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COMBINATION OF K SOURCE ETHANOL BY-PRODUCT AND MINERAL KCl ON N, P, K SUGARCANE UPTAKED AND SOIL CHEMICAL PROPERTIES OF ULTISOL IN CENTRAL LAMPUNG, INDONESIA

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ABSTRACT

Stillage is a residual liquid waste distillation of ethanol that contains a lot of potassium (K). Stillage utilization as a replacement for KCl fertilizer is expected to reduce production costs and capable to cope with environmental problems. The objectives of this study were 1) to determine effect of the combination of K source from KCl and stillage on sugarcane uptake of N, P and K, and 2) to define effect of the combination of K source from stillage and KCl to soil chemical properties. This experiment was conducted by using Randomized Complete Block Design (RCBD) with four replications and was designed with two factors; first factor was the dose of K with two levels, i.e. 200 kg/ha and 300 kg/ha; second factor was the combination of KCl and stillage K in five ratios; they were 100%:0%; 75%:25%; 50%:50%; 25%:75% and 0%:100%. This study results showed that doses of K and combination K source of KCl and stillage were not significant on sugarcane uptake of N, P and K, but the highest uptake was in treatment with a dose of 300 kg/ha and treatment C3 (25% KCl : 75 % stillage). Thus, stillage can be applied as a source of K to replace KCl and it can reduce the sugarcane production cost.

Keywords: KCl; stillage; sugarcane; ultisols; uptake

INTRODUCTION

Indonesia is a country with very wide agricultural and plantation land, but the agricultural and plantation potentials are not optimal yet. At this current time (2017), Indonesia still imports sugar commodity. The Indonesia Sugar Association (AGI) predicted that the sugar production in 2016 was only 2.3 million tons, which will also impact to increasing white crystal sugar (WCS) into 400,000 tons (Agrofarm, 2016). Based on this estimation, National sugar production should get

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more attention considering a big potential that Indonesia has to realize about sugar self-sufficiency. Reduced-productivity problems of sugarcane in Indonesia is using less fertile land.

Sugar Group Companies is one of sugar producers in Middle Lampung district consisting of three sugarcane plantations and sugar factories; PT. Gula Putih Mataram (PT. GPM), PT. Sweet Indolampung (PT. SIL) and PT. Indolampung Perkasa (PT. ILP), and one ethanol factory - PT. Indolampung Distillery (PT. ILD). Sugar and ethanol agroindustries always produce by-products that pollute environment. Sugar factory waste forms are solid (filter cake, bagasse and bagasse ash), liquid and gas.

Stillage or slop, or it is also called as vinasse, is liquid waste from the by-product of ethanol factory. This vinasse contains of various pollutant materials that reduce environment quality. Vinasse is directly disposed to water area, which will pollute its area, because *biochemical oxygen demand* (BOD) of vinasse is very high, up to 60,000 ppm (Hodge and Hildebrant, 1954 in Kurniawan, 1981; and Lin, 1973). Even though vinasse is potential as environment pollutant, but vinasse is interestingly containing organic materials (OM), potassium (K) and other rich nutrient elements.

Based on this analysis result, vinasse can be used as nutrient source (fertilizer) for plants (Brieger, 1970 in Sujanto, 1999). Vinasse/stillage in PT. Gula Putih Mataram is used to replace KCl fertilizer. Vinasse utilization as KCl fertilizer is expected to reduce production costs and overcome environment problems. Main objectives of this research were to discover influences of K source combination of stillage and KCl into soil chemical properties.

MATERIAL AND METHOD

This research was conducted in the Research and Development Department of PT. Gula Putih Mataram. The selected land was in plot number 024BS013 with lower soil K content (< 0.2 me/100 g) in Mataram Udik, Bandar Mataram, Lampung Tengah. Material in this study were seed cane (*Saccharum officinarum* L.), ZA fertilizer, TSP fertilizer, KCl, stillage and other chemical materials for laboratory analysis.

Field experiment was analyzed using randomized complete block design (RCBD) with four replications. It was designed with 2 factors. First factor was potassium (K) doses with 2 levels of treatment; potassium dose of 200 kg/ha KCl (K1) and 300 kg/ha KCl (K2). Second factor was combination of postassium (K) from KCl and stillage with 5 levels of treatments. These combination K source from KCl and stillage were 100%: 0% (C0), 75%: 25% (C1), 50%: 50% (C2), 25%: 75% (C3), and 0% : 100% (C4).

