

STUDY ON MADE FROM MUD FERMENTATION FOR BIOLOGICAL ORGANIC FERTILIZER

Junjie Tan¹ Hongwei Tan²

¹School of Economics and Management, Guangxi Normal University for Nationalities, Chongzuo 532200, China

²Sugarcane Research Institute, Guangxi Academy of Agricultural Sciences/Key Laboratory of Sugarcane Genetic Improvement, Nanning 530007, China ; **Corresponding author**)

ABSTRACT

【objective】 Sugar mill filter mud fermented into h biological organic fertilizer of high humic acid content. It was rich resource utilization which not only be able to solve mud pollution to the environment, but also be able to solve problem of soil fertility decline and promote the agricultural production to achieve sustainable development. **【method】** The representative regions selected to fermentation production of biological organic fertilizer and using the method of field experiment. It was studied the characteristics of fermentation production of biological organic fertilizer and fertilizer effect. **【results】** The rotting process of functional bacteria fermentation production of biological organic fertilizer was less affected by environmental factors, the effect of fermentation stability, and it took only 20-25 d to complete a rotting process. Fermentation temperature was up to 77.2 °C , and it was maintain a long period of time which more than 15 days generally at 60 °C ~ 77.2 °C. Functional bacteria fermentation production of biological organic fertilizer production organic components, such as bacteria protease, after fermentation of organic matter content and organic acid conversion rate increased by 30.2 and 12.3%(absolute value) respectively. The field experiment results show that the influence of the treatment applied functional bacteria fermentation production of biological organic fertilizer processing was greater than applied amount of traditional (natural) fermentation biological organic fertilizer processing, and it increased crops production yield of 28.9 kg/mu or 7.8%, 1491.9 kg/mu or 41.2% and 511.7 kg/mu or 6.9%, respectively on rice, cucumber and sugarcane. Five years in the field experimental results, the processing of functional bacteria fermentation biological organic fertilizer were compared to a traditional biological organic fertilizer (natural) fermentation processing high in soil organic matter, available nitrogen, available phosphorus and available potassium content. Utilization rates of nitrogen, phosphorus and potassium were 39.3%, 12.8% and 39.3% respectively, compared with traditional (natural) fermentation biological organic fertilizer processing of nitrogen, phosphorus and potassium utilization rates increased by 18.3%, 2.2% and 21.6% (absolute value), and increased by 15.0%, 4.5% and 30.8% (absolute value)

than the only chemical fertilizers treatment. **【conclusion】** The functional bacteria fermentation production of biological organic fertilizer than traditional (natural) fermentation biological organic fertilizer, it was rotting speedily, fermentation temperature was highest to keep maintain advantages such as longer time. And after fermentation of organic matter content and organic acid conversion, the obvious advantages occur. At the same time, also be able to increase production and improve the effect of soil fertility and fertilizer utilization rate.

Keywords: sugar mill; filter mud; fermentation; biological organic fertilizer; characteristic;

Introduction

Guangxi is one of the largest sugar industrial base in China, cane sugar production accounted for about 70% of the whole country. It is one of the important economic pillars that Guangxi sugar industry during the process of sugarcane in sugar per ton 3.5% - 4.8% of the filter mud in different sugar mill, and an average was about 4.2%. According to Guangxi, an annual 56 million tons of material sugarcane sugar is able to produce mud of about 2.352 million tons. But due to various reasons, a long time of sugar mill filter mud was drained off, cause serious environmental pollution. Sugar mill filter mud, in fact, the composition of various organic substances is mainly from sugar cane and absorption of various nutrients in the soil, and is needed to make crops grow of nitrogen, phosphorus, potassium and other large elements, trace elements. At the same time in the process of sugar, it also did not add any toxic substances such as heavy metals, etc. Therefore, by using the sugar mill filter mud fermented into humic acid content of biological organic fertilizer, and resource utilization in agricultural production, it not only be able to solve the sugar mill filter mud pollution to the environment, meanwhile but also be able to solve the problem of soil fertility decline in agricultural production, protect the environment, and promote the sugar industry sustainable development.

