Effects of Biogas Residue Organic Fertilizer on the Yield and Quality of Dragon Fruit

Xiaohong Huang, Jing Jiao, Zunxiang Li, Jihua Du*

Institute of Agricultural Machinery, Chinese Academy of Tropical Agricultural Sciences (CATAS), Zhanjiang 524091, China

* Corresponding author: dujihua050609@163.com

Abstract: In order to explore the effect of biogas residue organic fertilizer on the yield and quality of dragon fruit, field experiments were carried out in comparison with traditional fertilization and cattle manure organic fertilizer to provide technical support for the application of biogas residue organic fertilizer in dragon fruit production. The results showed that the yield per ha and sugar-acid ratio of dragon fruit treated with biogas residue organic fertilizer increased by 12.84% and 60.55% respectively compared with the traditional fertilization treatment, and the VCR (vario-cost ratio) value reached 4.95. Compared with cattle manure organic fertilizer, the yield per mu and sugar-acid ratio of dragon fruit increased by 9.82% and 5.58%, respectively, with a newly increased income of 11,900 RMB/ha. Therefore, biogas residue organic fertilizer has a good application prospect in pitaya cultivation.

1. Introduction

Fertilizer is one of the most important factors affecting the production of dragon fruit[1]. Reasonable application of base fertilizer and topdressing fertilizer can directly affect the yield and quality of fruits. Practice shows that chemical fertilizer cannot replace organic fertilizer in supplying organic nutrients and improving soil structure [2-3]. The combination of organic fertilizer and inorganic fertilizer has also become a research hotspot at home and abroad [4-6].

With the establishment of large and medium-sized biogas projects, more and more biogas residues are produced. Biogas residue contains organic matter, humic acid, various microorganisms, enzymes and other active substances. Its fertilizer efficiency has the characteristics of both quick and slow, and it is an ideal pollution-free fertilizer.

In order to provide adequate and suitable fertilizer for the production of dragon fruit in tropical areas, our team developed biogas residue organic fertilizer. In order to test the effect of biogas residue organic fertilizer in the production and application of dragon fruit, this experiment was carried out and promote the rapid development of dragon fruit industry in tropical areas.

2. Materials and methods

2.1 General situation of test area

Field experiments were conducted at the dragon fruit experimental base of Yunjiao Village, Huguang Town, Mazhang District, Zhanjiang, Guangdong Province. The base is located in Lei Cheu Peninsula, which belongs to tropical monsoon climate and marine climate. The effective accumulated temperature is 8309 ~ 8519℃, the annual average precipitation is 1417 ~ 1802 mm, and the...
evaporation is 1627 ~ 2129 mm. The soil type is tuff latosol and the texture is sandy clay [7]. Soil fertility characteristics before planting: organic matter 17.31%, alkali-hydrolyzed nitrogen 135.58 mg/kg, available P 390.76 mg/kg, available K 66.32 mg/kg, pH 4.03.

2.2 Materials
Dragon fruit for test: Local white heart pitaya varieties, fixed in May 2014, planting density is 140 columns per mu, around each column there are four pitaya trees.
Fertilizer for test:
- Cattle manure organic fertilizer: self-made by fruit growers (cow dung composting);
- Biogas residue organic fertilizer: developed by Biogas Base of Thermal Engine Institute (biogas residue composting). The main nutrient contents of the two organic fertilizers are shown in Table 1.

2.3 Experimental design
Three treatments were set up, one of which was the control, and the other two organic fertilizer treatments had the same fertilizer cost.
- T1: Traditional fertilization: according to local fruit farmers' habits, using cattle manure organic fertilizer made by fruit farmer for once a year, and compound fertilizer twice a year;
- T2: Cattle manure organic fertilizer: Cattle manure organic fertilizer made by fruit growers is applied in full amount three times a year;
- T3: Biogas residue organic fertilizer: The biogas residue organic fertilizer developed by biogas base of thermal engine institute is applied in full amount three times a year.
Eighteen columns of pitaya with uniform growth were selected for each treatment. Six trees were planted in each plot and repeated three times. Random block design was adopted. All treatments were fertilized in the radius of 30 cm per column, 5-6 cm deep soil layer and covered with soil. The other management operations were carried out according to the local pitaya production routine, and all treatments were consistent.

2.4 Investigation index and methods of measurement
Dragon fruit was harvested in batches on time after ripening.
• Yield Indicators: Single fruit weight and yield were measured by weighing method, yield was measured by the whole plant. Number of fruits was counted. The single fruit weight was investigated by randomly selecting 30% of the fruits collected in the experimental plot.

• Quality Indicators: 12 fruits were collected from four directions of east, south, west and north of each plot to determine the quality. Water content of the fruit was measured by drying and weighing method, the edible rate was determined by weighing method, soluble solids were determined by ATAGO PAL-1 mini-digital refractometer, the titratable acid was determined by standard acid-base titration and the total sugar content was determined by Filin reagent titration. The physical and chemical indexes of soil were determined by conventional methods. Data were analyzed and processed by Excel and DPS software.

