Effects of Functional Organic Materials on Morphological Indexes, Quality and Yield of Watermelon

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Abstract [**Objectives**] This study was conducted to explore suitable organic compound application models for watermelon growth. [**Methods**] With watermelon hybrid material "M22 × P18" as the test material, the effects of four functional organic materials, namely garlic straw treatment (T_1), onion straw treatment (T_2), garlic straw + sheep manure treatment (T_3) and onion straw + chicken manure treatment (T_4), on the morphological indexes, yield and quality of watermelon were investigated. [**Results**] Different functional organic materials had different effects on morphological indexes, yield and quality of watermelon. The morphological indexes, nutritional quality indexes and yield of watermelon treated with garlic straw and sheep manure compound (T_3) and onion straw and chicken manure compound (T_4) were significantly higher than those treated simply with garlic straw (T_1) and onion straw (T_2), and T_3 performed relatively better. Compared with treatment T_2, T_3 showed a stem diameter, vine length and leaf number increasing by 43.05%, 46.69% and 40.77% respectively, central sugar and side sugar contents increasing by 11.72% and 21.90% respectively, and a yield increasing by 42.91%, with significant differences from T_2. [**Conclusions**] This study provides technical support for high-quality and high-yielding cultivation of watermelon.

Key words Organic materials; Watermelon; Morphological index; Quality; yield

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Because of the high added economic value of watermelon, facility watermelon occupies an important position in protected vegetables. However, in the process of planting, long-term excessive application of chemical fertilizer and unreasonable application of organic fertilizer lead to leaching and accumulation of a large amount of soil nutrients in facilities, and agricultural non-point source pollution intensifies, which in turn leads to soil hardening, acidification, secondary salinization and soil-borne diseases[1]. With the continuous cropping obstacle becoming more and more serious, most growers have adopted increasing the amount of fertilizer and pesticides to maintain the growth and yield of crops, leading to further deterioration of soil quality and increasingly prominent problems of product quality and safety. At present, there are many kinds of organic fertilizers on the market, and some organic matter is difficult to be directly utilized by crops, so the application effect is poor[2]. Therefore, in this study, aiming at high-quality, efficient and safe production of watermelon, the effects of different kinds of organic materials on the growth, yield and quality of soil and watermelon plants in facilities were investigated through organic fertilizer materials such as chicken manure and sheep manure, and organic waste materials such as garlic straw and onion straw with insect prevention and disinfection functions, so as to screen the types and application rates of organic materials with remarkable effects. This study provides technical support for high-quality and high-yielding cultivation of watermelon and information reference for promoting the sustainable development of facility watermelon in Shangqiu City.

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Materials and Methods

General situation of experimental field and materials to be tested

The experiment was conducted in Bazhuang Experimental Station of Shangqiu Academy of Agriculture and Forestry from March 25 to July 15, 2023. The experimental plot was open field and the previous crop was maize. In 2022, after maize was harvested, the field was deeply ploughed with a depth of 20 – 25 cm, and it was fallow until March 10, 2023. The soil nutrient status of the 0 – 25 cm soil layer was as follows: available nitrogen 68.15 mg/kg, available phosphorus 19.87 mg/kg, available potassium 89.46 mg/kg, organic matter 12.16 g/kg, and pH 6.7 – 7.3.

The tested watermelon material was "M22 × P18" provided by Vegetable Research Institute of Shangqiu Academy of Agriculture and Forestry Sciences. The tested NPK ternary compound fertilizer ($N : P_2O_5 : K_2O = 15 : 15 : 15$) was produced by Shandong Kingenta Ecological Engineering Co., Ltd., and the tested sheep manure and chicken manure were obtained from local farms, while the tested garlic straw and onion straw were obtained from neighboring agricultural cooperatives.

