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REVIEW ARTICLE

The technical process of using biological and chemical pesticides to control insects and viral diseases damaging the tobacco plants in Vietnam

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ABSTRACT
Tobacco budworm (Heliothis virescens), aphids (Myzus nicotianae), caterpillar (Spodoptera litura), tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), potato virus Y (PVY) majorly damage on the tobacco field in Vietnam and causing serious damage to the tobacco yield and quality. If it has no effective technical process to control them and proper pesticides, they will injure serious harm in the tobacco field next time. Based on the research results of control of some major insects and viral diseases damaging tobacco plants by chemical and biological pesticides to ensure safe and effective tobacco production" from 2020 to 2021 in Bac Giang province, the Vietnam Tobacco Institute has built a technical process of using biological and chemical pesticides to control insects and viral diseases damaging the tobacco plants in Vietnam. During the experiment and application in tobacco cultivation practice from 2022 to 2023, this process is effective against some main insects and viral diseases on tobacco. The application of the process to increase effective control that is shown the damage rate of insects and disease index of TMV, CMV, and PVY were significantly reduced, contributing to increasing yield, quality, and income for tobacco farmers, do not harm the growth and development of tobacco plants, and little have residues in tobacco production. This process was issued according to Decision No. 233/QD-VTL, dated December 9 2021, by Vietnam Tobacco Institute and was applied popularly in all tobacco-growing regions in Vietnam.
Keywords: antivirus agents, insecticides, techinical process of pesticides, tobacco.

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INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is one of the most important industrial crops in Vietnam, especially in the northern mountain provinces. It is popularly transplanted in Cao Bang, Bac Kan, Lang Son, Gia Lai, and Tay Ninh provinces with a total area of 5.500 ha. Every year, there are many insects and diseases damaging tobacco plants. In that, tobacco budworm (*Heliothis virescens*), aphids (*Myzus nicotianae*), caterpillar (*Spodoptera litura*), tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), potato virus Y (PVY) majorly damage on the tobacco field. TMV mainly injures some tobacco varieties such as K326, C9-1, C7-1, and native tobacco varieties. The native tobacco varieties that are selected by farmers are very sensitive to TMV, CMV, PVY, black shank, and bacterial wilt. CMV and PVY cause all tobacco types. Variety GL9 and line GL10 are resistant to TMV and bacterial wilt (*Ralstonia solanacearum*), and moderately resistant to black shank disease (*Phytophthora parasitica*). TMV, CMV, and PVY were the most common pests in the tobacco field, with disease incidence of TMV ranging from 3,5% to 90%, CMV from 0,8% to 9,5%, and PVY from 2,1% to 31,5%. The growth of viral diseases depends on the variety, cultivation, region, climate, and weather conditions annually [6,7]. The annual damage rate of insects in the tobacco field ranged from 5 - 10%.

According to the United Nations Food and Agriculture Organization, the annual damage costs caused by organisms for crops worldwide are estimated at billions of dollars. Global agricultural output lost about

40%. Damage by insects and spiders was about 29.7 billion USD, occupying 13.8%, and diseases were about 24.8 billion USD, accounting for 11.6%. Oerke et al., 1994 [18] and Oerke, 2006 [17], yield losses due to insects, diseases, animals and weeds ranged from 20 to 40% of global agricultural production. David Pimentel, 2017 [10], yield losses by insects, diseases and weeds each year were over 40% of global agricultural production, despite using three million tons of pesticides and other control measures each year.

Tobacco budworm is a major pest of tobacco in the world. They preferentially feed on the young tissues of tobacco plants [31]. When infestations of 100% tobacco budworms, one larva/plant on tobacco plants at 3, 5, and 7 weeks after transplanting caused yield losses of 564, 197, and 245 kg/ha, respectively. However, tobacco quality reduced after 3 and 5 weeks after transplanting when infected tobacco [1]. In 2006, in Georgia, USA, the total damage caused by tobacco pests was about USD 2,229 million, including the cost of control of USD 1.308 million and the damage caused by pests of USD 0.921 million. Budworms caused the most damage with USD 0.74 million (2005: USD 1.0 million), thrips: USD 0.50 million and tobacco caterpillars with $0.45 million [22].

Tobacco aphids injured significant loss of tobacco by sucking the sap and honeydew deposition on which sooty mould grows on leaves and adversely affects the quality of tobacco. Aphids caused indirect loss as transmittable vectors of viral diseases, such as CMV and PVY [24, 26]. High tobacco aphid populations reduced the yield by up to 22 and 28% and the price of cured tobacco leaves by up to 7 and 9% in 1988 and 1989, respectively. The combined effects on both yield and prices resulted in observed losses in gross economic returns of 27% in 1988 and 30% in 1989 [9], the tobacco yield decreased by 25 - 30% and quality deteriorated by more than 50% [27].

Spodoptera litura is a main pest for many economically important crops. The tobacco in India was estimated that two, four, and eight larvae per plant reduced yield by 23 to 24%, 44.2% and 50.4%, respectively [19]. In tobacco nurseries, the damage rate of S. litura varied from 80 to 100%, 10 - 25% in the tobacco field, and reduced 23 to 50% of tobacco yield [20]. In case of severe infestation, larvae can destroy the seedlings and have to resow [15].

