Amend Material of Moon Basin Clay and Wastewater Treatment Sediment Application for Growth and Products of Jusmine Rice 105 in Saline Soil

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Abstract

This study, the benefits of using amend material of Moon Basin clay and wastewater treatment sediment to the growth and yields of Jasmine 105 rice in the saline area, was to investigate the quality of water and the use of amend material of Moon Basin clay and wastewater treatment sediment on the growth and yields of Jasmine 105 rice, the effect of nutrient amounts on the growth and yields of Jasmine 105 rice before and after cultivation, to compare the effect of the different types of soil improving materials on the growth and yields of Jasmine 105 rice. The study site was in a saline area in Tanot subdistrict, Non Sung district, Nakhon Ratchasima province. Water quality was measured the collected of natural water source used for growing rice. Three 1-kilogram soil samples were collected from each plot at the depth of 30 centimeters. All the samples were mixed together and used and the soil sample for the study. The growth of rice was randomly sampled for five clumps per plot and five tillers per one clump. The investigation was done for number of grains per panicle, number of defect grains per panicle, and rice yield per 25 square meters. The study found that the water quality in the controlled plot had the pH level of 6.48, while the water pH in the experimental plots was between 6.49 and 7.05. The conductivity and the salinity of the water in the controlled plot was higher than those of the natural water in the experimental plots, with the conductivity of 746 ms./cm. and 673-687 ms./cm. and the salinity level of 0.537 ppt. and 0.475-0.501 ppt. in the controlled plot and in the experimental plots, respectively. Soils in all experimental plots were sandy loam with good drainage. After soil improvement and rice cultivation, the soil structure changed to more clay loam which was suitable for growing rice. The improved soils had relatively neutral pH level and slightly changed after cultivation. The heights of the stem were similar in all plots and not statistically different at the .05 significance level. The growth and the yields of Jasmine 105 rice were not different at the .05 level among the plots. However, Plot 5, where the soil was supplemented with clay soil and wastewater treatment sediment at the 500 kg. + 500 kg./rai ratio, gave the highest yield of rice compared to other plots, with 10.34 kg of grain per 25 square meters. Plot 5 also gave the highest number of clumps per plot (410 clumps), while one clump contained 15 tillers. This was followed by Plot 2, supplemented with 10 tons of clay soil per ria, that gave the grain weight of 8.07 kg per 25 square meters. Rice in the controlled plot was found to have pale leave edges, which did not occur in all of the experimental plots.

Keywords : Moon Basin Clay, Wastewater Treatment Sediment, Jasmine Rice 105, Saline Soil

1. Introduction

Salinity will affect the growth of plants in different ways according to types of plants. For some plants, the leaves will be burnt and the color turns brown, while others, the leaves turn red as the chlorophyll is converted to anthocyanin, making leaves become withered, thickened, hardened, and dehydrated. Sodium and chloride are accumulated within the leaves when salinity increases, the salt is completely released, and the leaves finally fall out (Mongkon Tauon, 2004). Saline soils are soils that contain high amount of salts, which will hinder the plant growth through dehydration and the accumulation of toxic ions in plants. Moreover, balance of nutrients is altered in soils in the tidal-marsh zones (Napat Noinumsai, 2006). Particularly, rice grown in the saline soils will not grow uniformly with low stem reproduction, and burnt and curled leaves. In severely saline areas, patches of rice will die during the reproductive growth stage. If there is not sufficient water intake, the amount of salt will increase, causing defect spikelet and grains. In the present, the salinity condition in Northeastern Thailand has spread quickly via water. The major characteristic of saline soil is being in unstable conditions depending on water movement. When salt compounds are found in one source, they can be dissolved and carried away to other places by water (Land Development Department, n.d.). Saline soils which have not been improved, corrected, and solved will cause problems to the economic and social sectors. When the problem of saline soils becomes more severe and the environment is degenerated, farmers are unable to grow plants due to the effects of toxic from salts. Additionally, plant nutrients especially nitrogen and phosphorus are not in a usable form for plant growth, hence the crop yields decrease. As the result, saline soil needs to be improved by reducing the salinity level and increasing soil nutrients. This study aimed to use Moon Basin clay soil, which is found in the area of Ban Nong Kai Nam and a local material of Nakhon Rathchasima province. The clay soil is usually used for making landfills before building construction. Because clay soil composes of elements which can attract anions in saline soils and can be washed away easily by water, when mixing the clay soil with sediment of wastewater treatment, which consists of lime, the clay soil can help improve soil structure and reduce soil salinity, as well as adding nutrients for plants. In this study, Jasmine 105 rice, a popular rice variety in Northeastern Thailand which can be grown in saline soil, was grown and observed for growth, leave color, height, number of clumps and grains, and the yields. The study investigated how different types of soil improving materials improve the saline areas and solve salinity problems, as well as their benefits to saline soil areas according to their potential and nutrients. Growth of Jasmine 105 rice will be compared from different types of soil improving materials.

