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Effect of Filter Cake, Sludge Cake and Chemical Fertilizer on Growth and Yield of Five Rice Cultivars (*Oryza sativa* L.) Grown on Saline Soil

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Abstract: The experiment was laid in a split plot design with four replications. Five rice cultivars, i.e. Jasmine 105, RD 15, Klongluang 1, Suphanburi, and Phathumthani 1 were used as the main plots. Four types of soil conditions were used, i.e. control, added with filter cake at the rate of 18.75 t ha^{-1}, added with sludge cake at the rate of 18.75 t ha^{-1} and added with chemical fertilizer 16-16-8 (NPK) at the rate of 187.50 kg ha^{-1}. The results showed that filter cake and sludge cake significantly increased soil pH, soil organic matter, but slightly decreased soil electrical conductivity (EC) whilst chemical fertilizer did not. Both soil amendment materials diluted the mean value of Na from 3662 ppm to 1095 and 3340 ppm for filter cake and sludge cake, respectively. Both filter cake and sludge cake significantly increased plant heights, straw dry weights ha^{-1} and rice grain yields ha^{-1} of the five rice cultivars. Chemical fertilizer (16-16-8 NPK) gave the highest grain yield ha^{-1} followed by filter cake and sludge cake. Jasmine 105 cultivar gave the highest grain yield followed by RD 15, Klongluang 1, Suphanburi 1 and Phathumthani 1 cultivars with the grain yields of 2.34, 2.25, 1.99, 1.98, and 1.82 t ha^{-1}, respectively.

Key words: Filter cake, sludge cake, rice cultivars, grain yields

Introduction

Northeast Thailand has both land area and population of approximately one third of the country and the land area is a high land of river terraces with the flood plains and the surface elevations ranging approximately from 100-300 metres above sea level (Scholton and Siriphant, 1973). The majority of the population have engaged in agriculture for their daily life consumption for many decades and their main crops are rice, cassava, sugarcane, sesame, sunflowers, orchard crops and most of the vegetable crops. Rice crop has been obviously chosen as a priority crop for their daily living condition (Suksri, 1999). However, growing rice plants on the paddy fields in Northeast Thailand have been obviously facing some relative obstacles such as drought conditions due to erratic rainfall patterns, poor soil fertility due to high leaching rate and poor soil management but above all the problem on soil salinity has been a serious problem for rice growers from the past up to the present. It was stated that saline paddy fields of NaCl in Northeast alone accounted to 2.85 million hectares (Arunin, 1996). Saline soil condition had drastically reduced rice grain yields due to the toxicity of the salts particularly Cl^{-} (Mengel and Kirkby, 1987; Suksri, 1999) whilst Panchaban (2000) reported that saline soils in Northeast Thailand contained some large amounts of NaCl where the elements obviously had some large effects on the uptake of nitrogen and phosphorous in rice plants and he further stated that rice husk significantly improved soil property of the paddy land areas. Therefore, in order to obtain better rice yields out of the saline paddy fields then some remedial methods in diluting the high concentration of salts must be sorted out. For this work, some inexpensive soil amendment materials of filter cake and sludge cake were used along with the use of a complete chemical fertilizer 16-16-8 (NPK).

Materials and Methods

The experiment was laid in a split plot design with four replications. The Roi-Et soil series (Oxic Paleustults) was used for the experiment. The paddy area at Dan Khun Tod, Nakhon Ratchasima province was ploughing twice and harrowing once. The subplot size being used was a 4x4 metres, each subplots were completely separated from each other by ridges being used as walking paths among the subplots and the subplot numbers were altogether 80 subplots. The five rice cultivars being used were Jasmine 105, RD 15, Klongluang 1, Suphanburi, and Phathumthani 1 and they were used as the main plots. Four subplots of four types of soil conditions were used, i.e. control, added with filter cake at the rate of 18.75 t ha^{-1}, added with sludge cake at the rate of 18.75 t ha^{-1} and added with chemical fertilizer 16-16-8 (NPK) at the rate of 187.50 kg ha^{-1}. Filter cake and sludge cake together with rice husk at the rate of 6.25 t ha^{-1} were evenly applied to the plots by hand three weeks before the transplanting of the rice seedlings. The application of chemical fertilizer to their respective plots, each at the rate of 62.50 kg ha^{-1}, was carried out three times, i.e. after the transplanting of rice seedlings, tillering stage, and booting stage. Rice seedlings were transplanted at the age of 35 days after emergence. Six rice seedlings were used for each ditch. The initial determinations on soil pH, electrical conductivity (EC), organic matter (OM %), available phosphorous (P), exchangeable potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), sulphur (S), and cation exchange capacity (CEC) were carried out one week before the application of soil amendment materials. Some similar analyses as that of the initial soil analysis were carried out with soil amendment materials (filter cake and sludge cake). Soil pH was determined by the method of Black (1965), organic matter % by the method of Walkley and Black (Black, 1965; Page *et al.*, 1982), available phosphorous by the method of Bray II Extraction and Colorimetric (Bray and Kurtz, 1945; Murphy and Riley, 1962 and Page *et al.*, 1982), and extractable potassium by the method of NH_4OAC Extraction and Flame photometry (Cottenie, 1980). At the final sampling for grain yields, the following determinations were carried out, i.e. soil pH, soil electrical conductivity (EC), soil organic matter %, rice plant height/ditch, dry weights of straws and rice grain yields ha^{-1}. Most of the obtained data were subjected to statistical analysis using SAS (1989) computer programme.

