# Application of Non-toxic Pesticides in Vegetable and Fruit Pest Control

## – Hebei Yizhuo Tiancheng Biotechnology Co., Ltd. as an example

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**[Abstract]:** As an emerging environmentally friendly pesticide, biological pesticides are drawing hope. Relevant technologies and industries are also booming. In this paper, the application of non-toxic pesticides in vegetable and fruit pest control are studied. A multi-group controlled trial is carried out by data analysis methods DMRT and SSR. The conclusions are as followed: ①Biological pesticides can improve the quality of vegetables and fruits, as well as the land condition. ② Biological pesticides have better control effect and less pollution level than conventional chemical pesticides, and have broad prospects for development. ③At present, biological pesticides are lacking in effect. Meanwhile, relevant departments fail to carry out sufficient detection. Besides, some peasant households know little about biological pesticides. Therefore, it is suggested that relevant departments increase investment in R&D and production, develop detection standards for biological pesticides, and increase the promotion of the knowledge and technology associated with biological pesticides.

**[Key words]:** vegetable and fruit; non-toxic pesticide; pest control

## I. Introduction

Pesticides are one of the important means of production affecting agricultural development. With the constant improvement of human living standard, the public has paid more and more attention to food health. How to reduce pesticide residue and protect the environment while producing green food has been an important research topic in pesticide field. The International Union for Conservation of Nature put forward the concept of sustainable development in the *World Conservation Strategy* in 1980. As a large agricultural country, China stipulated the development of low toxicity and high efficiency chemical pesticides and the gradual development of biological pesticides.

In this paper, the application of non-toxic pesticides of Hebei Yizhuo Tiancheng Biotechnology Co., Ltd. in vegetable and fruit pest control is explored through test analysis mainly with non-toxic pesticides as an example. In addition, problems are summarized and suggestions offered according to the findings of the research survey.

## II. Literature Review

### (I) Development of biological pesticides

Biological pesticides have experienced a long process of evolution in the studies carried out by biologists from various countries. In 1800 Jim Dycoff, an American, found that Caucasian tribes used pyrethrum powder to kill pests and commercialized it in 1828. In 1848, Vockley produced the derris root powder pesticide. Metchnikoff from Russia used anisopliae to control wheat scarab larvae in 1879. In 1911, Bernay, a German, isolated Bacillus thuringiensis from Ephestia kuehniella Zeller. In 1926, G. B. Fanford successfully controlled potato common scab with antagonist.

In the early 1940s, Gibberellin became the earliest microbial pesticide commodity; and the mass production of this microbial pesticide began in the early 1950s. During the 1960s-1970s, bactericidal antibiotic biological pesticides emerged. In the 1990s, people actively used biological engineering technology in the R&D of biological pesticides. The biological pesticides in the world are expected to achieve a market cap of $9. 5 billion by 2025 and boom at an average compound annual growth rate of 15%-18%.

**(II) Introduction to non-toxic pesticides**

At present, biological pesticides can be roughly classified into microbial pesticides, mineral pesticides, biochemical pesticides, plant pesticides, protein or oligosaccharide pesticides, agricultural antibiotics, natural enemies of biological pesticides and other categories. The non-toxic pesticides referred to in this paper is the 2% chitosan soluble liquid, which is a new oligosaccharide pesticide. Its active ingredient chitosan, is the product of the conversion of chitin acetyl group. Its molecular formula is shown in Fig. 1.

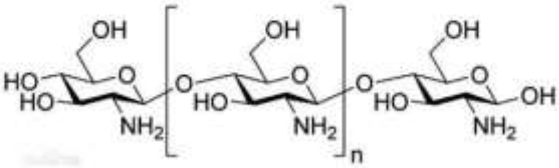

Fig. 1

Chitosan can inhibit the growth and reproduction of some fungi, bacteria and viruses. It is now believed that it has the following three possible bactericidal and insecticidal mechanisms: ①The polycations of chitosan tend to interact with negatively charged groups on the surface of fungal cells, changing the fluidity and permeability of pathogen cell membrane; ②Chitosan interferes with the replication and transcription of DNA(Chen, Zhou, Liu, 2009, p9); ③It blocks pathogenmetabolism.

This product is isolated from the carapaces and skeletons of crabs, shrimps and other creatures by microbial fermentation technology. It has broad-spectrum insecticidal, bactericidal and virucidal effects and a wide range of applications, and can kill the germs and pests on all land plants, some aquatic plants and edible fungi. Its application is not affected by soil and weather.

