



Effect of spent wash liquor on soil pH, electrical conductivity, organic matter, extractable calcium and magnesium of coarse-textured and fine-textured soils

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Abstract

Two sets of completely randomized design with 4 replications to investigate some changes of soil properties after applying 7 rates of spent wash liquor (0, 45, 90, 140, 190, 380, and 560 ton/ha) were performed on coarse-textured and fine-textured soils. Daily irrigation depending on annual rainfall distribution of 2015 was supplied into each experimental unit. After applying treatments for a year, it was found that spent wash liquor significantly increased soil pH, electrical conductivity (EC), and organic matter content of both coarse-textured and fine-textured soils. However, this effect was clearly shown in topsoil in that pH and EC were higher than that in subsoil. Regarding soil fertility, this research study also revealed that spent wash liquor significantly improved the availability of secondary nutrient elements (Ca and Mg), particularly in topsoil.

Keywords: Spent wash liquor, Soil pH, EC, OM, Ca and Mg, Soil texture

1. Introduction

Spent wash liquor is wastewater released from the process of ethyl alcohol production using molasses as substrate. Generally, the molasses released from sugarcane industry contains 50-55 percent of remaining sweetness concentration. Presently, Thailand produces approximately 1.9 million liters of ethyl alcohol a day and this industry releases spent wash liquor 20-30 million liters per day [1]. The spent wash liquor contains acidity (pH) 4.1-4.5, salinity measured by the electrical conductivity 20 dS/m, in which the high acidity and salinity will be able to affect soil properties in the case of long term application [2]. Continually applying organic matter on agricultural land for 10 years can reduce averagely 10 percent of soil bulk density while the capability of soil water infiltration in top soil increases more than double times [3]. For 14 years continually applying organic materials, however, shows significant increase of soil organic matter, soil porosity, soil fertility, and soil electrical conductivity [4]. Soil property of agricultural land is significantly considered as the most important fixed cost for agribusiness; therefore, there have been many research methodologies carried out to investigate appropriate technologies in improving soil property so that the acquired knowledge could be useful for further development.

The purpose of this research was to study the impact of different rates of spent wash liquor applied into different soil textures on the change of some soil properties.

2. Materials and methods

This research was carried out from 2014-2015. Composite samples of coarse-textured soils (sandy soil) containing 90:4:6 percent of sand:silt:clay, taken from top soil (0-15 cm), and subsoil (15-30 cm) containing 88:5:7 percent of sand:silt:clay were arranged in each pot of 7 kg with diameter 20 cm. According to this concept, fine-textured soils (sandy clay) containing 60:5:35 percent (sand:silt:clay) of top soil, and subsoil containing 55:7:38 percent (sand:silt:clay) were arranged in pots as well. Daily irrigation water depending on annual rainfall distribution was supplied into each pot through the year of 2014 to ensure that soil profile was completely setup. Soils prepared in all pots were used as experimental materials for a continual experimental design. Two sets of completely randomized design (CRD) with 4 replications were conducted for both coarse-textured and fine-textured soils. Seven treatments of spent wash liquor application based on farmer practices were performed in both soil textures. They were 0, 45, 90, 140, 190, 380, and 560 ton/ha, respectively. Daily irrigation depending on annual rainfall distribution of 2015 was supplied into each pot through the year of 2015. Annual rainfall distribution data were taken from Khon Kaen provincial meteorological station. Soil samples were collected from each pot at the depths of 0-15 cm and 15-30 cm to be analyzed for soil pH, electrical conductivity (EC), organic matter (OM), extractable calcium and magnesium of coarse-textured and fine-textured soils [5].

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3. Results and discussion

The effect of spent wash liquor on soil pH, EC, OM, extractable Ca and Mg of coarse-textured and fine-textured soils were as follows.

3.1 Soil pH

Application of spent wash liquor could reduce soil acidity by improving pH value of topsoil (0-15 cm) and subsoil (15-30 cm) for both coarse-textured and fine-textured soils as shown in Table 1. The distribution of all values in the table revealed that the trend of topsoil pH values is slightly higher than those of subsoil. The increasing rates of spent wash liquor application also increased soil pH. This effect can be explained in that the decomposition of organic matter from spent wash liquor associated with soil aeration condition in topsoil is better than those in subsoil while organic colloids are increased with the increasing of application rates. Therefore, the dissociation of organic compounds such as carboxylic group, phenolic OH- group, and other functional groups causes the increase of anion in soil solution [6-8]. As a result, hydrogen ions as active acidity in soil solution may be reserved to be in the form of potential acidity by organic colloids. Thus, the effect of applying spent wash liquor in this experiment reduced the effect of free hydrogen ions in soil solution and then increased soil pH.