Viral diseases often threaten the sustainable development of agricultural production in the world. They infected many crops and estimated about $600 billion in annual losses worldwide. Tobacco mosaic virus (TMV), the type member of the Tobamovirus genus, was a prevalent plant pathogen in the world and had the widest hosts of over 885 plant species in 65 families. TMV caused significant economic losses for many economically important crops worldwide [30], especially tobacco plants. The infected tobacco of TMV, leaf yield, grades and costs of dried leaf reduced by 13%, 16%, and 16%, respectively [4]. In 2000, TMV caused an estimated 1.4% loss in North Carolina's tobacco yield resulting in a USD 10.7 million loss [14]; as much as 60% reduction in crop value caused by early mosaic infection[29]; an average yield reduced range from 30 to 35% and more than a 50% in gross value [16]; yield losses of 20% in yield and 24% in value when plants were inoculated at transplanting [8]. PVY causes significant yield losses for tobacco [25, 28]. In recent years, PVY has tended to develop severely in tobacco-growing regions of the world [11]. The disease rate with PVY of 19 tobacco varieties in the Nelson district at the end of the 1964-1965 season varied from 0 - 72%, an average of 26%. PVY markedly reduced weight, leaf area, and quality of tobacco plants. In 1997, PVY caused damage of 640 tons, of which Tobacco mosaic virus (TMV) + Cucumber mosaic virus (CMV) caused damage of about 150 tons. In 2001, PVY damaged 100 tons, but TMV + CMV only damaged 6 tons. PVY can cause tobacco yield losses by up to 100% [12] and from 39% to 75%[28]. The sugar content of infected leaves decreased by an average of 9.8%. When infected tobacco plants were after 30 days of transplanting, tobacco yield reduced range from 71.2 - 74.8%, rate of sugar/nicotine: 3 - 4; infected tobacco after 44 - 60 days after transplanting little affected the yield, quality, and sugar/nicotine rate from 7.2 - 9.0, compared to healthy plants were 9.5 [13].

In recent years, pesticides have been widely used in agricultural production in Vietnam, even though they are misused to control harmful organisms leading to induce environmental pollution and biological imbalance, increase resistance to pesticides of pests and diseases, affect the plants and human health, and leave residues in agricultural products. In 2000, there were 12 active ingredients; in 2010, there were 56 active ingredients; in 2014: 67 active ingredients; in 2018: 1402 active ingredients (785 active ingredients for insects and 617 active ingredients for diseases); and in 2022, there were 1.340 active ingredients (689 active ingredients to control insects and 651 active ingredients with the disease). Lately years, some biological pesticides have been used in agricultural production and have high preventive effects for insects and diseases, widely active spectrum, low use dosage, and short isolation time. To increase the effectiveness of control, reduce environmental pollution and pesticide residues in tobacco production, and be suitable for safe, fresh, clean and sustainable agricultural production, the building process of using biological and chemical pesticides for controlling insects and viral diseases on tobacco is necessary.

THE STUDY RESULTS FOR BUILDING THE TECHNICAL PROCESS OF USING BIOLOGICAL AND CHEMICAL PESTICIDES TO CONTROL INSECTS AND VIRAL DISEASESON TOBACCO PLANTS

Antiviral agent: Ditacin 8SL (Ningnamycin), a concentration use of 1.0 litres/ha, with an isolation period of 2 days; Sat 4SL (Cytosinpeptidemycin), a concentration use of 0.8 litres/ha, with isolation period of 2 days; Exin 4.5SC (Salicylic acid), the concentration used 0.7 litres/ha, with isolation period of 0 days. Research subjects included tobacco budworm, caterpillar, aphids, tobacco mosaic virus, cucumber mosaic virus, and potato virus Y. The target surveillance was the effective control in room and field conditions, treatment concentrative thresholds, treatment time and technique; yield and quality; residue in dried leaf productions.

The study results about insecticide

Effective control: In 2020 and 2021, Vietnam Tobacco Institute experimented in room and field conditions in Bac Giang province with three biological and two chemical pesticides to find good pesticides and technical processes for using them. Including Tasieu 1.9EC (Emamectin benzoate) with a concentration use of 0.3 litres/ha and an isolation period of 7 days (recommended by the manufacturer); Reasgant 3.6EC (Abamectin) with a concentration use of 0.25 litres/ha, the isolation period of 7 days; Exin 2.0SC (Salicylic acid) with the concentration use of 1.5 litres/ha, with isolation period of 0 days; Confidor 100SL (Imidacloprid), the concentration use of 0.4 litres/ha, with isolation period of 7 days; Regent 800WG (Fipronil), the concentration use of 0.3 kg/ha and isolation time: 7 days. The study results from 2020 showed:

Tasieu 1.9EC, Regent 800WG, Confidor 100SL, Reasgant 3.6EC, and Exin 2.0SC were highly effective against tobacco budworm in the experimental room, with a mortality rate from 83.3 - 100%. The mortality rate reached 100% after one day of treating pesticide for Tasieu 1.9EC and two days of treatment for Regent 800WG. In the experiment's tobacco field, the highest effective control was Tasieu 1.9EC, reaching 100% in three days and seven days after spray, and the effective prevention of other insecticides of 37.1 - 60.2%. The active ingredient of emamectin benzoate can highly kill tobacco budworms through contact and toxin taste ways, while others are only highly effective control by contact way (Table no 1 and 2).

