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Effectiveness of bacteria and fungi inoculants in liquid organic fertilizer production

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Abstract

Bio-fertilizers in agriculture are divided into solid and liquid forms. Organic liquid fertilizers do not have a complicated production process. They derive from fresh organic materials that are fermented in closed systems. The objective of this research was to compare the effectiveness of two microorganisms, bacteria and fungi to decompose organic materials by following a natural fermentation process using three formulas of organic mixtures. The first formula consisted of a mixture of sweet fruits including longan (*Dimocarpus longan Lour*), Sapodilla (*Manilkara achras Fosberg*) and rambutan (*Nephelium lappaceum L*.). The second formula was a mixture of sour fruits including star gooseberry (*Phyllanthus acidus Skeels*.), orange (*Citrus sinensis Osb*.) and lime (*Citrus aurantifolia Swingle Syn*.: *C. medica* var *liman nipis Ridi*. *C. acdia Roxb*. *Limonia aurantifolia Christimann*.) whereas the third formula was a mixture of starch fruits including banana (*Musa sapientum Linn*.), sweet potato (*Ipomoea batatas' (L.) Lam*.) and taro roots (*Colocasia esculenta (L.) Schott*). These formulas were mixed with molasses with a ratio of fruits to molasses of 9.75:0.25 (by weight). Bacteria *Phodopseudomonas* sp. and fungi *Aspergillus* sp. were added separately to these systems. A measurement of 20 samples taken after 30 days of fermentation showed that the NPK nutrient levels in the organic liquid fertilizer from the third formula (starch fruits) had the highest values and that the NPK ratio from bacteria and from fungi were 8:6:3 and 9:9:11, respectively.

Keywords:

Introduction

In Thailand the volume fertilizer use has increased for both solid and liquid fertilizers in part due to recommendations from the Department of Agriculture. Farmers in Thailand have also increasingly used organic fertilizers to increase production efficiency replacing the use of chemical fertilizers with the of 71.57-73.52 million tons of organic fertilizers per year (Department of Economic Agriculture, 2008). Most organic fertilizers are made out of many kinds of agricultural wastes, such as animal dung, and plant residues. To keeping organic fertilizers for a long period of time, they may be compressed by a hydraulic compressing machine to create dry fertilizer pellets, However, a considerable capital investment is necessary to purchase such a machine (Poincelot and Raymond, 1979).

Organic fertilizers are increasingly playing a more important role as substitutes to chemical fertilizers. According to data from the Office of National Statistics, more farmers are using organic fertilizers, increasingly from 100,768 in 1998 to 155,646 persons applying organic fertilizers by 2003 (Office of the National Statistics, 2003). Studies that have compared different plant species as sources for organic fertilizers showed that plants high in sugar and starch had higher NPK values than other plants (Tako and Kato et al., 1994). Another study found that weed fermented fertilizer had higher nitrogen (N) values than fertilizers from fermented fruits (Supot, 2001). Studies have also shown that natural fungi increased the effectiveness of cellulose decomposition and obtained liquid fertilizers with higher NPK values than fertilizers produced with other microorganisms (Schlegel, 1990). Thus the objective of this research was to compare the effectiveness of bacteria and fungi inoculants to increase the NPK content in three formulas of liquid organic fertilizer.

Materials and Methods

Experimental fruits

Fruits in this research were divided into three groups:

1. Sweet fruits: Longan (*Dimocarpus longan Lour*), Sapadilla (*Manilkara achras Fosherg*) and Rambutan (*Nephelium lappaeum L.*) 20 samples

2. Sour fruits: Star Gooseburrey (*Phyllanthus acidus Skeels*), Orange (*Citrus Sinensis Osb.*) and Lime (*Citrus Aurantifolia Swingle Syn.*, *C.medica* var *liman nipis Ridi. C. acdia Roxb. Limonia aurantifolia Christimann.*) 20 samples.

3. Starch fruits: banana (*Musa sapientum Linn.*), sweet potato (*Lpomoea batatas'(L.) Lam.*) and Taro roots (*Colocasia esculenta(L.) Schott.*) 20 samples.

100 gm. For each fruit(only meat) per each sample.

Catalyst/Culture medium

Molasses were used as a mixture for culture medium of bacteria and fungi in each sample.

Microorganisms

Bacteria *Phodopseudomonas* sp. and fungi *Aspergillus* sp.

Procedure

Raw materials for organic fertilizer production were divided into 3 formulas:

First formula: sweet fruit juice + distilled water (475 mL.) + molasses (25 mL.) + bacteria or fungi

-20 samples were prepared with addition of bacteria 10 samples and fungi on 10 samples.

