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ISSN: 2155-9627
Journal of Clinical Research & Bioethics

Review Article

Research Progress and Status of Plant Antiviral Compounds: A Review

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ABSTRACT

Plant virus diseases cause considerable harm to agricultural production. Due to its unique biological character, it is a top priority for agriculture to effectively control plant virus diseases and reduce economic losses. In order to control, reduce or eliminate plant virus diseases, many control methods have been studied, such as the use of disease-resistant varieties and seed detoxification measures to prevent the occurrence of diseases; the use of biological control agents such as virus attenuated strains to interfere with virus infection and proliferation. Insecticides are used to control viral vectors in order to achieve the purpose of disease control. However, it is not yet possible to prevent the harm of the virus to the crops, and it is necessary to perfect the comprehensive control of the disease with the help of effective pesticides.

Keywords: Biological agents; Chemical pesticides; Disease resistance

INTRODUCTION

Plant virus diseases are one of the fundamental reasons of biological disasters in agriculture globally [1]. There is a great challenge of the control, prevention, complex transmission media and plant disease infection mechanism of plant viral diseases. For this, a productive green pesticide is earnestly required. Thus, pesticide specialists have concentrated on attributes, for example, low pesticide resistance, eco-friendliness, and novel mechanism, when creating applicant medicate prompts direct plant infections [2].

At the beginning of the 20th century, Allard discovered that TMV could not inoculate pokeweed with tobacco juice, and later found that CMV could not inoculate pokeweed into cucumber. Later, Duggar and Arnustrong discovered an antiviral substance from the commercial land, which caused a series of studies and led the control of plant virus diseases to the track of chemical control. But the real start of antiviral preparations was around the 1950s, peaking from 1953 to 1954. Such reports decreased sharply in the late 1960s, and in the 1970s, with the development of induced resistance research, the research on antiviral agents became active again. In 1973, the Japanese Plant Epidemic Prevention Association established a professional anti-plant virus research institute to carry out the development of anti-plant virus agents. In the following ten years, more than 20 substances have been tested [3]. After entering the 1980s, with the rise of bioengineering technology, some people have a certain prejudice against antiviral agents, thinking that there is no need for antiviral agent development and research, and even that it will be replaced [4]. Plant virus diseases, known as 'plant cancer', are the second largest plant diseases after plant fungal diseases, which have caused great damage to agricultural industry. Since now, the most direct and effective method for controlling viruses is chemotherapeutics, except for screening of anti-disease species. As the occurrence and harm of plant diseases intensify, production and consumption of pesticides have increased year by year, and greatly contributed to the fertility of agriculture, but also brought a series of problems, such as the increase of drug resistance of plant pathogens and the excessive pesticide residues. Over the years, biopesticide has increased more consideration than any time in recent memory and showed incredible advancement potential. Due to different work ways, biopesticide described as environmentally safe to non-target life forms and low residual because of better particularity and not as defenseless to produce drug resistance. Presently, on new biogenic anti-plant-virus substances much

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Received: 04-Feb-2022, Manuscript No. JCRB-22-15785; **Editor assigned:** 07-Feb-2022, Pre QC No.JCRB-22-15785 (PQ); **Reviewed:** 21-Feb-2022, QC No JCRB-22-15785; **Revised:** 25-Feb-2022, Manuscript No.JCRB-22-15785(R); **Published:** 04-Mar-2022, DOI: 10.35248/2155-9627.22.13.403.

Citation: Ahsan T, Ishaq H (2022) Research Progress and Status of Plant Antiviral Compounds: A Review. J Clin Res Bioeth. 13:403.

advancement has been made. There are different sources of biopesticide's active components include small molecules like alkaloids, flavonoids, phenols, essential oils, proteins, polysaccharides from plants, algae, microorganisms and oligochitosan from animals. This examination outlined the advance exploration of biogenic anti-plant-infection substances lately and set forward their further improvement. Recently, research on antiviral agents has received much attention. At present, the studied antiviral active substances involve chemical substances, animal-derived substances, plant-derived substances, and microbial-derived substances, which are now introduced separately. The natural and synthetic sources of anti-viral compounds are shown in Figure 1.

