# EFFECTS OF SOIL CONDITIONER ON GROWTH AND YIELD OF RICE GROWN UNDER ACID SULFATE SOIL

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## ABSTRACT

The experiment was conducted to study the effects of various soil conditioners, MK doses (0, 1.56, 3.12 and 6.25 tons/ha) and NPK fertilizers (16-8-8 and 16-16-8) on growth and yield of rice grown in acid sulfate soil in Thailand, a Rangsit (Rs) soil series. The result showed that application of MK caused an increase in tillers per 2 plants, biomass and grain yield as well as silicon uptake. However, there was no effect on native phosphorus in soil and phosphorus uptake. The 16-16-8 fertilizer application increased the number of tillers per 2 plants; shoots dry matter and grain yield were higher than in 16-8-8 fertilizer model. Grain yields showed highest response when 1.56 kg/ha of MK (0.63 kg grain/kg MK) was applied, and the harvest index was highest as well.

**Key words:** soil conditioner, silicon, rice, acid sulfate soil

**Acknowledgments:** This work was supported by a grant from the Construction Products Public Co.,Ltd. and Department of Soil Science, Faculty of Agriculture, Kasetsart University, Thailand. Furthermore I would like to thank prof. Jan Kren for assistance and guidance in writing process.

## INTRODUCTION

Acid sulfate soil is the common name given to soils and sediments containing iron sulfides, the most common being pyrite. When exposed to air due to drainage or disturbance, pyrite is oxidised, resulting in production of sulfuric acid, often releasing toxic quantities of iron, aluminium and heavy metals. In the soil profile we will meet yellow mottle from jarosite. Disturbing acid sulfate soils can have a destructive effect on plants.

Acid sulfate soils reduce farm productivity. The sulfuric acid lowers pH, which makes several soil nutrients less available to plants. The acid dissolves iron and aluminium from the soil so that they become available to plants in toxic quantities in soil water. These conditions reduce plant growth. Thailand has around 1.5 million ha of acid sulphate soils or 5.75% of cultivated lands. Around 60% of them are in the Center plain and the South of Thailand reaching 0.89 million ha. Acid sulfate soils are often planted under rice, so if they are not suitable for plants and crop management, they might increase the yields of rice.

There are many traditional and modern practices which can improve soil chemical properties of acid sulfate soils. One practice is the application of liming material. Lime is often more suitable for treating acid soil due to its higher solubility in the amount of about 6.25-12.5 ton/ha. The use of lime material together with chemical fertilizer, particularly nitrogen and phosphorus, can increase rice productivity. Moreover, silicon (Si) application can reduced aluminium toxicity to plants including rice (Hara et al.,1999). Silicon enhances the photosynthesis of rice and increases rice resistance to several rice diseases and insects (Ma and Takahashi, 2002)

"MK" as soil conditioner is a by-product from concrete manufacturing. The components of MK are calcium compounds and hydrosilicate compounds. About 60-70% forms other components such as silicon, aluminium and anhydrous silica. Its electrical conductivity is 2.1 dS/m, the cation exchange capacity is 25.0 cmol/kg and pH is very high (pH 10.2). Based on their properties, MK can be used as soil conditioners. Major goal of this project was to study the effect of MK on growth and yield of rice grown under acid sulfate soil.

## MATERIAL AND METHODS

The experiments were carried out in 2010 at The Experimental Study Project for Acid Soil Solution, The Chaipattana Foundation, Nakhon Nayok province, Thailand. Before establishing field trials, soil samples were taken for analysis. Soil samples were air dried at room temperature for four days and sieved through a 2 mm mesh sieve. The samples were characterized for soil pH which was determined using a 1:1 ratio of soil to deionised water. Electrical conductivity (EC) was determined using a1:5 ratio of soil to deionised water. Textural classification was measured using the pipette method (Gee et al. 1986). Organic matter content was determined by wet oxidation and titration using the Walkley and Black method (Nelson et al. 1982). The cation exchange capacity (CEC) was determined with 1 M $NH_4OAc$ solution buffered at pH 7 (Soil Survey Laboratory Staff, 1992). Total N in soil samples was determined by the Kjeldhal method. The available phosphorus was extracted with BrayII and was determined by flame emission. The exchangeable K in the $NH_4OAc$ solution was determined by atomic absorption spectrophotometry (AAS). Extractable Si was extracted by $CH_3COOH$ and the Si in the solution was determined by AAS.

