

Formation and Expansion of Salt Patches in the Paddy Field

I. A Salinization Process Observed in the Field

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ABSTRACT

Salt patches (salty and barren patches) which were recognized inside paddy fields of Northeast Thailand were examined in the fields. Repeated and detailed observations revealed that one type of salt patches were covered with sandy materials and was associated with destructed borders. These salt patches were formed and expanded both by spreading of the salty materials from borders of the paddy fields and by intrusion of the salty materials from the moderately to strongly salt-affected places by erosion which crossed the destructed parts of borders of the paddy fields. This process quickly occurred mainly at the pre-rain period to the beginning of wet season when a large amount of salt was accumulated on the surface of soils at moderately to strongly salt affected places and intermittent heavy rain induced rushing runoff water. In other words, this type of salinization consisted of two steps. The first step is accumulation of salt at the soil surface in rather limited places and the second step is wide spread of the salty materials formed by the first step. This process is hypothesized to be applicable to most of the salinization in Northeast Thailand. Another type of salt patch was not associated with the destructed borders and mainly found inside a few fields on the slope. It may be formed by coming up of the salt from below in the dry season which was leached down to the depth of the neighboring paddy field in the rainy season. Necessity to understand type and steps of salinization before countermeasures against salinization were proposed and emphasized

INTRODUCTION

In the salt-affected areas of Northeast Thailand, rice growth in a paddy field is sometimes patchy (Uvaniyoom, 1988). One main reason for this has been known to be patchy accumulation of salt ("salt patch") in the soil (Vichaidit, 1988). However, forming processes of the salt patch has not been fully understood.

Observations in the field suggested that there were several types of the salt patch. In this paper, results of field observations on two types of salt patch are reported. Among them, much attention is paid to a type formed by a two-step process, because this process is considered to be common for most of the salinization in Northeast Thailand. The other type of salt patch are supposed to be rather limited to the paddy fields at specific sites. Finally, the necessity to know the type and the step of salinization before selection of countermeasures against salinization will be stressed.

Salt Patches at Ban Phra Yun

Repeated observations were made from October, 1989 till July, 1990 both inside and outside the newly established experimental farm at Ban Phra Yun, Khon Kaen Province (Figures 1, 2). In this area, paddy fields were present outside the lower end of the newly established experimental farm. The paddy fields close to the experimental farm were strongly salt-affected and abandoned already. Salt patches of various shapes and sizes were recognized inside several paddy fields adjacent to these abandoned paddy fields. These salt patches diminished in size and number and finally disappeared with increasing distance from the newly established experimental farm.

During the rainy season, 1989, we found that no rice was present at salt patches in a paddy field and wondered how farmers recognized the salt patches before rice planting. When we observed the paddy fields after rice harvesting at beginning of the dry season, we noticed that weeds were growing everywhere inside the paddy field, though their growth was

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worse at the salt patches than other parts and that the salt patches were more sandy than the other parts of the paddy field. This suggested that the salt in the salt patches must have been carried from sandy areas along with sandy materials.

From detailed observations made at beginning of the dry season, 1989, we found that almost all the salt patches were associated with destructed parts of borders of the paddy fields. It appeared that these salt patches were expanded from the destructed parts of the borders (Figure 3). In addition, the severely destructed parts of borders were considered to be located in the passage of runoff water which originated at the moderately to strongly salt-affected places inside the experimental farm and passed through the abandoned paddy fields close to the experimental farm (Figure 4). In other words, the salt patches, the abandoned paddy fields and the moderately to strongly salt-affected places appeared to constitute a saline continuum.

These observations suggested that salt came down from the moderately to strongly salt-affected places and temporarily accumulated mainly at the borders which were located in the passage of runoff water and that these salty and dispersible parts of the borders were easily clamped by heavy rain in the rainy season. Thus, the salty sandy materials were spread over the paddy field resulting in the formation of the salt patches.