Results

With the initial soil properties, the results showed that the mean values of pH, EC, OM, available P, exchangeable K, Na, Ca, Mg, S, and CEC were 6.2, 3.3, 0.40, 4 , 17, 3662, 1047, 134, 352 and 5 cmole/kg soil, respectively whilst the mean values for pH, EC, OM, available P, exchangeable K, Na, Ca, Mg, S, CEC, and C/N ratio for filter cake were 7.6 (1:1 water:filter cake by volume), 1.4 (1:5), 26.90, 3.70, 0.60%, 1095, 5531, 654, 439 and 8.6 ppm, respectively. Similarly, the mean values for sludge cake were 7.5 (1:1), 4.3 (1:5), 15, 1.40, 0.5%, 3340, 6243, 456, 399 and 8.3 ppm, respectively.

Soil pH, EC and organic matter (%)

At the final sampling period the results showed that soil pH values (1:1 water:soil by volume) were similar among the tested cultivars with the values ranging from 6.2 to 6.6 for RD 15 and Jasmine 105, respectively. However, the results due to soil amendment materials showed that soil pH values were significantly affected by filter cake and sludge cake, i.e. the highest value was found with sludge cake followed by filter cake, chemical fertilizer, and the control item with the values ranging from 5.9 to 7.2 for control and sludge cake, respectively (Table 1).

The results on electrical conductivity (EC) were not differed from one another hence the results were omitted whilst the results on organic matter due to soil amendment materials were significantly found, i.e. organic matter percentages were highest with sludge cake followed by filter cake, chemical fertilizer 16-16-8 (NPK), and the control item with the values ranging from 0.39 to 0.63 % for control and sludge cake, respectively (Table 2).

Rice plant heights, straw dry weights and grain yields: With rice plant heights at the final sampling period, the results showed that rice plant heights were significantly affected by cultivars and soil amendment materials, i.e. the plant heights were highest with Jasmine 105 followed by RD 15, Suphanburi, Klongluang 1, and Phathumthani 1 with the values ranging from 92.92 to 112.08 cm/ditch for Phathumthani 1 and Jasmine 105, respectively (Table 3). The effects due to soil amendment materials were significantly found, i.e. the highest plant heights were found with chemical fertilizer 16-16-8 (NPK) followed by sludge cake, filter cake, and the control item with the values ranging from 92.81 to 113.67 cm for the control and chemical fertilizer 16-16-8 (NPK), respectively.

For rice straw weights/ditch, the results showed that the effects due to cultivars were relatively large and statistical significance. Jasmine rice straw dry weights/ditch were the highest followed by RD 15, Klongluang 1, Suphanburi, and Phathumthani 1 with the values ranging from 3.21 to 3.81 for Phatumthani 1 and Jasmine 105, respectively (Table 4). The effects due to soil amendment materials were relatively large and statistical significance, i.e. with the values ranging from 2.83 to 4.28 t ha^{-1} for control and chemical fertilizer 16-16-8 (NPK), respectively. The highest straw dry weights ha^{-1} were found with those grown under the chemical fertilizer 16-16-8 (NPK) and the lowest was with the control item with the values of 4.28 and 2.83 t ha^{-1}, respectively.

