Salinity control by farmers practices in sandy soil

Maeght, J.L.[1]*; O. Grungerger* [1]*; H.C.*[1]*; S. Sukchan*[2]*; C. Hartmann*[1]
and W. Wiriyakinateekul[2]

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Abstract

Northeast Thailand is an area where the population (near 20 million) is dependent on white rice production, for their livelihood. Rice is produced on low fertility sandy soils using traditional techniques within the context of significant socio-economic constraints. Rice production is generally low due to several constraints that are not entirely due to the farmer. The development of salinity is one of the environmental constraint that farmers face. Salinity often becomes evident as salt patches that appear as crusts during the dry season. In field studies it has been shown that a combination of flooding, puddling and drainage reduced the level of salinity by 50% (initial electrical conductivity >4 mS cm^{-1}). With this decline in salinity rice is able to grow adequately in these patches. However, this positive effect is only temporary. Field measurements indicated that, salt plumes due to the positive pressure head of the saline groundwater forced saline waters to the surface. The saline patches were located on slight elevations within the field, suggesting that they become points of salt concentration associated with capillary rise as the paddy dries out. Through land levelling these high points would be eliminated and reduce the risk of salt concentrations. In addition, levelling the field surface would during flooding result in a more uniform depth of water above the saline patches. Levelling cannot stop the upward movement of saline water under pressure but it can alleviate the secondary salinisation due to surface evaporation when the soil dries out. This simple and easily adopted practice represents an effective method of managing salinity associated with groundwater rise in these lowland rice production systems.

Introduction

According to recent estimations, 6.5% of the earth’s surface is affected by problems of salinisation (Cheverry et al., 1998). This is also the case, in Northeast Thailand on soils that are of low fertility. In this region, approximately 17% of soils are affected by salinity (Arunin, 1984) and a further 108,000 km^2, which is more than twice the size of Switzerland are potentially at risk from the same phenomenon. In Northeast Thailand, the main cause of the extent of salinisation is believed to be upland deforestation leading to a rise of the saline water table (Williamson et al., 1989). In some cases the salinisation causes saline patches to form, which can reach a diameter of 25 meters.

Salinisation of soil is of increasing importance to national stakeholders concerned with the conservation of their agricultural land (Kohyama K. and Subhasaram, 1993). A decrease in rice production yield due to the occurrence of these regional saline patches could have serious affects on this area’s ability to satisfy the rising food demands of its increasing population (Fukui, 1991. Kono, 1991). In addition, rice cropping forms an intricate part of Northeast Thai culture, well established and important in a socio-cultural and economic aspectsl (Formoso et al., 1977), for which a decreasing yield would have serious consequences. The majority of the local population produce glutinous rice intended for their own consumption. When the area is large enough, jasmine rice is also produced for commercial consumption (Berio, 2005). Pluvial monoculture of rice crops is the main source of agricultural income in this area.

The problems of salinisation have been studied for many years in this region of Thailand (Arunin, 1984; Mitsuchi et al., 1986; Yuvaniyama A. 2001). However, there are still unanswered questions on the dynamics of these saline patches, especially during the

[1] Land Development Department, Office of Science for Land Development/IRD, Phaholyothin Road, Chatuchak, Bangkok 10900, Thailand. E-mail Address: maeght@ird.fr
[2] Land Department Development, Office of Science for Land Development, Phaholyothin Road, Chatuchak, Bangkok 10900, Thailand.

rainy season and the possibility of the farmer’s practices controlling their development. With this objective, ways of controlling the effects of these saline patches were studied, and in particular, the tillage practices used in preparing the soil, that includes levelling in the presence of standing water within the field. This practice has already been used in other contexts and on other soils, notably in Senegal (Hammecker and Maeght, 1999). It was then necessary to evaluate the duration of the effects of the resulting desalinisation on the next season’s crops when the soil would be submerged. Topographic readings and measures by penetrometer were made in order to better explain the processes of soil evolution.

Materials and methods

Study area

The experiments were conducted on plots in Pra Yuhn, near Khon Kaen, Northeast Thailand (16º21′12.744″ North and 102º36′29.8″ East). The region’s soils are very sandy (Mitsuchi et al., 1986; Yuvaniyami 2001) and also poor in nutritive elements (Ragland and Boonpuckake, 1988). The soil has a sandy loam texture (Grunberger, 2002), less than 10% clay content and low levels of organic matter (Table 1).

