

STUDY ON FARMLAND APPLICATION OF VINASSE FROM SUGARCANE MOLASSES

By

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Abstract

DURING bio-ethanol production from sugarcane molasses, large amounts of vinasse, which is strongly acidic with high COD and BOD, is produced as a by-product. Disposal of vinasse is one restrictive problem for sustainable bio-ethanol production. In this study, possible application of vinasse to farmland was investigated. First, the staple characteristics of vinasse were determined. Second, availability of nutrients such as nitrogen and potassium to crops and dynamics in the soil environment were studied in the laboratory and, thirdly, crop growth experiments were carried out in the field. In conclusion, 1) potassium is the most common nutrient in vinasse; 2) large amounts of chloride are also present; 3) high COD and pigment from rind of sugarcane were also observed. Farmland application of vinasse as a substitute for one third of the potassium showed no significant damage to the growth of red-radishes and tomatoes. When large amounts of vinasse are applied to farmland as a substitution for the nitrogen in traditional chemical fertilisers, nitrogen deficiency symptoms, especially immediately after application, are expected. In addition, it is necessary to take into consideration the leaching of ions and the pigment in the vinasse for proper timing of application and soil conditions.

Introduction

Production of bioethanol from sugarcane molasses produces large amounts of vinasse, which is strongly acidic, and contains a high COD and BOD, as a by-product. Disposal is troublesome and restrictive for sustainable bio-ethanol production.

The objectives of this study were to determine the possibility of farmland application of vinasse based on the 1) characteristic of vinasse, 2) movement of organic nitrogen from vinasse in the soil, and 3) availability of potassium in vinasse by examining vegetables in laboratory and field experiments.

Materials and methodology

Vinasse

Vinasse was provided by Ryuseki Corporation in December, 2007. Vinasse was stored at room temperature until the experiments were performed.

Incubation test

The dynamics of nitrogen in the soil with vinasse or chemical fertiliser applied was investigated by an incubation experiment.

Shimajiri-maji soil (100 g) from the upland Miyako Island Branch of Okinawa Prefectural Agricultural Research Center was used in these experiments. Ammonium sulfate and vinasse (C/N ratio is 10.5) equivalent to 30 mg total nitrogen were added to the Shimajiri-maji soil. The soils were incubated at 30°C and soil moisture kept at 60%. NH₄-N, NO₃-N, and NO₂-N in the soil were measured every week.

Tomato and radish cultivation

The experiments were conducted at Kannodai, Tsukuba-shi, Ibaraki-ken, Japan. The experimental plots had been used to grow vegetables for several years. The tomatoes were planted on 12 May 2008 and harvested from 8 July 2008 to 29 August 2008. The red radishes were planted on 8 September 2008 and harvested on 12 November 2008.

Experiments (10 m² × 2)

(1) Tomato: control (only chemical fertiliser was applied),

Red radish: control

(2) Tomato: vinasse (670 L/10a, 1/3 volume of potassium fertiliser replaced with vinasse)

Red radish: control

(3) Tomato: control

Red radish: vinasse (450 L/10a, 1/3 volume of potassium fertiliser replaced with vinasse)

(4) Tomato: vinasse (the same as experiment 2)

Red radish: vinasse (the same as experiment 3)

Fertilisers :

Tomato: N: 30, P₂O₅: 20, K₂O: 30 kg/10a

Red-radish: N: 12, P₂O₅: 10, K₂O: 12kg/10a

Measurements

Tomato: Weight of each fruit, Brix of fruit.

Radish: Weight of each radish leaf and root, Brix of radish root, and length and width of radish root.

Results and discussion

Characteristic of vinasse

The chemical properties of vinasse are shown in Table 1. High contents of COD and TOC indicate a large amount of organic matter is included in vinasse. The characteristic of vinasse was content of COD_{Cr} > content of COD_{Mn} > content of BOD. BOD is the quantity of biodegradable organic matter. It was concluded that a large amount of decomposable organic matter was included in the vinasse. A problem is that some of the components, particularly those of darker colour are organic components which are difficult to decompose.

Table 1—Chemical properties of vinasse.

pH	4.28
COD _{Mn} (mg/L)	81 900
COD _{Cr} (mg/L)	172 000
BOD (mg/L)	50 900
TOC (mg/L)	55 400
K ⁺ (mg/L)	17 000 (135 000)
Cl ⁻ (mg/L)	11 500 (11 400)
SO ₄ ²⁻ (mg/L)	11 400
S (mg/L)	3800
Total nitration (mg/L)	1976
PO ₄ ⁻ (mg/L)	767 (120)
Na ⁺ (mg/L)	508 (423)
Chloride	44 000

*Content of dissolved elements are shown in parentheses

The content of potassium in vinasse is high and most of it is dissolvable. It is easy to use as a potassium fertiliser. However, the content of chlorine in vinasse was even higher, indicating we must carefully consider salinisation.

