Study the Effect of Microwave Plant-functional Water Irrigation on the Growth and Quality of Passion Fruit

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Abstract. Passion fruit is a tropical fruit with a balanced sweet and sour taste. However, the passion fruit cultivation process encounters a variety of pest and disease problems, which can lead to growth retardation, yield, and quality loss. In this study, the differences between microwave plant-functional water irrigation and traditional irrigation methods in terms of pest and disease control, fertilizer use, plant growth, flowering, fruit yield, and quality were derived from comparative experiments conducted at an experimental site in Hainan Province. The results showed that microwave plant-functional water irrigation technology can significantly reduce the incidence of pests and diseases, reduce the use of pesticides and fertilizers, increase the yield and quality of passion fruit, and improve the soil environment.

Keywords: Passion fruit, Pest and disease problems, Cultivation, Microwave plant-functional water irrigation

1 Preface

Passion fruit is a tropical edible fruit [1] introduced to Europe from Spain in the 16th century and spread to other regions. The scientific name of the passion fruit is '*Passiflora*', which comes from Latin, meaning flower of passion [2]. Its fruit is sweet, sour, and nutritious. It is rich in vitamin C and dietary fiber and contains antioxidants that help to boost immunity, promote digestion, and reduce the risk of chronic diseases [3]. In China, Hainan Province is one of the main production areas of passion fruit, located at 18°N latitude. Hainan Province has a tropical monsoon climate that is warm and humid with plenty of sunshine throughout the year. It is very suitable for tropical crops like passion fruit [4]. However, various pest and disease problems can be encountered during passion fruit cultivation, including stem basal rot, root rot, anthracnose, gray mold, and blight, and the main insect pests are fruit flies, thrips, mites, and aphids[5~7]. For their inhibition, various agricultural, biological, and chemical controls are available. Agricultural control mainly involves the selection of disease-resistant varieties, appropriate planting density, etc. Biological control mainly involves the use of natural

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enemies, biostimulants, and biopesticides, and chemical control involves the spraying of insecticides, fungicides, and acaricides [8]. These all are specific for their certain function and/or harmful to the ecosystem i.e. chemical control. Therefore, this study will explore a new physical control method, namely microwave plant functional water. It is a kind of water treated by microwave technology, which changes the structure of water molecules through microwave technology, improves the penetration ability of water to plant cells and the utilization efficiency of water by plants, and enhances the defense of passion fruit against pests and diseases.

2 Materials and Methods

The present study was conducted in Hainan Jintiandi Agricultural Passion Fruit Orchard, Qiongshan District, Haikou City. The experimental materials include vigorous and consistent growth conditions for passion fruit seedlings, professional microwave plant-functional water equipment, chemical pesticides of the national standard, and nutrient fertilizers. Comparing the effect of functional water, ordinary agricultural water was used for irrigation.

Black Microwave plant functional water technology is an innovative irrigation method. In the first step, the ordinary irrigation water was filtered to remove suspended solids, particulate matter, impurities, and some microorganisms. The filtered water was purified to a certain extent compared to the raw water for the treated water quality in this stage. The filtered water was passed through the magnetic field, changing the physical properties of water molecules into charged ions under the magnetization action. The magnetization caused the ions and molecules in the water to form smaller clusters, which can improve the permeability and bioavailability of the water. In the next step, the magnetized water was subjected to ultrasonic molecular oscillation, where the magnetized water was introduced into an ultrasonic generator and the high-frequency vibrational energy of the ultrasonic waves. It was utilized to break down the large molecular clusters in the water into smaller ones. Ultrasonic waves also cause cavitation phenomena in the water, resulting in high energy that can further destroy the organic matter in the water and microbial cell walls. Ultrasonic molecular oscillation operation can enhance the permeability and solubility of water, improve the adsorption capacity of plant cells, and have a certain bactericidal effect, reducing pathogens in the water.

Following the above treatment steps, the ozone ionization treatment technology was implemented. Through the ozone generator, oxygen was converted into ozone using the ultraviolet method. Afterward, the ozone gas was introduced into the treated water, where the ozone was dissolved to form ozone water. The strong oxidizing property of ozone was able to decompose the organic compounds in the water and break down the cell walls of microorganisms. The treatment by ozone ions can efficiently inactivate bacteria, viruses, and other microorganisms in the water. So, the ozone was finally decomposed into oxygen, which could not leave any harmful residues. Finally, a high-frequency oscillation device was utilized for the fine treatment of water. By applying a specific frequency and oscillation energy to the water, the specific frequency was able to change the hydrogen bonding structure between the water molecules, making the water molecule group smaller and more stable, thus greatly improving the permeability and bioavailability of the water. The oscillation energy was transferred to the water through the output part of the oscillation generator. Water treated with high-frequency oscillation technology enhanced the efficiency of water and nutrient uptake by plants, increased plant resilience, and overall improved crop performance and final yield.

