Kasetsart J. (Nat. Sci.) 44 : 17 - 23 (2010)

Utilization of Slop Ash as a Source of Potassium for Corn Grown on the Pakchong Soil Series

Pimolsiri Supasatienchai[1], Jongruk Chanchareonsook [1]* and Ed Sarobol[2]

ABSTRACT

Utilization of slop ash, a waste material from distilleries, as a source of potassium for corn in the Pakchong soil series was compared to potassium chloride fertilizer. The investigation was carried out in the greenhouse. A completely randomized design with three replications in a 2×3 factorial was used for the experiment. The first factor was sources of potassium (potassium chloride fertilizer and slop ash) and the second factor was potassium application rates (0, 75 and 150 mg K_2O kg^{-1} soil). Suwan 4452 corn cultivar was used as the test plant. The results showed that application of slop ash increased the available potassium content in the Pakchong soil series. The effectiveness of slop ash in increasing the available potassium in the soil was similar to that of potassium chloride fertilizer. Application of slop ash significantly increased growth, yield and total potassium uptake of corn compared with no application of potassium fertilizer. The effectiveness of slop ash in increasing growth, yield and total potassium uptake of corn was similar to that of potassium chloride fertilizer. Therefore, slop ash could be used as a source of potassium fertilizer for corn.

Key words: slop ash, potassium fertilizer, corn

INTRODUCTION

Potassium is an essential nutrient for the growth of plants (Havlin *et al*., 2005); it is vital for all crops (Brady and Weil, 2008). In Thailand, that corn grown on some upland soils is deficient in potassium (Aramrak *et al*., 2007; Nilawonk *et al*., 2008). For correcting such a deficiency, potassium fertilizer was applied to the soils. In recent years, interest in the utilization of waste materials as a source of plant nutrients has markedly increased, due to the high cost of chemical fertilizers and waste disposal problems. In addition, it has been reported that wood ash and fly ash could be used as sources of plant nutrients for crop production (Erich, 1991; Ohno, 1992; Mittra *et al*., 2005). The current research was carried out to study the used of slop ash, a waste material from distilleries, as source of potassium for corn grown on the Pakchong soil series. This soil series is an upland soil that occupies the major corn-producing area of Thailand. The objectives of this research were to: 1) study the effect of slop ash on the available potassium content in the Pakchong soil series; 2) study the effect of slop ash on growth, yield and total potassium uptake of corn grown on the Pakchong soil series; and 3) compare the effectiveness of slop ash as an alternative to potassium chloride fertilizer to increase corn growth and yield.

1 Department of Soil Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
2 Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
* Corresponding author, e-mail: agrjoc@ku.ac.th

Received date : 01/05/09 Accepted date : 01/10/09

MATERIALS AND METHODS

Soil samples of the Pakchong soil series (very fine, kaolinitic, isohyperthermic Rhodic Kandiustox) were collected from the National Corn and Sorghum Research Center, Nakhon Ratchasima province, Thailand. The soil was air dried, crushed to pass through a 2 mm sieve and mixed well. Some properties of the soil were determined. Slop ash was collected from a distillery factory in Pathum Thani province. Some chemical properties of this waste material were analyzed.

Laboratory experiment

The effect of slop ash on available potassium content in the Pakchong soil series was studied.

Soil samples made up of 10 grams of air-dried soil mixed with slop ash or potassium chloride fertilizer at the rate of 0, 75 and 150 mg K_2O kg^{-1} soil were incubated under field capacity moisture conditions at room temperature for 1, 2 and 4 weeks. The incubated soils were then extracted with a solution of 1 M NH_4OAc, pH 7 and the potassium content in the extracts was determined by atomic absorption spectrophotometer.

Greenhouse pot experiment

Slop ash was used as a source of potassium for corn grown on the Pakchong soil series and its effect on growth, yield and potassium uptake of the corn was investigated. A comparative study of the effectiveness of slop ash and potassium chloride fertilizer on corn was also conducted.

A completely randomized design with three replications in a 2×3 factorial was used for the experiment. The first factor was sources of potassium (potassium chloride fertilizer and slop ash) and the second factor was potassium application rates (0, 75 and 150 mg K_2O kg^{-1} soil). Each Pakchong soil sample (8 kg) was placed in a plastic pot and one of the above treatments applied. Urea and triple superphosphate were applied to all pots at the rate of 200 mg N kg^{-1} soil and 150 mg P_2O_5 kg^{-1} soil, respectively. The treated soils were then incubated at field capacity moisture. After seven days of incubation, five seeds of corn (Suwan 4452 cultivar) were planted in each pot and then thinned to one seedling 14 days after planting. The plants were irrigated with tap water. Height measurements were taken at 30 and 60 days after planting. Plants were harvested at day 75 after planting and dried at 65°C. Ear weight, stubble weight and total potassium uptake of corn were determined. Soil pH and electrical conductivity (EC) at the harvesting stage of corn were measured.