Experimental design

Four treatments were set in the experiment, corresponding to four functional organic materials, namely garlic straw treatment (T_1), onion straw treatment (T_2), garlic straw + sheep manure treatment (T_3) and onion straw + chicken manure treatment (T_4). The application rate of garlic straw in treatment T_1 was 4 500 kg/hm^2; the application rate of onion straw in treatment T_2

was 4 500 kg/hm^2; the application rate of garlic straw in treatment T_3 was 4 500 kg/hm^2, and the application rate of sheep manure was 7 500 kg/hm^2; and the application rate of onion straw in treatment T_4 was 4 500 kg/hm^2, and the application rate of chicken manure was 7 500 kg/hm^2. The application rate of NPK ternary compound fertilizer was the same for various treatments, at 900 kg/hm^2, and other management was the same as that of field. Each treatment was repeated 3 times, totaling 12 plots, and each plot was fertilized at one time according to the experimental design. The plot area was 28 m^2 (4 m × 7 m), and the row spacing of watermelon plants was 0.4 m × 2 m. When the watermelon seedlings reached the stage of three leaves and one heart, the seedlings with basically the same growth were selected for transplanting, and the transplanting was completed at one time with the a planting machine.

Determination indexes and methods

The vine length was the length from the cotyledon position to the growth point of main vine, measured by a ruler. The stem diameter was 0.5 cm below the cotyledon, measured by a vernier caliper. The center sugar and side sugar were determined by a TD-45 handheld sugar analyzer produced by Zhejiang Top Instrument Co., Ltd. The weight of single melon was weighed by an electronic balance, and the unit yield was converted according to plot yield.

Data processing and analysis

Excel 2016 software was used for data processing and plotting, and SPSS23.0 software was used for statistical analysis.

Results and Analysis

Effects of functional organic materials on morphogenesis of watermelon

It can be seen from Table 1 that different functional organic materials had different effects on the morphological indexes of watermelon. Compared with treatments T_1 and T_2 using only garlic straw and onion straw, the stem diameter, vine length and leaf number of watermelon under treatments T_3 and T_4 were significantly improved. In specific, the stem diameter of watermelon was the largest in treatment T_3, followed by treatment T_4, the third in treatment T_1, and the smallest in treatment T_2, and the value of T_3 increased by 43.05% compared with treatment T_2, showing a significant difference from treatment T_2. The vine length was the largest under treatment T_3, and the smallest under treatment T_2. T_3 increased by 46.69% compared with T_2, and was significantly different from T_2. The number of leaves was the largest in treatment T_3, followed by treatment T_4, but there was no significant difference between T_3 and T_4, which showed values increasing by 40.77% and 31.67% respectively compared with treatment T_2, exhibiting significant differences from treatment T_2. It could be seen that compared with other treatments, the functional organic material compounding garlic straw with sheep manure was more conducive to the increase of stem diameter, vine length and leaf number of watermelon, thus promoting the morphogenesis of watermelon.

Table 1 Effects of functional organic materials on morphogenesis of watermelon

Treatment	Stem diameter//cm	Vine length//cm	Leaf number//leaves
T_1	0.54 c	70.82 c	8.57 b
T_2	0.51 cd	62.33 c	8.02 b
T_3	0.73 a	91.43 a	11.29 a
T_4	0.68 b	83.71 b	10.56 a

Effects of functional organic materials on sugar content of watermelon

It can be concluded from Table 2 that different functional organic materials had different effects on the sugar content of watermelon. The central sugar content was the highest in treatment T_3 composed of garlic straw and sheep manure, followed by treatment T_4 composed of onion straw and chicken manure, but the difference between them was not significant, while they were 11.72% and 11.14% higher than that of treatment T_2, and the differences were significant. The change law of sugar content at the side was consistent with that in the center, and both showed an order of $T_3 > T_4 > T_1 > T_2$, in which T_3 was 21.90% higher than T_2, with a significant difference. The center-to-side difference was the largest in treatment T_2, the second in treatment T_1, the third in treatment T_4 and the smallest in treatment T_3. It could be seen that compared with other treatments, the functional organic material compounding garlic straw with sheep manure was more conducive to the increase of central sugar content and side sugar content of watermelon and the decrease of center-to-side difference, thus improving the quality of watermelon.

