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# Study on the Control Effect of *Empedobacte Brevis* on Cherry Fruit Fly

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**Abstract:**Fruit fly is a major boring pest of cherry fruits during the color change and maturity period. It causes serious damage and affects the quality and economic benefits of cherry fruits. In order to clarify the control effect of *Empedobacter brevis* on cherry fruit fly and provide basis for guiding scientific medication use. The test adopts the conventional spray method, and uses 60g•L$^{-1}$ spinetoram suspension as a control to compare and analyze the control effects of different dosages of *Empedobacter brevis* suspension on cherry fruit fly. The results show that on the three cherry varieties of Red lantern, Tieton and Napoleon, the control effects of *Empedobacter brevis* 600 times and 800 times and spinetoram 1000 times are better, and the control efficiency reaches more than 78-80%. There is no significant difference in control effects among the three, and they are safe for cherry trees. In cherry production, *Empedobacter brevis* can be promoted and applied as an effective biological agent to control fruit flies.
**Keywords:**cherry, fruit fly, *Empedobacter brevis*, control effect

## Introduction

In recent years, with the adjustment of the industrial structure, the cultivation area of large cherries has been increasingly expanded. In areas suitable for cultivation, large cherries have become one of the priority economic tree species [1]. Fruit fly, as an important fruit-boring pest that damages cherry fruits, has become more and more serious year by year with the expansion of cultivation area and continuous climate change [2]. Fruit flies belong to the insect family *Drosophilidae*, order Diptera. Fruit fly larvae resemble maggots and feed in the fruit, causing the pulp of cherries to become soft and rotten, and even lose their commercial value, seriously affecting the quality and economic benefits of the fruit. Fruit fly has gradually become one of the main factors restricting the healthy development of the cherry industry. The main fruit fly species that harm cherries include *Drosophila melanogaste*r Meigen, *Drosophila suzukii* Matsumura, *Drosophila hyde*i (Sturtevant) and *Drosophila immigrans*[3].

At present, there have been many reports on the prevention and control technology of cherry fruit fly. Common control methods include manual cleaning, orchard intercropping, physical trapping, poison bait trapping, and application of pesticides[4]. The long-term single use of chemical pesticides not only increases pesticide residues in fruits and causes ecological environment pollution in orchards, but also leads to the enhancement of pest resistance[5].

In recent years, with the requirements for sustainable development of agriculture, the use of biopesticides has become more urgent. The application of biological pesticides to the prevention and control of cherry fruit flies will greatly reduce the environmental pollution caused by chemical pesticides, reduce pesticide residues in fruits, improve the quality of cherries, and increase economic benefits. *Empedobacter brevi* is a newly developed microbial insecticide in recent years. It is of great significance to study the control effect of *Empedobacter brevi* on cherry fruit fly.

*Empedobacter brevis* is a new type of microbial pesticide with strong insecticidal activity, gastric poisoning effect on pests, good safety to humans, livestock, poultry and other non-target organisms, and compatible with the environment[6,7]. While protecting the ecological environment, it also ensures the food safety of crops.Spinetoram has a good control effect on fruit flies, and its effect lasts for a long time[8].In order to further understand the control effect of *Empedobacter brevis* on cherry fruit fly and the appropriate dosage in the field, this study used 60g•L$^{-1}$ spinetoram suspension as a control to comparatively analyze the effects of different dosages of *Empedobacter brevis* suspension on cherry fruit flies. The study aims to provide a basis for drug screening and guidance of scientific drug use for the prevention and control of cherry fruit fly.

## Literature Review

The cherry fruit fly belongs to the genus *Drosophila*, family *Drosophilidae*, order Diptera, and is an important pest found in recent years that damages cherry (*Prunus pseudocerasus*) fruits[9]. Cherry fruit fly is the general name for fruit flies that damage cherry fruits. Because it has caused serious damage to cherries in recent years, it is called cherry fruit fly[10]. Currently, cherry fruit fly is distributed all over the world[11], and is also distributed in many areas of China, but it has not been reported in Xinjiang[12]. This insect has a wide host range. In addition to damaging sweet cherries, it also mainly