During the mid dry season, 1989-1990, we noticed that a large amount of salt was accumulated on the soil surface at the moderately to strongly salt-affected places inside the newly established experimental farm. We wondered how the salt accumulated on the soil surface was disposed when it rained.

After sudden and heavy rains (39mm) occurring a few times in February, 1990, we noticed that these rains caused not only washout of all the salt accumulated on the soil surface but also induced severe soil erosion. This erosion was especially pronounced at the moderately to strongly salt affected places because these areas were sandy and not covered with plant.

Shallow channels through which runoff water had rushed down were clearly recognized (Figure 5). Sand particles were sedimented in these channels as well as at other parts. At some places, the sandy sediment was covered with a thin layer of dark colored clayey materials. Salt crust was quickly formed on the surface of the dark colored clayey materials after termination of the rains. A part of the eroded particles and salt were transported to the barren areas outside the experimental field. Some of them reached the preexisting salt patches inside the paddy fields (Figure 6). These observations forced us to amend the above mentioned supposition in the following way:

1. In the rainy season, the parts of the borders near the salt patches were destructed, because they

were composed of salty sandy materials and because they were located at the passage of runoff water. The salty sandy materials of the destructed parts of the borders were spread over the paddy field and contribute to form the salt patch.

2. A long sunny period in the mid-dry season caused a large accumulation of salt on the soil surface at the moderately to strongly salt-affected places of the middle parts of the slope.

3. In the late mid-dry season to the beginning of rainy season, sudden strong rains provoked strong runoff water which not only eroded soil materials but also dissolved and transported the salt accumulated on the soil surface through the abandoned paddy fields to the low-lying paddy fields, its main passage being water courses of the runoff water which crossed over the severely destructed parts of the borders. This led to both intensification and extension (expansion) of the preexisting salt patches inside paddy fields. One reason for the abandonment of paddy field was too wide expansion of the salt patch.

4. The salty materials buried the previous plant cover and inhibited growth of new plants probably because the sandy coverage was too compact for seeds to germinate, deficient in nutrients and easily desicated on sunny days.

Observations made in the end of May when rainy season had already start revealed that erosion was more serious than before and that most of the salt patches as well as other barren sandy salty areas were exposed to the air when many paddy fields were submerged. Consequently, our previous supposition was subjected to further amendment in the following way:

1. The places including the salt patches were slightly higher than other places due to repeated sedimentation of salty materials and were less easily submerged than other places in the rainy season. This reduced removal of salt by percolation from the salt patch because most of the rain water runs over the salt patch.

2. preparation of paddy fields by plowing and harrowing was not effective to completely eliminate the differences in both the level and the texture. When the salt patch was well developed, farmers easily distinguished and did not plow it for rice cultivation any more.

We considered that to stop expansion of the salt patches, paddy fields must be enclosed by tall and tough borders which protect the paddy fields against intrusion of the salty materials from the moderately to strongly salt affected places. One of the problems in doing so is how to construct tall and tough borders at the places where only the salty sandy materials are available. The borders made of these materials are

expected to be easily destructed by rain and runoff water.

In February, 1990, we observed an area outside another experimental field at Ban Phra Yun situated at the opposite side of Route 2062 that runs between the two experimental fields. This area was a part of a small catchment and paddy fields were distributed both on the gentle slopes and at the bottom of a shallow valley (Figure 2). Paddy fields at the bottom of the valley appeared to be seriously damaged by sedimented salty materials which were carried by runoff water and became bare. A farmer told us that many paddy fields at the bottom of the valley had been abandoned about 5 years ago. These facts suggested that expansion of the salt patch was quick and that to suppress it was one of the most urgent actions to be taken in the areas affected with salt.