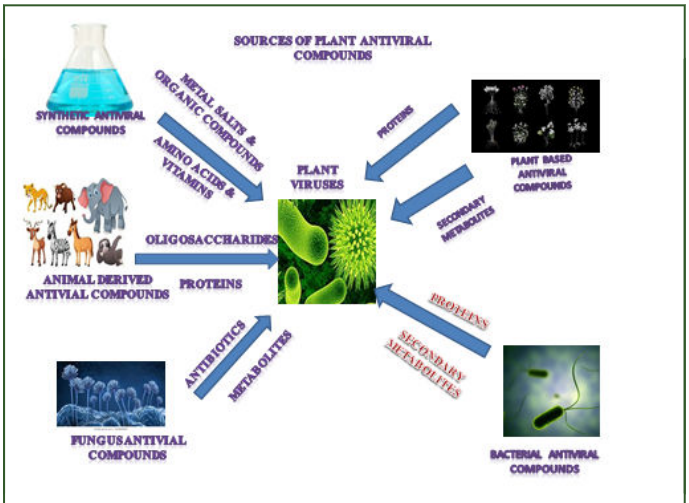

Figure 1: Natural and synthetic sources of antiviral compounds.

SYNTHETIC CHEMICAL SUBSTANCES

Many anti-plant virus chemicals have been studied, divided into the following seven categories:

1. Metal salts, such as $ZnSO_4$, $CaCl_2$
2. Organic chemicals, such as salicylic acid, flavonoids, anthraquinones [5], quaternary amine compounds
3. Purines and pyrimidines, such as 8-azoguanine, 2-thiouracil, triazines, etc
4. Amino acids, such as cysteine
5. Vitamins, such as VB2
6. Plant hormones, such as 2, 4-D, kinetin, etc
7. Proteins such as milk and skim milk

Weifan analyzed the antiviral mechanisms of the above seven types of the substances, and believed that some had *in vitro* passivation effects on plant viruses, some inhibited the virus and treatment *in vivo*, and some could induce host plants also has to produce proteins related to the disease course to increase resistance. Different strategies were used to control viral diseases which couldn't have been effective in decreasing or avoiding the virus infection, despite controlling fungi or bacteria were very effective; especially by chemical means [6]. Decrease fungal diseases. However, for virus diseases there is no such direct way available to control it so far [7]. Researches for virucide seem to be far behind when compared to similar areas using chemical compounds such as herbicide, fungicide and insecticide. Antiviral substances are strongly in demand to control virus diseases, but it has been documented that the agriculture field lacks antiviral chemicals [8]. Several chemicals have been found to be able to control virus replication and suppress virus disease symptoms [9], such as "benlate" and "bavistin", but unfortunately these chemicals failed to have any effect on the quantity of the virus in the leaves. Another problem is that many of these chemicals have negative properties such as, phytotoxic effects, probably bad effect on humans, animals, and the environment, so none of these compounds are used in applied fields for controlling plant viruses. These disadvantages make the regulations for the registration of any new chemical virucides very restricted and increases firmness of the regulations in many countries. The near future probably will not see any considerable progress of chemical virucides [10]. For example, a number of secondary metabolites are also exist which have properties against viral agents (anti-viral) and they compete with synthetic anti-viral drugs in their activities (*In-vitro* and *In vivo*) [11]. It has been indicated that phyto-antiviral agents interacts with numerous viral sites and cause the release of virus from cells through the inhibition of several viral specific enzymes *i.e.*, reverse transcriptase and protease etc, [12].

SUBSTANCES OF ANIMAL ORIGIN

Proteins have a passivation effect on plant viruses, such as skim milk, fish and earthworm blood have the effect of reducing or preventing virus invasion. Majority of animal metabolites with anti-plant virus activities have not been much explored. However, it is documented that a couple of oligosaccharides such as chitin and chitosan have anti-plant virus characteristics [13]. These are hydrolysed products from chitosan polymers which have potential to activate plant defenses against invading viruses [14].