Second formula: sour fruit juice + distilled water (475 mL.) + molasses (25 mL.) + bacteria or fungi

-20 samples were prepared with addition of bacteria 10 samples and fungi on 10 samples.

Third formula: starch fruit juice + distilled water (475 mL.) + molasses (25 mL.) + bacteria or fungi

-20 samples were prepared with addition of bacteria 10 samples and fungi on 10 samples.

A total 60 samples from the 3 formulas were used for chemical and plant nutrients analysis. Samples taken 30 days after fermentation were also collected for chemical and plant nutrient analysis contents.

Analysis of bio-liquid fertilizer

Chemical analysis and plant nutrients analysis were determined as following:
1. pH by pH meter Orion model 720 A
2. Total nitrogen by Kjedahl method
3. Phosphorus by spectrophotometer at wave length 420 nm.
4. Potassium by Atomic Spectrophotometer AS400
5. Carbon analysis by Walkley and Black method (1942) wet oxidation
6. Experimental design and statistical analysis

A Nested Design was used to analyze experimental data using a Split pilot design model. Regression analysis was performed with analysis of variance, ANOVA. Average values were compared by Least Significant Difference Test (LSD) at a significance level of 95%.

Results and Discussion

Chemical analysis and nutrient content analysis of the bio-liquid fertilizer were determined at the initial stage of fertilizer preparation, prior to fermentation, as shown in table 1.

Table 1: Chemical analysis and nutrient content analysis at the initial stage of fertilizer preparation, prior to fermentation.

	Formula1		Formula2		Formula3	
Parameter	Fungi	Bacteria	Fungi	Bacteria	Fungi	Bacteria
pH	3.9	3.8	3.2	3.1	4.0	3.9
EC (ms/cm)	9.4	10.0	11.0	10.9	9.1	9.2
C/N	29.3	28.1	28.0	28.2	32.0	32.1
N (%)	7.1	7.0	5.0	5.1	7.2	7.3
P (%)	6.0	6.0	5.6	5.7	7.1	7.0
K (%)	8.1	8.1	6.2	6.2	8.2	8.1

Chemical analysis and nutrient contents analysis of bio-liquid fertilizers taken after 30 days of fermentation are shown in table 2.

Table 2: Chemical analysis and nutrient contents analysis taken after 30 days of fermentation

Parameter	Formula1		Formula2		Formula3	
	Fungi	Bacteria	Fungi	Bacteria	Fungi	Bacteria
pH	3.1	3.8	2.4	3.2	3.5	3.2
EC (ms/cm)	10.3	10.5	10.2	9.9	9.5	9.2
C/N	28.0	27.8	28.2	28.9	33.5	32.9
N (%)	6.4	5.8	5.4	6.8	9.0	8.3
P (%)	6.0	5.8	5.1	5.4	9.0	6.4
K (%)	4.5	5.1	6.1	4.2	11.0	3.0

After 30 days of fermentation, the bio-liquid fertilizers were dark brown and their smell was similar to that after wine fermentation. The chemical properties and nutrient content of the three formulas of fermented liquid fertilizers shown in table 2 are summarized as follows:

First formula

A mixture of sweet fruit juice and distilled water totalling 475 mL with molasses 25 mL for each sample. A total of 20 samples with the addition of fungi in 10 bottles/samples and the addition of bacteria in the other 10 bottles were tested. Acidity, EC and C/N values did not vary significantly between fungi- and bacteria- based samples as shown in Fig. 1. However, N and P values were greater in samples were bacteria was added compared to the fungi-based samples. P values were not affected by the microbial treatments. The P values of fungi- and bacteria-based liquid fertilizer samples were 6.0 and 5.8 respectively.

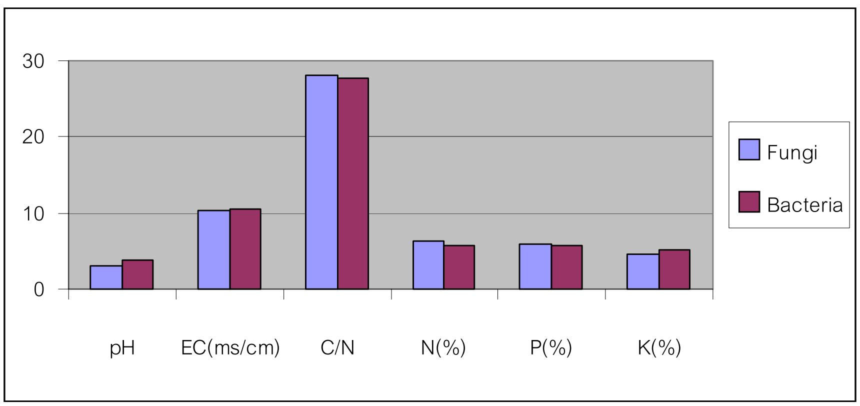

Figure 1: Chemical and nutrient content analysis taken after 30 days of fermentation with the first liquid fertilizer formula.