We found that some paddy fields on the slopes were enclosed with newly constructed tall and big borders (about 75 cm high, 100 cm wide) which were composed of pieces (20x20x10cm) of undisturbed plow layer containing rice roots (Figure 7). For the purpose of this construction, the plow layer at narrow bands (about 1.5 m wide) along both sides of the newly constructed borders were completely scraped out. Probably, farmers understood that 1) the damage of their paddy fields were mainly caused by intrusion of the salty materials and 2) tall and tough borders were effective to protect their paddy fields against the damage by this process and might consider pieces of the undisturbed plow layer containing rice roots were not easily disintegrated in the rainy season. Actually, farmers told that salt came down from upper parts of the slope and damaged their lower paddy fields. Unfortunately, the newly constructed tall borders were already partially damaged after being exposed to a few heavy rains in the dry season.

On the basis of these observations, we can say that enclosing the paddy field with tall and tough borders is really feasible and effective. To materialize this consideration, we must find practical and cheap techniques to construct the tall and tough borders in the salt affected areas. Utilization of a sheet of inexpensive plastic plate or of plastic film may be useful for reinforcing the borders.

Salt Patches at Ban Daeng yai

We observed a few times from October, 1989, till May, 1990, paddy fields and strongly salt-affected bare places at Ban Daeng Yai, Khon Kaen Province.

In the first survey to examine the impermeable layers (Puengpan et al., in press) we walked down from west to east along a slope acrossing the road and passing through strongly salt-affected places at the foot of the slope till the submerged paddy fields. At that time we noticed several salt patches inside some of the paddy fields on the slope. However, we could not get

any idea on the forming process of both the salt patches and the strongly salt-affected places, mainly because most of the area were covered with paddy rice.

In the second survey, we approached to the same strongly salt-affected places along a gentle slope from south to north. This time we had a chance to glance distribution pattern of the salt-affected places, because paddy rice was absent and salt crust and salt-affected bare places were clearly observed.

A part of tht strongly salt-affected bare places were sandy and found to be actually abandoned paddy fields. Development of the salt crust was most remarkable at the foot of the west-east slope and decreased with the distance from it. The strongly salt affected places with thick salt crust were slightly higher than other parts of the area. Salt patches were recognized inside the paddy fields surrounding the strongly salt-affected bare places. Most of them were covered with sandy materials and extended from the east side of the borders of the paddy fields to the west side. Size of salt patches decreased with distance from the foot of the west-east slope. The plow layers of paddy fields far from the strongly salt-affected places and free from the salt patches were clayey.

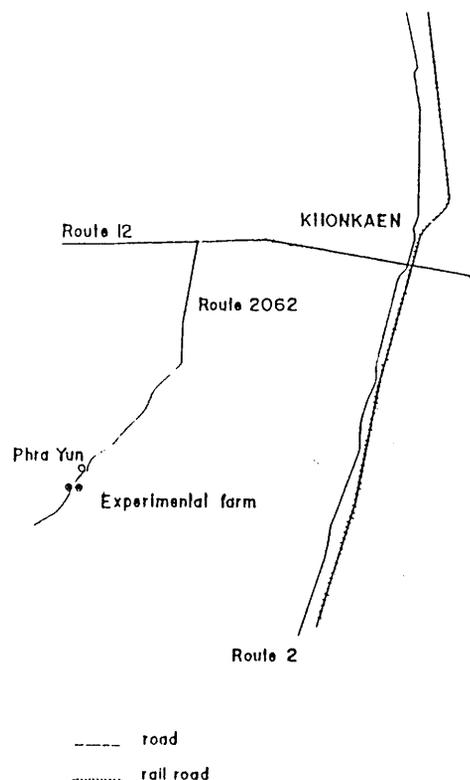


Figure 1 Site of investigation.

These observations suggested that in Ban Daeng Yai, most of the salt patches inside paddy fields at the foot of the slope were formed by being supplied with the salty materials from the strongly salt-affected places. That is, formation and expansion of the salt patches near the foot of the slope of Ban Daeng Yai were essentially the same as those of Ban Phra Yun.