The experimental design was oriented into two groups of passion fruit seedlings. Plants of group A were irrigated with microwave plant-functional water. Whereas, normal water was utilized for the plants of group B. Both groups were applied with the same amount of organic fertilizer, elemental fertilizer, medium and trace elemental fertilizer, and bacterial fertilizer. After days of the experiment, the growth parameters of passion fruit seedlings in both groups were regularly observed and recorded.

3 Results and Analysis

3.1 Disease Control Effectiveness

The effect of plant-functional water irrigation on the growth and yield of passion fruit with the comparison of normal water is shown in Table 1. The experimental results showed that microwave plant functional water at a lower dose (20%) exhibited preventive and curative effects on various diseases such as stem rot, root rot, anthracnose, gray mold, and wilt. In contrast, normal irrigation water showed similar control effects at high doses (90%). Additionally, plants irrigated by normal water revealed significantly affected growth and flowering of plants while plant-functional water had no negative influence on the growth and flowering of plants. Therefore, microwave plant functional water was found more significantly efficient and environmentally friendly than regular irrigation water while ensuring healthy crop growth.

Table 1. Disease control effectiveness

Disease name	groups	dosage	Prevention and treatment effects	Effect on flowering and fruiting	Plant growth effects
stem rot	A	20%	excellent	not affect	not affect
	B	90%	excellent	affect	affect
root rot	A	20%	excellent	not affect	not affect
	B	90%	excellent	affect	affect
anthrax	A	20%	excellent	not affect	not affect
	B	90%	excellent	affecting the fruit	not affect
gray mold	A	20%	excellent	not affect	not affect
	B	90%	excellent	affect fruit set	not affect
a blight	A	20%	excellent	not affect	not affect
	B	90%	excellent	affecting the fruit	not affect

3.2 Pest Control Effectiveness

A comparison between microwave plant functional water (group A) and normal irrigation water (group B) in terms of pest control is presented in Table 2. Both irrigation sources were dosed at 90%, had preventive and curative effects and rated as "excellent" for fruit flies, thrips, mites and aphids. However, in terms of effects on flowering and fruiting, normal irrigation water showed negative effects. While microwave plant functional water had no negative effect on flowering and fruiting of plants. Similarly, normal watr irrigation exhibited negative impact on the growth of plant as compared to the plant functional water irrigation. This results indicated that microwave plant functional water has more positive impact on plant growth and reproduction while maintaining efficient pest control, compared to normal irrigation water which is effective in pest control but has a negative impact on plant flowering, fruiting and growth.

Table 2. Pest control effectiveness

Pest name	Groups	dosage	Prevention and treatment effects	Effect on flowering and fruiting	Plant growth effects
fruit fly	A	90%	excellent	not affect	not affect
	B	90%	excellent	affect	affect
thrip	A	90%	excellent	not affect	not affect
	B	90%	excellent	affect	affect
mite	A	90%	excellent	affect	affect
	B	90%	excellent	affect	affect
greenfly	A	90%	excellent	affect	affect
	B	90%	excellent	affect	affect

3.3 Effectiveness of Fertilizer Use

The comparison of fertilizer application with the microwave plant functional water irrigation group and normal water irrigation group of the passion fruit is shown in Table 3. Microwave plant functional water irrigation had a more positive influence than normal water in promoting plant growth and improving production efficiency. The use of organic fertilizer, macro elemental fertilizer, trace elemental fertilizer, and bacterial manure fertilizer was reduced by 50% for plant-functional water irrigation. It has been revealed that plant growth was increased under functional water with even the reduced quantity of fertilizer. This observation intuitively reflects the positive effect of plant-functional water irrigation on crop growth. Moreover, plant-functional water irrigation prompted the average number of flowers up to 400 per plant and indicated a positive impact on plant biomass accumulation. Similarly, a fruit yield of 40 jin per plant has been obtained by irrigation with plant-functional water, reflecting the more effective role of plant-functional water in promoting fruiting.