Second formula

A mixture of sour fruit juice and distilled water totalling 475 mL with 25 mL molasses added to each sample. A total of 20 samples with the addition of fungi in 10 bottles/samples and the addition of bacteria in the other 10 bottles were tested. Acidity or pH of fungi-based fertilizers was 2.4 and the pH of bacteria-based fertilizers was 3.2. However, the EC and C/N ratios were not affected by microbial treatments as shown in Fig. 2. Both N and P values of bacteria-based fertilizers were higher than that of fungi-base fertilizers. The K values were also affected by the microbial treatments with K values for fungi-based and bacteria-based liquid fertilizers of 6.1 and 4.2 respectively.

Figure 2: Chemical analysis and nutrient contents analysis taken after 30 days of fermentation with the second liquid fertilizer formula.

Third formula

The third formula consisted of a mixture of starch fruit juice in distilled water totalling 475 mL with 25 mL molasses added. A total of 20 samples with the addition of fungi in 10 bottles/samples and the addition of bacteria in the other 10 bottles were tested. Acidity, EC and C/N values were not affected by the microbial treatments as shown in Fig.3. The N, P and K values of fungi-based fertilizers were higher than that of bacteria-based fertilizers. However, K values were considerable different with K values for fungi-and bacteria-based fertilizers of 11.0 and 3.0 respectively.

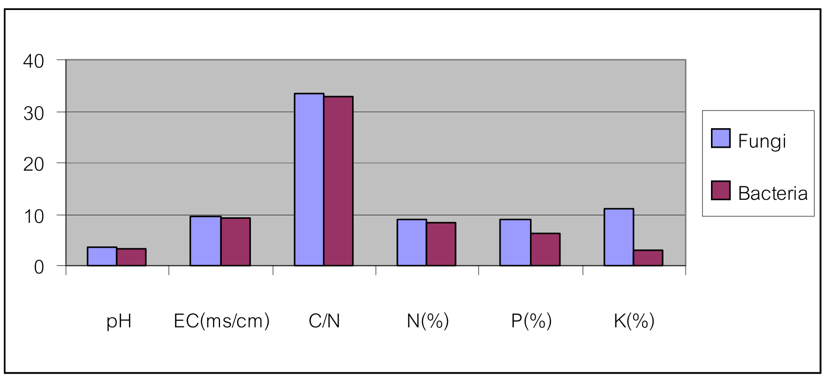

Figure 3: Chemical and nutrient contents analysis taken after 30 days of fermentation with the third liquid fertilizer formula.

The Comparison of NPK in the three formulas is shown in Fig.4.

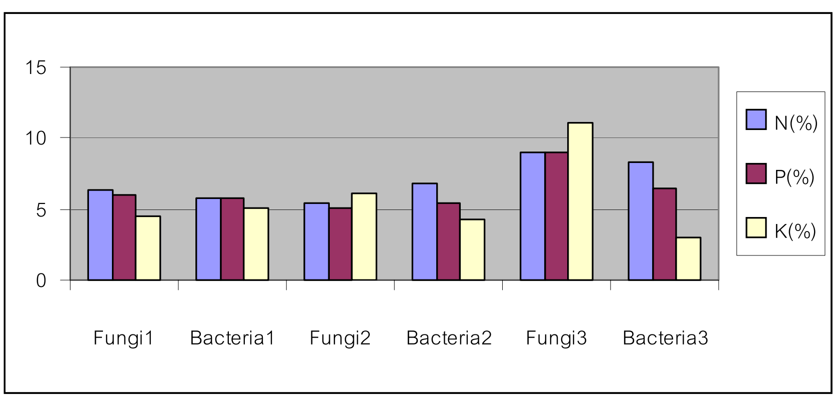

Figure 4: Comparison of NPK levels in three formulas of liquid fertilizers inoculated with bacteria and fungi

The highest NPK values were observed in the third liquid fertilizer formula. This formula was derived from starch fruits. The NPK ratio of bacteria-and fungi-based liquid fertilizers were 8:6:3 and 9:9:11 respectively. This research used simple fruits that are low cost and available in local production areas. Other kinds of fruit that have similar properties the ones tested in these experiments, may also be effective for the production of liquid organic fertilizers. However, other microorganisms should be evaluated to improve the efficiency of liquid fertilizer production and nutrient contents. The liquid fertilizers evaluated in this experiment should be tested in field experiments with cultivation of plants to determine their effectiveness as liquid fertilizers and to make sure that the nutrients in the liquid fertilizer are properly taken up by plants.

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