Recently studies show that, reasonable development of filter mud such as different filter mud compound fertilizer preparation, is able to improve the soil physical and chemical properties, reduce environmental pollution, and offer more effective ways that improve the comprehensive benefit of sugar mill (Huyuson, 1998). Lin's (1997) research found that, the raw material including filter mud, is able to be developed and transformed from inorganic fertilizer to organic-inorganic compound fertilizer in the end. This research has been recognized by the provincial technical appraisal committee, and it offers the best solution to sugar factories for getting filter mud resource supply. Factories don't have to face the problem of direct emissions and certain related pollutant discharge fee. In JuRan's (2011) studies, microbial growth necessary nutrients were found in sugar cane sugar filter mud. The filter mud contains large number of organic

matter, nitrogen, phosphorus and trace elements. Xiao Xing (1999) stated that, sugar producers in Guangdong Province produced large amount of waste residue, filter mud from raw material of sucrose by using compound fertilizer production equipment. Zuo JianJun (2014) pointed out that, sugar factories can use sugar mill filter mud to produce compound fertilizer, or to made animal feed as well.

Sugarcane is the major cash crops in Guangxi, the sugar output accounts for more than 70% of the country, sugar cane planting area (1.06 million ha) accounted for about Guangxi a quarter of the total cultivated area (4.2 million ha). For a long time, sucrose filter mud as the main raw material matches with inorganic fertilizer to develop organic-inorganic compound fertilizer. However, latest research relating to the functional bacteria fermentation of sugar mill filter mud turn into biological organic fertilizer is very seldom. Also, there is no such biological organic fertilizer made from fermented sugar mill filter mud research reports be found in the public.

Guangxi sugarcane planting sugar mill filter mud and the function of the most representative bacteria fermented biological organic fertilizer, experimental study in sugar mill to made from filter mud with functional bacteria fermentation characteristics and laws of biological organic fertilizer, to provide technical support for the sustainable production measure sugarcane area, at the same time for the government to provide decision-making reference for agricultural environmental protection policies.

Materials and methods

1.1 Experimental sites

Currently, sugar mill with general or cooperate with filter mud treatment. 60% of filter mud, generally directly by the enterprise to produce fertilizer, and 40% sold to farmers for personal use or to subcontract business.

Experimental sites was in Xingbing district of laibin city and Daxin county of congzuo city respectively, and there are all important sugar production in Guangxi.

1.2 Test materials

Sugar mill mud filter and the *Bacillus subtilis*, *Bacillus megaterium* and A jelly like *Bacillus* and so on. Functional bacteria was *Bacillus subtilis*, *Bacillus megaterium* and A jelly like *Bacillus* and so on.

Application of *Bacillus subtilis*, *Bacillus megaterium* and A jelly like *Bacillus* Made of mushroom.

1.3 Fermentation production of biological organic fertilizer

Traditional fermentation production of biological organic fertilizer (natural) plan 1: using filter mud fermentation (heap retting) of pile type, the water content was in the 50-65% of the filter mud piled in 1.5 2.0 m wide, 0.5 m high bar pile fermentation. This pile of retting way was an average of 7-9 d turns mow.

Functional bacteria fermentation production of biological organic fertilizer solution 2: the same filter mud fermentation (heap retting) of pile type, the water content was in the 50-65% of the uniform filter mud mixed with strains, heaped up 1.5 2.0 m wide, 0.5 m high bar pile fermentation. This way of heap retting was average 4-5 d turns mow.

1.4 Determination of fermentation production of organic inclusions

Bacteria protease determination by ultraviolet spectrophotometer method.

Per gram of enzyme preparation in the calculation of enzyme activity: $\Delta A \times 1000 / \text{unit/g} (t * w)$
enzyme activity of enzyme preparation

As type of delta - A sample with blank absorbance difference (namely the absorbance values of A1 and B1);

T - enzyme action time (this experiment for 10 min);

W - the amount of enzyme in the reaction, g

Determination of sucrose content by titration method.

$$X = (R2, R1) \times 0.95$$

Type: X - sucrose content in the samples, %;

R2 - hydrolysis after processing the content of reducing sugar, %;

R1 - not by hydrolyzing reducing sugar content in %.