PLANT-DERIVED COMPOUNDS

Plants are natural gatherings, around at least 2400 species; contain biologically and organically dynamic substances for controlling infections and creepy crawly bugs, insects, pests etc. Animals and microorganisms also totally dependents on plants due to their biological significance [11]. As of 1988, more than 180 angiosperms from different families have been found to strongly inhibit plant virus infection [15]. American pokeweed (*Phytolacca americana*) was the first plant to be reported to contain a virus inactivating substance. In 1948 Kassanis and Klezckowski proved that this inactivating substance was a glycoprotein with a molecular weight of 13KD. In 1975, Irvin discovered that PAP (phytolacca antiviral protein) can inhibit the replication of spinal and influenza viruses, but it is unclear whether plant viruses have this function. In 1977, Grasso isolated a protein that can inhibit virus infection from the American land of commerce. This protein can partially interfere with the proliferation of virus particles in the early stage of virus infection, and combine with the virus to generate ionic bonds in vitro and combine them. So the virus cannot infect. Japan reported that using a special method to make wild American pokeweed leaf coarse powder, the extremely low concentration can obviously inhibit the formation of local lesions of TMV on

kidney bean leaves. In the future, experiments will be focused on practicality [16].

Azadirachta indica in India is considered a magic tree. There are many uses, and the leaf extract has been developed as an antiviral agent. Both spinach and beet extracts from Chenopodiaceae can inhibit TMV and prevent TMV from producing necrotic spots in *Nicotiana glutinosa*. In 1947, Kuntz and Walker discovered that the extract of rapeseed had the ability to inhibit TMV when diluted to 10-3, and that the dilution to 10-4 still effectively inhibited the camomile leaf virus. *Dianthus caryophyllaceae* has obvious inhibitory effects on TMV [17]. An antiviral protein that can effectively prevent the transmission of plant viruses was extracted from the juice of jasmine, and it has obvious inhibitory effects on TMV, PVY, and CMV, and can also induce systemic disease resistance on tobacco plants Dan et al. [18] found that Jasmine leaf pulp can inhibit PVY and PVYN mutual infection. In 1961, Media observed that the extracts of kidney bean embryos and seed coats inhibited both the kidney bean mosaic virus and the bean yellow mosaic virus [19] the stem extracts of Four-ridged and White powder vines have certain control effect on rice Tongue virus. In addition to higher plants, some lower plants such as: bryophytes also contain proteins that inactivate TMV. Fern *Ampelopteris prolifena* leaf extracts can induce local and systemic resistance of villous tobacco to TMV and CMV [20]. Many medicinal plants also contain antiviral substances, such as Banlangen, Guanzhong, Rhubarb, Arnebia, *Houttuynia cordata*, *Scutellaria baicalensis*, etc Qiyan et al. [21] demonstrated that the water extract of Banlangen roots reduced the smoke spot of heart leaf tobacco by virus TMV infection by more than 80%, and the extract of Banlangen acetic acid showed a decrease of the number of dead spots by more than 90%, which showed induced resistance. The antiviral agents AE-1 and AE-2 developed by Hongguo et al. [22] have TMV and CMV effects, respectively, to prevent infection and inhibit virus replication. AE-3 has a broad spectrum and inhibits the above-mentioned viruses Ying Xu et al. [23] extracted polyhydroxybinaphthol (CT), quercetin (EK), and flavonoid (EH) from six medicinal plants. These three substances have inhibitory effects on TMV. Plants that inhibit virus infection include Aloe vera (*Aloereravar chinensis*), Onion (*Allium cepa*), *Acacia arabica*, and Portulacaeae (*Portulaca splendens*) can inhibit PVX by more than 40%, cedar (*Cedrus deodara*), yew (also known as *Taxus cuspidate*), Strawberry, tomato, etc., Kubo et al. [24] reported and registered an antiviral pesticide called Mazanonai, a polymer of alginates derived from marine plants.