3.2 Electrical conductivity (EC)

Applying spent wash liquor significantly increased soil electrical conductivity depending on the application rates. The protonation of amine group on organic particles may increase cation while the dissociation of organic compounds increases anion and then exchanges them into soil solution. This may cause the increase of soil electrical conductivity [9]. In Table 2, this research study showed that soil salinity indicated by EC values for the depth 0-15 cm of coarse-textured soil are still ranged in safety interval for the tolerance of some crops such as rice and sugarcane in the case of applying at the rates of 45-90 ton/ha (EC 1:5 for rice and sugarcane production should not higher than 1.6 dS/m). The same trend of the EC change was also found in fine-textured soil. It was also supported by Indraratne et al. (2009) stating that continually incorporating organic matter into the soil for 14 years increases electrical conductivity [4].

3.3 Soil organic matter (OM)

As shown in Table 3, percentage of organic matter content found in both coarse-textured and fine-textured soils

for both topsoil (0-15 cm) and subsoil (15-30 cm) clearly indicated that the increasing rates of spent wash liquor application significantly increased the accumulation of organic matter content.

However, the result is different from Srisuda et al. (2012) reporting that applying spent wash liquor at the rates of 62.5, 125, and 187.5 m³/ha into loamy sand soil for sugarcane plantation did not improve the level of soil organic matter accumulation [10]. In this research study, it was found that the trend of soil organic matter accumulation in fine-textured soil, particularly in the subsoil (15-30 cm), is higher than that accumulated in coarse-textured soil. This effect can be discussed in that soil aeration in topsoil, especially for the coarse-textured soil, is better than the soil aeration in subsoil; therefore, the decomposition process under aerobic condition is better whereas the remaining organic matter under the effect of leaching with infiltration water shows the higher accumulation in both topsoil (0-15 cm) and subsoil (15-30 cm) of fine-textured soil.

3.4 Extractable calcium (Ca) and magnesium (Mg)

Table 4 showed that the greater volume of spent wash liquor resulted in the amount of extractable calcium that significantly increased in both topsoil and subsoil of the coarse-textured soil. The values of top soil were in the range of 78-316 ppm while the values of subsoil were in the range of 94-128 ppm. This similar change was also found in the topsoil of fine-textured soil where extractable calcium values were in the range of 887-1350 ppm.

Nevertheless, the maximum value of extractable calcium found in subsoil of fine-textured soil was 1118 ppm when applying spent wash liquor at 45 ton/ha. On account of the fact that both calcium (Ca) and magnesium (Mg) are secondary nutrient elements for plant growth, in this research study, it was not only extractable calcium but the amount of extractable magnesium in the soil also directly varied to the change of spent wash application rates. As shown in Table 5, the increasing rates of using spent wash liquor significantly increased the amount of extractable Mg in both coarse-textured and fine-textured soils.

There are a number of research projects reporting that applying spent wash liquor results in the increase of soil, pH, EC, OM, Ca, and Mg due the effect of increasing organic matter decomposition, organic colloids, and cation exchange capacity [6-10]. However, the experimental results and contribution may be different in details for each location of various environmental conditions.

Table 1 Soil pH (1:2.5)

Spent wash liquor (ton/ha)	Coarse-textured soil*		Fine-textured soil*	
	(0-15 cm)	(15-30 cm)	(0-15 cm)	(15-30 cm)
0	6.6f	6.6e	4.8f	4.7f
45	6.8e	6.6e	5.2e	5.1e
90	7.5d	6.9d	5.4d	5.1e
140	8.6c	8.0c	5.6c	5.4d
190	9.3b	8.0c	5.7c	5.8c
380	9.6a	8.3b	6.2b	6.0b
560	9.7a	8.8a	6.5a	6.4a
CV (%)	1.19	1.18	1.71	1.83

*Average of four replications. In each column, means followed by the same letter are not significantly different ($p < 0.05$) by Duncan's New Multiple Range Test.