3. Results and analysis

3.1 Statistical analysis of dragon fruit yield

The effects of different treatments on the yield of dragon fruit are shown in Table 3. There are significant differences in the fruit number per column, the yield per column, the average weight of single fruit and the yield per mu. Among the three treatments, the highest fruit number per column was in the biogas residue organic fertilizer treatment group. The fruit number per column increased by 20.43% and 16.35% respectively compared with traditional fertilization and cow manure organic fertilizer. The results showed that the application of biogas residue organic fertilizer in the cultivation of dragon fruit could protect flowers and fruits and improve fruit-setting rate, so as to achieve the purpose of increasing production. Yield per column and yield per ha of dragon fruit treated with biogas residue organic fertilizer were the highest, which were significantly different from those of the traditional fertilization group, with growth rate reached 12.88% and 12.84%. There was no significant difference compared with cattle manure organic fertilizer group, but the yield per hectare increased to 199.61 kg with an increase of 9.82%. There was no significant difference in the maximum single fruit weight among the three treatments.

Table 3 Statistical analysis of dragon fruit yield

| Treatment                          | Traditional fertilization | Cattle manure organic fertilizer | Biogas residue organic fertilizer | Increase of biogas manure (%) |
|------------------------------------|---------------------------|----------------------------------|-----------------------------------|------------------------------|
|                                    |                           |                                  |                                   | Compared with tradition | Compared with cattle manure |
| Fruit number per column (column)   | 52.17 b                   | 54.00 b                          | 62.83 a                           | 20.43                       | 16.35                        |
| Yield per column (kg/column)       | 14.13 b                   | 14.52 ab                         | 15.95 a                           | 12.88                       | 9.85                         |
| Maximum single fruit weight (g)    | 515 a                     | 522 a                            | 515 a                             | 0                           | -1                           |
| Yield per hectare (kg/ha)          | 29676.00 b                | 30491.70 ab                      | 33485.85 a                        | 12.84                       | 9.82                         |

Note: The data in the table are the average of three repetitions, and the difference expressed by different letters after each column is 5%.

3.2 Quality analysis of dragon fruit

The quality changes of dragon fruit are mainly manifested in the changes of soluble solids, total sugar, total acid, sugar-acid ratio, water content and other factors of the fruit. Among them, sugar-acid ratio is an important index to measure the quality of fruit [8], which directly affects the taste and flavor of the fruit. Table 4 shows that the sugar-acid ratio in the dragon fruit treated with biogas residue organic fertilizer is the highest, 29.14. Some studies suggest that [9], the fruit with sugar-acid ratio between 20 and 60 is excellent. There was significant difference between biogas residue organic fertilizer and traditional fertilizer, which indicated that application of biogas residue organic fertilizer could improve
the sugar-acid ratio of dragon fruit to a certain extent. In addition, the soluble solids, total sugar, edible rate and water content of dragon fruit treated with biogas residue organic fertilizer were increased to varying degrees, but there was no significant difference compared with the other two groups.

Table 4 Quality analysis of dragon fruit

| Treatment                        | Soluble solids (%) | Total sugar (%) | Total acid (%) | Sugar-acid ratio | Edible rate (%) | Water content (%) |
|----------------------------------|--------------------|-----------------|---------------|------------------|----------------|------------------|
| Traditional fertilization        | 6.95 a             | 6.95 b          | 0.38 a        | 18.15 b          | 0.73 a         | 86.17 a          |
| Cattle manure organic fertilizer | 11.2 a             | 9.24 a          | 0.33 ab       | 27.60 ab         | 0.76 a         | 85.70 a          |
| Biogas residue organic fertilizer| 11.68 a            | 9.29 a          | 0.32 b        | 29.14 a          | 0.78 a         | 86.09 a          |

Note: The data in the table are the average of three repetitions, and the difference expressed by different letters after each column is 5%.

3.3 Effect of biogas residue organic fertilizer on economic benefit of dragon fruit

The ratio of output to input is one of the decisive factors affecting the popularization of fertilizers, which is affected by the price of fertilizer and the price of pitaya [7]. In this study, except for different fertilizer inputs, all other inputs (such as medication, management and employment) were the same. Biogas residue organic fertilizer is produced by composting and fermentation of biogas fermentation residues, which belongs to waste recycling. Considering the market promotion and referring to the average price of organic fertilizer, it is assumed to be 600 RMB/ton, which is the same as the price of cow manure organic fertilizer. Compared with the traditional fertilization treatment, cattle manure organic fertilizer and biogas residue organic fertilizer treatments increased the amount of organic fertilizer applied and the cost of fertilizer increased. The cost of additional fertilizer was equal between the two groups.