0.95 - reducing sugars (glucose) for sucrose conversion coefficient.

The content of organic acid by titration method.

According to the concentration of NaOH standard solution c and calculating the content of organic acid consumption volume V:

$$\omega(H_xA) = \frac{cVM(H_xA)}{m_s \times 1000} \times 100\%$$

Type: c - The concentration of standard solution, %;

V - The volume of consumption;

M - Samples from organic acid.

Results and analysis

2.1 Physical and chemical characteristics and mud fermentation production of organic fertilizer test

Sugar mill filter mud has the characteristics as rich nutrient content, low content of heavy metal elements of harmful. Such as pH 4.6 to 6.3, organic matter content of the filter mud is 30.3 to 67.2, and containing of N, P₂O₅, K₂O, CaO and MgO is 0.9 1.3%, 0.6 1.4%, 0.4 0.7%, 4.9 5.9% and 0.9 1.2% respectively, sucrose is 0.35 to 1.21%. Main harmful elements as Pb 0.0 mg/kg, Cr 17-38mg/kg, Cd 2.4-3.9 mg/kg, Hg 0.5-1.9 mg/kg, As 3.5-7.7 mg/kg, were below the national biological organic fertilizer allow content standards.

The traditional retting pile fermentation method to be perfect. Toy factory article adopts traditional chock type pile retting, groove type retting pile fermentation method producing fertilizer, some even open heap retting, covers an area of big, not only easy to produce odor and sewage, affect the surrounding environment. But also restricted by weather conditions, the quality is not stable, the production cycle is long, high operation cost. Rotten slow, are greatly influenced by environmental factors, fermentation effect is very unstable, often need 35 to 45 d process to complete a rotten. And the way of retting covers an area of big, the high cost of booths, in order to save costs, companies often open heap retting, sewage easily with the rainwater flowing around, dust is bigger, a larger influence on surrounding environment.

Using functional bacteria fermentation production of biological organic fertilizer has the rotten speed, less affected by environmental factors, fermentation effect is stable, often need 20 to 25 d process can complete a rotten. Selected species have: huge bacillus, saccharomyces cerevisiae, jingyang Streptomyces, green trichoderma viride, white-floored mildew and thermophilic spore mildew, re candida yeast, bacillus subtilis, round brown azotobacter, jelly bacillus, the red swamp pseudomonas, etc.

After more than ten years research and practice, a breakthrough in the following aspects.

(1) solve the antagonistic effect between flora disturbance. Product production process successfully solves the antagonistic effect of interference and balance between bacteria fertilizer effect of quantitative relationship. The technical challenges of breakthrough, determines the crop straw and organic waste of biological fertilizer was produced by this technology, practicality and high efficiency in production.

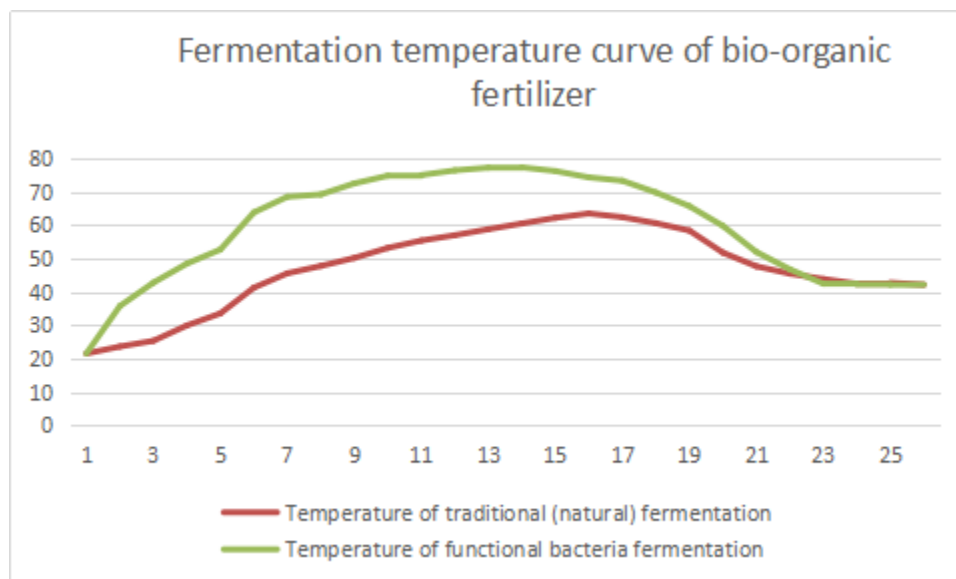
At the same time, with the production of biological fertilizer, crop straw and organic waste product development breakthrough thinking over the traditional thinking, between nitrogen fixation, phosphate-solubilizing, match the beneficial bacteria group focused on in the soil to form a powerful beneficial biological group, and by these bacteria rally metabolism and multi-level decomposition and into various active group, and continuously produce humic acid, prompting the soil organic matter into the fine plant nutrients.