RESULTS AND DISCUSSION

The properties of the Pakchong soil series and slop ash

The Pakchong soil series was clayey in texture, with a neutral pH (Table 1). It had a low content of available K (Land Classification Division and FAO Project Staff, 1973). The organic matter content, available calcium and available magnesium in the soil were high.

The slop ash was alkaline in nature and had a high EC. It contained a high amount of potassium (Table 1).

Effect of slop ash on available potassium content in the Pakchong soil series

Slop ash significantly increased the amount of available potassium in the Pakchong soil series (Figure 1). The effectiveness of slop ash at increasing the amount of available potassium in the Pakchong soil was similar to that of potassium chloride fertilizer. Comparing the patterns of available potassium released between the Pakchong soil series amended with slop ash and a sample with potassium chloride fertilizer indicated that slop ash released available potassium at a similar rate to potassium chloride fertilizer (Figure 2). Accordingly, most of the potassium in slop ash must be in the form of inorganic potassium as is the case with potassium chloride fertilizer.

Table 1 Some properties of the Pakchong soil series and slop ash.

Items	Pakchong soil series	Items	Slop ash
Soil texture[1/]	clay	pH	12.6
pH[2/]	6.8	EC (dS m^{-1})	156
EC(dS m^{-1})[3/]	0.13	Total K (mg kg^{-1})	258,894
Organic matter (g kg^{-1})[4/]	34		
Available phosphorus (mg kg^{-1})[5/]	7		
Available potassium (mg kg^{-1})[6/]	48		
Available calcium (mg kg^{-1})[6/]	4,684		
Available magnesium (mg kg^{-1})[6/]	401		
Available zinc (mg kg^{-1})[7/]	1.95		
Available manganese (mg kg^{-1})[7/]	26		
Available iron (mg kg^{-1})[7/]	3.43		
Available copper (mg kg^{-1})[7/]	0.85		

[1/] Pipette method [2/] pH meter (Soil:H_2O; 1:1) [3/] Electric conductometer 1:5 H_2O
[4/] Walkey and Black method (Walkey and Black, 1934) [5/] Bray 2 method (Bray and Kurtz, 1945)
[6/] Ammonium acetate method (Brown and Warnke, 1988) [7/] Extracted with 0.005 M DTPA pH 7.3 (Lindsay and Norvell, 1978)

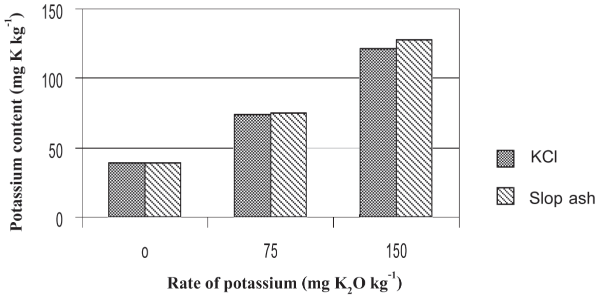

Figure 1 The available potassium content of the Pakchong soil series after incubating with various sources and rates of potassium at four weeks.

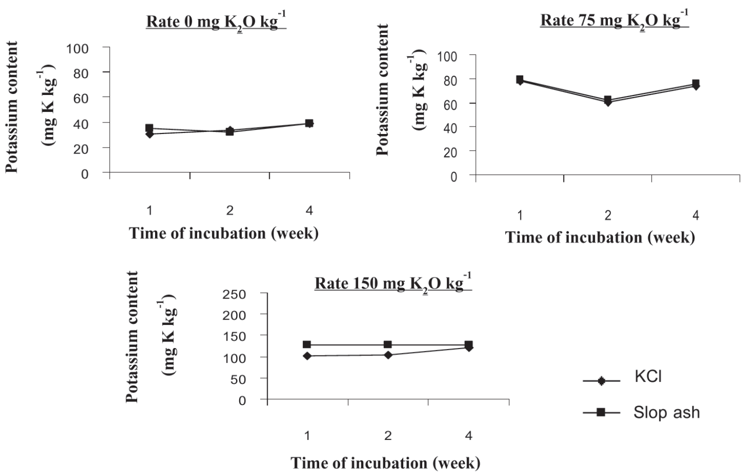

Figure 2 The available potassium content of the Pakchong soil series after incubating with various sources and rates of potassium at 1, 2 and 4 weeks.