Tobacco caterpillar (Spodoptera litura), tasieu 1.9EC was the highest control, reaching 100% after one day of treatment, and others ranged 50 - 70% in room condition after three treatable days. In the field condition, tasieu 1.9EC had the best effectiveness against tobacco caterpillar, reaching 95.8% after seven days of treatment. Confidor 100SL and Exin 2.0SC were not effective against the tobacco caterpillar by toxin taste way (Table no 3 and 4).

Tobacco aphids are the main insects injuring tobacco. In addition to sucking the plant's nutrients, it is a vector for transmitting many viral diseases such as CMV and PVY. Tasieu 1.9EC and Confidor 100SL were the highest effective against aphids by contact, reaching 100%, Regent 800WG: 90%, and Reasgent 3.6EC and Exin 2.0SC from 40 - 50% after three days of spray. While in field condition, the effective control of Tasieu 1.9 EC, Reasgant 3.6EC, Exin 2.0SC ranged from 47.4 - 60.9%; Regent 800WG: 85.5%; and Confidor 100SL was 96.9% after three treatment days. After seven days of treatment, the effective control of Confidor 100SL achieved 90.6%; Regent 800WG: 49.1%; For Tasieu 1.9 EC, Reasgant 3.6EC, Exin 2.0SC, they did not control aphids after seven days of spray. From those study results, we collected Tasieu 1.9EC to control tobacco budworm, caterpillar, and Confidor 100SL for aphids (Table no 5 and 6).

The residue level in dried leaves: In 2021, we sprayed three insecticide times to control aphids, budworms, and caterpillars when they occurred at economic threshold level (ETL) with ETL of budworms and caterpillars ≥ 10%, aphids ≥ 10% with density > 50 aphids/upper leaf. Confidor 100SL, ai Imidacloprid, was sprayed three times at a strong growth period of tobacco with a concentration of 0.4 litres/ha. Dried leaf samples for residue analysis were taken after the last spray 30 days. The analytical results showed that the residue in dried tobacco leaf was 4.57 mg/kg and under the max residue level (MRL) of Vietnam, China and Coresta: ≤ 5 mg/kg, FAO 2001: ≤ 6 mg/kg. When increasing concentration from 0.6 - 1.0 litres/ha, residue in dried tobacco leaf ranged from 5.72 - 6.50 mg/kg and exceeded the MRL from 0.72 - 1.5 mg/kg. For Tasieu 1.9EC, ai emamectin benzoate, when sprayed from 0.3 litres/ha to 0.75 litres/ha, residue in dried tobacco leaf was very low, only from 0.03 to 0.09 mg/kg and under MRL (≤ 1 mg/kg) (Table no 9 and 10).

Study the isolation time of agents for residue: Tasieu 1.9EC, residue in dried tobacco leaf after three treatment days was 0.03 mg/kg and under MRL; For confidor 100SL, residue in dried tobacco leaf after three treatment days was 6.72 mg/kg and exceeded MRL of 1.72 mg/kg; after seven treatment days was 5.07 mg/kg and approximately equal to MRL (≤ 5 mg/kg); and after ten treatment days: 3.28 mg/kg and under MRL (Table no 11).

Impact of pesticides on yield and quality: Tasieu 1.9EC treatment gave the highest fresh and dry yields of 19.5 tons/ha and 2.03 tons/ha, respectively. Experimental agents did not affect the smoke quality of tobacco. The taste and flavour points of sprayed tobacco by Tasieu 1.9EC reached 9.5 points and 9.1 points, respectively, and Confidor 100SL: 9.8 points and 9.3 points compared to the control: 9.3 points and 9.1 points (Table no 7 and 8).

The study results about antivirus agent

The effective control: The studies were performed in the net-house and field condition in the brand of Vietnam tobacco Institute in Bac Giang province in 2020. The field experiment was arranged in a randomized complete block design with three replications. In net-house, we artificially inoculated 30 plants with stages from 5 leaves to 6 leaves by phosphate buffer 0.1M, pH = 7. The research results showed:

Study in net-house condition, the study results showed that treating Ditacin 8SL from 3 to 6 times before infected plants had effective control of PVY ranging from 24 - 33%; TMV: 28,9 - 50%; and CMV: 42,6 - 60% after 21 inoculative days. Sat 4SL, effective control of TMV ranged from 23,7 – 31,6%; CMV: 20,0 - 24,4% and PVY: 28,9 - 35,6% after 21 inoculative days.

Study in the field condition, the effective control of Ditacin 8SL reached 100% for TMV; PVY: 93,5%; CMV: 60,5% and TNRV: 52,1%. With Sat 4SL, the effective control of TMV reached 70,9%; CMV: 58,3%; PVY: 96,4% and TNRV: 36,9%. For Sat 4SL, it was the lowest effectiveness in room and field conditions. Spraying antiviral agents in the stage from 3 - 4 leaves/plant to 16 - 18 leaves/plant was the best control of viral diseases, increased the yield, grade index, and less impact on the property of smoke [6].

