Effects of Artificial Zeolite and Hydrated Lime on Acid Soils Erosion

◯ **Andry Henintsoa*, A. Sato*, T. Yamamoto*, and M. Fukada****

Introduction

Acid soil covers one third of the world's arable land. A vast area of the acid soil region is found under suitable climate conditions for agricultural production; however, the soils often have serious aluminum toxicity problems, and eventually produce severe soil erosion and off-site pollution. In situ immobilization reduces negative effects of contaminants by adding an immobilizing chemical to the soil. The additives have to obviously possess a high binding capacity. Many additives have been screened for their potential to immobilize heavy metals in soils. Many of them are alkaline materials such as limes, zeolites.

In addition to binding sites on the surface of the immobilizing material, an increase in soil pH also contributes to the immobilization of heavy metals in soil by making existing sites in the soil (present at the surface of clay, iron oxides, organic matter, etc.) more reactive toward metal binding due to a decreased proton competition. This study is mainly focused on the effect of changing soil pH on acid soil erosion. To study the sediment delivery as results of soil response, rainfall simulation experiments under the calm conditions were carried out at Arid Land Research Center in Tottori University.

Materials and Methods

A drip-type rainfall simulator at the height of 12 m was used to study soil erosion. The rainfall intensity of 65 mm h^{-1} was applied for 1-hour experiment. The rainfall distribution uniformity was 95 %. The rainfall kinetic energy was 27.7 J m^{-2} mm^{-1}, and the EC of the rainfall was 0.13 dS m^{-1}.

Artificial zeolite (Ca type) and commercial hydrated lime were used as binding agents. Two different manners of treatment were applied: mixing (5 % and 10 % zeolite, 0.5 % and 5 % lime) with dry soil and spreading (2 Mg ha^{-1} and 0.5 Mg ha^{-1} which are the equivalent of 0.02 g cm^{-2} and 0.005 g cm^{-2}, respectively) on the surface of the air-dry soil packed on the tray. 5 %, and 10 % zeolite, 0.5 % and 5 % lime were chosen in order to get randomly of soil pH values.

Acid soil taken from Yamaguchi prefecture was the main soil (sand: 39, silt: 42, and clay: 19 [%]). Air-dry soil aggregate of 2 mm was packed on the soil plot, 30 cm by 50 cm by 5 cm, with bulk density of 1.38 g cm^{-3} and 3 cm of thickness placed above 1.5 cm gravel filter layer (3-4 mm). The soil plot system was placed on 10° slopes and subjected to simulated rain.

Results and discussion

There is not considerable difference in the soil EC values, except for 5 % lime which had three times higher than the others. The ranking of soil pH increased from control <5 % zeolite <10 % zeolite < 0.5 % lime <5 % limes. The trend of EC from the runoff of spreading treatment showed that the initial soil pH on the surface could be probably closed as the initial of the mixing soils (not shown).

Focusing for the mixing treatments within the early 30 minutes, surface runoff trend showed that 5 % lime and 10 % zeolite delayed in the early stage; the others, 0.5 % lime and 5 % zeolite followed the same trend of the control (**Fig. 1**). As effect of adding clay content, the unsaturated hydraulic conductivity or the pounding time on soil surface was improved. After the simulation, this treatment showed that there was no significant difference between the control and the treated soils in cumulative sediment load, however there are between the treated soils themselves. The ranking of the cumulative sediment load increased from 5 % lime <10 % zeolite <control <0.5 % lime <5 % zeolite.

Focusing for the spreading treatments, all of the treated soils followed the similar surface runoff trend with the control. There is no considerable effect on the soil hydraulic gradient with this method. There is no significant difference between the control and the treated soils in the amount of the sediment load, however there are between the treated soils themselves (**Fig. 1**). The ranking of the cumulative sediment load increased from 0.5 Mg ha^{-1} lime <control <2 Mg ha^{-1} zeolite <0.5 Mg ha^{-1} zeolite <2 Mg ha^{-1} lime. The trends of EC from surface runoff showed that 0.02 g cm^{-2} had the highest initial EC value, approximately 6.3 mS cm^{-1}. The soil aggregate might be destabilized due to the low simulated rainfall electrolyte concentration. Nishimura et al. (2005) found that the EC of runoff the gypsum-treated Kunigami mahji soils was high throughout a simulated rainfall. They suggested that the enhanced dispersion of and runoff

* Arid Land research Center, Tottori University
** Faculty of Agriculture, Yamaguchi University
Keywords: acid soil, binding agents, soil response,

from the acid soil due to application of gypsum could not be explained by the electric double layer theory. It seems the same process was happening on Yamaguchi soil; the removal of Al compounds, which generally have the role of binding particles, from the acid soil, enhanced dispersion (Nishimura et al., 2005).