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There were 40 land plots with 8 rows x 10 meters for each plot. Furrowing was conducted to separate planting row into double rows, as seed cane take a place for planting. After furrowing, stillage and potassium (K) from KCl fertilizer were applied manually, which its quantities were according to each treatments.

Next stage was applying TSP and ZA fertilizers conventionally, which doses were 100 kg/hectare for TSP and 100 kg/hectare for ZA for each plot. These doses were in accordance with doses applied in replanted sugarcane in PT. Gula Putih Mataram. Sugarcane was planted with *double overlap* 50% seed by using double rows planting system, 185 cm space between rows, and planting between plants in a row was 50 cm.

Soil samples were taken two times; first sampling time was before applying treatment and second one was in time when plants growth 6 months later. Soil sampling was done in composite, which samples were analyzed by soil pH analysis, C organic analysis with Walkey and Black method, N total method by Kjedahl, extraction of Bray I and available K. Sugarcane leaf samples were taken when plants aged 6-months-old.

Variance analysis of data in this study was conducted to discover influences of treatment into parameter. If its influence was significant ($F_{count} > F_{table}$) with significance of 5%, then analysis was able to continue with Duncan's Multiple Range Test (DMRT) by using SAS version 9.1.3. This statistic method was using for discovering which treatment has significantly difference. Data was presented in tables.

RESULT AND DISCUSSION

Initial soil

PT. Gula Putih Mataram as the part of Sugar Group Companies has land with Ultisols. Ultisols has the highest soil acidity with average pH of < 5.50, high aluminium (Al) density, low macronutrient contents especially P, K, Ca and Mg, and high organic material content. It can inhibit sugarcane growth over there.

Initial ultisols used in this research had high acidity level (pH H_2O 5.27), but very low organic carbon (0.77%) and total nitrogen (0.10%). It also had high phosphor content (28,90 ppm), but low content of potassium (0.09 me/ 100 gram soil). Sugarcane plant was significantly influenced by soil fertility and required additional fertilizer to fulfil their land by sufficient soil nutrients for growing plants. Potassium (K) was one of additional fertilizer, that was essential for improving sugarcane growth. Role of K is related to biophysics and biochemistry processes (Beringer 1980).

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Table 1: The nutrient content of stillage from PT. Indolampung Distillery

Material	pH	% material				ppm					
		C-org.	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
Stillage	4.65	2.58	0.40	0.03	2.00	0.37	0.14	91.2	14.3	1.20	3.60

Stillage to use

Stillage pH was acid (4.65), which its C organic content was 2.58%. It was purposed to improve soil C organic content. When soil carbon was sufficient, those soils will attain correct physical, chemical and biological properties for optimal sugarcane growth. In addition, sttillage had also high content of potassium (2.00%). Main purpose of stillage application in sugarcane land was to substitute potassium fertilizer utilization.

The influence of the treatment to soil chemical properties

Potassium (K) doses did not affect soil pH H_2O and KCl (Table 2). The highest pH H_2O (4.67) was obtained in treatment with dose of 300 kg/ha. Study result of treatment with combination of potassium source from KCl and stillage remain the same as it, but this treatment did not impact pH of H_2O and KCl. The highest pH H_2O (4.79) was obtained in treatment C4 (100% stillage). Stillage has acid condition, so that after stillage application, soil pH did not decrease due to ultisols specific property can maintain it.

Table 2: Influence of potassium dose and combination of potassium source from KCl and stillage to some ultisol soil chemical properties

Treatment	pH H_2O	pH KCl	C organic (%)	Total N (%)	Available P (ppm)	Available K (cmol(+)/kg)
K1	4.64a	4.38a	0.86a	0.08a	79.81a	0.11a
K2	4.67a	4.42a	0.85a	0.08a	67.50a	0.11a
C0	4.57a	4.28a	0.87a	0.08a	68.78a	0.10a
C1	4.65a	4.39a	0.86a	0.09a	77.97a	0.11a
C2	4.54a	4.28a	0.83a	0.08a	69.87a	0.11a
C3	4.74a	4.50a	0.83a	0.08a	73.56a	0.12a
C4	4.79a	4.55a	0.87a	0.08a	78.11a	0.10a
Interaction	-	-	-	-	-	-

Notes: numbers followed by the same letter in the same column does not differ significantly at Duncant's Multiple Range Test (DMRT) and (-) mark indicates there is no interaction to the combination treatment.