In addition, we noticed another type of salt patches inside paddy fields at Ban Daeng Yai. These salt patches were not associated with destructed border and was mainly distributed inside the paddy fields on the slope (Figure 8). It was frequently present at the foot of an undestructed border between the paddy field concerned and its upper neighboring paddy field. This suggested that these salt patches were supplied with salt from the upper neighbor. Probably, salt in the lower horizons of the upper neighboring paddy field was leached down to certain depth during the period of paddy cultivation and came up from below at the paddy fields concerned in the dry season. The coming up of salt is commonly restricted at the foot of the borders. However, it may be possible for a part of the salt to come up to the place apart from the borders, the distance from the borders being controlled by various

factors including rain fall. Really, in some paddy fields, not only the foot of the border but also a narrow band in parallel with the border was salt-affected. A farmer told us that the salt patch at the foot of border appeared every year at the same place but the distance of the salt patch from the border varied from year to year.

Forming process of this type of salt patch is essentially the same as that induced by construction of reservoirs, though they are much different in scale.

Preparation of thick impermeable plowsoil or deeply inserting a piece of plastic plate along borders or covering the soil surface with some material (mulching) may be effective for preventing formation and expansion of this type of salt patches. Farmers put piles of compost or of garbage on the surface of the salt patch of this type in the hope that these materials were effective in eliminating the salt patch. To our impression, this farmers' practice was a complex of several unit operations. For instance, the piling of compost or garbage on the soil surface was a kind of mulching with materials containing nutrients and seeds of weeds. Actually, growth of weeds was vigorous on the piles of compost. Some of the weeds growing on the compost extended their territories to the surrounding salt patch. Consequently, the salt patch appeared amended.