**(III) Bactericidal and insecticidal mechanisms of chitosan**

In terms of the bactericidal mechanism, the polycations of chitosan tend to interact with negatively charged groups on the surface of fungal cells, changing the fluidity and permeability of pathogen cell membrane. This interaction can destroy the cell walls of pathogens parasitic on its plants and cause the death of pathogens.

In terms of the insecticidal mechanism, chitosan can directly kill the eggs laid by pests on plants and destroy the cell walls of such eggs, so that no larvae can be hatched from eggs. The sucking organs of the larvae just hatched are also destroyed when they are sucking the juice of plants. As a result, no adults will appear even larvae are hatched.

**III. Data and Analysis**

**(I) Data from trial on vegetable and fruit pest control with non-toxic pesticides**

In this paper, field efficacy trials on the control of tetranychus cinnabarinus on eggplant and field trials on the control of tomato early blight are carried out with 2% chitosan soluble liquid. A multi-group controlled trial is carried out with DMRT and SSR as the data analysis methods.

1. Field efficacy trials on the control of tetranychus cinnabarinus on eggplant

The experimental subject was eggplant; and the pest controlled was tetranychus cinnabarinus on eggplant. The experimental area was 0. 04 $hm^2$. 300 eggplant plants were planted. The liquid was diluted in 1:300 profortion to treat the plants with one run of root-irrigation and two runs of spraying, 100 ml per plant, the amount of pesticide liquid used per hectare being 750 L. 400 eggplant leaves damaged by pests were randomly selected from the experimental area and were marked by signs. The cardinal number of pests was surveyed before pesticide application. The number of live tetranychus cinnabarinus on the marked eggplant leaves was investigated on Day 1, 3, 7 and 14 after pesticide application, respectively. The control efficiency (%) was calculated by the following formula.

$$\text{Control efficiency (\%)} = \left(1 - \frac{CK0 \times PT1}{CK1 \times PT0}\right) \times 100$$

CK0: the cardinal number of pests in the blank control area before pesticide application,
CK1: number of live pests in the blank control area after pesticide application;
PT0: the cardinal number of pests in the pesticide treatment area before pesticide application,
PT1: number of live pests in the pesticide treatment area after pesticide application.
The results of these trials are listed in Table 1.

Table 1 Results of Field Efficacy Trials on the Control of Tetranychus Cinnabarinus on Eggplant with 2% Chitosan Soluble Liquid

| Trial code | Pesticide | Content of active ingredient (mg/kg)/ ($g/hm^2$) | Preparation dilution concentration (times)/ ($ml/hm^2$) | Control efficacy on Day 1 after pesticide application | | Control efficacy on Day 14 after pesticide application | |
|---|---|---|---|---|---|---|---|
| | | | | Control efficacy (%) | Significance of difference 5% 1% | Control efficacy (%) | Significance of difference 5% 1% |
| A | 2% chitosan soluble liquid | 66. 7 | 300 | 86. 12 | a A | 91. 60 | a A |
| B | | 57. 1 | 350 | 83. 46 | b AB | 89. 56 | a AB |
| C | | 50 | 400 | 80. 62 | c B | 86. 49 | b B |
| D | Chlorfenapyr suspending agent | 72 | 300 | 86. 69 | a A | 91. 05 | a A |

Notes: The data in this table are the average value of 4 repetitions of each treatment. Uppercase and lowercase letters represent the significance at the 1% and 5% levels, respectively.

Experimental results and conclusions are as follows: ①On Day 1 after pesticide application, the control efficacy of high-dose treatment for tetranychus cinnabarinus on eggplant was 86. 12%, which was close to and equivalent to the treatment effect (86. 69%) with the corresponding dose of 240 g/L chlorfenapyr suspending agent, the control pesticide. ②On Day 14 after pesticide application, the treatment with different doses of 2% chitosan soluble liquid maintained good insecticidal effect on tetranychus cinnabarinus on eggplant. The control efficacy of the treatment with medium and high doses maintained at 89%～91% and was equivalent to that of the treatment with the corresponding dose of the control pesticide. ③The treatment of the corresponding doses of all pesticides was safe and harmless to eggplant, causing no harm to non-target organisms or land pollution.

