IMPLEMENTATION OF REFORESTATION AND AGRO-FORESTRY USING SHALLOW WELL FOR SOIL SALINIZATION MITIGATION AND MANAGEMENT IN THE NORTHEAST OF THAILAND

R. Im-Erb, C. Dissataporn, P. Yamclee, P. Pongwichian and A. Somrang
Land Development Department, Bangkok 10900, Thailand

Abstract
The impact from soil salinization has been of primary concern to our country. The Land Development Department has been operating the Prevention of Soil Salinization and Rehabilitation Plan. The Reforestation Project was implemented in an area of 2000 ha of Nakhon Ratchasima province in the north-east region from 1996-1999. The results, however, are satisfactory in the physical aspect but a number of farmers do not accept it, particularly in the recharge area where there is no impact from salinity at all. This problem has resulted from the types of trees planted, most of which do not generate income and farmers are being hampered by their poverty.

An alternative way has been used in the Salinity Prevention Using Shallow Well for Irrigation Project. The objective of the project is to utilize perched groundwater to lower the groundwater table, resulting in that the saline groundwater in the adjacent discharge area will be unable to transport salts to the soil surface. An agro-forestry system was applied to the recharge area of this project in 2003. This area is grown to cash crops, fruit trees, fast growing trees, native vegetation, with some fish ponds for 125 farmers. It covers an area of 100 ha across 17 north-eastern provinces. The results show that farmers are satisfied with farm products for their living and particularly the additional income. With positive farmer responses, the Land Development Department extended this project in 2004 to cover 287 farmers and an area of 230 ha. However, this in this extension the farmers will have to partly pay for the costs.

Key words: salt-affected soil, soil salinization mitigation

Introduction

The north-east region covers approximately one-third of the total area of Thailand. It comprises 19 provinces with 9.25 million hectares of agricultural land, representing almost one-half of the total arable land of the country. The geomorphologic characteristics of this region are different from the others; it is a plateau, uplifted from the sea, with rolling and undulating topography. Almost all of its area is under rainfed condition. An average annual rainfall in most of the region is below 1100 mm with irregular distribution and long drought periods and concentrated in summer season, resulting to occurrence of seasonal dry land. With a large area, it comprises of various degraded soils. Among these soils, salt-affected soils are the most important problem soils in this region.

The salt-affected areas in north-east region cover an area of 2.8 million hectares and potential salt-affected lands exist in 3.1 million hectares. The formation of salt-affected soils in these areas was caused by the weathering of salt-bearing rocks and rock salts under the ground of Khok Kruat and Mahasarakham formations, including saline groundwater. Although the salt-affected areas in the Northeast region are only 5.4 percent of arable land of the country but it is constrained and has become a major problem which causes serious effects on the productive capacity of the land.

As degraded soils with serious problems are directly related to national agricultural production and rural poverty issues in the country, the government considers that the introduction and implementation of appropriate strategies and effective countermeasures such as reforestation and agro-forestry using shallow well for soil salinization mitigation and management have been selected and used to cope up with increasing adverse effects of salinity development which continues to extend to arable land and overcome production constraints, for a better crop production. This shows the magnitude of the problems that must be solved in order to achieve sustainable use of land resources for our future generations.

Materials and Methods

Deforestation and planting shallow-rooted crops resulted in less consumption of rainwater and more excess water penetrates down to the water table. These changes in groundwater hydrology have resulted in the movement of saline groundwater and its salinity level. Accumulated salts in the soil since long ago have dissolved and transported toward the soil surface. Reforestation and the use of good quality of groundwater for agriculture are the alternative ways to lower groundwater table through the consumptive use of water by trees.

Reforestation for salinity control
The project was conducted at Khamtalaeso District, Nakhon Ratchasima Province in 1996-1999. The study area was approximately 2000 hectares, comprising of various geographical features such as hills, low terraces, slightly undulating and low-lying areas, with different salinity levels. Land use of these areas on the upland have been used for orchard plantation, cassava, kenaf and shrubs, while in the lowland it has been used for paddy rice, salt production, with some patches of barren land. Soils are infertile with coarse texture, high salinity and water shortage, which are impeded to crop production.