Study about concentration: In 2021, we sprayed increasing concentration of antiviral agent from 1.0 - 2.5 times with usable concentration levels of Ditacin 8SL from 1.0, 1.5, 2.0, and 2.5 litres/ha; Sat 4SL: 0.8, 1.2, 1.6, and 2.0 litres/ha; Exin 4.5SC: 0.7, 1.05, 2.0, and 2.5 litres/ha) from the stage of 3 - 4 leaves/plants to before topping one week, and the time between each spray was six days in field condition. The results showed that increasing agent concentration increased effectiveness against the viral diseases from 22.4 - 63.8% with Ditacin 8SL, 5.5 - 46.3% with Sat 4SL, and 8.2 - 52.0% with Exin 4.5SC. The best effective control of agents was at increasing concentration of 2.0 - 2.5 times (37.7 - 63.8%) [7].

The residue level in dried leaves: Spray Ditacin 8SL with six days/times from stage 3 - 4 leaves/plants before topping one week with other concentration levels showed that when spraying agent concentration of 1.0 - 1.5 litres/ha, dried leaf samples did not detect the residue; at a concentration of 2.0 - 2.5 litres/ha, the residue of this tobacco samples was only from 0.01 - 0.02 mg/kg (MRL ≤ 1 mg/kg) [7].

Yield and quality: Some antiviral agent treatments reached a dried tobacco yield of 1.2 - 1.5 tons/ha and dry leaf weight of 6.3 - 6.5g/leaf compared to control the dried tobacco yield of 0.9 tons/ha and dry leaf weight of 6.0 g/leaf. Experimental agents did not affect the quality and flavour scores of the spray formula ranging from 9.1 to 9.3 points compared to the control: 9.1 points; taste scores: 9.1 points to 9.5 points (control: 9.1 points) [7].

The effective control of mixture of agents for viral diseases

The effective control: To evaluate the effectiveness of a mixture of pesticides for controlling viral disease on tobacco in season 2021 in Bac Giang province, we mixed between antiviral agent and antiviral; antiviral agent and insecticide with five spray times. The insecticide controlled aphids that transmitted viral diseases for the crop as CMV and PVY. The study results showed that spraying a mixture of antiviral agent + insecticide (confidor 100SL) was effective against CMV, PVY from 32.6 to 40.6% and higher than using a single antiviral agent (5.5 - 30.2%) and a mixture of 2 antiviral drugs (Ditacin 8SL + Exin 4.5SC and Sat 4SL + Exin 4.5SC) with the effective control of 6.7 - 24.9%. For TMV, spraying a mixture and single agents had effectiveness against viral diseases, reaching 92.3 to 100% [7].

The residue level in dried leaves: The residue level in dried leaves: Spray 5 times a mixture of Ditacin 8SL (1 litre/ha) + Confidor 100SL (0.4 litre/ha) from the stage of plants with 4 - 6 leaves to 1 week before topping, and six days/times, the dried leaf samples had residue levels under the maximum residue level (MRL). The detail of MRL of Ditacin 8SL was 0.02 mg/kg compared to MRL of china ≤ 1 mg/kg, and Confidor 100SL: 3,13 - 4,33 mg/kg (MRL of china and Coresta: ≤ 5 mg/kg)[7].

Yield and quality: The tobacco plants treated with pesticides had fresh yield and dried yield higher than control from 10.3 - 39.7% và 18.8 - 38.2%, respectively. The treatments of a mixture of antiviral agents + insecticide achieved the highest yield and had statistically significant differences. The grade 1 + 2 of dried tobacco leaves ranged from 54.7% to 65.6% and higher than the control (40.6%), and grade 4 was lower (0.8 - 15,1%) than the control (30.3%)[7].

TECHNICAL PROCESS OF USING BIOLOGICAL AND CHEMICAL PESTICIDES TO CONTROL INSECTS AND VIRAL DISEASES ON TOBACCO PLANTS

To produce safe, effective tobacco production; and protect the ecological environment of agriculture, the selection of pesticides is based on the results of investigation and analysis of the field ecology. In addition, combining other cultivatable measures enhances the resistance of plants against harmful organisms and reduces the resources of pests and diseases in the field.

Cultivatable measures reduce harmful organism in the field

Resistant variety: Using resistant varieties is one of the important measures in pest management. The resistant varieties are usually used to grow in severely infected areas. For tobacco mosaic virus, resistant varieties (GL2, GL6, GL7, GL9, GL10 and D65) are usually used; Potato Virus Y: variety GL6.