MICROBE BASED ANTIVIRAL AGENTS

Microbes, as the largest organisms on the planet, contain many species that are beneficial to humans. It is a treasure trove of human society. Microbial resources can be called the continuous development of supplementary chemical pesticides, resulting in increasingly scarce candidate compound resources. Other valuable and high-quality products such as various enzymes, hormones, and human and animal medical supplies can be developed from them. Microorganisms are mainly bacteria, fungi and actinomycetes. The actinomycetes, algae, microbes and parasites are classified into several pathogenic and non-pathogenic organisms. Against TMV metabolites from these life forms have been clarified further. In fungi different peptides, proteins and polysaccharides are the well-known metabolites which have anti-viral properties [25,26].

Agricultural antibiotics have made great achievements in the application of microbial resources to control pests and diseases, but progress has been slow in the field of antiviral disease control. In this regard, Japan has taken the lead in registering *Lentinus edodes* fermentation under the trade name Rentemui in the 1970s. This has caused countries to pay more attention to the prevention and treatment of viral diseases by antibiotics, and achieved certain results.

EXTRACTS FROM BACTERIA

Many antiviral antibiotics of bacteria are peptides, such as bacitracin, which inhibited to a certain extent or inactivate TMV [12]. Bacteria will also produce some other types of antibiotics, such as yeast (nonas B. nonas Ql) is a polysaccharide that has a certain passivation effect on TMV [27]. Protein derived from bacteria against the TMV [28].

EXTRACTS FROM FUNGI

Among the four fungi, Fungi imperfecti produces more antiviral antibiotics, such as Citromycin produced by Aspergillus, which can easily penetrate the heart leaf tobacco inoculated with TMV. Within, it strongly inhibited the formation of diseased spots, and the inhibitory effect of cumin on TMV proliferation increased with increasing treatment concentration and time. Penicillin produced by Penicillium, Jing et al. [29] found that it has a good effect on CMV, can passivate CMV particles and reduce the initial infection of the disease. There are not many antiviral antibiotics produced by Pyomyces and Ascomycetes. The antibiotics produced by Basidiomycetes have only attracted attention since the 1970s. They are mainly driven by immune theory to find enhancement The host body's immune defense mechanism is used to screen out polysaccharides and glycopeptides produced by Basidiomycetes, such as Trichothecin (C19H24O5) produced by Trichoderma, which is a kind of polysaccharides, which is effective for TMV, SBMV, and TNV. Lentinan listed in Japan has a certain effect in preventing CMV, TMV and PVX. Current clinically used antiviral drugs such as adenosine and trifluorothymidine, etc., inhibit virus proliferation by inhibiting the replication of viral nucleic acids. Drstamycin combines with viral DNA templates to inhibit viral replication. The structure of (Formycin) is similar to that of nucleic acids. Inhibiting RNA synthesis can also inhibit virus reproduction. Antivirubin can directly inactivate the virus [30]. Reported that the culture filtrate of *Trichoderma harzianum* and *Rhizoctonia solani* can inhibit TMV infection of Sansei tobacco. Antitoxin No. 1, a metabolite of *Lentinula edodes*, has two proteoglycans as its active substance, and the inhibition rate of TMV is 79.7% ~ 89.4%.

Actinomycetes

Of the thousands of antibiotics discovered by microorganisms to date, more than 60% are produced by actinomycetes. The antiviral antibiotics produced by actinomycetes have a variety of chemical structures and inconsistent properties. It has been the research direction of new antibiotic workers. Actinomycetes are widely distributed in nature. Many species can be detected from soil, flora and fauna, rivers, lake bottoms, and the ocean. Especially, there are many types and large numbers of actinomycetes in the soil. In 1963, Kaikai discovered a non-protein high-molecular metabolite of actinomycetes, which has a passivation effect on TMV, and mainly affects the host cell infection site Yeo et al. [31] reported that the antibiotic ASA (aspirin) produced by actinomycete B25 can inhibit TMV infection, and the system of noformycin produced by *Nocadia formica* on TMV reproduction and virus system infection and extension all play a role in inhibiting. Other antiviral antibiotics isolated from Streptomyces include Cyclo heximide, Ningnanmycin, Laurusin, Kanmycin, Qingnian Gentamicin, Tubercidir, Bihoromycir, Abomycin, Chloramphenicol, Antiviral antibiotic 16704A (macrolides) and pyramycin (Tianzhumycin) and so on. Moreover, Actinomycetes which have great importance regarding commercial production of medicines [32,33] also have anti-plant virus characteristics such as Ningnanmycin extracted from *Strepcomyces noursei* [34] and Cytosinpeptidemycin isolated from *Streptomyces ahygroscopicus* [18,35].