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Treatment 200 kg/ha KCl doses attained higher percentage of soil organic carbon (C) than 300 kg/ha KCl doses, by only 0.86% in differences (Table 2).

Other treatment using combination of potassium (K) source from KCl and stillage, has aim the highest level of soil organic C in both C0 and C4 treatments. Whilst level of organic C in stillage application was low at 2.58% (Table 1), it described that there was no remarkable effect of stillage application toward soil organic C proportion.

Regarding to this study, it also obtained any information about percentage total Nitrogen (N) soil of each treatment. It showed that total N soil remain the same for potassium (K) doses application sample, just 0.08 % (Table 2). This amount of total N defined as low number for soil (Balitan 2005). Furthermore, other treatment using combination of K source from KCl and stillage also did not effect total N soil. Total N of stillage application was 0.40% (Table 1). Since this amount of total N was obviously not able to improve total N soil, it showed that stillage application had no influence over total N soil percentage.

Treatment of potassium (K) dose and combination of K source from KCl and stillage had no considerable influence toward phosphate (P) availablility of soil. However, treatment C4 (100% stillage) gained the highest amount of P soil, with 78.11 part per million (ppm). In conclusion, this study described clearly that total P of stillage application was too low, in 0.03 ppm, so it was using in potassium (K) treatment did not effect availability of P soil. Essential factor in terms of influencing P soil accessibility for planting was pH level. For this occasion, phosphor was the most easily absorbed by plant in normal pH ranges of soil (from 6 to 7) (Ardike *et al.*, 2008).

Potassium (K) soil came out of soil minerals (feldspar, mica, vermiculite, biotite, and so on) and also organic materials from plant waste. This kind of mineral moved in its nature, which caused it was easy to disappear through leaching process (Winarso, 2005).

Study variance analysis in 5% significant level showed that K dose had no remarkable influence over K level of soil. Moreover, K proportion of soil was 0.11 cmol(+)/kg in both treatment with 200 kg/ha and 300 kh/ha doses (Table 2).

The treatment influence to sugarcane agronomy

Population of sugarcane stalk

Concerning of variance analysis results, it indicated that treatment by using combination potassium (K) doses and combination of K source from KCl and stillage, did not demonstrate interaction between sugarcane stalks. Table 3 also gave other information that treatment of combination K doses and combination of K source from KCl and stillage, did not influence to sugarcane stalk population.

Table 3: The influence of potassium dose and combination of potassium source from KCl and stillage to sugarcane agronomy

Treatment	Stalk Population (000/ha)	Fresh Leaf Weight (kg/mDR)		Stalk Dry Weight (kg)	Dry Leaf Weight (kg/mDR)	
		Green Leaf	Dry Leaf		Green Leaf	Dry Leaf
K1	24.50 a	4.27 a	1.08 a	2.70 a	1.10 a	0.67 a
K2	25.45 a	4.39 a	1.78 a	2.96 a	1.15 a	0.90 a
C0	27.50 a	4.55 a	1.30 a	3.20 a	1.18 a	0.67 a
C1	23.63 a	4.29 a	1.11 a	2.72 a	1.13 a	0.66 a
C2	25.63 a	4.46 a	1.29 a	2.69 a	1.16 a	0.75 a
C3	24.25 a	4.00 a	2.24 a	2.68 a	1.16 a	1.19 a
C4	23.88 a	4.34 a	1.21 a	2.85 a	1.12 a	0.64 a
Interaction	-	-	-	-	-	-

Note:

- Number followed with the same letter in the same column does not differ significantly at DMRT.
- (-) mark indicates there is no interaction to the combination treatment.

Fresh leaf weight

Fresh leaf weight was a combination of absorbed-root and translocating nutrients from soil. Table 3 illustrated that there is no interaction between combination and treatment. In addition, treatment with potassium (K) dose of 200 kg/ha and 300 kg/ha had no significantly difference. Treatment of C0, C1, C2, C3, and C4 also did not show significantly difference. To sum up, both of treatment using K doses and combination of K source from KCl and stillage, did not influence significantly into fresh weight of green and dry leaf.