Producing disease-free seedlings: Disease-free seedling is an important measure to decrease pest resources in the tobacco field. Many research papers showed that tobacco plants were infected with viral diseases after fifteen days of transplanting, the tobacco seedlings were infected in the nursery. So, to limit the damage of insects and viral diseases, it performs some technical methods such as (1) in the previous crop, the nursery land was not planted with tobacco and other host plants of tobacco pests and diseases, especially plants of family Solanaceae as tomato, potato, chilli, etc. The nursery is far from wild crops where many organisms can infect and damage tobacco seedlings. (2) Fertilize balance (N: P: K), especially avoid applying a lot of nitrogen, which makes plants easy to attract insects to harm and reduces the resistance of plants to diseases. Tobacco seedlings recover quickly after transplanting, seedlings have to prune leaves regularly, the balance between N: P: K, and create drought to increase the strong root development and hard stem lead to tobacco seedlings adapting quickly after transplanting conditions. (3) The severely infected tobacco-growing regions spray insecticides to control vector insects that transmit viral diseases to tobacco or produce tobacco seedlings in the net-house. (4) To increase effective control of viral diseases on tobacco such as TMV, CMV, PVY, and TNRV, tobacco seedlings are sprayed with two times antiviral agents before transplanting for six days/times and do not use seedlings in infective nurseries. Infective nursery need to destroy early to avoid harmful organisms in the tobacco field.

Crops rotation: It has an important role in integrated pest management for reducing the pest resources in the tobacco field. Some main crops to rotates, such as rice and maize, are not rotated with tomato, potato, chilli, eggplants, etc.

Field sanitation: Sanitate and destroy remnants of tobacco plants and another host plant in the field before the new season and after the complete season. Do not transplant tobacco crops close to secondary host plants of tobacco insects and diseases. For viral diseases, detect and destroy diseased plants early to limit the initial infection source in the field from the stage of the tobacco plants with 3 - 5 leaves to 16 - 18 leaves. After this stage, do not destroy diseased plants because infected plants will be little effect on tobacco yield and quality. In the transplanting period, destroy diseased plants and use disease-free seedlings to replant. Particularly for TMV, do not replant on the site of the diseased plant, and no contact between diseased and healthy plants during the cultivation. Because TMV is transmitted by mechanical contact and the other viruses (CMV, PVY, TNRV, and TLCV) are transmitted through vector insects. Destroying diseased plants of CMV, PVY, TNRV, and TLCV are performed after the treatment of insecticide.

Technical process of using biological and chemical pesticides to control insects and viral diseases on tobacco plants

Scope, subjects and scientific basis

Based on the scientific research results of the project "Research on the control of some major insects and viral diseases damaging tobacco plants by chemical and biological pesticides to ensure safe and effect in tobacco production" belong to the Ministry of Industry and Trade, Vietnam in 2020-2021.

This process is applied to control tobacco budworms (*Helicoverpa virescens*), catterpillars (*Spodoptera litur*a), tobacco aphids (*Myzus nicotianae*), tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), and potato virus Y (PVY) damaging tobacco in all tobacco regions of Vietnam.

Technical process of using biological and chemical pesticides for controlling tobacco insects and viral diseases

To use Tasieu 1.9EC, Confidor 100SL, Ditacin 8SL, Sat 4SL and Exin 4.5SC, and a technical mixture of insecticides with viral agents for increasing effective prevention and safety, limiting residues in tobacco production need to follow the four correct principles in use pesticides (use correct pesticide, right time, concentration, and technique) and ensure isolation time.

Use correct pesticides and ensure isolation time: They have an important role in increasing effective control; reducing residue of pesticides, environmental pollution, resistant pesticides of pests; and imbalance of ecological agriculture, etc. When deciding to use pesticides, it is necessary to know the pest species. Prioritize the use of agents with selective effects, high potency, short isolation time and low toxicity to beneficial organisms and warm-blooded animals. In the process of using drugs, there is a rotation of agents with different active ingredients and no use of drugs for a long time to prevent the drug resistance of the pest. Some pesticides control insects and virus diseases in Vietnam, including:

Tasieu 1.9EC (ai Emamectin benzoate) is a biological insecticide that has high effective against tobacco budworm (Heliothis virescens), tobacco caterpillar (Spodoptera litura) through contact and toxin taste ways and a short isolation time. But for aphids, it is only highly effective control by contact way, and low effect by toxin taste way. Agent's isolation time for safe tobacco production is three days after spray. The effective control of Tasieu 1.9EC can last ten days in the field condition. Tasieu 1.9EC can be used to spray in the period of the strong growth of tobacco plants and stage of harvesting, but ensure the isolation time for 3 days after spraying. For confidor 100SL, ai imidacloprid, is a systemic insecticide and has highly effective control for tobacco aphids, tobacco budworms, and caterpillars by contact ways, but it is low effectiveness against tobacco budworm, and caterpillars by toxin taste way. So it is mainly used to control tobacco aphids and white flies in the tobacco field. Agent's isolation time is seven days after spray, and the effective control of the agent can last ten days. Confidor 100SL is major used in the stage of strong growth of tobacco plants and is not used in the harvesting period.

Antiviral agents: Ditacin 8SL (Ningnanmycin), Sat 4SL (Cytosinpeptidemycin), and Exin 4.5SC (Salicylic acid) were biological agents that had effective against TMV, CMV, and PVY. The isolation time of Ditacin 8SL and Sat 4SL for safe tobacco production was three days after spray, and Exin 4.5SC was not isolation time. In addition, Ditacin 8SL and Sat 4SL can control fungal and bacterial diseases damaging tobacco. These agents are used in the stage of strong growth and development of tobacco plants and the harvesting period.