(2) Equipping bacteria number of innovation. Equipping strains reached 10 to 11 strains, strain multifunctional role is extensive; The production of effective and qualitative, screening fungus production material particle size and the use level mixing fermentation method, the combination of effectively ensure bacteria play a key role in helping the quality of the product.

(3) The design and application the strain of high temperature resistance. Cultivation of strain, fermentation temperature was up to 77.2°C generally at 60°C~77.2°C and maintain a long time, it was more than 15 days. So time fermentation temperature was not only shorten the rotten of organic matter decomposition, and also can kill other harmful bacteria in the pile of rotten raw materials.

2.2 The fermentation production of biological organic fertilizer temperature change characteristics

Functional bacteria fermentation production of biological organic fertilizer, heap retting temperature can reach 45 to 54°C in 3 days, then heat up to more than 60°C and can keep up to 60~77.2°C at 10~15 days. And traditional natural fermentation production of biological organic fertilizer, heap retting temperature was 40°C in 6 days, and then heat up to 50°C, 50~63°C at 10~12 days, it was significantly lower than the functional bacteria fermentation production of organic fertilizer.



2.3 Fermentation production of organic components

Useful microorganism metabolites are produced in this phase, there are mainly three kinds of metabolites, one is the enzymes, such as group of cellulose leaven, protease, saccharifying enzyme, hydrolysis, oxidase enzyme, acylation of amino acid enzyme, etc. Second is organic acid, such as humic acid, heteroauxin and gibberellic acid and citric acid, etc. Third is biotin, such as gibberellin, and all kinds of antibiotics, ketone.

Bacteria protease activity assay, the result of the traditional fermentation production of biological organic fertilizer (natural) bacteria protease enzyme activity was 1.023×10^4 unit/g enzyme preparation, it was significantly lower than that functional bacteria fermentation production of biological organic fertilizer bacteria protease enzyme activity was 1.793×10^6 unit/g of enzyme preparation.

Table 1 Bacteria protease activity assay results by ultraviolet spectrophotometer method

Treatments	bacteria protease enzyme activity unit/g enzyme preparation
Traditional (natural)fermentation	1.023×10^4
functional bacteria fermentation	1.793×10^6

Such as sugar mill filter mud after fermentation of organic waste, because the yeast, decompose organic wastes in sugar of mud, sucrose content was by 0.39-1.21% (average 0.99%), reduced to 0.05-0.13% (average 0.07%), it was effective for the sugar mill filter mud organic waste fermentation production of biological organic fertilizer.

Table 2 Mud of sucrose content before and after fermentation

Treatments	Sucrose content (%) before fermentation	Sucrose content (%) after fermentation
Traditional (natural)fermentation	1.04	0.89
functional bacteria fermentation	1.04	0.07

Traditional (natural) fermentation production of biological organic fertilizer, organic material into organic acid conversion rate was 59.7%, and functional bacteria fermentation production of biological organic fertilizer organic material into organic acid conversion rate was 30.2%, it was significantly higher and the traditional (natural) fermentation after fermentation of organic matter content is 45.7% 12.3% higher than the traditional (natural) fermentation.