Dynamics of vinasse nitrogen in the soil

Figure 1 shows changes in inorganic nitrogen of the soil. The incubation test, clearly showed that the $\text{NH}_4\text{-N}$ in soil treated with chemical fertiliser was almost completely converted into $\text{NO}_3\text{-N}$ within two weeks.

On the other hand, the inorganic N decreased 50% in the soil during the initial two weeks when vinasse was applied, but 30% of $\text{NO}_3\text{-N}$ increased in the soil over a period of 48 days when vinasse was applied.

Therefore, nitrogen deficiency, especially just after application, can be expected when large amounts of vinasse are applied to farmland.

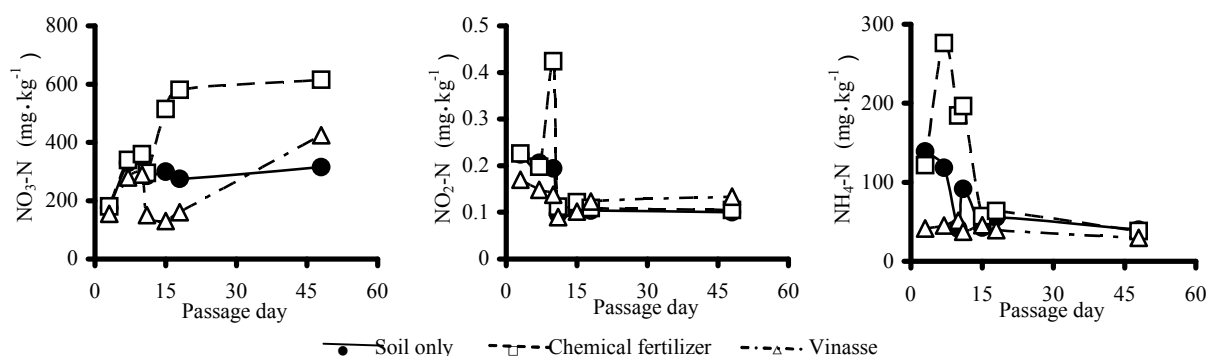


Fig. 1—Changes in inorganic nitrogen of the soil.

Tomato and radish cultivation

The yields, individual weights and Brix of tomatoes in each experimental plot are shown in Figure 2. Many small and middle sized fruits less than 200 g were harvested from the vinasse plot such that the average weight of tomatoes in the vinasse plot was lighter than the tomatoes in the control plot. The numbers of tomatoes in the vinasse plot was greater than in the control plot. As a result, the yield of tomatoes in the vinasse plot was higher than in the control plot. In addition, the sugar content of the tomatoes in the vinasse plot was slightly higher than in the control plot.

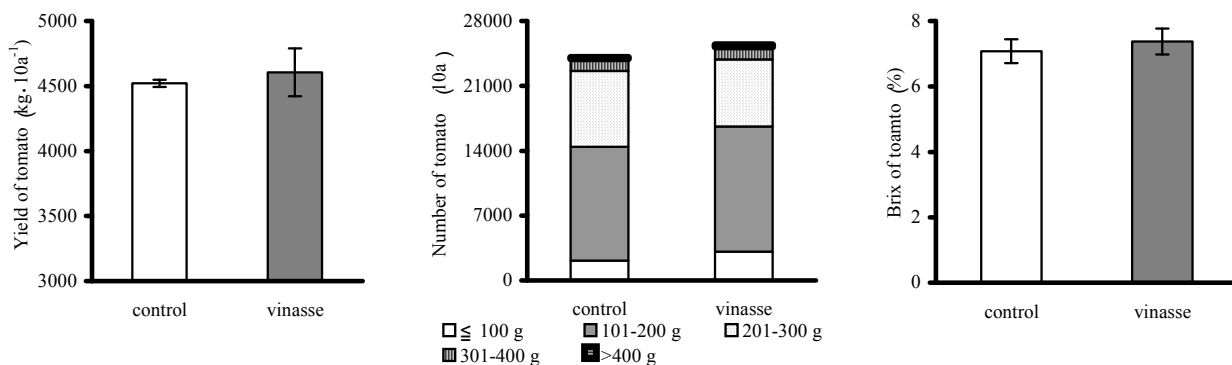


Fig. 2—Growth of tomatoes.

The total weight of red radishes, the ratio of the weight of the roots and leaves, and the length and width of the roots are shown in Figure 3.

The highest weight of red radish was in the control (vinasse) plot. In the other three plots, there were no significant differences in total weight and root weight of red radishes. It is apparent that tomato and red radish are not affected by the application of vinasse and chemical fertiliser.