Piezometers were installed at the depth of 5, 10, 15, 20 and 30 m to monitor the changes of the groundwater. Water samples and water level of each piezometer were measured monthly from September 1995 to June 1997. Soils were collected to analyze for physical and chemical properties.

Designation of recharge and discharge areas was done by using of Electromagnetic Induction Meter (EM 34) to obtain apparent electrical conductivity values (EC_a), which surveys on 1 x 1 km grid, given nominal reading depths of 7.5, 15 and 30 m below the soil surface. They were identified on the average ratio of EM reading as following equation: EM slope = 0.33 (V30/ V15 + V30/ V7.5 + V15/ V7.5); where the EM slope is greater than 1.2 that is the recharge area. However, the areas are classified into non-saline soil (0-80 mS m^{-1}), slightly saline soil (80-120 mS m^{-1}), moderately saline soil (120-160 mS m^{-1}), severely saline soil (160-200 mS m^{-1}) and very severely saline soil (>200 mS m^{-1}).

Planting procedures were used on screening tree varieties for reforestation. It is necessary to select the suitable plant varieties for its area depending on environment conditions such as soil salinity level, water logging, etc. Moreover, the farmers had participated on selection of favored plant varieties to grow on their farms. In the recharge areas where the soils have low salinity, selected fast-growing trees and fruit trees were eucalyptus, neem tree *(Azadirachta indica)*, tamarind, manila tamarind, while in the discharge areas, *Acacia ampliceps* was planted as a highly salt-tolerant tree. On both sites, they were planted at a spacing of 2 x 2 m.

In order to promote favorable condition of plant growth, land preparation, and planting techniques including soil management were applied in the project which are seedbed preparation (single row beds), mature seedlings, soil amendment (farmyard manure, 12.5 t ha^{-1}), mulching (rice husk, 12.5 t ha^{-1}), chemical fertilizer (NPK: 15-15-15, 12.5 t ha^{-1}). A double mound (M-shaped) bed was used to prevent salt accumulation on soil surface in the discharge areas where the salinity of soils is high.

Use of shallow well for soil salinization mitigation and management
In the Northeast region, the reforestation for salinity control is sometime not acceptable to farmers due to the types of plant varieties and their poverty. They do not appreciate the usefulness of the fast-growing trees provided by the government. The alternative ways are identified to solve the problems.

Interest on the use of shallow well for crop production in the Northeast region was started at Ponduen Sao-ae village, Suwanapum district, Roi-et Province in 1988. Survey on water quality was carried out; water samples from 166 wells were analyzed including color, temperature, depth, water level and the width of the well. Most of its area, approximately 32 hectares, were used for agricultural production, comprising various kinds of vegetables such as egg plant, cucumber, tobacco, chili, etc. (Sombatpanit, et al., 1988).

Later in 2003 the Land Development Department has succeeded in conducting a techno/demonstration farm at Kamrean Village, Banphai District, Khon Khaen Province. Farms of approximately 1.0 hectare in size, with two shallow wells, were arranged for agro-forestry system. Various kinds of plants and cash crops have been planted, with fish culture included. After that, the implementation on using of shallow well for soil salinization mitigation and management was extended to 15 areas covering 100 ha (125 farmers) in 2003 and 230 ha (287 farmers) in 2004.

Results and Discussion

Reforestation for salinity control
The total recharge areas covered 600 hectares where the soils are classified as slightly and moderately saline soil with electrical conductivity (EC) of 2-12 dS m^{-1} while the discharge area extended in an area of 2400 ha with high salinity, the EC levels being in the range of 12-45 dS m^{-1}. The groundwater table was in the range of 50-100 cm below soil surface. An average of salinity level of soils in recharge and discharge areas was decreased from 3.23 to

1.28 dS m^{-1} and 19.2 to 8.66 dS m^{-1}, respectively. Moreover, the salinity level of the soils under plant canopy and outside the canopy ranged from 33-99 and 57-101 mS m^{-1}, respectively.