Stalk dry weight

Table 3 gave information that there is no interaction between combinations and treatments. Moreover, either treatment by using K doses or K source combinations, has no significantly difference. To conclude, those kind of treatments also had no significantly influence of stalk dry weight.

Dry leaf weight

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Observation of dry weight can produce data informations which be useful to learn more about plants. Green leaf dry weight provided knowledge of photosynthesis process result in its leaf. By this study, table 3 showed that there is no interaction between combination and treatment. Either treatment of 200 kg/ha and 300 kg/ha potassium (K) doses or treatment of C0, C1, C2, C3, and C4, had no significantly difference. It literally declared that K doses and combination of K source from KCl and stillage had no impact toward dry leaf weight (Table 3).

The treatment influence to leaf nutrient degree

Treatments of fertilizer doses and combination of potassium (K) source from inorganic fertilizer and stillage had no considerable effect into sugarcane leaf nutrients, such as nitrogen (N), phosphate (P), and potassium (K). Sugarcane as dried-land plant, absorbs N through NO_3^- conformation. Though, fertilizer was added in urea types and NH_4^+ like ZA fertilizer. Percentage of N nutrient in sugarcane leaf was just from 1.74% to 1.81% (Table 4). Addition treatment in this occasion was K fertilizer, which had no influence over N proportion of sugarcane leaf.

Regarding to table 4, this observation demonstrated about phosphate (P) content of sugarcane, which was from 0.27% to 0.28%. Sundara (1998) literature declared that sugarcane growth was normally being too much dependent on P availability. Phospate (P) content was dissolved into conformation, which was capable to absorb by plant on its soil. Essential P content had association with maturity phase and carbohydrate storage stage (generative growth).

Study of biophysics mechanism, potassium (K) had an important role in regulating osmosis pressure and turgor, which finally had influences upon cellular growth and development. It had also effect on opened-closed of stomata. A sufficiently-potassium plant will maintain water content in its tissues due to capability of absorbing humidity from soil and water-binding. As consequence of it, plant will survive from dryness (Subandi, 2013). Potassium content of 6-months-old sugarcane leaf was in ranges from 1.31% to 1.36% (Table 4). However, there was no significant difference upon treatment in this study. Based on this observation, the highest K content was obtained 1.34% by 300 kg/ha fertilizer doses, whilst 200 kg/ha doses was only at 1.31%. This obviously stated that 300 kg/ha fertilizer doses treatment had higher K availability percentage of leaf than others, but there was no significant difference.

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Table 4: Influence of potassium dose and combination of potassium source from KCl and stillage to degree and uptake of N, P, and K

Treatment	N (%)	P (%)	K (%)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
K1	1.78a	0.27a	1.31a	171a	26a	125a
K2	1.78a	0.27a	1.34a	197a	30a	148a
C0	1.79a	0.27a	1.31a	179a	27a	131a
C1	1.74a	0.27a	1.31a	169a	26a	127a
C2	1.79a	0.27a	1.31a	186a	28a	136a
C3	1.78a	0.27a	1.33a	214a	33a	160a
C4	1.81a	0.28a	1.36a	172a	26a	129a
Interaksi	-	-	-	-	-	-

Note: number followed by the same letter in the same column does not show significant difference in the DMRT and (-) mark indicates no interaction in the combination treatment.

In regards to table 4, treatment C4 (100% stillage) was the highest K content, in 1.36%. Stillage had a high K proportion, which be more useful as K source for plants.

Influence of leaf nutrient uptake

Variance analysis result showed that there was no interaction between potassium (K) doses combination and combination of K source from KCl and stillage upon aptake of N, P, and K. Table 4 illustrated that K doses combination and combination of K source from KCl and stillage had no effect toward uptake of N, P, and K.

Treatment of 300 kg/ha doses provided higher number of N, P, and K (in 197 kg/ha; 30 kg/ha, and 148 kg/ha respectively) uptake than 200 kg/ha doses (in 171 kg/ha; 26 kg/ha, and 125 kg/ha respectively). Furthermore, Treatment C3 KCl:stillage (25%:75%) was the highest uptake N, P, and K in comparison of other treatments.