These utisols of the Roi Et series have low cation exchange capacity, less than 5 $cmol_c$ kg^{-1} of soil (Table 1). In the saline patches the exchangeable complex has a higher sodium content compared to outside the patch. The region has a tropical, Savannah climate with rainfall of 1,200 mm that fall pre-dominantly from May to October. Evaporation is higher than precipitation, except in the height of the rainy season from July to September (Bolomey, 2002). Soil is regularly saturated by solutions of NaCl as the water table rises and conductivity has an average value of 20 dS m^{-1} and pH of 5.82. The water table is near the soil surface at the end of the rainy season and draws down by two metres in the dry season.

The soil was cultivated using traditional implements whilst maintaining a sufficient water level so that the entire field surface was covered. The soil surface was levelled and once completed, the excess surface water was drained from the field.

Three sampling exsercises were undertaken using a grid made up of squares each measuring 2 m^2 that covered the whole plot. The quantity of reference points gathered has enabled the results to be presented in map form. It has also been possible to describe the form of the saline patches seen at soil surface in a spatial context. The topsoil (0-20 cm) of soil were removed in a tube and then mixed. EC of the soil extract (1:5) was measured on each sample. Two hundred samples were collected over the three sampling dates. The first phase took place before working the soil, the second, just after drainage of surface water following cultivation and levelling. The third phase took place after rice was harvested. The first two phases of sampling will show the effect of desalinisation by cultivation of the soil under a shallow water layer and the third phase will give information as to the persistence of this desalinisation.

The levelling of the topsoil was made easier by using topographic references (with a precision of 1 cm) on the same grid system as the maps of salinity. Seven other maps were made of the topographic surface on other plots with saline patches in order to provide more information. Resistance measures were made using a hand penetrometer (Eijkelkamp), on several plots of the same area inside and outside the saline patches and at profiles from 0-80 cm. Each layer was tested five times for each profile 5 by 5 cm.

Results

The initial map of salinity, made on the plot prior to cultivation of the soil clearly showed the presence of saline patches covering 20% of the area (Figure 1).

Maximum EC values exceeded 4 ds m^{-1} at many points in the saline patch. The second map, made after the soil was worked resulted in a significant decline in EC with maximum values not exceeding more than 2 dS m^{-1}. This was attributed to the diluting effect of

Table 1. Selected soil chemical and physical properties in and external to a salt patch

Depth (cm)	Interior of the salted spots						External of the salted spots					
	Sand %	Silt %	Clay %	CEC $cmol_c$ kg^{-1}	pH H_2O	C %	Sand %	Silt %	Clay %	CEC $cmol_c$ kg^{-1}	pH 1:5	C %
0-9	66	28	6	1.4	7.0	0.4	55	40	4	2.0	4.4	0.4
15-20	60	34	6	1.5	6.7	0.1	63	31	6	2.0	5.7	0.1
25-35	63	31	6	1.5	6.4	0.0	60	34	5	2.4	5.9	0.0
45-55	48	29	14	4.7	7.5	0.0	44	42	15	2.5	5.6	0.0

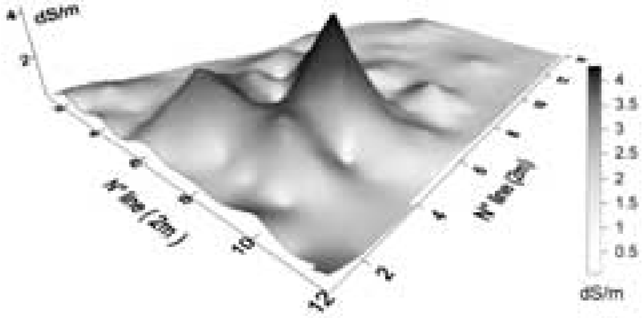

Figure 1. Map of electrical conductivity (EC) prior to land preparation

Figure 2. Distribution of saline patches after cultivation, puddling and subsequent draining of the field prior to rice establishment

the standing water and the subsequent draining of the field (Figure 2).

The third map, made after the harvest of the rice crop clearly shows that the salinity has started to rise during the growing season reaching values of 2.6 dS m^{-1} (Figure 3).

These readings show that it has not been possible to maintain the positive effect of desalinisation during the four months of crop cycle where the soil surface is submerged under a surface layer of water that is maintained due to the presence of bunds. The rising saline water table increased salinity in the centre of the saline patch to a depth of 20 cm from soil surface, the depth from which the soil samples were collected.

The topographic map reveals that the saline patches are found on slight elevations within the field of around 5 cm compared to surrounding soil surface (Figure 4).