Table 3. Effectiveness of fertilizer use

Fertilizer name	Groups	Quantity of fertilizer used	Vegetative growth	Anthesis	Fruit yield
Organic fertilizer	A	0.5 tons/mu	excellent	average 400 flowers per plant	average 20 kg per plant
	B	1 ton/mu	good	average 380 flowers per plant	average 16.5 kg per plant
Macro Elemental Fertilizer	A	25KG/mu	excellent	average 401 flowers per plant	average 20 kg per plant
	B	50KG/mu	good	average 380 flowers per plant	average 16.5 kg per plant
trace element fertilizer	A	0.5KG/mu	excellent	average 402 flowers per plant	average 20 kg per plant
	B	1KG/mu	good	average 380 flowers per plant	average 16.5 kg per plant
bacterial manure	A	1 packet/acre	excellent	average 403 flowers per plant	average 20 kg per plant
	B	2 packet/acre	good	average 380 flowers per plant	average 16.5 kg per plant

3.4 Overall Comparison of Gross Growth

The comparison of plant-functional water irrigation and normal water irrigation on the growth performance of passion fruit at the seedling, flowering, and harvesting stages is presented in Table 4. Plant-functional water irrigation is rated as "excellent" in terms of nutritional growth at the seedling stage, which is comparable to normal water irrigation. However, at the flowering stage, plants irrigated by plant-functional water had more flowers (42 flowers/plant) than the plants irrigated by normal water irrigation (39 flowers/plant). At harvest, plants had a significantly higher fruit yield (3640 fruit) and commercial fruit rate (91%) when irrigated by functional water than normal water (2985 fruit and 80.5% commercial fruit rate). That indicated the plants irrigated by plant-functional water had better overall growth. The commercial fruit rate (91%) was significantly higher than in plants irrigated by normal water having 2985 fruits and an 80.5% commercial fruit rate.

Table 4. Comparison of total value of passion fruit growth

Growing period	Groups	Vegetative growth	No. of flowers	No. of fruit	Commercial fruit rate
Seedling stage	A	excellent			
	B	excellent			
Flowering stage	A		42 per plant		
	B		39 per plant		
Harvesting period	A			3640	91%
	B			2985	80.5%

In addition to the effect on plant growth and yield, microwave plant functional water positively impacted soil and water and fruit quality. Concerning soil and water improvement, the soil microbial activity in the area irrigated with microwave plant functional water was enhanced, the species and number of bacteria were increased, and the phenomenon of soil crusting was reduced. Moreover, the permeability and water retention capacity were improved, therefore the plants were found to be more developed. The thickness of leaves was increased, the area was enlarged, and the color was more intense green. Regarding fruit quality, the passion fruit irrigated with microwave plant functional water had a large, rounded appearance, bright color, and significantly higher average weight of a single fruit than that of the plants irrigated with normal water. Stronger fruit flavor and the internal sugar content of the fruit reached 20.3%, compared with the sugar content of the passion fruit irrigated by normal water, which was 18.9%.

4 Summary and Discussion

This study aimed to investigate the effects of microwave plant-functional water irrigation on the growth and fruit quality of passion fruit. The experimental results showed that the passion fruit plants irrigated with microwave plant-functional water showed significant responses in terms of growth potential, flower production, fruit yield, and commercial fruit rate, which can be beneficial for the economic aspects. Specifically, the use of microwave plant-functional water not only promoted vigorous plant growth but also significantly increased the commercial value of the fruit.

Further analysis revealed that microwave plant-functional water irrigation had a significant inhibitory effect on the occurrence of pests and diseases, thus significantly reducing the use of chemical pesticides, which is important for reducing pesticide residues and improving fruit quality. Meanwhile, the irrigation method had less negative impact on the flowering and fruiting of passion fruit and plant growth, which helped to maintain the healthy state of the plant.

In addition, microwave plant-functional water irrigation technology has achieved increased yields while reducing the use of chemical fertilizers and has had a positive impact on the soil environment. The technology promotes the enrichment of soil microflora, avoids soil compaction, enhances root development, and results in thicker, greener leaves, thus providing a more solid foundation for plant growth.

Regarding fruit quality, passion fruits irrigated with microwave plant-functional water showed excellent characteristics in terms of fruit shape, single-fruit weight, flavor intensity, and sugar level, with large and rounded fruit shape, increased single-fruit weight, more intense flavor and higher sugar level, which further proved the significant effect of the technology on improving fruit quality.

In summary, microwave plant functional water irrigation technology provides an efficient, environmentally friendly, and sustainable solution for passion fruit cultivation, which can not only improve the fruit yield and quality but also improve the soil environment and promote the ecological balance while reducing the use of chemical fertilizers and pesticides, which provides a new way of intellectual and practice path for the sustainable development of passion fruit industry.

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