2. Field efficacy trials on the control of tomato early blight

The experimental crop was Provencal tomato. The experimental control object was tomato early blight. The experimental area was 0. 02 $hm^2$. 180 tomato plants were planted. Root-irrigation with 1000× pesticide liquid was performed once at the beginning of the disease, 100 mL diluent/plant. The whole plant was evenly sprayed twice with an interval of 7 days, 900 L/$hm^2$. 200 plants were randomly sampled from the experimental area, with 10 upper, middle and lower leaves of each plant observed. The plants were graded by the percentage of diseased spot area on each leaf. The number of diseased fruits (including fallen ones) was investigated while surveying leaves. The control efficacy was expressed by the rate of diseased fruit. The pesticide effect was calculated as follows:

$$\text{Rate of diseased fruit (\%)} = \frac{\text{(number of diseased fruit)} \times 100}{CK1 \times PT0}$$

Control efficacy (%) = (rate of diseased fruit in the clearwater control area - rate of diseased fruit in the pesticide treatment area) × 100 / Rate of diseased fruit in the clearwater control area

$$\text{Disease index} = \frac{\sum \text{(umber of diseased leaves at each grade} \times \text{relative grade value)} \times 100}{\text{Total number of leaves surveyed}}$$

$$\text{Control efficacy (\%)} = \left(1 - \frac{CK0 \times PT1}{CK1 \times PT0}\right) \times 100$$

CK0: disease index in the clearwater control area before pesticide application;

CK1: disease index in the clearwater control area after pesticide application;

PT0: disease index in the pesticide treatment area before pesticide application;

PT1: disease index in the pesticide treatment area after pesticide application.

The results of these trials are listed in Table 2.

Table 2 Results of Field Efficacy Trials on the Control of Tomato Early Blight with 2% Chitosan Soluble Liquid

| Treatment N. | Pesticide name (active ingredient dosage ga. i. /$hm^2$) | Root-irrigation preparation Dosage | Disease index before pesticide application | After the 1st spraying 7 d (leave) | | After the 2nd spraying 14 d (leave) | | After the 2nd spraying 14 d (fruit) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Disease index | Control Efficacy (%) | Disease index | Control Efficacy (%) | Rate of diseased fruit （%） | Control Efficacy (%) |
| A | 2% chitosan soluble liquid (60. 00) | 1000 × liquid | 0. 76 | 0. 69 | 76. 86 B b | 0. 84 | 80. 39 B b | 2. 21 | 74. 18 B b |
| B | 2% chitosan soluble liquid (67. 50) | | 0. 83 | 0. 69 | 79. 09 AB b | 0. 77 | 83. 82 AB ab | 2. 01 | 76. 53 AB b |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| C | 2% chitosan soluble liquid (75. 00) | | 0. 81 | 0. 56 | 82. 42 A a | 0. 64 | 86. 79 A a | 1. 75 | 79. 63 A a |
| D | 70% propineb wettable powder （1575. 00） | / | 0. 89 | 0. 76 | 78. 67 AB b | 0. 92 | 82. 23 AB b | 2. 10 | 75. 55 B b |

Notes: The data in this table are the average value of 4 repetitions of each treatment. Uppercase and lowercase letters represent the significance at the 1% and 5% levels, respectively.

Experimental results and conclusions are as follows: ①When the active ingredient dosage is 60. 00~75. 00ga. i. /hm$^2$, the control efficacy increases with the dosage; ②There is no significant difference in the control efficacy between the two pesticides after 7 days since the 1st spraying; after 14 days since the 2nd spraying, the control efficacy of the treatment of different doses of pesticides for the leaf and fruit of tomato early blight is 80% and 74%, respectively, and is better than that in the control group. ③The treatment of the corresponding doses of all pesticides is safe and harmless to tomato, causing no harm to non-target organisms or land pollution.

## IV. Benefits from Application of Biological Pesticides

### (I) Quality improvement for vegetables and fruits

It can be seen from the two groups of trial above that the control efficacy of non-toxic pesticides is equivalent or slightly better than that of chemical pesticides with corresponding functions. Meanwhile, the application of non-toxic pesticides also avoids the damage of chemical components to the quality of crops. After the application of non-toxic pesticides, various organic products taste good; and the quality and taste of vegetables and fruits are improved.

### (II) No water pollution

Chitosan comes from organisms and can be easily degraded. It not only preserves water quality, but also can adsorb toxic heavy metal ions and purify waters. Many hydroxyl and free amino groups are distributed on the molecular chain of chitosan, forming a positively-charged high-molecular compound. Chitosan forms cage molecules with the help of hydrogen bonds. Chitosan has an equatorial bond structure that allows it to chelate with metal ions when pH < 6. 5. (Liu, et al., 2022, p59)Therefore, chitosan can effectively precipitate the organic matter in the solution to capture toxic heavy metal ions.