RESEARCH STATUS OF ANTIVIRAL ANTIBIOTICS

Agricultural antibiotics have been developed with the development of medical antibiotics. The research, development and utilization of medical antiviral antibiotics are an important supplement to current antiviral drugs. Agricultural antiviral antibiotics have played a positive role in agricultural production, and the economic benefits are also very significant. Thanks to the country's strong support and the efforts of scientific and technological workers, research on antiviral antibiotics has made some progress. According to the structure of antiviral antibiotics, they can be roughly divided into nucleosides, aminoglycosides, quinones, and macrolides, among which nucleosides are the main ones. Based on the structure, the following summarizes antiviral antibiotics from agricultural and medical aspects:

AGRICULTURAL ANTIVIRAL ANTIBIOTICS

Nucleosides

Classes of naturally dynamic biologically active compounds, which are fundamentally identified as purines, pyrimidine nucleosides or nucleotides present in cells, are described as nucleoside antibiotics or anti-infection agents. Nucleoside anti-infection agents have been utilized as structural analogs and inhibitors, because of their auxiliary structural relationship [36]. Currently, nucleoside antibiotics are being used as lead to carry out structural modification to explore antiviral drugs. Since the first nucleoside antibiotic cordycepin was isolated in 1950, more than 200 species have been discovered so far. Nucleoside antibiotic-producing bacteria are mostly actinomycetes, but also bacteria, molds, and basidiomycetes. Nucleoside antibiotics are mostly hydrophilic compounds, which are often adsorbed by activated carbon in the culture medium and eluted with acetone water, acidic or alkaline methanol; many are adsorbed with cation or anion exchange resins, and diluted with hydrochloric acid or ammonia. Elution is also possible by direct extraction with butanol or amyl acetate at the appropriate pH 3. The typical structure of nucleoside antibiotics is shown in Figure 2.

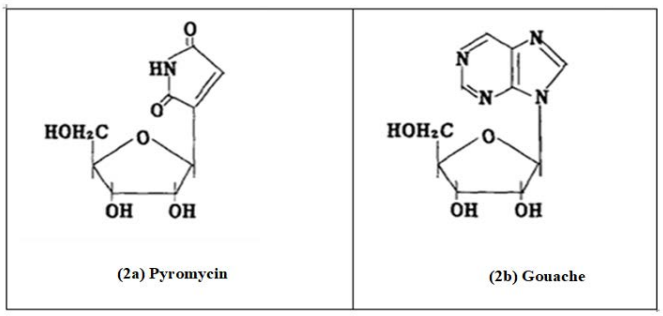

Figure 2: Typical structure of nucleoside antibiotic.