Table 5 shows that compared with the traditional fertilization group, the sufficient application of biogas residue organic fertilizer can increase the yield and thus increase the net income. The newly increased income is 152,000 RMB/ha, and the VCR (vario-cost ratio refers to the ratio of the income of increased agricultural product after fertilization to fertilization expenditure) value reaches 4.95. Food and Agriculture Organization of the United Nations believes that VCR > 2 is economically reasonable [10]. The data shows that the newly increased income can reach 4.95 RMB for every input of 1 RMB, and the income could be increased by applying biogas residue organic fertilizer in sufficient amount. Compared with the full application of cattle manure organic fertilizer group, the application of biogas residue organic fertilizer could obtain a higher benefit of 119,000 RMB per ha under the condition of the same cost of fertilization. Therefore, it is economically feasible to apply biogas residue organic fertilizer in dragon fruit cultivation.

Table 5 Effect of biogas residue organic fertilizer on economic benefit of dragon fruit

| Treatment                        | Yield (kg/ha) | Output value (10,000 RMB/ha) | Newly increased income (10,000 RMB/ha) | Fertilization cost (RMB/ha) | VCR |
|----------------------------------|---------------|------------------------------|---------------------------------------|-----------------------------|-----|
| Traditional fertilization        | 29676.00      | 11.87                        | -                                     | 0.83                        | -   |
| Cattle manure organic fertilizer | 30491.70      | 12.20                        | 0.33                                  | 1.13                        | 1.06|
| Biogas residue organic fertilizer| 33485.85      | 13.39                        | 1.52                                  | 1.13                        | 4.95|

Note: The data in the table are based on the current market price, compound fertilizer is 300 RMB/50kg, cattle manure organic fertilizer is 600 RMB/ton, biogas residue organic fertilizer is self-made, calculated as 600 RMB/ton according to the market organic fertilizer market, the purchase price of pitaya fruit is 4.0 RMB/kg, VCR = net income added value/fertilization cost added value.
4. Conclusion
In the same fertility pitaya orchard, 18.9 tons of biogas residue organic fertilizer is applied per hectare, and the fruit number per column reaches 62.83, which is significantly higher than that of the same amount of cattle manure organic fertilizer and the traditional fertilizer. The yield per hectare is 33485.85 kg, which is 2994.15 kg/ha higher than that of the cattle manure organic fertilizer, with an increase of 9.82%, and 3809.85 kg/ha higher than that of the traditional fertilizer, with an increase of 12.84%, the difference is significant. With the increase of yield, the total sugar content increases and the total acid content decreases, this significantly increases the sugar-acid ratio of the fruit and improves the quality of fruit. In a word, the application of biogas residue organic fertilizer shows better effect on increasing yield and improving quality. VCR value analysis shows that the full application of biogas residue organic fertilizer is economically reasonable, and has a good application prospect in dragon fruit production.

Acknowledgments
This work was financially supported by the Science and technology plan projects in zhanjiang (No. 2017A03018) and the Central Public-interest Scientific Institution Basal Research Fund for Chinese Academy of Tropical Agricultural Sciences (No. 2017YFD0800802).

References
[1] Chen Zhenjin, Chen Min. Contrast experiment of yield and quality of dragon fruit on different organic fertilizer planting [J]. Gardening, 2016, 33(2): 75.
[2] Engracia Madejón, Rafael López et al. Agricultural use of three (sugar-beet) vinasse composts: effect on crops and chemical properties of a Cambisol soil in the Guadalquivir river valley (SW Spain) [J]. Agric. Ecosyst. Environ. 2001, 84: 55 - 65.
[3] Kong Yue. Effects of Bio-organic Fertilizer on Growth and Quality of Tomato and Pakchoi [D]. Wuhan: Huazhong Agricultural University, 2007.
[4] Tang Jiwei, Lin Zhian, Xu Jianxin, etc. The Role of Organic Fertilizer and Inorganic Fertilizer in Improving Soil Fertility [J]. Soils and Fertilizers Sciences in China, 2006, (3):44-47.
[5] Zhang Hongmei, Jin Haijun, Ding Xiaotao, etc. Effects of combined application of organic and inorganic fertilizers on growth, yield and quality of cucumber in greenhouse [J]. Plant Nutrition and Fertilizing Science, 2014, 201(2):247-253.
[6] LIZ P, LIU M, W U X C etal. Effects of long-term chemical fertilization and organic amendments on dynamics of soil organic C and total N in paddy soil derived from barren land in subtropical China [J]. Soil and Tillage Research, 2010, 106: 268-274.
[7] Zang Xiaoping, Ma Weihong, Zhou Zhaoxi, etc. Effects of Different Organic Fertilizers on Yield, Quality and Soil Fertility of Ziziphus mauritiana Lam. Chinese Journal of Soil Science, 2014, 45 (6) : 1445-1448.
[8] Sui Changling, Song Baoan, Song Jie, etc. Effect of humic acid functional fertilizer on the yield and quality of dragon fruit [J]. Guizhou Agricultural Sciences, 2014, 42(6):124-128.
[9] Li Shuzhi. Effect of Different Fruiting Parts on Sugar-acid Ratio of Autumn Red Late Honey Peach [J]. Northern Horticulture, 2007(11): 61-62.
[10] Xiao Yanbo, Duan Zongyan, Su Fan, etc. Study on Rational Application of Nitrogen Fertilizer in Different Planting Ways of Maize [J]. Journal of Maize Sciences, 2002, 10(1):78-80.