### (III) No soil pollution

By contrast, chemical pesticides cannot avoid environmental pollution, while non-toxic pesticides do not destroy the planting environment after application. for their raw materials come from organisms. The residues of non-toxic pesticides in soil can be decomposed and utilized by microorganisms for plant growth as nutrients. Therefore, there is no soil pollution.

## V. Problems in the Application of Biological Pesticides in Vegetable and Fruit Pest Control

### (I) Slow effect of biological pesticides

According to the comparison of biological pesticides and chemical pesticides, compared with the direct poisoning by chemical pesticides, most biological pesticides prevent diseases by participating in the metabolism of pests, resulting in a relatively long period of pest killing and disease prevention. To sum up, biological pesticides cannot meet the needs of peasant households for rapid pest control during planting due to their complicated operation and slow effect.

### (II) Insufficient detection of biological pesticides by relevant departments

Currently, China has introduced a number of laws and regulations on pesticides, such as the *Regulations on the Administration of Pesticides*, the *Measures for the Administration of Pesticide Registration*. The pesticide management system in China has been more and more standardized. However, there are such problems as long registration time, lack of unified data detection standards in access, efficacy detection and residue detection.

### (III) Some peasant households' lack of relevant knowledge

It can be concluded from the survey carried out by Hebei Yizhuo Tiancheng Biotechnology Co., Ltd. in nearby villages that most peasant households do not know well about the mechanism of action of biological pesticides. Besides, biological pesticides are not properly used. Meanwhile, poor control efficacy and certain environmental pollution are caused due to the lack of trainings on specialized knowledge among quite a great number of peasant households. Biological pesticides are generally less accepted and less frequently used by peasant households than traditional chemical pesticides. (Zhou, 2020)

## VI. Suggestions on the Application of Biological Pesticides in Vegetable and Fruit Pest Control

### (I) Increasing investment in R&D and production

The government should increase support for the R&D of new products and the support for the capital, tax, talent and other aspects of biological pesticide manufacturers to allow their rapid and sound development, constant innovation and the R&D of more optimized, more market-oriented products.

### (II) Formulating detection standards for biological pesticides

At present, the detection of pesticide residues in agricultural products is insufficient in China. The agricultural product pesticide residue detection mechanism and punishment mechanism should be perfected. Strict and comprehensive standards of use should be formulated. Peasant households' rule awareness should be enhanced to make them consciously follow standards of use, so as to reduce the phenomenon of non-standard use of pesticides. Faced with an increasing variety of products, relevant departments need to keep up with the development of the industry, introduce standards for various levels, ensure strict compliance by agricultural operators and high quality production by manufacturers, and establish effective supervision and administration systems and mechanisms to ensure food safety. (Zhou, 2020)

### (III) Strengthening the promotion of knowledge and technology associated with biological pesticides

After peasant households have grasped more professional biological pesticides use technology, better pest control efficacy can be achieved; and they will be more willing to buy biological pesticides. Therefore, relevant departments and biological pesticide enterprises are recommended to promote biological pesticides by multiple ways and multiple media. Moreover, training on knowledge of biological pesticides and the guidance work on biological pesticide application technology is necessary to raise peasant households' food safety and environmental awareness and expand the range of application of biological pesticides and, in addition, promote sustainable agriculture.

**VII. Conclusion and Discussion**

In this paper, experimental exploration is performed with non-toxic pesticides as an example. The composition, use and advantages of non-toxic biological pesticides are analyzed; and some suggestions are put forward. The development of biological pesticides accords with the concept of low-carbon economy, circular economy and clean green economy. Biological pesticides can play a positive role in providing the green agricultural products to meet the needs of the masses, maintaining the balance of agricultural ecology and promoting sustainable agricultural development. Biological pesticides are of extremely profound significance in pesticide development in China and agricultural progress in the world.

However, some questions still need to be discussed. Since the government plays a vital role in developing sustainable development, it's obvious that the government should be mainly responsible for the promotion work, which is currently is hindered by many obstacles. For example, the technologies at present is not mature enough, and it's difficult to convince households in rural areas to replace chemical pesticides with biological ones. Environmental benefits seem to be less important compared with profits for peasant households, which has raised the difficulty of popularization. So as consumers, once urban residents realize the advantages of products of sustainable agriculture and welcome them more, they will accelerate the widespread application of biological pesticides by farmers, and solve the problem. It is believed that biological pesticides can enjoy better development and play a vital role in the action to maintain world food security under the vigorous support from governments and international organizations and the joint efforts of the whole industry.

**VIII. Appreciation**

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