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damages bayberry (*Myrica rubra*), peach (*Prunus persica*), plum (*Prunus salicina*), blueberry (*Semen trigonellae*), raspberry (*Rubus corchorifolius*), blackberry (*Rubus occidentalis*), strawberry (*Fragaria ananassa*), kiwi (*Actinidia chinensis*), persimmon (*Diospyros kaki*), fig (*Ficus carica*) and grape (*Vitis vinifera*) and other fruit trees[13-16]. After investigation, there are four main species of fruit flies that harm sweet cherries, namely *Drosophila melanogaster*, *Drosophila suzukii*, and *Drosophila hydei* and *Drosophila immigrans*, among which *Drosophila melanogaster* and *Drosophila suzukii* cause the most serious damage, and both types of fruit flies can damage a variety of fruits, and can occur in combination[17]. The female adults of *Drosophila melanogaster* lay eggs under the peel of nearly mature or cracked cherry fruits. After the eggs hatch, the larvae feed on the pulp and cause damage. The later cherry fruits gradually soften, brown, and rot [18]. *Drosophila suzukii* has a black serrated ovipositor, and the female adult can directly lay eggs in the pulp of immature or nearly mature cherries. After the eggs hatch, the larvae feed on the pulp and cause serious damage to the fruit, which affects cherry yield and quality[19]. In the United States, Germany, Italy and other countries, *Drosophila suzukii* has caused 100% losses to a large number of soft-skinned fruits[20].

*Empedobacter brevis* is a new biopesticide variety isolated, screened and purified from diseased and dead *Spodoptera litura* larvae [21]. Studies have shown that it has good control effect against *Spodoptera litura*, diamondback moth, rice leaf roller, cotton bollworm, spotted leafminer, apple coreworm, tea looper, etc. Research on the use of *Empedobacter brevis* to control *Spodoptera litura* in tea gardens has shown that *Empedobacter brevis* has good quick-acting and long-lasting effects on *Spodoptera litura* indoors and outdoors, and it is a biological pesticide and is recommended for use [22]. Indoor toxicity tests show that *Empedobacter brevis* 10 billion spores/ml suspension has a good control effect on diamondback moth. Due to the unique mechanism of action of this product, within 24 to 48 hours, diamondback moth refuses to feed, and the pest mortality rate is low. It reaches the peak after 72 hours, and the control effect can last for a week. The suitable insect age for controlling diamondback moth is 1 to 3 years old, and the application temperature is 25 to 30°C. Under the condition of dilution 500 to 2000 times, it has a higher prevention and treatment effect on diamondback moth [21]. Test results of *Empedobacter brevis* used to control rice leaf rollers in Fujian, Zhejiang, Guangdong, Jiangsu and other places showed that the average control efficiencies of 820.33, 937.42, and 1093.75mL/hm$^2$ were 70.03%, 76.92%, and 81.56% respectively, higher than the control, and is safe for rice, has no adverse effects on natural enemies, is safe for humans, livestock, and poultry, and has great promotion and application value [23]. Using *Bacillus thuringiensis* 16000IU/mg wettable powder 1500g/hm$^2$ as the control dose, the results of the efficacy test of *Empedobacter brevis* against cotton flyworms showed that *Empedobacter brevis* 10 billion spores/mL suspension 750 ~ 1250mL/hm$^2$ dosage has a relatively ideal control effect on cotton flyworms, is safe for cotton and other non-target organisms, and has good promotion and application value[24].Field efficacy test results show that, comparing the results after single application and continuous application, one application of 10 billion spores/mL *Empedobacter brevis* suspension can effectively control tobacco caterpillars/armigera[25]. After applying the *Empedobacter brevis* agent, it can produce similar control effects to commonly used pesticides for controlling leafminers, and the agent lasts for a long time. There is no significant difference in the control effect with 1.8% avermectin EC on the 10th day. During the test, it was observed that the test agent had no adverse effects on cucumber growth within the tested concentration and was safe for cucumber plants[26]. Using chlorpyrifos as a control agent, a efficacy test was conducted on apple heartworm by *Empedobacter brevis* 10 billion spores/mL suspension. The test results show that the 600 times solution of *Empedobacter brevis* 10 billion spores/mL suspension has the best continuous control effect on apple heartworms and is safe for apple trees and other non-target organisms. It is an ideal promotion and application product in the field of apple heartworm prevention and control[27]. 10 billion spores/mL *Empedobacter brevis* suspension suspension 500 times has good control effect on tea loopers. The control effect on the 1st, 3rd and 7th day after treatment is close to that of the control agent 2.5% bifenthrin 1000 times. It is safe to natural enemies of tea gardens such as ladybugs, spiders, and mantises, has no harmful effects on tea leaves, has basically no impact on the quality of tea leaves, and has a certain effect on killing insects and preserving yields[28].

## Materials and Methods

***Overview of the test site:***

The experiment was implemented at the cherry orchard based in Wucaizhuang Village, Shuanghou Town, Yinan County, Linyi City, Shandong Province, China (priviat farming, standardized management). The experimental orchard area is 1.9764 acres, the tree age is 10 years, the varieties are Red lantern, Tieton and Napoleon. The soil is brown soil and the organic matter content is about 1%. The yield per acre is 4800-6000 kilograms and watering conditions are available during drought. During the test period, the cherry growth conditions and agricultural operation and management measures such as fertilizer and water were basically the same in each treatment area.