2. Objectives

1.To investigate the quality of water and the use of amend material of Moon Basin clay and wastewater treatment sediment on the growth and yields of Jasmine 105 rice, the effect of nutrient amounts on the growth and yields of Jasmine 105 rice before and after cultivation

2.To compare the effect of the different types of soil improving materials on the growth and yields of Jasmine 105 rice.

3. Material Methods

3.1 Material

1. Soil improvement materials included Moon Basin clay, wastewater treatment sediment, and cow manure fertilizer.
2. Agricultural material was the jasmine 105 rice.
3. Analyzing Tools
   3.1 X – ray Fluorescence Spectrometer for analyzing soil improvement materials
   3.2 Sedimentation cylinder and Hydrometer for analyzing soil structures
   3.3 Standard method for Water quality analysis

3.2 Methods

The study was the Randomized Complete Block Design (RCBD) with three repetitions for each experimental plot in five treatments making 15 plots of 5 x 5 meters for growing the Jasmine 105 rice.

Treatment 1 (T.1) The controlled plot (Farmer growing method; no Moon Basin clay and wastewater treatment sediment)

Treatment 2 (T.2) Moon Basin clay (10,000 kg./rai) and farmer growing method with 25 kg. cow manure fertilizer

Treatment 3 - (T.3) Moon Basin clay (5,000 kg./rai) + wastewater treatment sediment (5,000 kg./rai) and farmer growing method with 25 kg. cow manure fertilizer

Treatment 4 - (T.4) Moon Basin clay (2,500 kg./rai) + wastewater treatment sediment (2,500 kg./rai) and farmer growing method with 25 kg. cow manure fertilizer

Treatment 5 - (T.5) Moon Basin clay (500 kg./rai) + wastewater treatment sediment (500 kg./rai) and farmer growing method with 25 kg. cow manure fertilizer

4. Results

1. Physical properties of water quality

The investigation of water quality in the rice plot on the growth of Jasmine 105 rice showed that the controlled plot, which had no soil improvement treatment, had the water pH level of 6.48 (slightly acidic), the conductivity of 746 ms / cm, and the salinity of between 0.43-0.53 ppt.

Table 1
The analysis results of the Water quality in the rice plots

Plots / Soil properties	Natural water source	Plot 1 (Controlled)	Plot 2	Plot 3	Plot 4	Plot 5
pH	6.90	6.48	6.60	6.49	7.05	7.00
Dissolved oxygen (mg. / L)	2.51	**2.59**	2.87	**3.75**	**3.75**	**4.05**
Conductivity (ms / cm)	602	746	684	673	687	**680**
Total dissolved solid (mg. / L)	847	1,049	967	939	967	960
Salinity (ppt.)	0.433	0.537	0.498	0.475	0.501	**0.500**

Remarks: Plot 1 (Controlled plot)
Plot 2 Clay 10,000 kg./rai
Plot 3 Clay + Wastewater Treatment Sediment 5,000 kg. +5,000 kg./rai
Plot 4 Clay + Wastewater Treatment Sediment 2,500 kg. +2,500 kg./rai
Plot 5 Clay + Wastewater Treatment Sediment 500 kg. +500 kg./rai