Effect of slop ash on growth and yield of corn grown on the Pakchong soil series

The height, ear weight and stubble weight of corn are shown in Tables 2, 3, 4 and 5. The results showed that the application of potassium in the form of slop ash or potassium chloride fertilizer significantly increased the height, ear weight and stubble weight of corn, although the response was limited to a rate of 75 mg K_2O kg^{-1} soil. This revealed that the Pakchong soil samples were deficient in potassium, so that the application of potassium either in the slop ash or in the potassium chloride fertilizer enhanced growth and yield of corn (Stromberger *et al*., 1994; Havlin *et al*., 2005; Brady and Weil, 2008). There were no significant differences between the impact of slop ash and potassium chloride fertilizer on the height, ear weight and stubble weight of corn, indicating that their effectiveness at increasing growth and yield of corn grown on the Pakchong soil series was similar.

Table 2 Effect of slop ash and potassium chloride (KCl) on the height (cm) of corn 30 days after planting.

Rate of potassium ($mg\ K_2O\ kg^{-1}$)	Source of potassium		
	KCl	Slop ash	Mean
0	31.3	34.7	33.0b
75	39.5	39.7	39.6a
150	38.2	36.8	37.5a
Mean	36.3	37.1	36.7
F-test (source of potassium)		ns	
F-test (rate of potassium)		**	
F-test (source x rate of potassium)		ns	
Coefficient of variation (CV) (%)		7.5	

ns = not significant ** = significant at $p \leq 0.01$

Within column values followed by a common letter were not significantly different using Duncan's Multiple Range Test ($p \leq 0.05$).

Table 3 Effect of slop ash and potassium chloride (KCl) on the height (cm) of corn 60 days after planting.

Rate of potassium ($mg\ K_2O\ kg^{-1}$)	Source of potassium		
	KCl	Slop ash	Mean
0	171.3	172.0	171.7b
75	186.0	194.7	190.3a
150	188.3	194.3	191.3a
Mean	181.9	187.0	184.4
F-test (source of potassium)		ns	
F-test (rate of potassium)		**	
F-test (source x rate of potassium)		ns	
Coefficient of variation (CV) (%)		5.1	

ns = not significant ** = significant at $p \leq 0.01$

Within column values followed by a common letter were not significantly different using Duncan's Multiple Range Test ($p \leq 0.05$).

Effect of slop ash on total potassium uptake of corn grown on the Pakchong soil series

Total potassium uptake of corn is shown in Table 6. The results showed that the application of potassium as slop ash or potassium chloride fertilizer significantly increased the total potassium uptake of corn. When the rate of application of slop ash or potassium chloride fertilizer was increased, the total potassium uptake of corn was also increased. The effect of slop ash and potassium chloride fertilizer on the total uptake of corn was not different. This indicated that the effectiveness of slop ash in increasing the total uptake of potassium in corn grown on the Pakchong soil series was similar to that of potassium chloride fertilizer. This finding was similar to that observed by Erich (1991) who completed a study using wood ash.

Effect of slop ash on pH and electrical conductivity (EC) of Pakchong soil series

The pH and EC values of Pakchong soil

Table 4 Effect of slop ash and potassium chloride (KCl) on the dry ear dry weight (g pot^{-1}) of corn 65 days after planting.

Rate of potassium ($mg\ K_2O\ kg^{-1}$)	Source of potassium		
	KCl	Slop ash	Mean
0	45.8	49.3	47.6b
75	64.4	67.0	65.7a
150	74.7	65.4	70.0a
Mean	61.6	60.6	61.1
F-test (source of potassium)		ns	
F-test (rate of potassium)		**	
F-test (source x rate of potassium)		ns	
Coefficient of variation (CV) (%)		9.8	

ns = not significant ** = significant at $p \leq 0.01$

Within column values followed by a common letter were not significantly different using Duncan's Multiple Range Test ($p \leq 0.05$).

Table 5 Effect of slop ash and potassium chloride (KCl) on the stubble dry weight (g pot^{-1}) of corn 65 days after planting.

Rate of potassium ($mg\ K_2O\ kg^{-1}$)	Source of potassium		
	KCl	Slop ash	Mean
0	77.9	68.3	73.1b
75	82.0	88.3	85.2a
150	87.3	88.7	88.0a
Mean	82.4	81.8	82.1
F-test (Source of potassium)		ns	
F-test (Rate of potassium)		**	
F-test (Source x rate of potassium)		ns	
Coefficient of variation (CV) (%)		5.8	

ns = not significant ** = significant at $p \leq 0.01$

Within column values followed by a common letter were not significantly different using Duncan's Multiple Range Test ($p \leq 0.05$).

Table 6 Effect of slop ash and potassium chloride (KCl) application on total potassium uptake (mg pot^{-1}) of corn.