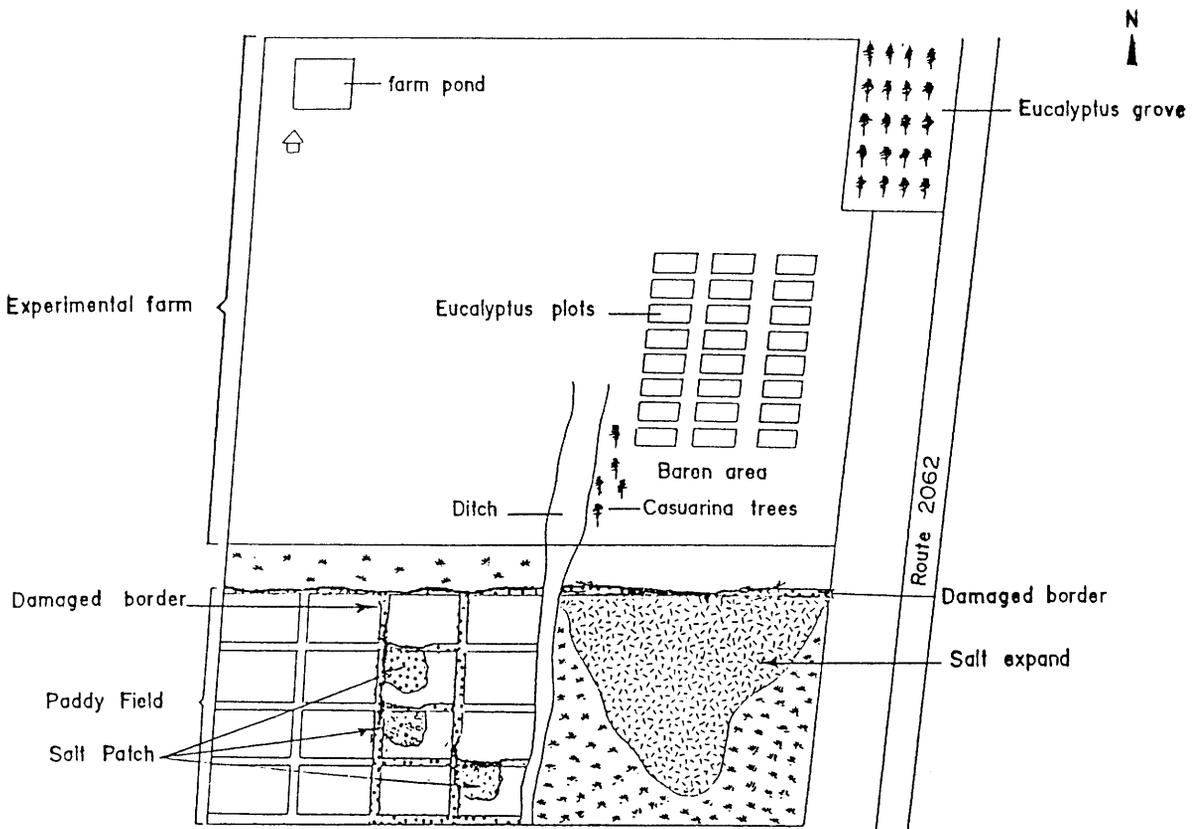


Figure 2 Experimental site at Ban Phra Yun, Khon Kaen Province.



Figure 3 A salt patch associated with a destroyed part of the border.



Figure 4 Salt patches extending from a destroyed part of the border.



Figure 5 Shallow channels and salt crusts formed by erosion after a shower in the mid-dry season.



Figure 6 A salt patch in expanded by sedimentation of the salty materials which were originated from the moderately to strongly salt affected place (right hand) and transparented across destructed parts of borders.



Figure 7 A tall and tough borders.



Figure 8 Salt patches not associated with destructed parts of the border.

GENERAL DISCUSSION

Among two types of salt patch mentioned above, some problems concerning the first type still remain to be discussed.

Formation and expansion of the salt patch of the first type is a 2-step process. Salt accumulated at the surface soil by any mechanisms (capillary rise, seepage, naum duns and even salt making (Furukawa and Wichaidit, 1989) in the dry season (or in any season) must be subjected to erosion when shower falls. In this sense, we can say that most of the salinization in Northeast Thailand are consisted of these two steps. **Naum duns** are mounds of varying heights and sizes and formed by spouting of confined saline ground water along with soil materials at the places of mechanical weakness.

Transportation of salt accumulated at the soil surface to the low-lying places by runoff was suggested by Arunin et al. (1989) for explaining the fact that low-lying places were more saline than terrace on the slope at Ban Daeng yai. Salt at the low-lying places was supplied by transportation from upper parts of the slope as well as by seepage of the saline ground water. However, the following facts are incompatible with the consideration that the transported salt is the main cause of expansion of the salt patch.

1. The bare salt patches were usually covered with reddish sand particles.
2. The boundary between the salt patch and the non-saline parts of the paddy field was clear.
3. The range of extension of the salt patch, which was considered to be originated from one point source of salt, was usually less than about 100 m.

All These facts support our supposition that sedimentation of the eroded salty materials are a real cause of expansion of the salt patch. In other words, if the transported salt were responsible for expansion of the salt patch, a much larger area would be salt affected at much quicker rate and boundary between the salt patch and non-salt patch places in the paddy field would be much more diffuse.

Some persons still ask the following questions:

1. Why is the salt patch covered with reddish sand particles?
2. Why is salinity in the part near the lower border of the paddy field not higher than that in the salt patch? The former must receive larger amount of salt than the salt patch itself, because most of the salt contained in the runoff water must pass over the salt patch and reach to that place.
3. Why are weeds always absent at the salt patches inside paddy fields?

To answer these questions, we examined salt

patches in the middle of rainy season and obtained the following information:

1. The salt patch was actually composed of many layers or lamellae of different texture and composition. The thickness of the sediments decreased with increasing distance from the destructed upper border (In one case, 15 cm near the upper border). The top layer was composed of reddish sand particles and its thickness also decreased with increasing distance from the destructed upper border and disappeared at the boundary between the salt patch and the non-salt patch places. Dark colored clayey lamellae of varying thickness which appeared similar to the impermeable layer were recognized in the depth. This internal organization of the salt patch must be a reflection of repeated sedimentation of transported materials by runoff water with different flow rates.