2. Physical properties of soil structure and soil properties in the rice plots

2.1 Properties of soil improvement materials

The sediment of Moon Basin which is in the Nawa soil series is a common local material usually used for land filling for 100 baht per ton. If this material is used for soil structure improvement especially in the salty sandy areas, agricultural sector would gain more benefits and added values. The Moon Basin clay sediment has the property of holding water and absorbing ions to reduce salinity. On the other hand, wastewater treatment sediment contains silicon, an essential element that strengthens the plant's stem. The Moon Basin clay soil improvement material has the properties of Clay loam with the Nitrogen amount of less than 0.1 percent, 743.15 mg/kg of phosphorus, and the Sodium Absorption Ratio of 24.13 mEq./L. The wastewater treatment sediment contained less than 0.10% of Nitrogen. The compound analysis with the X – ray Fluorescence Spectrometer found that the wastewater treatment sediment contained 50.34 percent Silicon, 26.58 percent Aluminum, 0.32 percent Calcium, and 0.90 percent Magnesium – all these compounds can reduce the soil salinity and improve crop strength, suitable for using as soil improvement materials.

2.2 Soil properties in the experimental plots

The soil used for growing rice in the experimental plots was the brownish sandy loam, neutral pH, moderate salinity, with suitable amount of macronutrients essential for crop growth. After soil improvement and cultivation, the soil was still sandy loam and dark brown and yellow in color, with slightly reduced salinity level and nutrient amounts, and low pH (acidic). From the properties, the soil improvement materials were found to increase nutrient absorption of the plant and were suitable for using as soil improvement materials (Land Development Department, 2005). The study of the effect of soil improvement materials on the height and reproduction of rice compared the average height and the reproduction rate of the Jasmine 105 rice in the experimental plots with different types of soil improvement materials.

Figure 1. Rice paddles preparation, soil improving Moon Basin clay soil, and waste water sediment

Table 2
Properties of soil improvement materials and soils in the experimental plots

Soil improvement materials / soil properties	Waste water sediment	Moon clay soil	Experimental soil
Soil type	-	Clay loam	Sandy loam
Nitrogen (mg. / L)	nd	<0.10	<0.10
Phosphorus (mg. / L)	0.01	743.15	29
Potassium (mg. / L)	0	137.60	48
Calcium (mg. / kg.)	40.23	1,907.00	64.08
Magnesium (mg. / kg.)	6.12	254.05	2,021
Sodium (mg. / kg.)	0.13	nd	nd
Sodium absorption ratio (mg. / L)	nd	24.13	1.35
Chloride (mg. / kg.)	nd	5,373.93	24.55
Salinity (ppt.)	nd	4,229.00	106.50
Iron (mg. / kg.)	1.47	nd	nd
Aluminum (mg. / kg.)	0.10	nd	nd
Silicon (mg. / kg.)	13.10	nd	nd

The soil structure in most plots was sandy loam, with good drainage, accept for Plot 2 which consisted of 10,000 kg./rai of clay that had the property of clay loam, and Plot 5 (clay + wastewater treatment sediment at the 500+500 kg./rai ratio) which was the sandy clay loam.

Table 3
Change in soil properties in the experimental plots after soil improvement

Plots/Soil Properties	Plot 1 (Controlled)	Plot 2	Plot 3	Plot 4	Plot 5
pH	6.8	6.9	7.3	6.8	7.0
Nitrogen (mg./ L(	0.042	<0.10	0.10	0.10	0.79
Phosphorus (mg./kg.(	29	743.15	150.5	354.4	60
Potassium (mg./kg.(	48	137.60	781.50	781.50	94
Chloride (mg./kg.(	5,373.93	277.43	277.43	277.43	200
Salinity (ppt.)	2.20	2.10	2.00	2.00	2.00
Calcium (mg./kg.(	nd	1,907	nd	nd	450
Magnesium (mg. / kg.(	nd	254.05	nd	nd	150
Conductivity (ms / m)	4.98				2.87
Sodium Absorption Ratio (mEq / L(	2.50	24.13	**2.50**	**2.50**	2.00
Soil type	Sandy Loam	Clay loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
Soil color	Brown	Dark brown	Brown	Dark brown	Dark brown