Soil samples had the following characteristics: The Rs series (Rangsit soil series) had a clay texture; 1.96% organic matter; pH of 3.10; EC of 0.55 dS/m; CEC of 23.8 cmol/kg; total N of 1.2% ; available P of 5.83 mg/kg ; exchangeable P of 66.7 mg/kg and extractable Si of 5.83 mg/kg. The result showed that the soil had very low pH, P and extractable Si. Therefore it is necessary to use soil conditioners for improving soil pH and some elements such as P and Si.

The experiment was conducted with 4 replications. Two factors were studied. The first factor consisted of 2 variants of fertilizer management with NPK ratios 16-8-8 and 16-16-8 applied in a dose of 500 kg/ha. The second factor represented 4 rates of MK 0, 1.56, 3.12 and 6.25 ton/ha. Pesticides and insecticides were applied according to the suggestion of the Department of Agriculture, Thailand. The size of each plot was 12 $m^2$ and the harvest area was 6 $m^2$. Twenty days after seeding, 2 seedlings were always transplanted into one hole, in each plot with the space of 25x25 $cm^2$. Harvest was carried out 120 days after transplanting. MK was applied 14 days before transplanting. Every treatment included application of N fertilizer (46-0-0) at the ear initiation state.

## RESULTS AND DISCUSSION

All rates of MK increased the number of tillers. The 6.25 ton/ha of MK and 16-16-8 fertilizer model caused increased number of tillers per 2 plants which was higher than the treatment with 0, 1.56, 3.12 ton/ha and 16-8-8 fertilizer, respectively. Nevertheless, Si compounds within soil conditioner did not have any effect on native phosphorous in soil and phosphorous uptake by plants. However, MK application showed effect on silicon uptake in plants. Table 1 shows that the use of MK increased shoots dry matter by 21-140%, and grain yields by 42-59% when compared to the control. Moreover, higher rates of soil conditioners caused more increase in grain yield, however, the highest efficiency and the highest harvest index was observed in the variants with application of 1.56 kg/ha (0.63 kg yield/kg MK). Data in Table 1 indicate that higher rates of MK (3.12 and 6.25 ton/ha) improved more vegetative growth compared to grain production. 16-16-8 fertilizer model increased shoot dry matter and grain yield by 45% and 40%, respectively, when compared to the treatment 16-8-8. These fertilizers increased harvest index as well.

Soil conditioner had higher effect on grain yield because of soil pH increase. Rice could also intake Si which was released from soil conditioners. Rangsit soil series had low extractable Si (53.5 mg $SiO_2$ /kg), therefore rice was grown in soils with low silicon (less than 105 mg $SiO_2$/kg) and would response well to silicon fertilizers (Kawaguchi and Kyuma ,1969). Hossain et al. (2001) found that silicon in calcium silicate form increased grain weight of rice more than in the variant of soils without applied silicon fertilizers.