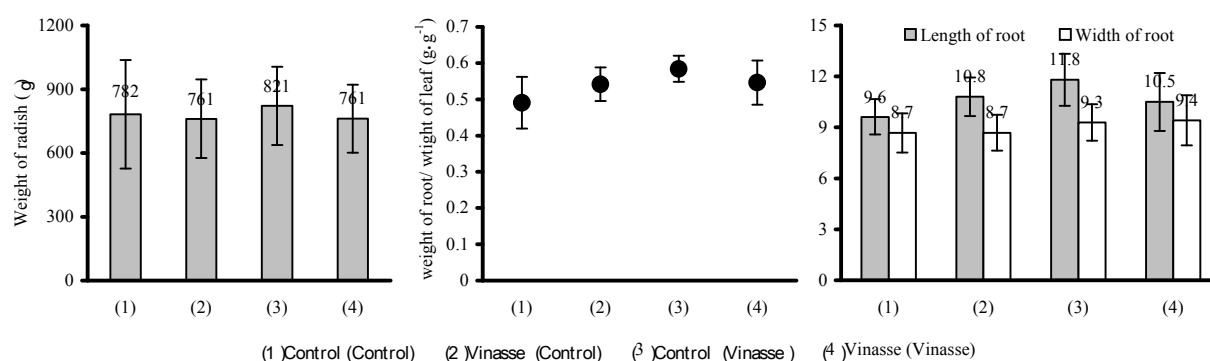


Fig. 3—Growth of red radishes.

Conclusion

This study dealt with the influence of application of vinasse to the soil on dynamics of nitrogen and tomato and red radish growth. The results showed there was no significant damage to red radish and tomato growth with substitution of one third of the potassium fertiliser requirement being substituted by vinasse. This indicated that vinasse can be substituted for potassium fertilisers. However, when large amounts of vinasse are applied to farm land, it is suspected that nitrogen deficiency, especially just after application, can be expected.

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ETUDE DE L'APPLICATION DE LA VINASSE PROVENANT DE LA MÉLASSE DE CANNE À SUCRE SUR DES TERRES CULTIVÉES

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MOTS CLÉS: Mélasse de Canne à Sucre, Pigment, Tests d'Incubation, Culture de Tomates et de Radis

Résumé

PENDANT la production de bioéthanol à partir de la mélasse de canne à sucre, de grosses quantités de vinasse, qui est un sous produit très acide avec un DCO et DB_O élevés, sont disponibles. La disposition de la vinasse est une contrainte pour une production durable de bioéthanol. L'application de la vinasse sur les terres cultivées a été évaluée dans cette étude. Les caractéristiques de base de la vinasse ont d'abord été déterminées. Deuxièmement, la disponibilité des nutriments tels l'azote et la potasse à la culture et leur mouvement dans le sol ont été étudiés en laboratoire et troisièmement, des essais de croissance de la culture ont été mis en place dans les champs. Pour conclure, 1) la potasse est le nutriment principal dans la vinasse; 2) de grosses quantités de chlorure sont aussi présentes; 3) une forte DCO et des pigments provenant de l'écorce de la canne sont aussi observés. L'application au champ de la vinasse comme substitut pour un tiers des besoins en potasse n'a pas eu d'effets négatifs sur la pousse des radis-rouge et des tomates. Quand de grosses quantités de vinasse sont appliquées dans les champs, comme substitut à l'azote chimique, des déficiences d'azote sont attendues, surtout juste après l'application. De plus, le lessivage des ions, le pigment dans la vinasse ainsi que les conditions du sol doivent être considérés pour le calendrier d'application.

ESTUDIO SOBRE LA APLICACIÓN DE VINAZA DE MELAZA DE CAÑA DE AZÚCAR EN TIERRAS CULTIVABLES

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PALABRAS CLAVE: Melaza De Caña De Azúcar, Pigmento, Incubación, Prueba, Cultivo De Tomate Y Rábano.

Resumen

DURANTE la producción de bio-etanol a partir de melazas de caña de azúcar, se genera como subproducto gran cantidad de vinaza, la cual es fuertemente ácida y con elevadas DQO y DBO. La eliminación de la vinaza es un problema restrictivo para la producción sustentable de bio-etanol. En este estudio, se investigó la posible aplicación de vinazas a tierras de cultivo. En primer lugar, se determinaron las características básicas de la vinaza. En segundo lugar, se estudió en laboratorio la disponibilidad de nutrientes como el nitrógeno y el potasio para los cultivos y su dinámica en el entorno edáfico y, en tercer lugar, se llevaron a cabo en campo experimentos de crecimiento de cultivos. En conclusión, 1) el potasio es el nutriente más común en la vinaza; 2) también contiene grandes cantidades de cloruro; 3) se observó elevado DQO y pigmento de la corteza de la caña de azúcar. La aplicación de vinaza a tierras de cultivo de vinazas con un sustituto de un tercio del potasio no mostró ningún daño significativo sobre el desarrollo de rábanos rojos y tomates. Cuando grandes cantidades de vinaza son aplicadas a tierras cultivables como sustitución del nitrógeno contenido en los fertilizantes químicos tradicionales, se esperan síntomas de la deficiencia de nitrógeno, especialmente después de la aplicación. Además, es necesario tomar en consideración la lixiviación de los iones y el pigmento en la vinaza para encontrar el momento adecuado de aplicación y las condiciones del suelo.