The changes of salinity in groundwater show that the EC_w in recharge and discharge areas was in the range of 1.3-0.6 and 7.35-5.80 dS m^{-1}, which tended to decrease to 0.81-0.67 and 6.96-5.26 dS m^{-1}, respectively from 1 year of planting (Im-Erb and Yamclee, 1997). After 4 years from planting, however, the water level in piezometers in recharge and discharge areas was lowered from 4.81 to 5.81 m and 0.48 to 1.04 m, respectively. These results might be the consequence from the effect of precipitation during wet and dry period of each year and salt excretion process of trees. Similar to Arunin (1989) who reported that 5-6 year old eucalyptus tree planted in recharge area could lower the groundwater level to 1-3 m. Reforestation using fast-growing trees with rooting depth greater than 2 m in recharge area could be the most appropriate practice for salinity control (Williamson *et al*., 1989).

Performance of trees showed a good sign of survival under circumstantial saline soils condition in Northeast region, which depended on salt toleration of their varieties. After 4 years, *Azadirachta indica, E. camaldulensis* and *A. ampliceps* were able to tolerate moderately saline soils (Pongwichian et al., 2004). Marcar (1997) reported that *A. ampliceps* was one of the species that performed well in inland saline soil in Thailand. The survival percentages of trees that grew in 1996 and 1999 were found to be 20.3, 24.0, 37.5 and 42.0 percent, respectively (Table 1).

Table 1. Survival percentage of trees at the fourth year after planting

Planting year	Plant species	Total plant	Survival percentage
1996	*A. amplicep, A. indica* *E. camaldulensis*	800,000	20.34
1997	*A. amplicep, A. indica* *E. camaldulensis* *C. siamea*	1,456,000	24.06
1998	*A. amplicep, A. indica* *E. camaldulensis* *C. siamea*, *T. Indica* *P. dulce*	1,200,000	37.5
1999	*A. amplicep, A. indica* *E. camaldulensis* *C. siamea*, *T. Indica* *P. dulce*	1,600,000	42.0

Sources: Yvaniyama 2003 and Pongwichian 2004

Using of shallow well for soil salinization mitigation and management

The water quality of wells at Tung Kularonghai, Roi-et Province showed that 55 wells had EC_w of groundwater < 0.10 dS m^{-1}, 62 wells were in the range of 0.10-0.25 dS m^{-1}, 35 wells were in the range of 0.25-0.75 dS m^{-1}, 13 wells were in the range of 0.75-2.25 dS m^{-1}, and 1 well was > 2.25 dS m^{-1}. The width of the wells was 90-110 cm. Groundwater level from soil surface was 254-265 cm while the water depth from the bottom of well to surface of water was 53-74 cm. However, an average of water temperature was 27-28°C. In Muang Pia Village, Ban Pai District, Khon Kaen Province, an average EC_w of groundwater from well was 0.50 dS/m with pH level of 6.6 while temperature was 27.5°C.

For the attitude of farmers on reforestation about 34 percent showed that they appreciated the usefulness of its return due to types of plant varieties and poverty (Yamclee *et al*., 2002). Agro-forestry was introduced to farmer as techno/demonstration farm. The selected economic crops such as vegetables and fruit trees, as well as fish culture, were used to implement for increasing production capacity and income. Economic return was recorded which showed that growing a single cash crop (morning glory) within 40 days on techno/demonstration farm in an area of 220 m^2 gave a net profit of 1583 Baht or US$40. However, if the farmer expands its area to 1600-3200 m^2 as a normal size for growing cash crop of small-scale farmers, the profit would be 11500-23000 Baht or US$375-575. With quick economic return and particularly the crops are also palatable, most farmers have been satisfied with the new concept. The Land Development Department has therefore positively responded by extending the project to involve 125 farmers, covering an area of 100 hectares in 2003 and later to 287 farmers in 230 hectares in 2004.

Conclusions

Reforestation project on salt-affected soils showed that the selected plant varieties were grown with a good performance in the Northeast region condition, resulting to a tendency of lowering groundwater table and

decreasing salinity level of soils in recharge and discharge areas. Although the project is satisfactory in the physical aspect but a number of farmers do not accept due to type of plant varieties and poverty. Salinity Prevention Using Shallow Well for Irrigation Project was implemented as alternative way of soil salinization mitigation. Agro-forestry was introduced in recharge area of its project where cash crops, fruit trees, fast growing trees, native vegetables were grown and fish ponds were conducted. With positive farmer responses, the Land Development Department has extended this project in an area of 100 ha in 2003 and 230 ha in 2004.

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