Remarks: Plot 1 (Controlled plot)
Plot 2 Clay 10,000 kg./rai
Plot 3 Clay + Wastewater Treatment Sediment 5,000 kg. +5,000 kg./rai
Plot 4 Clay + Wastewater Treatment Sediment 2,500 kg. +2,500 kg./rai
Plot 5 Clay + Wastewater Treatment Sediment 500 kg. +500 kg./rai

4. Growth rate and production yields of the Jasmine rice

4.1 Jasmine rice growth rate

After 1 week of transplanting, most rice stems was quite well rooted at similar rates in all plots, accept for the controlled plot that some patches of stems were dried and rotten. The rice in Plot 2, which was improved by using 10,000 kg./rai of clay soil, had the average height of 85 cm.The second highest growth was at Plot 5 (500 kg./rai of clay soil + 500 kg./rai of wastewater treatment sediment) where the average height was 83 cm. and the highest number of clumps per plot (410 clumps) in the 25 square meter plot. The second highest number of clumps per plot(402) was found at Plot 2 which was prepared with 10,000 kg./rai of clay soil. Plot 5 had the highest rate of 16 tilters per clump, followed by Plot 2.


Controlled Plot


Experimental Plot: Clay soil (10,000 kg./rai)


Experimental Plot: Clay soil + Waste water sediment (5,000 kg.+5,000 kg./rai)


Experimental Plot: Clay soil +Waste water sediment (500 kg.+500 kg./rai)


Experimental Plot: Clay soil + Waste water sediment (2,500 kg.+2,500 kg./rai)

Figure 2. Growth rate of rice within 1 week after transplantation into the rice experiment paddy in the salinity area

4.2 Jasmine Rice Yields

The jasmine rice grown in the soil with 500 kg./rai of clay soil and 500 kg./rai of wastewater treatment sediment gave the highest average yield of 10.34 kg./25 sq.m., followed by the rice in Plot 2 (using 10,000 kg./rai of clay soil) which yielded 8.07 kg./25 sq.m. Other plots gave similar yields (see Table 4).

Table 4
Growth rate of Jasmine Rice 105

Experimental Plots	Growth rate and Yield (25 square meter plot)						
	Height (cm.)	Clumps per plot (Clump)	Tillers per clump (tiller)	Grains per panicle (grain)	Defect grains per panicle (grain)	Rice weight (Kg.)	Leave color
Plot 1: Controlled	71	400	10	150	33	7.08	Pale leave

							edges
Plot 2:Clay	85	402	14	160	20	8.07	Normal
Plot 3:Clay + Water treatment sediment	76	400	13	155	25	7.40	Normal
Plot 4:Clay + Water treatment sediment	76	400	13	155	25	7.33	Normal
Plot 5:Clay + Water treatment sediment	82	410	15	165	20	10.34	Normal

Remarks: Plot 1 (Controlled plot)
Plot 2 Clay 10,000 kg./rai
Plot 3 Clay + Wastewater Treatment Sediment 5,000 kg. +5,000 kg./rai
Plot 4 Clay + Wastewater Treatment Sediment 2,500 kg. +2,500 kg./rai
Plot 5 Clay + Wastewater Treatment Sediment 500 kg. +500 kg./rai

Table 5
Compare mean of product of Jasmine Rice 105

Comparing Plots		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Controlled plot - Plot 2	-2.67	9.37	3.83	-12.50249	7.17249	-.696	5	.517
Pair 2	Controlled plot – Plot 3	-.87	4.87	1.99	-5.99312	4.21979	-.446	5	.674
Pair 3	Controlled plot – Plot 4	-.88	4.87	1.99	-5.98326	4.23326	-.440	5	.678
Pair 4	Controlled plot – Plot 5	-3.71	9.41	3.84	-13.58856	6.16856	-.965	5	.379
Pair 5	Plot 2 - Plot 3	1.78	4.76	1.94	-3.22108	6.77775	.914	5	.402
Pair 6	Plot 2 - Plot 4	1.79	4.76	1.94	-3.20609	6.78609	.921	5	.399