Use agent at the right time: Spray pesticides at stages when pests are most susceptible with drugs when larvae of insects are small (age of 1 and 2), and at the early stages of the diseases. Spraying in the shade, not too sunny to prevent the drug from rapidly decomposing, or when it is rain that will wash away the agent. Specifically, such as:

Tobacco insects: Spray the pesticides when the density of insects and disease rate reach the economic threshold level. For insects, spray when tobacco budworm appears in over 5% of the infective plants from the stage of the tobacco plant has 3 - 4 leaves to 6 - 8 leaves; ≥ 10% of infective plants when plants have 8 -10 leaves/plant to 1 week before topping. Tobacco caterpillar appears in over 10% of damaging plants, and aphids are in over 10% of the infective plants with a density of ≥ 50 individuals/upper leaves.

Viral diseases (TMV, CMV, PVY): Spraying antiviral agents when tobacco plants are not infected with the virus or viral symptoms have not appeared on the leaves will achieve the highest prevention efficiency. The effectiveness of the control decreases according to the severity of the symptoms. To increase effectively against the viral disease, we need to treat agents 2 times before transplanting in the seedling nursery and 3 - 4 times in the field, from the stage of tobacco plants with 3 - 5 leaves to 18 - 20 leaves. Each spray is a space of 6 days. Areas with a history of the popularly viral disease should spray regular agents when the diseased symptoms do not yet appear in the tobacco field. Regions have a low viral disease rate, spray agents when the disease rate is above 0.5%.

Each virus has its way of spreading and causing harm, so the time and method of prevention are also different. TMV is only transmitted through mechanical contact and not through vector insects, so the formula for spraying to control TMV is antiviral agent + foliar fertilizer. Foliar fertilizers will increase the growth of tobacco and the resistance of plants to control many diseases. CMV and PVY are spread through vector insects, so the formula for spraying to control them is antiviral agent + insecticide + foliar fertilizer. Insecticides, use special agents to treat the sucking insects that transmit viruses to tobacco plants, such as confidor 100SL (Imidacloprid), Actara 25WG (Thiamethoxam), etc.

Use a correct concentration of pesticides: It is necessary to use the exact concentration and dosage, including the amount of pesticide and the amount of water mixed for spray on a unit of crop area according to the manufacturer's instructions or the researchable result's recommendations on the crop. Increasing drug concentration will endanger users, plants, animals, environment and increase costs. If spraying at a concentration is too low, it will make pests and diseases resistant to agents, creating a risk of outbreaks. Based on the study results, the concentration of study agents used to apply in tobacco production.

Insecticide: Tasieu 1.9EC, Emamectin benzoate, spray at a concentration of 0.3 litres/ha, the maximum concentration of the drug does not exceed 1.5 times according to the manufacturer's instructions (0.45 litres/ha). For confidor 100SL, imidacloprid, spray at a concentration of 0.4 litres/ha, the maximum concentration of the drug does not exceed 1.5 times (0.6 litres/ha).

Antiviral drugs (Ditacin 8SL, Sat 4SL and Exin 4.5SC): In low infective regions of viral diseases, spray at a concentration of 1.0 litres/ha; for the high infective disease regions, spray at a concentration of 1.5 - 2.5 litres/ha.

Use correct technical pesticide:Calculate the exact amount of agent and water needed. First, put 1/3 - 1/2 amount of water into the bottle, then add the drug and stir well. Then add enough amount of water into the bottle and stir thoroughly so that the drug is evenly dispersed in the water. Spray in cool weather, morning or afternoon, and avoid spraying in the hot sun, rainy weather or wet leaf surface.

Technical spray: With tobacco budworm and aphids, spray evenly wet the upper young leaves, including buds and 3-4 adjacent leaves below. For aphids, especially spray the underside of the leaves. For the tobacco caterpillar, spray evenly wet the lower leaves, especially the underside of the insect-infected leaves. If the young caterpillars (age 1-2) do not disperse, spray only on insect-infected plants. For viral diseases, the spray evenly wets all leaves of crops, especially the young and immature leaves.

APPLYING TECHNICAL PROCESS OF USING BIOLOGICAL AND CHEMICAL PESTICIDES TO CONTROL INSECTS AND VIRAL DISEASES IN TOBACCO PRODUCTION IN VIETNAM

The process of PVY management had been issued by the Tobacco Institute under Decision No. 141/QD-VTL, dated November 27, 2018, and had been applied to prevent PVY in the tobacco field in 2019 - 2022. In 2021, Vietnam Tobacco Institute continued to issue the technical process of using biological and chemical pesticides to control insects and viral diseases on tobacco according to Decision No. 233/QD-VTL, dated December 9, 2021. This technical process was applied effectively in tobacco season 2022 in all tobacco-growing areas of Vietnam.