The results of the control readings for the topography of 8 other plots confirm that for this area, 100% of the highest salinity occurs on elevated soil (Figure 5).

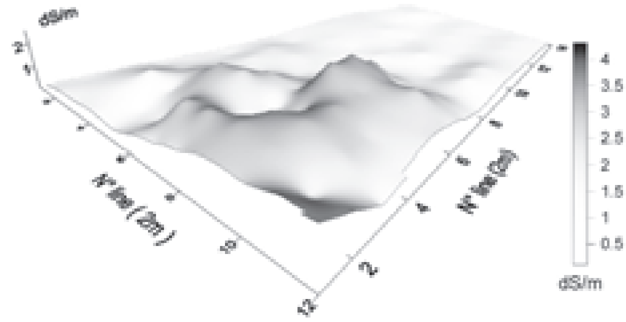

Figure 3. Electrical conductivity measurements conducted at the time of the rice harvest

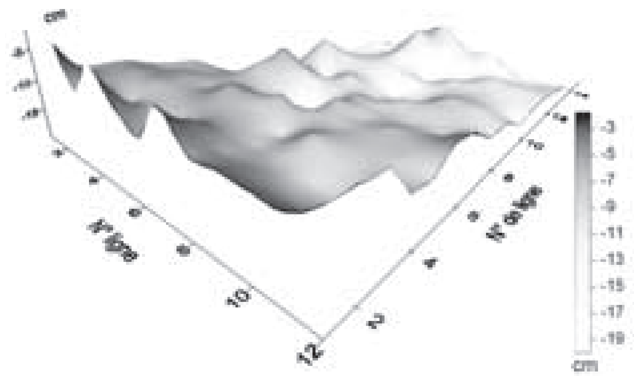

Figure 4. Topographic map of height differences within a field indicating the non-uniform levelling achieved

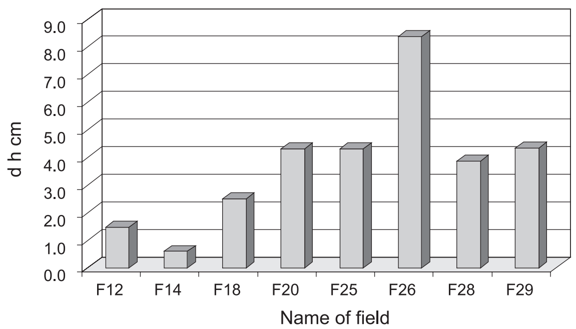

Figure 5. Differences between the average height of saline patches when compared to non-saline areas in each of 8 fields sampled

The soils in the study plot typically show a layer of compact, resistant soil between -40 and -70 cm from surface. However, resistance measurements by penetration at the centre of the saline patches have shown that this resistant layer is absent (Figure 6). These results show an important difference in layer structure between the soil profile inside and outside the patch. This raises many questions as to the role of this compact layer and suggests the need for further research to understand the reasons for this modification in the profile which normally appears to be homogenous.

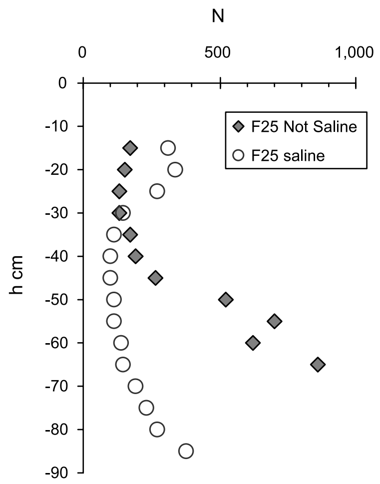

Figure 6. Penetrometer resistance measurements on soil profile inside and outside saline patch

Conclusion

This study has shown that it is possible to temporarily reduce the salinity associated with saline patches using simple farming techniques to work the soil. This desalinisation is altered by the rise of the saline water table towards the soil surface during the period of submersion. Salinity was however, found to be lower to that measured at the beginning of the field's crop cycle. This technique therefore enables at least temporarily more favourable growing conditions by reducing salinity by 50% in the elevated centre of the patch. This reduction even though temporary, also helps to prevent an eventual build up of salinity over the seasons.

The levelling out of the soil to reduce topographic differences between the elevated saline patch, and the rest of the field also has beneficial effects. The surface water could be maintained more evenly over the field's entire surface, helping to dilute salinity from the rising saline water table during submersion. The levelling of the sureface also helped to slow down the eventual formation of a drawing-up action on the higher parts of saline patches, sticking out from the surface during the dry season.