Table 3 Mud after fermentation of organic matter content and organic acid conversion rate

Treatments	Organic matter content (%) after fermentation	Organic material into organic acid conversion rate (%)
Traditional (natural)fermentation	33.4	59.7
Functional bacteria fermentation	45.7	89.9

2.4 Effect of biological organic fertilizer

Biological organic fertilizer on rice, cucumber and sugarcane yield field experiment results show that the application of functional bacteria fermentation production of biological organic fertilizer processing rice yield an average was 398.1 kg/mu, and increased 28.9 kg/mu, or 7.8% than the treatment with traditional (natural) fermentation biological organic fertilizer. Application of functional bacteria fermentation production of biological organic fertilizer treatment an average yield was 5113.7 kg/mu, and increased 1491.9 kg/mu, or 41.2% than treatment with traditional (natural) fermentation biological organic fertilizer. Application of functional bacteria fermentation production of biological organic fertilizer treatment an average yield was 7918.7 kg/mu, increased 511.7 kg/mu, or 6.9% than treatment with traditional (natural) fermentation biological organic fertilizer rates yield.

Table 4 Effects of biological organic fertilizer on sugarcane yield (kg/mu)

Treatments	Functional bacteria fermentation	Traditional (natural)fermentation
Rice average yield	398.1	369.2
Cucumber average yield	5113.7	3621.8
Sugarcane average yield	7918.7	511.7

2.5 Biological organic fertilizer on soil fertility and nutrient utilization

In sugarcane planting areas, soil organic matter and the effect of continuous application of biological organic fertilizer research results shown, due to high temperature and rainy, strong leaching process of soil organic matter decomposition is rapid, the pursuit of sugarcane yield and a large number of chemical fertilizers, sugarcane take large amount of nutrients, resulting in a decline in soil fertility. How to maintain and improve soil fertility will be key to this area of sugarcane production stable high yield.

Effects applied biological organic fertilizer for five years, the field experimental results of functional bacteria fermentation biological organic fertilizer processing of soil organic matter, available nitrogen, available phosphorus and available potassium content are better than traditional (natural) fermentation processing of biological organic fertilizer is high, the following table 5.

Table 5 Effects applied biological organic fertilizer on soil nutrient

Treatments	Functional bacteria fermentation	Traditional (natural)fermentati on	Soil nutrient before experiment
Soil organic matter(g/kg)	15.75	14.99	14.53
Available N(mg/kg)	67	49	47
Available P(mg/kg)	14	7	4
Available K(mg/kg)	69	52	49

The effects of biological organic fertilizer on nutrient utilization, application of functional bacteria fermentation production of biological organic fertilizer processing utilization rate of nitrogen, phosphorus and potassium are 39.3%, 12.8% and 39.3% respectively, compared with traditional (natural) fermentation biological organic fertilizer processing utilization rate of nitrogen, phosphorus and potassium increased by 18.3%, 2.2% and 21.6% (absolute value) respectively, and than the only chemical fertilizers treatment increased by 15.0%, 4.5% and 30.8% (absolute value). Traditional (natural) fermentation of biological organic fertilizer processing utilization rate of nitrogen, phosphorus and potassium are 21.0%, 10.6% and 21.0% respectively, compared with only the chemical fertilizers treatment of phosphorus and potassium utilization rate increased by 2.3% and 2.3% (absolute value), and nitrogen utilization rate reduced by 3.3% (absolute value).

Table 6 Biological fertilizer effect on fertilizer utilization ratio

Treatments	Functional bacteria fermentation	Traditional (natural)fermentati on	No fertilizati on	Application of chemical fertilizer
N utilization rate(%)	39.3	21.0	-	24.3
P utilization	12.8	10.6	-	8.3