Table 2 Electrical conductivity (EC 1:5), dS/m at 25 °C

Spent wash liquor (ton/ha)	Coarse-textured soil*		Fine-textured soil*	
	(0-15 cm)	(15-30 cm)	(0-15 cm)	(15-30 cm)
0	0.07f	0.08d	0.56f	0.28e
45	0.59e	0.12d	1.23e	0.56d
90	0.96d	0.23c	1.40d	0.61cd
140	2.16c	0.87b	1.95c	0.69cd
190	2.21c	0.90b	2.33b	0.71c
380	2.36b	1.16a	2.38b	0.88b
560	2.53a	1.13a	3.34a	1.02a
CV (%)	3.88	7.89	4.75	11.48

*Average of four replications. In each column, means followed by the same letter are not significantly different ($p < 0.05$) by Duncan's New Multiple Range Test.

Table 3 Soil organic matter (%)

Spent wash liquor (ton/ha)	Coarse-textured soil*		Fine-textured soil*	
	(0-15 cm)	(15-30 cm)	(0-15 cm)	(15-30 cm)
0	1.51e	1.53e	3.85g	4.11f
45	1.67d	1.92d	4.06f	4.42e
90	1.71d	2.24c	4.49e	4.85d
140	2.60c	2.28c	4.67d	4.93cd
190	3.16b	2.33bc	4.84c	5.05c
380	3.17b	2.45b	5.06b	5.27b
560	3.34a	2.52a	5.63a	5.48a
CV (%)	3.80	3.27	2.03	2.30

*Average of four replications. In each column, means followed by the same letter are not significantly different ($p < 0.05$) by Duncan's New Multiple Range Test.

Table 4 Extractable calcium (ppm)

Spent wash liquor (ton/ha)	Coarse-textured soil*		Fine-textured soil*	
	(0-15 cm)	(15-30 cm)	(0-15 cm)	(15-30 cm)
0	78f	94c	887e	985c
45	94e	113b	1095d	1118a
90	91e	115b	1145c	1067b
140	167d	117ab	1180bc	1105a
190	266b	123ab	1218bc	900c
380	244c	123ab	1229b	893cd
560	316a	128a	1350a	891d
CV (%)	6.19	5.45	3.91	4.89

*Average of four replications. In each column, means followed by the same letter are not significantly different ($p < 0.05$) by Duncan's New Multiple Range Test.

Table 5 Extractable magnesium (ppm)

Spent wash liquor (ton/ha)	Coarse-textured soil*		Fine-textured soil*	
	(0-15 cm)	(15-30 cm)	(0-15 cm)*	(15-30 cm)
0	38e	41f	167g	171g
45	84e	81e	370f	239f
90	159d	96d	392e	274e
140	390c	160c	452d	366d
190	573b	162c	593c	394c
380	805a	175b	792b	420b
560	875a	195a	974a	472a
CV (%)	9.71	5.06	1.63	2.89

*Average of four replications. In each column, means followed by the same letter are not significantly different ($p < 0.05$) by Duncan's New Multiple Range Test.

4. Conclusions

Spent wash liquor as an industrial residual can be efficiently used as a soil improvement material for crop production. In the situation of extremely insufficient soil organic matter, particularly in the land resource of Northeast Thailand, applying spent wash liquor certainly improves soil

properties. The application rates from 45 to 560 ton/ha for coarse-textured and fine-textured soils in root zone (topsoil, 0-15 cm) and subsoil (15-30 cm) can increase soil pH, electrical conductivity (EC), organic matter content, the availability of secondary nutrient elements (Ca and Mg); therefore, it has potentiality in the management of this industrial residual to be appropriately used in agriculture.

However, spent wash liquor could be used for appropriate economic crops which are low to moderate tolerance to soil salinity (crop varieties which can stand for soil EC 1:5 until meet 1.6 dS/m). Additionally, spent wash liquor should not be continually applied into the same area for long term application longer than 3 years because the accumulation and increase of soil pH and EC may be harmful to crop growth. The availability of the other essential elements in soil solution such as N, P, Fe, B, Mn, Cu, and Zn may also be decreased in the case of high pH. Therefore, this research study recommends that appropriate application rate, soil texture, durations of application, and salinity tolerance of crops, should be considered before applying spent wash liquor for agricultural purposes.

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