To control insects and viral diseases in 2022 - 2023, we have applied the technical process of using biological and chemical pesticides to control insects and viral diseases damaging the tobacco plants in Vietnam and the process for potato virus Y (PVY) management on tobacco plants in Northern Vietnam (Nguyen Van Chin et al., 2022). The application results showed damage rate of insects and viral diseases rate has strongly decreased in the spring season of 2021 and 2022. In 2014 - 2015, PVY caused heavy damage in Bac Son - Lang Son province, with a disease rate of 20 - 36%, and many tobacco fields were severely damaged (60 - 100%). In 2016 - 2017, the PVY disease continued to cause severe damage in Bac Son and Chi Lang - Lang Son province, with a disease rate of 9.7 - 13.5%, especially causing too heavy damage over 5 hectares in Bac Son district and 10 hectares in Chi Lang - Lang Son province with a diseased rate of over 31% (Nguyen Van Chin et al., 2022). In 2019 - 2020, the PVY caused mild damage in most of the tobacco-growing provinces of the North, with a disease rate below 2.3%. In 2021 - 2022, PVY only appeared with a disease rate below 0.5% in tobacco-growing areas of Northern Vietnam.

According to the investigation of Tobacco Institute in the last years, tobacco budworms (Heliothis virescens) and caterpillars (Spodoptera litura) usually appeared popularly in the tobacco field with infective plants rate ranging from 10 - 15%, and aphids (Myzus nicotianae) from 20 - 30% with a density of aphids over 50 individuals/upper leaves. Tobacco mosaic virus generally occurred in the field in Northern Vietnam (Cao Bang, Bac Kan, and Lang Sơn provinces), with disease incidence ranging from 3,5% to 90%. TMV is severe damage in native tobacco varieties with a disease rate of reaching 100% and approximately 100% with a light damage level on variety K326 in southern Vietnam (Tay Ninh province) in 2020 and 2021. The native tobacco varieties were planted popularly and occupied more than 50% of the tobacco-growing areas. For the cucumber mosaic virus, the disease rate ranged from 0.8 to 9.5% [6,7].

After applying two technical processes to prevent insects and viral diseases, the damage rate of insects and the viral diseases in the tobacco field reduced significantly from 2021 to 2023. Especially coming March 2023, TMV, CMV, and PVY only appear to scatter in the tobacco fields of southern and northern provinces, with disease rates under 0.5%. In some tobacco fields of farmers who grew native tobacco varieties and do not apply the technical process to control the virus, the disease rate of TMV ranges from 10 - 100%, and CMV and PVY below 5%. Tay Ninh and Gia Lai provinces tobacco plants have been harvested; for Cao Bang, Bac Kan, and Lang Sơn provinces, tobacco plants have 10 - 12 leaves, and this stage is sensitive to insects and diseases.

So, applying two technical processes for preventing insects and viral diseases increase the effective prevention of TMV, CMV, and PVY; ensures the growth and development of tobacco; guarantees yield and quality; and does not have residue of pesticides in tobacco production; increases income for tobacco growing farmers in 2022 and 2023.

CONCLUSION

The technical process of using biological and chemical pesticides for controlling tobacco insects and viral diseases has been highly effective in preventing the tobacco budworm, caterpillar, aphids, TMV, CMV and PVY; reducing the residue of pesticides in tobacco production; contributing to increasing yield, quality and increase income for tobacco growing farmers in the all tobacco growing regions of Vietnam. The process of PVY management according to Decision No. 141/QD-VTL, dated November 27, 2018, and the technical process of using pesticides with Decision No. 233/QD-VTL, dated December 9, 2021.

The technical processes for controlling and using pesticides that help tobacco production companies in Vietnam are proactive in preventing insects and viral diseases damaging the tobacco field.

Table no 1. Infective control of pesticides for tobacco budworm (Heliothis virescens) in room condition

No	Treatments	Concentration	Effective control (%)		
			1 day	2 days	3 days
1	Tasieu 1.9EC	0.3 litre/ha	100.0	-	-
2	Regent 800WG	0.3 kg/ha	50.0	100.0	-
3	Confidor 100SL	0.4 litre/ha	50.0	83.3	83.3
4	Reasgant 3.6EC	0.25 litre/ha	66.7	91.7	91.7
5	Exin 2.0SC SAT	1.5 litre/ha	50.0	91.7	91.7

Table no2. Infective control of pesticides for tobacco budworm (Heliothis virescens) in the field condition

No	Treatments	Concentration	Effective control (%)		Decrease rate after 7 days (%)
			3 days	7 days	
1	Tasieu 1.9EC	0.3 litre/ha	100	100	0.0
2	Reasgant 3.6EC	0.25 litre/ha	77.8	37.1	52.3
3	Exin 2.0SC SAT	1.5 litre/ha	84.2	55.3	34.3
4	Confidor 100SL	0.4 litre/ha	58.0	50.0	13.8
5	Regent 800WG	0.3 kg/ha	73.8	60.2	18.4

Table no3. Infective control of pesticides for tobacco caterpillar (Spodoptera litura) in room condition

No	Treatments	Concentration	Effective control (%)		
			1 day	2 days	3 days
1	Tasieu 1.9 EC	0.3 litre/ha	100	-	-
2	Confidor 100SL	0.4 litre/ha	30.0	40.0	50.0
3	Exin 2.0SC SAT	1.5 litre/ha	30.0	60.0	70.0
4	Regent 800WG	0.3 kg/ha	20.0	30.0	60.0
5	Reasgant 3.6EC	0.25 litre/ha	20.0	50.0	60.0

Table no 4. Infective control of pesticides for tobacco caterpillar (Spodoptera litura) in the field condition