Pair 7	Plot 2 - Plot 5	-1.05	2.63	1.07	-3.80566	1.71566	-.973	5	.375
Pair 8	Plot 3 - Plot 4	.012	.029	.01	-.01832	.04166	1.000	5	.363
Pair 9	Plot 3 - Plot 5	-2.82	4.83	1.97	-7.89584	2.24917	-1.431	5	.212
Pair 10	Plot 4 - Plot 5	-2.84	4.83	1.97	-7.90795	2.23795	-1.437	5	.210

Remarks: Plot 1 (Controlled)
Plot 2 Clay 10,000 kg./rai
Plot 3 Clay + Wastewater Treatment Sediment 5,000 kg. +5,000 kg./rai
Plot 4 Clay + Wastewater Treatment Sediment 2,500 kg. +2,500 kg./rai
Plot 5 Clay + Wastewater Treatment Sediment 500 kg. +500 kg./rai

5. Discussion

Plot 5 which was enriched by soil clay and wastewater treatment sediment at the 500:500 kg./rai ratio, gave the highest rice yield of 10.34 kg. per 25 sq.m. When compared to the non-improved soil in the controlled plot, plots using clay soil and wastewater treatment sediment as soil improving materials at all ratios gained higher amount of rice production, although not statistically significant at the .05 level. The results were consistent with the study by the Department of Mineral Resources (2013) where local clay soils were used for improving soil structure in the salinity area to be used for cultivation that gave good crop production. Local clay soil consists of soil layers resulted from weathered mudstone, claystone, shale, and siltstone. Most of the clays contain Kaolinite, Montmorillonite, and Quartz. Mineral resource of local clay can be commonly found in the northeastern part of Thailand, especially sediments weathered from Nawa Member, Phu Tok formation, called "Nawa Clay Soil", mostly consisting of clay and fine clay sediments, suitable for saline soil improvement. Prajuck Boonaree (2001: 55-56) studied local wisdom in solving saline soils. Normally, rice growing areas in northeastern Thailand contain salts, particularly the areas near hill footage and those used to be forests. Village farmers used many methods to solve salinity problems such as building large ridges separating farming areas from salts and growing salt-resisted trees on the ridges such as Siew (*Phyllanthusta xodiifolius* Beille) and Sakae (*Combretum quadrangulare* Kurz). The ridges will help keeping water within the paddy. When the water level in the paddy is higher than the surrounding salty areas, water will flow out washing salt down to lower swamp areas or rivers, changing the salt water directions, making the paddy become usable for normal rice cultivation. In cases where the salty rice fields are in lower areas, the farmers will make cannels of 0.5 meter deep and 1-2 meters wide and build ridges as in the first method along the cannels. The cannels will receive salt water from the soil surface and send the salt away to the nearby rivers. The village farmers learn that ridges and high land areas that have trees growing on have less salt or no salt in the soils. Trees will also allow grasses to grow in the former salty areas, making soils more fertile; therefore, the village farmers grow salt-resisted trees on their ridges to prevent salinity. They also use manure fertilizer, husk, and plant chips to improve soil fertility or prevent soil salinity. Moreover, the farmers use salt-resistant rice varieties together with other methods such as building ridges for water storage to reduce salinity. Dividing rice fields into small plots by high ridges for better water storage together with manure and organic fertilizers can make the soil usable for growing rice. This prevents the crop from dehydration and defect grains due to insufficient water amount. Krisana Tiwatri (2003) studied the use of organic fertilizers together with wastewater treatment sediment and organic liquid and found that these three materials provided the best growth of Jasmine rice varieties because the materials added main plant nutrients to soil, enhanced nutrient absorption by plants, and maintained main nutrient balance appropriate for the growth of Jasmine rice.