With rice grain yields (t ha^{-1}), the results showed that rice grain yields were significantly affected by both the cultivars and the soil amendment materials, i.e. the highest grain yields were found with the Jasmine 105 followed by RD 15, Klongluang 1, Suphanburi and Phathumthani 1 with the values ranging from 1.82 to 2.34 t ha^{-1} for Phathumthani 1 and Jasmine 105, respectively (Table 5). The effects due to soil amendment materials were highest

Table 1: Mean values of soil pH as affected by soil amendment materials and chemical fertilizer 16-16-8 (NPK) at the final harvest for rice grain yields grown on saline soil in Northeast Thailand

Cultivars	Control	Filter cake	16-16-8 (NPK)	Sludge cake	Average soil pH
soil pHJasmine 105	6.3	6.8	5.9	7.5	6.6
RD 15	5.4	6.2	6.3	7.2	6.2
Klongluang 1	6.0	6.4	6.0	6.9	6.3
Suphanburi	6.4	6.2	6.2	7.1	6.5
Phathumthani 1	5.6	6.8	5.3	7.7	6.4
Average soil pH	5.9[c]	6.4[b]	6.0[d]	7.2[a]	6.5

Table 2: Mean values of soil organic matter (OM %) at the final harvest for rice grain yields as influenced by soil amendment materials and chemical fertilizer 16-16-8 (NPK) grown on saline soil in Northeast Thailand

Cultivars	Control	Filter cake	16-16-8 (NPK)	Sludge cake	AverageOM %
Jasmine 105	0.2	0.7	0.4	0.5	0.5
RD 15	0.4	0.5	0.3	0.7	0.5
Klongluang 1	0.4	0.6	0.5	0.7	0.6
Suphanburi	0.5	0.6	0.6	0.6	0.6
Phathumthani 1	0.4	0.4	0.6	0.6	0.6
Average OM %	0.39[c]	0.57[ab]	0.48[bc]	0.63[a]	0.56

Table 3: Mean values of rice plant heights/ditch (cm) as affected by cultivars and soil amendment materials and chemical fertilizer 16-16-8 (NPK) grown on saline soil in Northeast Thailand

Cultivars	Control	Filter cake	16-16-8 (NPK)	Sludge cake	Average plant height
Jasmine 105	99	110	129	111	112.08[a]
RD 15	99	110	118	114	110.25[ab]
Klongluang 1	88	99	106	100	98.42[c]
Suphanburi	93	109	112	106	105.08[b]
Phathumthani 1	85	88	103	95	92.92[c]
Average plant height	92.81[c]	103.26[b]	113.67[a]	105.33[b]	103.75

Table 4: Mean values of straw dry weights (t ha^{-1}) of five rice cultivars at the final grain harvest as affected by cultivars and soil amendment materials and chemical fertilizer 16-16-8 (NPK) grown on saline soil in Northeast Thailand

Cultivas	Control	Filter cake	16-16-8 (NPK)	Sludge cake	Average
Jasmine 105	3.39	3.57	4.69	3.58	3.81[a]
RD 15	3.14	3.51	4.45	3.64	3.69[b]
Klongluang 1	2.65	3.99	4.20	3.40	3.44[c]
Suphanburi	2.50	3.40	4.23	3.00	3.28[d]
Phathumthani 1	2.48	3.26	3.84	3.23	3.21[d]
Average	2.83[c]	3.45[b]	4.28[a]	3.71[b]	3.48

Table 5: Mean values of rice grain yields (t ha^{-1}) as influenced by soil amendment materials and chemical fertilizer 16-16-8 (NPK) grown on saline soil in Northeast Thailand

Cultivars	Control	Filter cake	16-16-8 (NPK)	Sludge cake	Average grain yields
Jasmine 105	2.04	2.20	2.95	2.17	2.34[a]
RD 15	1.85	2.13	2.91	2.13	2.25[b]
Klongluang 1	1.47	1.95	2.64	1.89	1.99[c]
Suphanburi	1.49	2.02	2.64	1.79	1.98[c]
Phathumthani 1	1.34	1.78	2.39	1.75	1.82[d]
Average grain yields	1.64[d]	2.02[b]	2.71[a]	1.94[c]	2.08

Letters indicate significant differences of Duncan's Multiple Range Test (DMRT) at P = 0.05

with the chemical fertilizer 16-16-8 (NPK) followed by filter cake, sludge cake, and the control item with the values ranging from 1.64 to 2.71 t ha^{-1} for control and chemical fertilizer 16-16-8 (NPK), respectively.