No	Treatments	Concentration	Effective control (%)	
			3 days	7 days
1	Tasieu 1.9EC	0.3 litre/ha	91.7	95.8
2	Reasgant 3.6EC	0.25 litre/ha	33.3	33.3
3	Exin 2.0SC SAT	1.5 litre/ha	0.0	0.0
4	Confidor 100SL	0.4 litre/ha	0.0	0.0
5	Regent 800WG	0.3 kg/ha	84.0	84.0

Table no5. Infective control of pesticides for tobacco aphids (Myzus nicotianae) in room condition

No	Treatments	Concentration	Effective control (%)		
			1 day	2 days	3 days
1	Tasieu 1.9 EC	0.3 litre/ha	100	-	-
2	Confidor 100SL	0.4 litre/ha	100	-	-
3	Regent 800WG	0.3 kg/ha	90.0	90.0	90.0
4	Reasgant 3.6EC	0.25 litre/ha	50.0	50.0	50,0
5	Exin 2.0SC SAT	1.5 litre/ha	40.0	40.0	40.0

Table no6. Infective control of pesticides for tobacco aphids (Myzus nicotianae) in the tobacco condition

No	Treatments	Concentration	Effective control (%)	
			3 days	7 days
1	Tasieu 1.9 EC	0.3 litre/ha	56.3	0.0
2	Reasgant 3.6EC	0.25 litre/ha	47.4	0.0
3	Exin 2.0SC SAT	1.5 litre/ha	60.9	0.0
4	Confidor 100SL	0.4 litre/ha	96.9	90.6
5	Regent 800WG	0.3 kg/ha	85.5	49.1

Table no7. Infective control of pesticides on tobacco yield and quality

No	Treatments	Fress leaf yield (tons/ha)	Dry leaf yield (tons/ha)	Grade of dry tobacco leaf (%)		
				1 + 2	3	4
1	Tasieu 1.9EC	19.5[a]	2.03	60.9	24.7	14.4
2	Reasgant 3.6EC	16.7[ab]	1.73	51.5	36.3	12.2
3	Exin 2.0SC	16.3[b]	1.69	60.9	26.2	12.9
4	Confidor 100SL	15.8[b]	1.63	45.5	38.6	15.8
5	Regent 800WG	17.6[ab]	1.75	57.6	30.1	12.3
6	Control	15.7[b]	1.62	58.6	19.1	22.3
CV%		*6.6*				
Critical Value for Comparison		*3.16*				

Table no 8. Result of smoking with tobacco production of treatments Unit: point

No	Treatments	Flavour	Taste	Heavy level	Fire level	Colour	Total points
1	Tasieu 1.9EC	9.5	9.0	6.9	7.0	6.8	39.2
2	Reasgant 3.6EC	9.7	9.3	6.9	7.0	7.0	39.9
3	Exin 2.0SC	9.4	9.1	7.0	7.0	7.0	39.5
4	Confidor 100SL	9.8	9.3	7.0	6.3	7.0	39.4
5	Regent 800WG	9.2	9.0	7.0	6.3	7.0	38.4
6	Control	9.3	9.1	7.0	7.0	6.8	39.2

Table no9. Impact of concentration levels of Tasieu 1.9EC on effective control and residue

Concentration	Effective control (%)			Residue level (mg/kg)	
	5 days	7 days	10 days	Leaf C	leaf X
0,3 litre/ha	99.8	100	100	0.03	0.04
0,45 litre/ha	100	100	100	0.04	0.04
0,6 litre/ha	100	100	100	0.07	0.04
0,75 litre/ha	100	100	100	0.09	0.08

MRL ofE. benzoate of Vietnam: ≤ 0,2 mg/kg, spray 3 times:day 17/02/2021, 26/02/2021, and 12/3/2021

Table no 10. Impact of concentration levels of Confidor 100SL on effective control and residue

Concentration	Effective control (%)										Residue level (mg/kg)
	Times 1			Times 2			Times 3			Average	
	5 days	7 days	10 days	5 days	7 days	10 days	5 days	7 days	10 days		
0,4 litre/ha	98.6	99.2	92.4	100	100	98.9	98.6	95.8	90.4	97.1	4.56
0,6 litre/ha	99.1	99.5	96.0	100	100	99.6	99,4	98.5	93.0	98.3	5.72
0,8 litre/ha	100	100	97.7	100	100	100	100	98.8	95.1	99.1	6.19
1,0 litre/ha	100	100	98.8	100	100	100	100	99.2	97.4	99.4	6.50

MRL of Imidacloprid of Vietnam: ≤ 5 mg/kg; spray 3 times at times 1: 17/2/2021, times 2: 26/2/2021, and times 3: 12/3/2021. Analysis tobacco samples had isolation time last pray about 30 days.

Table no 11. Impact of the isolation time on residue levels in tobacco production

No	Pesticides	Active ingredients	Residue levels of isolation time (mg/kg)		
			3 days	7 days	10 days
1	Tasieu 1.9EC	*Emamectin benzoate*	0.03	0.03	0.03
2	Confidor 100SL	*Imidacloprid*	6.72	5.07	3.28

COMPETING INTERESTS
Authors have declared that no competing interests exist.

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