**Table 1.** The effects of soil conditioner (MK) and chemical fertilizers on growth, yield, biomass, harvest index, phosphorus and silicon concentration of rice grown under acid sulfate soil.

| Treatment | The number of tillers per 2 plants | | | | Shoot dry matter | | Grain yield | | Responsiveness | Harvest Index | | P uptake in plants | | Si uptake in plants | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT[1/] | 60 DAT[1/] | 90 DAT[1/] | % | $kg/m^2$ | % | $kg/m^2$ | % | (kg grains/kg MK) | HI | % | mg/kg | % | mg/kg | % |
| Soil conditioner rate (kg/ha) | | | | | | | | | | | | | | | |
| 0 | 10.9 | 24.1 | 18.5 | 100 | 0.61 | 100 | 0.23 | 100 | - | 0.37 | 100 | $1.4x10^5$ | 100 | $4.91\ x10^6$ | 100 |
| 1.56 | 14.6 | 27.1 | 20.3 | 116 | 0.74 | 121 | 0.33 | 142 | 0.63 | 0.42 | 112 | $1.4\ x10^5$ | 104 | $5.78\ x10^6$ | 118 |
| 3.12 | 15 | 25.2 | 19.2 | 111 | 0.96 | 157 | 0.34 | 148 | 0.35 | 0.35 | 94 | $1.3\ x10^5$ | 94.7 | $6.71\ x10^6$ | 137 |
| 6.25 | 19.6 | 29.5 | 20.3 | 130 | 1.46 | 240 | 0.36 | 159 | 0.12 | 0.28 | 73 | $1.3\ x10^5$ | 92.5 | $6.95\ x10^6$ | 141 |
| Fertilizers | | | | | | | | | | | | | | | |
| 16-8-8 | 13.6 | 23.2 | 18.4 | 100 | 0.77 | 100 | 0.25 | 100 | - | 0.32 | 100 | $1.2\ x10^5$ | 100 | $5.47\ x10^6$ | 100 |
| 16-16-8 | 16.4 | 29.7 | 20.8 | 121 | 1.12 | 145 | 0.35 | 140 | - | 0.34 | 105 | $1.5\ x10^5$ | 119 | $6.71\ x10^6$ | 123 |

[1/] Day after transplanting

## CONCLUSIONS

Soil conditioner applications had effect on tillering of rice, shoot dry matter and grain yield formation especially in the highest rate (6.25 ton/ha). However, the highest yield response was observed when applied 1.56 ton/ha of MK. No effect of MK and chemical fertilizers on available phosphorous in soil was observed.

## REFERENCES

GEE GW, BAUDER JW., 1986: Particle size analysis. In: Klute A (ed) Method of Soil Analysis Part 1 Physical and mineralogical methods. 2nd edn.American Society Agronomy. Madison, Wisconsin. 399-404.

HARA,T., GU, M.H. AND KOZAMA, H., 1999: Amelioration effect of silicon on aluminium injury in the rice plant. Soil Sci. Plant Nutr. 45 (4), 929-936.

HOSSAIN, K.A. HORIUCHI, T. AND S. MIZAGAWA., 2001: Effects of silicate materials on growth and yield of rice plants grown in clay loam and sandy loam soils. Jourual of Plant Nutrition. 24 (1) : 1-13.

KAWAGUCHI, K. AND K. KYUMA, 1969: Lowland rice soils in Thailand. The Center for Southeast Asian Studies, Kyoto University.

MA,J.F. AND E. TAKAHASHI, 2002: Soil fertilizer and plant silicon research in Japan. Elsevier Science, The Netherland. 281 pp.

NELSON DW, SOMMERS LE., 1982: Total carbon, organic carbon and organic matter. In: Page AL, Miller RH, Keeney DR (eds) Methods of Soil Chemical Analysis, Part2: Chemical and Microbiological Properties. 2nd edn. ASA and SSSA. Madison, Wisconsin. 570-572.

SAIGUSA, M., YAMAMOTO, A AND K. SHIBUYA: 1999: Effects of porous hydrated calcium silicate on silicon nutrition of paddy rice. In Silicon in Agriculture. Program Agenda and Abstracts. Sept 26-30 1999. Lago Mar Resort, Fort Lauderdale, Florida, USA.

SOIL SURVEY STAFF, 1992: Soil survey laboratory methods manual. Soil survey investigations report No. 42 (version 2.0). USDA-SCS. U.S. Gov. Print. Office, Washington, DC.