Ningnanmycin is a new agricultural antibiotic isolated from the fermentation broth of *Streptomyces noursei var. Xichangensis*. Since this bacterium is isolated from the soil of Ningnan Country, Sichuan Province, its fermentation product was named Ningnanmycin [37], after a chemical classification study, is a cytosine-nucleotide peptide broad-spectrum antibiotic. It can both control diseases and promote yield increase. It is a highly effective biological pesticide. It has been tested for acute, subacute, pathogenic mutations and other toxicity, indicating that this agricultural antibiotic has low toxicity, low residue, no accumulation, no teratogenic and carcinogenic effects. Harmless biological pesticides, Chen et al. [38] conducted a multi-point control experiment with a total area of 901.86 hm^2 in Sichuan and Yunnan provinces of China. The demonstration results show that the control effect of Ningnanmycin on tobacco mosaic disease is 69.4%-95.4%, and the average yield increase effect is 26.1%, which is better than Phytospermine, Bendoxin and 83 resistance enhancer, which are currently popularized to prevent and cure tobacco mosaic disease, and can significantly improve the inherent quality of tobacco leaves Chaorong et al. [39] research showed that 2% Ningnanmycin has better control effect on tobacco mosaic virus disease, and has the function of regulating the growth of flue-cured tobacco, and the yield increase effect is obvious. The concentration of 75mg/kg is the best, more than 150 mg/kg has a slight inhibition on flue-cured tobacco showed that Ningnanmycin had a 65% effect against tomato virus disease, which was 55.9% higher than that of poison buster, and a 72.7% effect against green pepper virus disease, which was higher than 71.6%. Ningnanmycin can also control 81.2% and 47.6% of tomato and green pepper diseases [40]. Therefore, Ningnanmycin has obvious control effect on tomato and green pepper virus disease. Polyoxin has the effect of anti-TMV, and has the advantages of not affecting the intrinsic quality of tobacco leaves and improvingthe quality of tobacco by one level. In 1965, a strain of

Streptomyces cacaoi var.asoensis isolated from the soil of Aso region in Kumamoto Prefecture by Suzuki and others in Japan was produced. There are 13 components in total, and the control targets of each component are different. China's polyoxin-producing bacteria are *S. auroochromogenes*. The 6% wettable powder is produced by Jilin Yanbian Pesticide Factory. Practice has proved that it is very toxic to humans, livestock, and fish, and it is harmless to plants.

Pestilin S was discovered by Takeuchi *et al.*, Japan in 1958. The antibiotic was isolated from the culture fluid of *Sterpomyces griseochromogenes*. When the concentration is 0.05 μg/mL, it can inhibit more than 50% of Tobacco Mosaic Virus (TMV); in addition, it can also reduce the infection rate of rice plant stripe virus. The mechanism of action of blasticidin S on the virus is to strongly inhibit the synthesis of tobacco mosaic virus ribonucleic acid, and to inhibit the synthesis of enzymes related to the polymerization of TMV-RNA. It is a cytosine nucleoside-type weakly alkaline water-soluble antibiotic. Currently, production of blasticidin S may be stopped due to its high toxicity to humans, mammals and fish. Puromycin is a 3'-deoxyadenine antibiotic produced by Porter in 1952 from the culture of Streptomyces alboniger. It is structurally similar to the 3'-terminus of amido t-RNA (Figure 3).

Puromycin has an inhibitory effect on a broad spectrum of organisms and a strong inhibitory effect on gram-positive bacteria, but has only weak activity against gram-negative bacteria and acid-resistant bacteria, and is also effective against some viruses. However, puromycin's effect is antibacterial, not bactericidal, it is an effective inhibitor of peptide synthesis, so it is quite toxic to higher animals. Miharamycin, produced by *Sterpomyces miharaensis sp.*, White powder, alkaline, hydrochloride is a fine prism crystal, the structure is a unique purine nucleoside, for TMV, PVX, CMV And the inhibition of the proliferation of rice stripe virus and the formation of local lesions. With 2.5 *ppm* hydrochloride, the effect of inhibiting the formation of local lesions in tobacco TMV is as high as 90%, and 1ppm is 81%. Spray can suppress the appearance of symptoms. However, it has been taught about the phytotoxicity of plants. It has been reported that tripromycin can significantly reduce the phytotoxicity by detoxifying complexes.