2. The clayey lamellae were already strongly reduced probably because they were rich in organic matter and always saturated with water.

3. At the non-salt patch places, the surface horizon were not covered with the reddish sand particles (frequently covered with a thin dark clayey materials) and were devoid of above mentioned internal organization.

On the basis of these observations, we can answer to the above questions.

1. At the salt patch, past runoff water was slow and sometimes came to a standstill, resulting in sedimentation of clay particles and in accumulation of salt. This was especially noticeable during the dry season, when the runoff water was strongly saline and its range was short.

2. The rate of the present runoff water was much higher at the salt patch than at the non-salt patch places due to difference in the slope so that only sand particles could be sedimented at the salt patch. Consequently, the non-salt patch places were covered with a thin clayey materials.

3. Most of the present rain water ran over the surface and/or moved through the surface sandy layer of the salt patch and only its small fraction percolated into the deeper layers. This resulted in insufficient removal of the salt containing in the clayey lamellae of the salt patch.

4. The non-salt patch place near the lower borders of the paddy field received small amount of runoff water containing salt and clayey when it showered in the dry season and became saline to some degree. However, in the rainy season, this place was submerged by receiving a large amount of slightly to weakly saline runoff water, which had passed through the desalted sandy coverage of the salt patch. Consequently, the salt accumulated in the non-salt patch place during the dry season was diluted with the slightly to weakly saline water or was leached down by percolating water if the ground water table was low.

5. In a large part of the salt affected area, weeds changed in their species according to the season. The "rainy season weeds" were tolerant to strongly reductive soils and tolerant to low salinity. On the contrary, the "dry season weeds" were intolerant to reductive state developed in the soil and tolerant to high salinity (Puengpan *et al.*, submitted to Srinakharinwirot (in press) University Science Journal). The salt patch was unfavorable for both the "rainy season weeds" and the "dry season weeds", because at the salt patch, salinity was too high for the former and reduction of the soil was too strong for the latter through the year. In addition, seeds were found to be easily washed out from the salt patch by runoff water. Thus no weed could grow at the salt patch.

The impermeable layers play an important role in formation and expansion of the salt patch of this type. They enhance the runoff water which is the key process of the second step of salinization. In addition, the salt patch is similar to the place with an impermeable layer at shallow depth in regard to internal organization, movement of water and salt and growth of weeds.

The result of the present investigation tells us that we must at first know the type and the step of salinization in the places concerned when we want to prevent expansion of salinization, because an appropriate countermeasure against salinization varies with the type of salinization.

LITERATURE CITED

- Arunin, S., W.H. Patrick, P. Jermsawatdipong, N. Puengpan, L. Chunchartprasert, K. Amornraksa, S. Rothanhavibhata, S. Poosittisak, T. Srithanratana and C. Danvirutai. 1989. Technology development for reclamation of salt affected areas in Northeast Thailand. Research Development Institute, Khon Kaen University, Khon Kaen, Thailand.
- Furukawa, H. and P. Wichaidit. 1989. Salt and sink-hole-corrosion as a principal factor governing topography and mass movement in Northeast Thailand. *Southeast Asian Studies*, 27, 3-34.
- Puengpan, N., T. Subhasaram, P. Patcharapreecha, K. Miura and H. Wada. Impermeable layers in salt affected sandy soils in Northeast Thailand. *J. of Sci. Society of Thailand*. (in press)
- puengpan, N., T. Subhasaram, K. Shiraishi, and H. Wada. Soil-plant relationships at moderately to strongly salt affected areas in Northeast Thailand. submitted to Srinakharinwirot University Sci. J.
- Uvaniyoom, A. 19880 Saline soil in Northeast Thailand. In Handbook No. 8, Department of Land Development, Bangkok, Thailand. pp. 75-79. (in Thai)
- Wichaidit, P. 1988. Utilization and interpretation of soil maps for salinity problems in Northeast Thailand. Handbook No. 8, Department of Land Development, Bangkok Thailand. pp. 80-83. (in Thai)