6. Conclusion

1. Water and Soil Quality

1.1 Water Quality

The results showed that the water quality which affected the growth of Jasmine 105 rice in the controlled plot, which had no soil improvement treatment, had the water pH level of 6.48 (slightly acidic), the conductivity of 746 ms / cm, and the salinity of between 0.43-0.53 ppt.

1.2 Soil Quality

The soil structure in most plots was sandy loam, with good drainage, accept for Plot 2 which consisted of 10,000 kg./rai of clay that had the property of clay loam, and Plot 5 (clay + wastewater treatment sediment at the 500+500 kg./rai ratio) which was the sandy clay loam. After the soil improvement and rice cultivation, soil structure of all plots changed from sandy loam to more clay loam which was quite suitable for rice cultivation that need the soil types that can hold water better than sandy soil. All the plots had similar pH levels, average crop heights, which were not significantly different with different types of soil improvement materials.

2. The growth and yield of Jasmine rice

2.1 The investigation of the growth of Jasmine 105 rice showed that growing rice on the soils which were improved with Moon Basin clay soil and wastewater treatment sediment gave similar high yields in all plots. That is, most rice stems was quite well rooted at similar rate in all plots, accept for the controlled plot that some patches of stems were dried and rotten. The rice in Plot 2, which was improved by using 10,000 kg./rai of clay soil, had the average height of 85 cm. The second highest growth was at Plot 5 (500 kg./rai of clay soil + 500 kg./rai of wastewater treatment sediment) where the average height was 83 cm. and the highest number of tillers per plot (410 tilters) in the 25 square meter plot. The second highest number of tillers per plot(402) was found at Plot 2 which was prepared with 10,000 kg./rai of clay soil. Plot 5 had the highest rate of 16 tilters per clump, followed by Plot 2.

2.2 The jasmine rice grown in the soil with 500 kg./rai of clay soil and 500 kg./rai of wastewater treatment sediment gave the highest average yield of 10.34 kg./25 sq.m., followed by the rice in Plot 2 (using 10,000 kg./rai of clay soil) which yielded 8.07 kg./25 sq.m. Other plots gave similar yields. The growth and the yields of Jasmine 105 rice were not different at the .05 significance level ($p < 0.05$). With these, Plot 6 (500 kg./rai of clay soil + 500 kg./rai of wastewater treatment sediment) gave the highest yield of 10.34 kg. per 25 sq.m., 410 clumps per plot, and 15 tillers per clumps.

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References

Department of Mineral Resources. (2013). The development of saline soils in Northeastern Thailand. Division of Mineral Standards. Bangkok.

Land Development Department. (n.d.). Saline soil management. Measurements and Land and Water Conservation Standard Document Committee, Land Development Department, Ministry of Agriculture and Cooperatives.77 pages.

Krisana Tiwatri. (2003). Effects of chicken manure on soil available phosphorus and yield of rice and corn grown in RoiEt soil series.MA Thesis. Master of Science in Soil Science, Graduate Schools, Kasetsart University.

Napat Noinumsai. (2006). Teaching Materials on Environmental Pollution. Faculty of Science and Technology. Nakhon Rathchasima Rajabhat University.457 pages.

Thani Cheunban. (2008). Effects of kinds and rates of organic fertilizer on growth, yield and grain quality of Khao Dawk Maki 105 rice under rain feed condition in Surin Province. MA Thesis. Master of Science in Agronomy. Graduate School, Khon Kaen University.

Prajuck Boonaree. (2001 : 55-56). Wisdoms in Solving Saline Soil Problems. Ubon Ratchathani Rajabhat Institute.

Suradeth Wongsritha. (2004). Effect of salinity levels, organic and chemical fertilizer on growth, yield and grain quality of KDML 105 rice variety.MA Thesis. Master of Science in Agricultural Resource and Environmental Management.

Dobermann, A. and T.H, Fairhurst. .2000Rice nutrient disorders and nutrient management. Oxford graphic printers ltd. 191pp.