Table 2 Effects of functional organic materials on sugar content of watermelon %

Treatment	Central sugar content	Side sugar content	Center-to-side difference
T_1	10.53 b	7.48 b	3.05 b
T_2	10.41 b	7.26 b	3.15 a
T_3	11.63 a	8.85 a	2.78 c
T_4	11.57 a	8.72 a	2.85 c

Effects of functional organic materials on watermelon yield and quality

It can be seen from Fig. 1 that different functional organic materials had different effects on watermelon yield. There was no significant difference between treatment T_1 applying only garlic straw and treatment T_2 applying only onion straw on watermelon yield, but treatment T_3 combining garlic straw with sheep manure and treatment T_4 combining onion straw with chicken manure were significantly higher than treatments T_1 and T_2, and treatment T_3 had the largest value, followed by treatment T_4. Specifically, treatments T_3 and T_4 increased by 42.91% and 32.34% compared with treatment T_2, respectively, both showing significantly differences from treatment T_2.

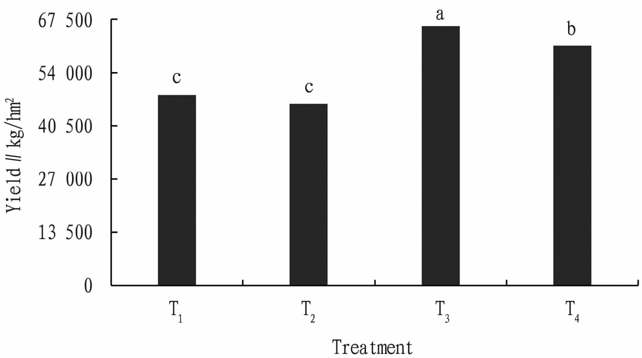

Fig. 1 Effects of functional organic materials on watermelon yield and quality

Conclusions and Discussion

Stem diameter, vine length and leaf number are important reference indexes for measuring the growth speed and plant health of watermelon. The results of this study showed that compared with the simple application of garlic straw or onion straw, the functional organic material composed of garlic straw and chicken manure and the functional organic material composed of onion straw and sheep manure could significantly increase the stem diameter, vine length and leaf number of watermelon, and the functional organic material composed of garlic straw and chicken manure had the greatest promotion effect on watermelon morphogenesis. It is because chicken manure, compared with sheep manure, garlic straw and onion straw, contains higher organic matter, nitrogen, phosphorus, potassium and medium and trace elements, which can increase the content of soil active organic carbon, promote the propagation and growth of rhizosphere soil microorganisms, and not only improve soil physical and chemical properties and soil structure, but also provide more nutrients for plant growth[3].

Excellent nutritional quality is one of the important production goals of watermelon cultivation, and it is also an important prerequisite for watermelon to obtain high economic benefits. The central sugar, side sugar and center-to-side difference are important reference indexes for evaluating the quality of watermelon fruit. High yield is another important reference index for watermelon to pursue high economic benefits. Rational application of organic fertilizer and chemical fertilizer is more conducive to the improvement of crop quality and yield than single application of organic fertilizer or chemical fertilizer[4]. The results of this study showed that the functional organic material composed of garlic straw and chicken manure and the functional organic material composed of onion straw and sheep manure were more conducive to the increase of central sugar content and marginal sugar content of watermelon, the decrease of center-to-side difference and the improvement of watermelon yield and quality than the simple application of garlic straw or onion straw, because chicken manure and sheep manure could improve soil aggregate structure and soil enzyme activity and provide a suitable soil environment for plant growth[5-6]. The functional organic material T_3, composed of garlic straw and chicken manure, performed relatively well, which might be because chicken manure has a comprehensive and balanced nutrition and long-lasting fertilizer effect, contains macroelements of nitrogen, phosphorus and potassium, medium elements such as calcium and magnesium and trace elements such as iron, magnesium and zinc, which are necessary for crop growth, and is also rich in organic sugars such as humic acid, various enzymes and beneficial microorganisms, thus providing a comprehensive and lasting nutrient supply for plant growth[7].

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