Discussion

In general saline soils obviously affected growth and yields of the crop plants. The saline paddy land area of Roi-Et soil series (Oxic Paleustults) being used for this work was considered to be one of the poor soil types in Northeast Thailand although rice growers have been using this paddy land area for rice production for many decades (Chuasavathi and Trelo-ges, 2001). In the past, the annual rice production has been relatively low compared with the paddy areas without the presence of NaCl salt, hence it is of imperative value for scientists to carry out more experiments in growing rice crop in order to find some appropriate technologies for rice growers in the region as to assist the growers to attain a better way for sustainable agriculture when growing rice plants in saline soils.

The results of soil analysis revealed that this soil type can be considered as a poor soil type with a high concentration of sodium salt (NaCl), which was up to 3.3 dS/m. Furthermore, cation exchange capacity value of 5 cmole/kg soil was relatively low. The results suggested that this rice paddy condition could relatively affect the growth and grain yields of the rice plants. However, not only the relatively high NaCl salt contents but also the low CEC value, other minerals presented in the soil were also relatively low. The low amounts of soil nutrients could possibly be attributable to the previous history of the rice crop being cultivated in the past when growers failed to improve soil condition with a proper management.

The use of some soil amendment materials to improve soil properties such as crop residues, animal manure and composts has been recognised by growers and many workers, e.g. Alexander (1977), Kunda and Guar (1982), Gibbons (1984), Miller and Donahue (1990), Suksri (1999) and Chuasavathi and Trelo-ges (2001). Within this decade, there have been some enormous amounts of filter cake and sludge cake as by-products from the local industries hence it is of a tangible value for growers to improve their soil properties with these inexpensive industrial by-products. The results found with this work showed that both filter cake and sludge cake significantly improved soil properties and nutrient contents of the saline rice paddy land. This could have been attributed to the dilution of sodium salt by these soil amendment materials as it was evidently found that the concentration of salt in soil declined largely and at the same time organic matter percentages had significantly increased. However, it was found that soil EC values due to amendment materials were not differed significantly among the treated plots. This could have been attributed to the added amount of rice husk to the soil decreased evaporation rate of water by decreasing the rises of capillary water in soil (Srinarong *et al.*, 2001).

It was found that the rice plant heights were significantly differed from each other due to cultivars and filter cake and sludge cake. The results indicated the differences in genetic traits in growth habits of the rice cultivars where Jasmine 105 had the highest value in height than the rest. In addition, straw dry weights ha^{-1} were having a similar trend as that of the plant height yet chemical fertilizer 16-16-8 (NPK) gave the highest straw dry weights than the rest. This may presumably be attributable to the greater amount of nutrients available in the chemical fertilizer than the filter cake and sludge cake where it provided better soil nutrients than these soil amendment materials as reported by Orly (1984).

Some significant differences in rice grain yields were attained, i.e. Jasmine 105 had the highest grain yield than the rest. This could presumably be due to the differences in the genetic traits of the cultivars where the Jasmine 105 had a better gene combination for growth than the rest since this cultivar was carefully and specifically bred for northeastern region of Thailand whilst the majority of the other four cultivars were specifically bred for use in the Central Plain area of the country. The differences in grain yields due to filter cake, sludge cake over the control item where filter cake possessed better grain yields than the sludge cake could be attributable to the dilution of sodium salt when filter cake provided the better EC value (0.8 dS/m) whilst sludge cake provided higher value of EC (1.0 dS/m) hence filter cake had a greater effect in diluting salt concentration in soil resulted in providing better soil nutrients than the sludge cake (Black, 1965).

To sum up, filter cake and sludge cake significantly improved soil properties of the paddy field of the Roi-Et soil series (Oxic Paleustults) where chemical fertilizer did not. Filter cake had a better effect on soil properties than sludge cake. Filter cake and sludge cake significantly increased straw dry weights and rice grain yields ha^{-1} of the treated rice cultivars. Jasmine 105 gave the highest grain yield followed by RD 15, Klongluang 1, Suphanburi and Phathumthani 1 with the grain yields of 2.34, 2.25, 1.99, 1.98 and 1.82 t ha^{-1}, respectively. Chemical fertilizer 16-16-8 (NPK) gave the highest grain yield followed by filter cake, sludge cake, and the control item with grain yields of 2.71, 2.02, 1.94, and 1.64 t ha^{-1}, respectively.

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