Sugarcane N uptake was low, which was consequence of moving-material of N nutrient. Addition nitrogen soil was effortlessly removed by leaching, nitrification, denitrification, and volatility (Tan, 1993). Plants can intake nitrogen soil in an inorganic forms way of NH_4^+ or NO_3^- Utilization of superior sugarcane variety germs can improve N uptake over soil. In addition, environment factors give an effect of nutrient element uptake. They are light intensity, wind speed and pest attack. Improving sugarcane N uptake requires proper soil management which was reducing N loss.

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Treatment C3 with KCl:stillage (25%:75%) had the highest P uptake (33 kg/ha). On the contrary, treatment C1 with KCl:stillage (75%:25%) and C4 (100% stillage) had the lowest P uptake (26 kg/ha). Phosphate (P) availability was determined by soil properties and root abilities of P uptake. Plant root absorbed P in $H_2PO_4^-$ and HPO_4^{2-} conformation (Black, 1968 *cit*. Pujiyanti, 2007). Furthermore, Nopriansyah (1999) stated that P uptake plant was very dependent on root interaction into P soil solutions. It described that high root volumes in contact with soil, will decline as long as distribution root in soil had decrease too.

Treatment of K doses did not affect significantly upon sugarcane K uptake, even though the highest K uptake (148 kg/ha) was obtained by K2 treatment. Treatment in using combination of K source from KCl and stillage also gave no influence over K uptake. However, the highest K uptake (160 kg/ha) was obtained by C3 treatment with KCl:stillage (25%:75%), but the lowest (127 kg/ha) was obtained in C1 treatments with KCl:stillage (75%:25%). Extention of K uptake plant was influenced by plant weight and K concentration plant.

This observation illustrated that KCl 200 kg/ha (K1) had K content about 0.128 me/100g, while KCl 300 Kg/ha (K2) had K content about 0.192 me/100g. This proportion of K was not sufficient yet for increasing K content availability.

The treatment influence to sugarcane productivity

Sugarcane productivities of different areas were basically consequences of interaction between plant genetic and environment factors. Each sugarcane variety had its production ability. Their varieties also had affect into environment factors, include climate, soil and cultivation method. Based on this study, either potassium (K) doses treatment or combination of K source from KCl and stillage, had noticeable impact into sugarcane productivity, which were presented in Table 5.

Table 5: Impact of potassium doses and combination of potassium source from KCl and stillage

Treatment	Sugarcane productivity (ton /ha)
K1	91,09a
K2	87,60a
C0	85,03a
C1	87,44a
C2	94,04a
C3	91,95a
C4	88,26a
Interaction	-

Note: number followed by the same letter in the same column does not show significant difference in the DMRT and (-) mark indicates no interaction in the combination treatment.

In conclusion of table 5 in this study, treatment of potassium (K) dose and combination of K source from KCl and stillage, had no interaction between them. Both of treatments had no significantly influence toward sugarcane productivity.

Sugarcane productivity in 200 kg/ha K doses was in 91.9 ton/ha. It was higher than 300 kg/ha K doses, only in 87.60 ton/ha. Treatment of 200 kg/ha K doses did not significantly difference into 300 kg/ha K doses due to K lack had fulfilled by 200 kg/ha K doses treatment.

Combination of K source from KCl and stillage did not impact significantly upon sugarcane productivity. C2 treatment with KCl:stillage (50%:50%) obtained the highest productivity (94.04 ton/ha). On other hand, C0 treatment with KCl(100%) attained the lowest of it (85.03 ton/ha). Regarding to this observation, stillage application can be used as replacement of K source from KCl.

Balance of soil nutrient

Fertilizer application as nitrogen source were ZA and urea, whilst TSP was phosphate (P) source and KCl was potassium (K) source. A balance of given-nutrient onto soil and uptake-nutrient by plant was presented in Table 6.

Table 6: Balance of N, P, and K soil nutrients (K1C0 and K2C0)

Nutrient Additions (A)				kg/ha			
Treatment K1 C0	ZA	UREA	N	TSP	P	KCl	K
As mineral fertilizer	100	283	151	100	20	200	100
Nutrient Uptake (B)			181		27		131
Balance (A-B)			-30		-7		-31
Nutrient Additions (A)				**kg/ha**			
Treatment K2 C0	ZA	UREA	N	TSP	P	KCl	K
As mineral fertilizer	100	283	151	100	20	300	150
Nutrient Uptake (B)			177		26		132
Balance (A-B)			-26		-6		+18

By this research, ZA and urea fertilizers in certain doses of 100 kg/ha and 283 kg/ha respectively, contributed into 151 kg nitrogen allocation. Total uptaked-nitrogen by sugarcane were 181 kg (treatment K1 C0) and 177 kg (treatment K2 C0). For this reason, N deficiencies of them were 30 kg and 26 kg, respectively. These deficiencies can be cured by sugar cane wastage, likely leaf and shoot.