rate(%)				
K utilization rate(%)	52.8	31.2	-	22.0

Discussion

Huyuson (1998), such as rational development filter mud, preparation into different filter mud compound fertilizer is to improve the soil physical and chemical properties, reducing environmental pollution and the effective ways to improve the comprehensive benefit of sugar mill. Lin Tianmu (1997), such as sucrose, filter mud as the main raw material, match with inorganic fertilizer developed into organic-- inorganic compound fertilizer on December 20, by the provincial technical appraisal committee of science and technology. Sucrose filter mud are the biggest sources of long plagued sugar mill, without processing, direct emissions, cause serious pollution, and have to pay a lot of pollutant discharge fee. JuRan (2011) such as sugar cane sugar filter mud contains a large number of organic matter, nitrogen, phosphorus and trace elements such as microbial growth necessary nutrients. Xiao xing (1999) some sugar factory in Guangdong province, by providing the compound fertilizer production equipment, the use of sucrose, produce the large amount of waste residue, filter mud. Zuojianjun (2014), such as the comprehensive utilization of sugar mill filter mud can be summarized as filter mud compound fertilizer production, processing into animal feed, extract sugarcane wax and plant sterols, preparation of materials and additives, as biomass fuel and so on five aspects.

These studies mainly discuss mud pollution problem and the use of filter mud rich in organic matter, nitrogen, phosphorus and trace metal elements such as microbial growth necessary nutrients, such as the production of organic-inorganic compound fertilizer or processed into animal feed, extract sugarcane wax and plant sterols, preparation of materials and additives, as biomass fuel, etc., not involving the application of microbial technology and functional bacteria fermentation production of biological organic fertilizer. This study systematically from a functional bacteria screening, function bacteria fermentation, biological organic fertilizer applied in the field experiment and functional bacteria fermentation production of biological organic fertilizer such as large-scale production work and made good progress.

Conclusion

(1) Application of functional bacteria fermentation production of biological organic fertilizer was fast than traditional (natural) fermentation biological organic fertilizer. It was with rotten, fermentation temperature up to 77.2°C 60°C-77.2°C and maintain a long time, more than 15 days.

(2) Functional bacteria fermentation production of biological organic fertilizer, production organic components, such as bacteria protease increased significantly. After fermentation of organic matter content and organic acid conversion obvious advantages, increased by 30.2 and 12.3% respectively.

(3) The use of functional bacteria fermentation production of biological organic fertilizer the rice yield increased 28.9 kg/mu or 7.8%, cucumber yield increased 1491.9 kg/mu or 41.2% and sugarcane yield increased 511.7 kg/mu or 6.9%, respectively, than application of traditional (natural) fermentation biological organic fertilizer.

(4) Application of functional bacteria fermentation biological organic fertilizer, soil organic matter, available nitrogen, available phosphorus and available potassium content are better than the treatment with traditional (natural) fermentation of biological organic fertilizer. Nitrogen, phosphorus and potassium utilization rate are 39.3%, 12.8% and 39.3% respectively, it was compared with traditional (natural) fermentation biological organic fertilizer of nitrogen, phosphorus and potassium utilization rate increased by 18.3%, 2.2% and 21.6% (absolute value), and the only chemical fertilizers treatment increased by 15.0%, 4.5% and 30.8% (absolute value).

References:

Huyuson, Wang xing-min. A feasibility study on the development and application of compound filter mud 《Journal of northwest normal university: natural science edition》 no. 4, 1998, 56, 58.

Lin Tianmu. Sucrose filter made of organic clay-a high efficient inorganic compound fertilizer success 《Fujian textile》 01, 1997, 42 to 45.

Juran, Xu Yan, Wang Zheng Deng Jinming. Sulfite method of sucrose filter mud used in sewage treatment experience 《Light industrial science and technology》, 2011 (11) : 93-94.

Xiao xing. Filter mud filling material for compound fertilizer 《Phosphate fertilizer and compound fertilizers》 1999 (5) : 46-46.

Zuojianjun. Yin HuaLiang, Wang Weiwei, cane sugar mill filter mud of resource-oriented utilization analysis 《Enterprise of science and technology and the exhibition》 2014 (7) : 19-21.

Tan Hong-wei, Zhou Liuqiang, Xie rulin, Huang Meifu, Xie Gang. Sugar utilization of organic wastes in the production 《 Popular science and technology》 , 2016, 17 (5) : 110-112.

Tan Hongwei, Zhou Liuqiang, Xie Rulin and Huang Meifu. The Soil Organic Matter and Effect of Long Term Application of Compost Product in Sugarcane Planting Area 《Journal of Life Sciences》 6 (2012), 390-397.