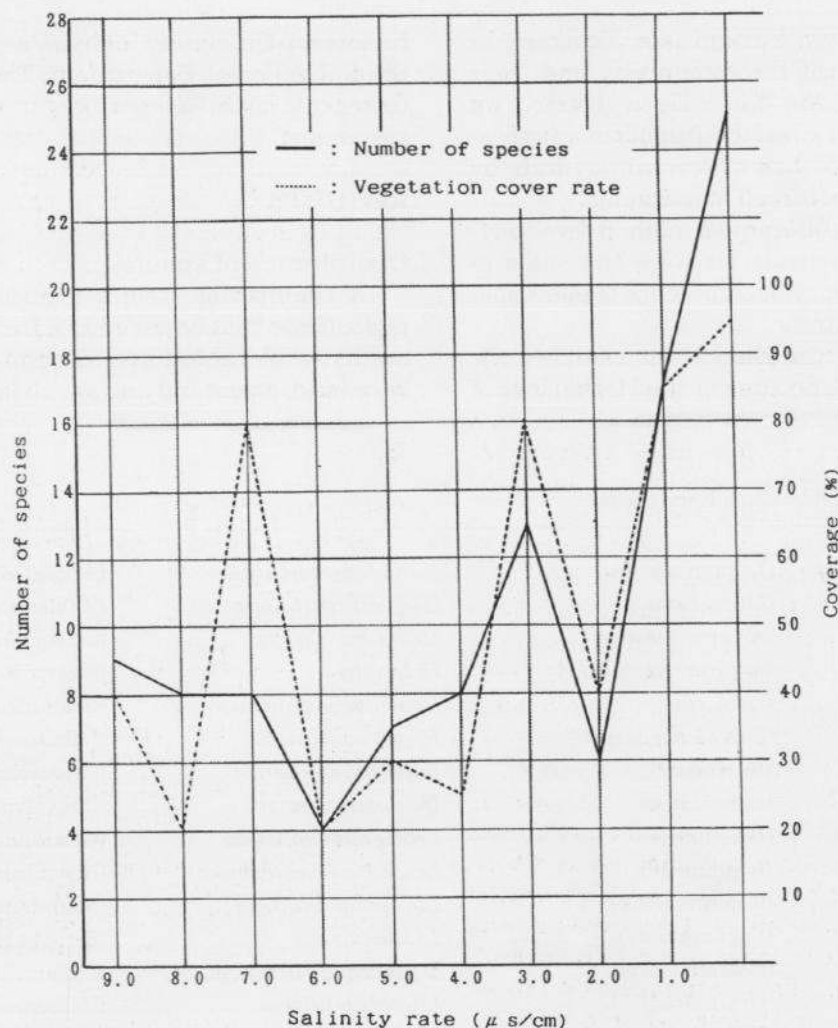


Fig. 2. Number of plant species and vegetation coverage on salinity rate.

Soil salinity and the occurrence of plant species.

Plant species which were found in each of 23 selected plots (in the above-mentioned land with the three types of vegetation affected by soil salinity) can be summarized as Fig. 2, in a decreasing order of salinity

These results show that the higher the salinity, the less species grow. This means that only a limited number of species can grow in highly salt-affected soil. These species are halophytes, though it is not clear whether they are tolerant to salt, or euryhaline of it. Although it is impossible to discern accurately how much salinity halophytes can stand, the graph indicates that the number of species shows a sharp increase at an EC of 2.00 or less and these species do not occur in salt-affected soil above that critical level. Thus, species which are found in soil with an EC of more than 2.00 can be called halophytes.

Halophytes based on this criterion are:

- Azima sarmentosa* Benth. et Hook. (Salvadoraceae)
- Cyperus alternifolius* L. (Cyperaceae)
- Cyperus haspan* L. (Cyperaceae)
- Fimbristylis aestivaris* Vahl (Cyperaceae)
- Fimbristylis dichotama* Vahl (Cyperaceae)
- Gisekia pharnacioides* L. (Aizoaceae)
- Maytenus mekongensis* Ding Hou (Celastraceae)
- Panicum repens* L. (Gramineae)
- Paspalum orbiculare* Forst. (Gramineae)
- Pluchea indica* Less. (Compositae)
- Synostemon bacciformis* G.L. Webst. (Euphorbiaceae)

The number and coverage of species

It would create problems if we were to determine a limited number of species as halophytes, based on the frequency of occurrence. Plants grow in different conditions in the plots surveyed: even a single poor tree is also counted as a single species. Since species should be compared with one another in growth condition as well as frequency, we placed the cover-

age of species on the frequency graph (Fig. 2).

According to this graph, the number of species is not necessarily parallel with their coverage. Low coverage indicates low development of communities in spite of a large number of species. Conversely, high coverage indicates high development of communities, even when the number of species is few.

CONCLUSIONS

Based on the foregoing results, halophytes could be identified in the salt-affected soil of the Khon Kaen district in northeastern Thailand. We were also able to understand the ecological characteristics of these halophytes, as indicators of soil salinity and their adaptability to the environment.

Two types of vegetation consisting of halophytes can be identified in this highly saline district.

One type is found in strongly saline areas where crystalline salt is observed on the ground in the dry season and many halophytes can be found. These halophytes are highly tolerant to salt and extremely resistant to drought. There is a large variation in species observed between the wet and dry season.

Even if areas are flooded in the rainy season, in some places rainwater remains undrained and salt may not disappear though it is diluted. Accordingly, a few species of halophytes which grow in coastal areas also occur in these areas. These species will, however, wither as they cannot stand extreme aridity in the dry season. Their communities can be found in paddy fields or in areas around brackish ponds through the year.

The other is found in dry grassland to low shrubland. This vegetation is better developed than the former. It is characterized by communities of somewhat succulent herbs which exist sparsely in grassland of mainly Gramineous herbs, where communities of shrubs also partially exist. The halophytes found in these areas are not only tolerant to salt but also physiologically and morphologically adaptable to intense aridity. More specifically, they include succulent plants, plants having thorns on their main stems and branches and some species of herbaceous monocotyledons.

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