These simple methods of working the soil whilst submerged, levelling the surface and then draining off of the excess standing water can improve soil conditions for rice production. Easily implemented by farmers, these techniques are valuable in the control of soil salinity.

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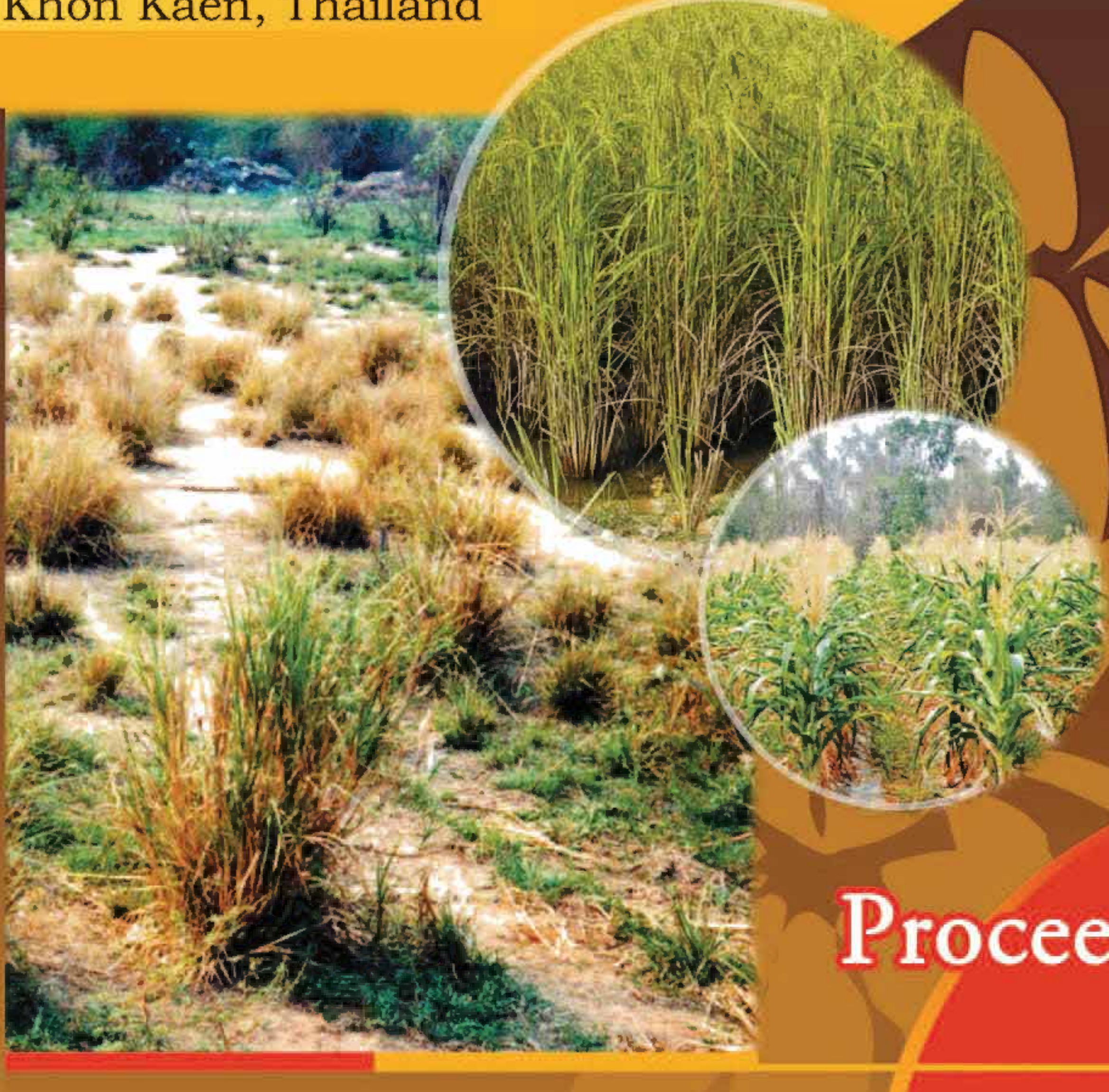

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For copies write to: Yuji Niino
Land Management Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200
THAILAND
Tel: (+66) 2 697 4000
Fax: (+66) 2 697 4445
E-mail: Yuji.Niino@fao.org

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