Rate of Potassium	Source of potassium		
(mg K_2O kg^{-1})	KCl	Slop ash	Mean
0	556.3	566.3	561.3c
75	948.1	1059.8	1004.0b
150	1345.0	1440.9	1393.0a
Mean	949.8	1022.3	986.1
F-test (source of potassium)		ns	
F-test (rate of potassium)		**	
F-test (source x rate of potassium)		ns	
Coefficient of variation (CV) (%)		9.7	

^{ns} = not significant ** = significant at $p \leq 0.01$

Within column values followed by a common letter were not significantly different using Duncan's Multiple Range Test ($p \leq 0.05$).

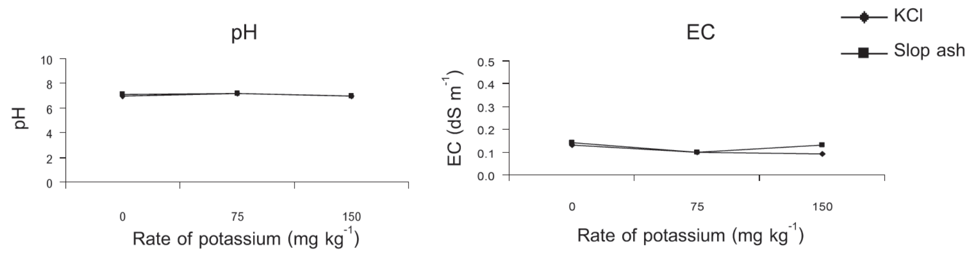

Figure 3 pH and EC of the Pakchong soil series after harvesting corn.

amended with slop ash and potassium chloride fertilizer at the corn harvesting stage are shown in Figure 3. The results showed that the pH and EC values of Pakchong soil amended with either slop ash or potassium chloride fertilizer at the rate of 0, 75 and 150 mg K_2O kg^{-1} soil were rather similar. This indicated that the application of slop ash or potassium chloride fertilizer in Pakchong soil did not change the pH and EC of the soil. This might be due to the small amount of these materials that was applied to the soil. Application of slop ash had no detrimental effect on these two soil properties.

CONCLUSIONS

Application of slop ash significantly increased growth, yield and total potassium uptake of corn grown on the Pakchong soil series. The effectiveness of slop ash in increasing yield and potassium uptake of corn was similar to that of potassium chloride fertilizer. Slop ash could be effectively used as a source of potassium for corn grown on the Pakchong soil series.

ACKNOWLEDGEMENTS

The authors wish to thank the Graduate School, Kasetsart University, for providing financial support for this research.

LITERATURE CITED

Aramrak, S., J. Chanchareonsook, C. Suwannarat and E. Sarobol. 2007. Assessment of multi-element extractants for prediction of available potassium in Thai Soils. **Kasetsart J. (Nat. Sci.)** 41(3): 461-466.

Brady, N.C. and R.R.Weil. 2008. **The Nature and Properties of Soils**. 14th ed. Practice-Hall, Inc., New Jersey, USA. 956pp.

Bray, R.H. and N. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. **Soil Sci.** 59: 39-45.

Brown, J. R. and D. Warnke. 1988. Recommended cation tests and measures of cation exchange capacity, pp. 15-16. *In* W.C. Dahnke (ed.). **Recommended chemical soil test procedures for North Central Region**. North Dakota Agric. Exp. Stn. Bull. 499.

Erich, M.S. 1991. Agronomic effectiveness of wood ash as a source of phosphorus and potassium. **J. Environ. Qual.** 20: 576-581.

Havlin, J.L., J.D. Beaton, S.M. Tisdale and W.L. Nelson. 2005. **Soil Fertility and Fertilizers: an introduction to nutrient management.** 7th ed. Pearson Prentice Hall Inc., New Jersey. 515p.

Land Classification Division and FAO Project Staff. 1973. **Soil Interpretation Handbook for Thailand**. Dept. of Land Development, Min. of Agri. Coop., Bangkok. 435p.

Lindsay, W.L. and W.A. Norvell. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. **Soil Sci. Soc. Am. J.** 42: 421-428.

Mittra, B.N., S. Karmakar, D.K. Swain and B.C. Ghosh. 2004. Fly ash-a potential source of soil amendment and a component of integrated plant nutrient supply system. **Fuel** 84(11): 1447-1451.

Nilawonk, W., T. Attanandana, A. Phonphoem, R. Yost and X. Shuai. 2008. Potassium release in repressentative maize-producing soil of Thailand. **Soil Sci. Soc. Am. J.** 72: 791-797.

Ohno, T. 1992. Neutralization of soil acidity and release of phosphorus and K by wood ash. **J. Environ. Qual.** 21: 433-438.

Stromberger, J.A., C.Y. Tsai and D.M. Huber. 1994. Interaction of potassium with nitrogen and their influence on growth and yield potential in maize. **J. Plant Nut.** 17(1): 19-34.

Walkey A. and I.A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. **Soil Sci.** 37: 29-38.