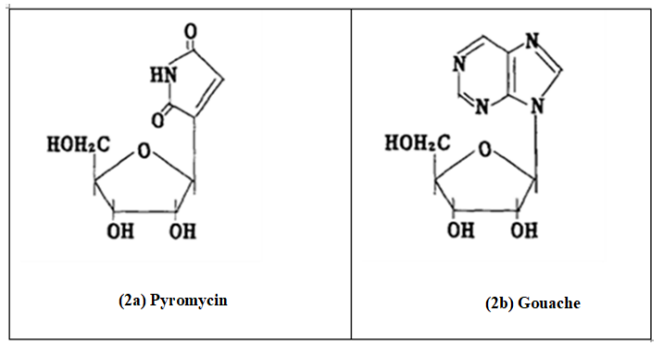

Figure 3: Structure of puromycin.

Pyramidin is a novel cytosine nucleoside antibiotic isolated from the fermentation broth of *Streptomyces mutans* (*Streptomyces.tz*) which does not absorb water. Its antiviral mechanism is manifested by inactivating viruses *in-vitro* and *in-vivo*. Inhibiting virus proliferation and inducing plant resistance to disease [41]. The acute oral toxicity of pyrimidin to rats LD50>4640 mg/kg and transdermal toxicity LD50> 2150 mg/kg were confirmed by toxicity tests. They are non-irritating to the skin and non-irritating to rabbit eyes. It is a low-toxic, broad-spectrum agricultural antibiotic with good control effect on a variety of plant viruses. Tunicamycin, a pyrimidine-containing nucleoside antibiotic produced by *Streptoyces lysosuperificus*, is effective against gram-positive bacteria, pear spores, and viruses. Nucleoside N9705 A peptidylcytosine nucleoside derivative produced by a Streptomyces strain has a broad spectrum of anti-life properties. N9705 can inhibit the pathological damage of herpes virus type I (HSV2I) on Vero cells and tobacco mosaic virus (TMV) on tobacco leaf cells. It has a strong inhibitory effect on four rice pathogenic fungi and one tobacco pathogenic fungus. It has killing effect on saprophytic and pine wood nematodes.

Aminoglycoside antibiotics

Jinggangmycin A is the main active ingredient of Jinggangmycin. Jinggangmycin is a highly effective, low-toxic and ideal biological pesticide for controlling *Rhizoctonia solani*, which isolated from the culture broth. The pure product of Jinggangmycin A is a white powder. Its molecular structure is composed of D-glucose, available oxygen amine A and effective dilute amine, so it is a unique aminoglycoside antibiotic investigated the effect of Jinggangmycin A on Shanxi tobacco on the number of blight spots caused by TMV and its chitinase, β-1,3 glucanase activity in plants and The relationship, and understanding of the inhibitory effect of the agent on the virus through the plant and its mechanism [42]. The results show that the activities of these two enzymes seem to be inversely related to the reduction of TMV blemishes. Jinggangmycin A can induce systemic antiviral effects in plants. Kanamycin is produced by *S. kanamyceticus* and contains three components A, B, and C. The main product of the domestic product is A, and it also contains a small amount of B (below 5%). C Content is minimal. Aminoglycoside antibiotics are mainly used clinically to treat non-viral diseases, and agricultural has been found to have a certain control effect on TMV.

MECHANISM OF ANTIBIOTICS TO CONTROL PLANT VIRUS DISEASES

NNM induces and promotes pathogenesis-related proteins in tobacco mosaic virus-inoculated tobacco [43]. Most antiviral antibiotics can inhibit viral nucleic acid replication or protein synthesis in host cells [44], such as chloramphenicol, actinomycin D, and actinomycin. Other antibiotics with antiviral activity currently found are oromycin, stachylosporin, lauromycin, citrinin, dextromycin, mitomycin, oxytetracycline, aspirin (acetylsalicylic salicylate) Acid) etc. have a certain control effect on TMV, while m-mycin, nocardiomycin, holomycin, apomycin (polypeptides) have a control effect on TMV, respectively on PVX, SBMV, and carob flowers and leaves Viruses work with ToMV and CMV. Truffles, daunomycins work on tobacco tumors, chloramphenicol, tuberculin, daunorubicin, and mithromycin, both work on tobacco tumors and TMV. In addition, chloramphenicol It also plays a role in PVX for TNV and daunorubicin. Monoclosporins have a