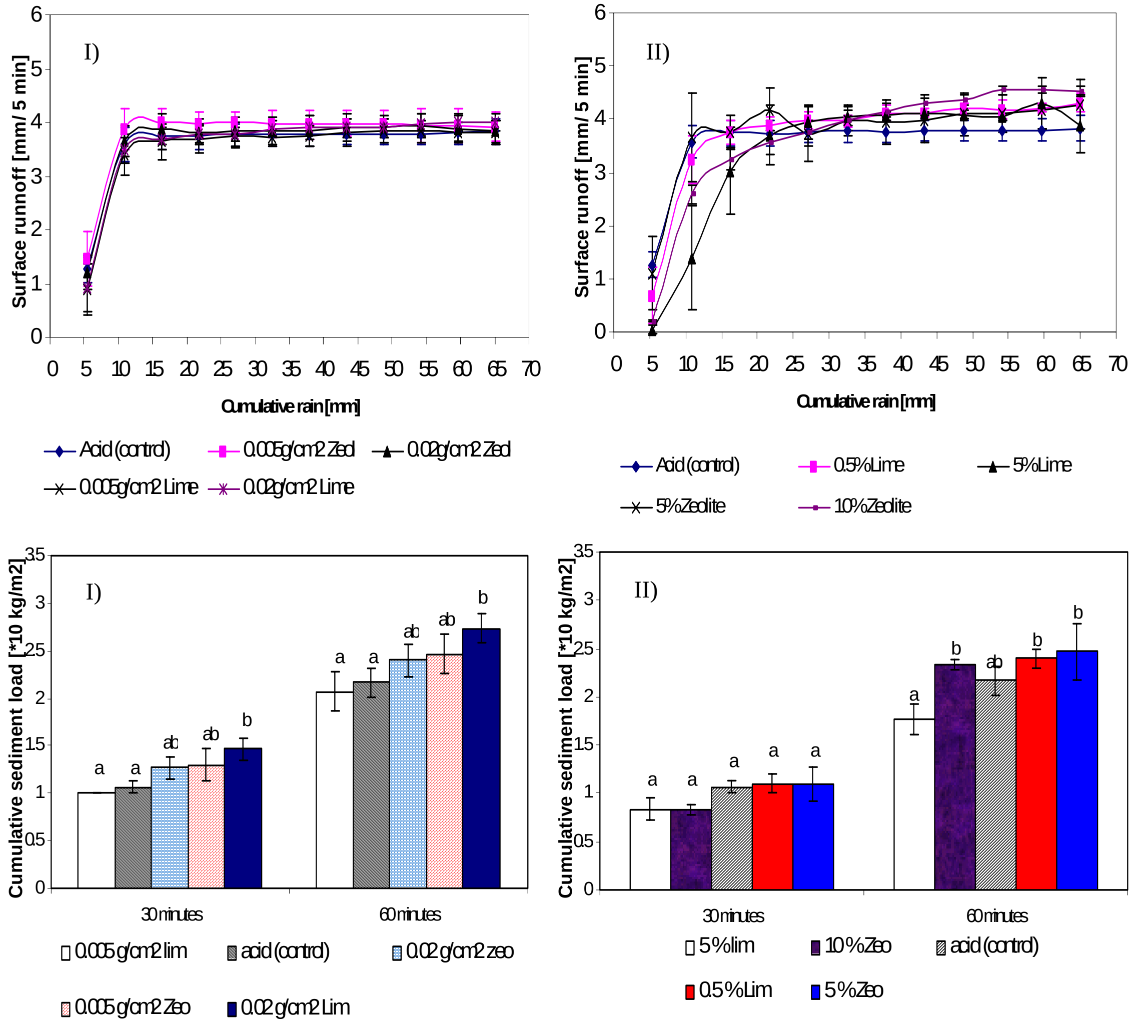

Fig. 1 Surface runoff and cumulative sediment load of spreading (I) and mixing (II), respectively. Where the letters showed the significance level at 99 %.

Conclusion

To establish a sustainable plant cover, successful reclamation should not only reduce acidity and Al^{3+} activity in the shallow amended surface layer, but also in the untreated subsoil material which would increase the rooting depth. The effects of two binding agents on the soil response of Yamaguchi acid soil erosion have been analyzed. The treatment consisted of two methods, mixing and spreading with the soil. The results showed that the soil response changed due to the method of treatment; the spreading proportion respond quickly to the raindrop impact so even at the early 30 minutes of simulation, the cumulative sediment load showed significant difference between the treated soil. Based on the properties of the binding agent, the application of these two materials showed that soil pH did not affect actively to the soil response of Yamaguchi soil due to the raindrop impacts. However increasing the soil pH value increases in part the exchangeable sodium ratio of soil that might affect the soil aggregate stability due to the rainfall property.

Reference

Nishimura, T., M. Kato, T. Yamamoto, and S. Suzuki. 2005. Effect of gypsum and polyacrylamide application on erodibility of an acid kunigami mahji soil. Soil Sci. Plant Nitru.