***Test materials:***

*Empedobacter brevis* 10 billion spores/mL suspension which is produced by Zhenjiang Runyu Biotechnology Development Co., Ltd.;

60g•L$^{-1}$ spinetoram suspension which is produced by Dow AgroSciences of the United States and is commercially available.

The pesticide application equipment is a push rod sprayer, a Knapsack sprayer branded SX-LK16 from Taizhou City, Zhejiang Province.

***Experimental design:***

***Community design and area:***
The experiment was conducted on three varieties: Red lantern, Tieton and Napoleon. Each variety had 5 treatments, 3 repetitions, 15plots, randomly arranged, and each plot was equipped with a protection row. There are three fruit-bearing trees in each plot, and the tree vigor is basically the same.

***Dosage handling:***
*Empedobacter brevis* 10 billion spores/mL suspension is designed in 3 types: 600times solution (dose 1250mL/hm$^2$), 800times solution (dose 937.5mL/hm$^2$), and 1000times solution (dose 750mL/hm$^2$).
The control agent is 60g•L$^{-1}$ spinetoram suspension concentrate 1000 times (conventional dosage)
Clear water control area was set up.

***Application time:***
Start applying pesticides during the color changing period of cherry fruits. Spray the whole tree, subject to even spraying of cherry leaves and fruits. Apply pesticides once every 7 days. Depending on the growth period of the variety and the weather, spray 2-3 times. The amount of pesticide applied is 2-3L each time. All treatments were sprayed on May 16 and 23, 2023; the late-maturing variety (Napoleon) was sprayed again on June 1. The application time is from 9 am to 11 am. There was no precipitation within 24 hours after application.

***Investigation methods:***
***Drug efficacy investigation:***
Randomly survey 2 trees in each plot, randomly pick 100 fruits around the crown of each tree and in the middle and upper part of the inner cavity, and pick and survey a total of 200 fruits from the 2 trees; the fruits are required to be highly mature and dark in color, and should be placed for 4 days after picking. After all the fruit flies have emerged from the fruit, conduct a fruit fly inspection. Calculate the fruit fly rate and control effect. Excel software was used for statistical analysis of the test data, and Duncan's new multiple range method of SPSS software was used to analyze the significance of the differences in the control effects of each treatment.
Insect fruit rate (%) = (number of insect fruits/total number of fruits) × 100
Control effect (%) = [(CK number of worm fruits - number of worm fruits in the treatment area)/CK number of worm fruits] × 100

***Investigation of chemical hazards:***
Observe whether the test chemicals have any adverse effects on cherry leaves, branches and fruits during the entire test period after application.

**Results and Analysis**

***Control effect on cherry fruit fly:***
***Control effect on cherry fruit fly of Red lantern variety:***
The results are shown in Table1. The insect fruit rate treated with four different concentrations of chemicals was significantly lower than the insect fruit rate in the clear water control, and the control effects were all above 80%. Among them, the control effect of *Empedobacter brevis* 600 times on cherry fruit fly was 87.14%, which was the best. There is no significant difference in the control effect among the 600 times and 800 times solutions of *Empedobacter brevis* and the 1000 times solution of spinetoram, but there is a significant difference between the 1000 times solution of *Empedobacter brevis*.

| Treatments | Insect fruit rate（%） | Control effect（%） |
|---|---|---|
| *Empedobacter brevi* 600 times | 1.50 | (87.14±0.31)a |
| *Empedobacter brevi* 800 times | 1.83 | (84.30±2.33)a |
| *Empedobacter brevi* 1000 times | 2.33 | (80.01±2.29)b |
| spinetoram 1000 times | 1.67 | (85.69±2.68)a |
| Clear water control (CK) | 11.67 | |

Table 1: Control effects of different treatments on fruit flies (Red lantern) 1)

1) Different letters after the control efficacy data in the same column indicate significant differences (P <0.05)

***Control effect on cherry fruit fly of Tieton variety***:

The results are shown in Table 2. The results are similar to the results of the Red lantern variety. The insect fruit rate decreased significantly after chemical treatment compared with the clear water control. The control effect of *Empedobacter brevi* 600 times solution and the control agent spinetoram 1000 times solution was better, 87.67% and 86.33% respectively. The control effect of *Empedobacter brevi* 800 times solution was second, at 84.94%. There is no significant difference in effectiveness. The control effect of *Empedobacter brevi* 1000 times solution was slightly worse than the other three treatments, the difference was significant, but it was still above 80%.

| **Treatments** | **Insect fruit rate（%）** | **Control effect（%）** |
|---|---|---|
| *Empedobacter brevi* 600 times | 1.50 | (87.67±0.29)a |
| *Empedobacter brevi* 800 times | 1.83 | (84.94±2.24)a |
| *Empedobacter brevi* 1000 times | 2.33 | (80.83±2.20)b |
| spinetoram 1000 times | 1.67 | (86.33±2.02)a |
| Clear water control (CK) | 12.17 | |