certain control effect on PVX and cytosporin on rice, citrus, sugarcane virus disease, SBMV and TMV. During infection, the coat protein (CP), which is delivered by viral particles into Susceptible host cells, provides protection for viral RNA. Here, we found that Ningnanmycin (NNM), a commercially used plant antibacterial agent, inhibits the assembly of the CP by directly binding several residues. These interactions cause the disassembly of the CP from discs into monomers, leading to an almost complete loss of pathogenicity [45]. Most antiviral antibiotics can inhibit viral nucleic acid replication or protein synthesis in host cells, such as chloramphenicol, actinomycin D, and actinomycin. The action mechanism of anti-viral compounds inside the plant cell is depicted in Figure 4.

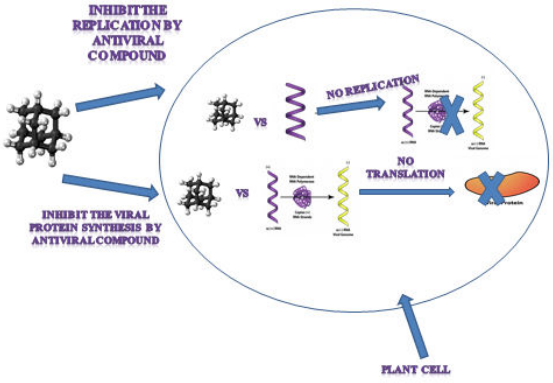

Figure 4: Action mechanism of antiviral compounds inside the plant cell.

PROSPECTS OF ANTIVIRAL AGRICULTURAL ANTIBIOTICS

Chemical pesticides are under pressure from environmental protection and commerce, biological pesticides are valued, and they are in a favorable position. Research on antiviral antibiotics has also made considerable progress. At present, many process technologies for improving the active effect and stability of biological pesticides have made great progress, and further development of production processes that can reduce production costs. There are inevitably restrictions in the development process. An important limitation is the regulations for the registration and marketing of biological pesticides. Almost all countries require registration of microbial pesticides (bacteria, fungi, viruses), while higher-level organisms (nematodes and beneficial insects) are exempt from registration.

As early as 1971, the forecast of future safe pesticide development published by the Japan Science and Technology Agency listed the practical use of anti-plant virus agents as one of the five development contents, and it was predicted that it would be realized from 1977 to 1997. However, due to the complexity of virus infection and insufficient understanding of the essential mechanism of plant virus diseases, there is no practical breakthrough in the application of antiviral antibiotics. Most of the drugs developed so far lack systemic effects, and can only prevent and treat contact with infectious viruses. The therapeutic effect is not strong. Therefore, antiviral agents should be developed to prevent the virus system from spreading in plants or indirect infection by plants, and they can block or inhibit the virus. Proliferating antiviral agents. Judging from the current situation of plant virus disease prevention and control, there are not many disease-resistant varieties, and the application of disease-resistant genetically engineered plants in production is still far away. There are also some problems with biocontrol agents such as satellite nucleic acids. Farmers' scientific and technological level is not high. Farmers can only realize the prevention and control only when they see the symptoms. Some preventive measures are generally not easy to be adopted. Therefore, the development and research of antiviral antibiotics has great practical significance and market.

DISCUSSION AND CONCLUSION

Although antiviral antibiotics have made certain developments, there is still a certain gap compared with foreign countries, which is reflected in the less developed varieties, the promotion area, the market sales share, the scope of application compared with international, and the level of research is generally low. It is far from being able to adapt to the prevention and control of viral diseases in China. At present, such agents cannot replace chemical pesticides. Although chemical pesticides will still play an important role in agricultural production in the new century, the pollution of chemical pesticides to the environment and crops will continue to increase, and the resistance of disease and insects to chemical pesticides will continue to increase, which will make the application of chemical pesticides more and more severe limits. At the same time, due to the energy crisis, it is necessary to save petroleum raw materials for the production of pesticides, which will give antibiotics and biological pesticides for virus control an unprecedented development opportunity.

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