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On other occasion, phosphate (P) fertilizer application came out of TSP with 100 kg/ha doses, which total P was 20 kg. Based on this study, P essential for sugarcane was 27 kg (treatment K1 C0) and 26 kg (treatment K2 C0). P deficiencies of them were 7 kg/ha and 6 kg/ha, respectively. These deficiencies can be cured by remained P in soil.

Treatment of 200 kg/ha K doses (K1 C0) provided potassium (K) contents about 100 kg. Plant required 131 kg, which meant it occured deficiency of 31 kg K contents. These deficiencies can be cured by sugarcane wastage likely leaf and shoot, so that absorbed-potassium can be higher than total given-potassium into soil. At treatment 300 kg/ha Kcl doses (treatment K2 C0), given-potassium content was 150 kg and absorbed-potassium was 132 kg. By this, there was a surplus of 18 kg. Potassium was the most dynamic element after nitrogen. Unabsorbed-potassium in soil can remove by leaching process.

CONCLUSION AND RECOMMENDATION

Conclusion

Giving potassium doses of 200 kg and 300 kg did not influence significantly toward chemical properties of ultisols, sugarcane quality, nutrient uptake and productivity.

Combination of potassium (K) source from KCl and stillage treatment had no effect upon chemical properties of ultisols, sugarcane quality, nutrient uptake and productivity.

Recommendation

It is necessary to conduct further research with other K_2O levels, which is higher than 0,192 me/100g or KCl with doses higher than 300 kg/ha (400 kg/Ha and 500 Kg/ha)

Upcoming research about stillage application doses properly is essential to conduct, in order to provide significant influence over sugarcane productivity.

REFERENCES

Agrofarm, 2016. Indonesia Defisit Gula,Impor Menggila Di 2017. Diakses tanggal 23 Mei 2016 http://beta.tirto.id/20160225-media-cetak/indonesia-defisit-gulaimpor-menggila-di-2017-6504/.

Ardika, B. D., A. W. N. Jati dan I. P. Yuda 2008. Uji efektifitas penambahan Cocopeat terhadap pertumbuhan legum sebagai tanaman penutup di area reklamasi bekas tambang batubara. Universitas Atma Jaya.

Balai Penelitian Tanah. 2005. Analisa Kimia Tanah , Tanaman, Air , dan Pupuk. Departemen Pertanian, Bogor.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Beringer, H. 1980. The role of potassium in crop production.Hal : 25-32. In Proceedings of International Seminar on the Role Of Potassium in Crop Production, Pretoria, Reublic of South Africa, 12-13 November 1979.

Berieger, F. O. 1970. The distribution of distillery slope in SCO Paulo, Brazil. Sugar Azucar, pp. 41-49.

Kurniawan, Y. 1981. Pendayagunaan limbah pabrik alcohol (slop). Majalah Perusahaan Gula, TH. XVII, Maret. P3GI. 1:6-12.

Lin, S. F. 1973. Manufacture of fodder yeast from molasses alcohol slop.Taiwan Sugar. 20 (5) : 185-188.

Pujiyanti, D. 2007. Serapan P, Pertumbuhan dan Hasil Tanaman Jagung Dengan Pemupukan Biofosfat di Andisol. Fakultas Pertanian, Universitas Gadjah Mada.

Subandi. 2013. Peran dan pengelolaan hara kalium untuk produksi pangan di Indonesia. Balai Penelitian Kacang-kacangan dan Umbi-umbian, Malang.

Sundara, B. 1998. Sugarcane Cultivation. First Edition. Vikas Publishing House Pvt Ltd, New Delh. 292 p.

Tan, K. H. 1993. Principle of Soil Chemistry Marcel Dekke Inc. New York.

Winarso. S. 2005. Dasar Kesehatan dan Kualitas Tanah. Penerbit Gava Media, Yogyakarta.