Table 2: Control effects of different treatments on fruit flies (Tieton) 1)

1) Different letters after the control efficacy data in the same column indicate significant differences (P <0.05)

***Control effect on cherry fruit fly of Napoleon variety***:

It can be seen from Table 3 that the insect fruit rate of the four treatments of Napoleon variety was slightly higher than that of Red lantern and Tieton, but it was also significantly lower than that of the clear water control. The control effects of the four agents were lower than those of the corresponding treatments of Red lantern and Tieton varieties. Among them, only *Empedobacter brevi* 600 times solution had a control effect of more than 80%. The control efficacies of the control agents spinetoram 1000 times solution and *Empedobacter brevi* 800 times solution were second, with 79.72% and 78.49% respectively. There was no significant difference in control efficacy among the three treatments. The 1000 times solution of *Empedobacter brevi* had the lowest control effect, with no significant difference from the 800 times solution, but a significant difference from the 600 times solution and the control agent.

| **Treatments** | **Insect fruit rate（%）** | **Control effect（%）** |
|---|---|---|
| *Empedobacter brevi* 600 times | 2.50 | (81.01±0.41)a |
| *Empedobacter brevi* 800 times | 2.83 | (78.49±2.02)ab |
| *Empedobacter brevi* 1000 times | 3.33 | (74.64±2.71)b |
| spinetoram 1000 times | 2.67 | (79.72±2.45)a |
| Clear water control (CK) | 13.17 | |

Table 3: Control effects of different treatments on fruit flies (Napoleon) 1)

1) Different letters after the control efficacy data in the same column indicate significant differences (P <0.05)

***Phytotoxicity on cherry trees:***

Field observations during the trial showed that no adverse symptoms such as leaf curling, yellowing, or shrinkage occurred on the cherry trees in each treatment area, and no phytotoxicity occurred on the branches and fruits of the cherry trees.

**Discussion**

*Empedobacter brevi* is a newly developed microbial insecticide in recent years. Studies have shown that it has good control effects on tea loopers, diamondback moths, *Spodoptera litura*, rice leaf rollers, spotted leafminers, apple heartworms, etc., indicating that this bacterium has application and promotion value. Research by Wu Haibin *et al.* showed that 24, 30 and 40 mg/L of 60 g/L spinetoram suspension, 5.00, 6.25 and 8.33 mg/L of 5% emamectin saline dispersible granules, and $1.00\times 10^7$, $1.11\times10^7$ and $1.25\times10^7$ spores/mL 10 billion spores/mL *Empedobacter brevis* suspension have good control effect on cherry fruit fly (cherry variety Labins), but has no adverse effect on cherry leaves, branches and fruits[29].The results of this study show that the 10 billion spores/mL suspension of *Empedobacter brevi* has a good control effect on cherry fruit fly. After application, its 600 times solution and 800 times solution can produce similar control effects to the commonly used spinetoram 1,000 times solution, and the control effect can reach more than 78-80%. Under the condition of dilution 1000 times, it also has a good control effect on cherry fruit fly, with a control effect of more than 74%. By comparing the fruit fly control effects of three cherry varieties: Red lantern, Tieton and Napoleon, the control effect of the late-maturing variety Napoleon is lower than that of Red lantern and Tieton, which may be related to factors such as the late picking period, climatic conditions, and heavier fruit fly occurrences. The test chemicals have no adverse effects on the growth of cherry trees within the tested concentrations and are safe for cherry trees. This result shows that *Empedobacter brevis* has a very good control effect on cherry fruit fly from the perspective of different varieties and different dosages, and has application and promotion value.However, the ecosystem is a dynamic equilibrium system formed after long-term co-evolution. Only by more in-depth study of the impact of *Empedobacter brevi* on non-target insects and secondary pests in cherry orchards can we provide more theoretical basis for scientific decision-making on pollution-free management of cherry pests.

**Conclusion**

On the three cherry varieties of Red lantern, Tieton and Napoleon, the control effect of *Empedobacter brevi* 600 times and 800 times and spinetoram 1000 times was better, with the control efficiency reaching more than 78-80%. There is no significant difference in control effect among them, and it is safe for cherry trees. In the production of cherries, *Empedobacter brevi* can be promoted and applied as an effective biological agent for controlling cherry fruit flies.Based on comprehensive considerations of control effect and economical use of medication, it is recommended to select 800 times of *Empedobacter brevi* 10 billion spores/mL suspension as a rotation or replacement agent for fruit fly control in cherry production. Start spraying during the color change period, spray once every 7 days, and spray 2-3 times.

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