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**RE: PRIA 3 M007: Request to Extend Exclusive Use Data Period for Spinetoram (62719-539)**

Dear Mr. Stephen Schiable:

Dow AgroSciences LLC (DAS) hereby requests EPA to extend the Exclusive Use Period for Spinetoram (62719-539) by three years for a total exclusive use of data period of September 28, 2007 until September 28, 2020. As set forth below, DAS respectfully submits that it has satisfied the requirements for extending the traditional ten year exclusive use of data period for new active ingredients by three years, in accordance with the minor use provisions of FIFRA § 3(c)(1)(F)(ii). Specifically, DAS has registered Spinetoram, a Presidential Green Chemistry Challenge Award winner and a Reduced Risk Pesticide, on more than nine minor use crops within seven years of its original registration and DAS has satisfied three conditions of FIFRA 3(c)(1)(F)(ii); the alternatives posed greater risks; spinetoram plays or will play a significant part in managing pest resistance; and spinetoram plays or will play a significant part in an integrated pest management program.

DAS representatives would be pleased to meet with the Agency to discuss the matter.

**Background:**

EPA first registered Spinetoram Technical (originally XDE-175; 62719-539), as well as two formulations (Delegate WG - 62719-541 and Radiant SC - 62719-545) on September 28, 2007. Spinetoram represents the next generation of spinosyn insecticides. Spinosyns are naturally derived fermentation products for arthropod pest control produced by the soil organism *Saccharopolyspora spinosa*, a novel bacterium of the order Actinomycetales. Spinetoram is a synthetically-modified spinosyn that is prepared from a mixture of two natural spinosyns produced by *S. spinosa* and possess the same insecticidal mode of action (MOA) as spinosad. Spinosad, a highly successful reduced risk insecticide, is the only other spinosyn insecticide commercially available today.

Spinetoram provides control of lepidopteran pests, leafminers and thrips in vegetables that is equal to or superior than spinosad, at use rates that are one-half (or less) of the rates used for spinosad. Spinetoram is more potent than spinosad, as it has increased activity at the (nicotinic acetylcholine receptor) target site. In addition, spinetoram is more stable in the sunlight and provides longer residual activity. Spinetoram provides control of Lepidoptera, thrips and other key pests of pome fruit, stone fruit, and tree nuts at relatively low use rates. Additionally, spinetoram controls other pests that spinosad does not, or is less active against, including codling moth, oriental fruit moth, navel orangeworm, plum curculio, and pear psylla. This increased level of control and residuality has allowed spinetoram to replace older products in markets, such as in pome and stone fruit, where spinosad use was limited.

Although spinosad and spinetoram are sometimes labeled on the same crops/uses, most growers prefer spinetoram due to the reduced rates required, and the additional control provided. Growers will either use spinosad or spinetoram, and normally do not use both on their crops. At this time, most spinosad use is in the organic markets, with conventional growers having converted to spinetoram products, with a few exceptions.

**DAS Spinetoram Minor Use Registrations:**

To date, DAS has registered more than 25 minor uses on spinetoram products. However, at this time, the focus of the following report will be on just 9 crops that currently have production data to demonstrate that the crops are below 300,000 acres, thus deemed "Minor" crops.

The current minor crops that are labeled for spinetoram and that will be discussed in the document below are:

| Crop | 2013 (acres harvested) | 2012 (acres harvested) | Source |
|---|---|---|---|
| | | | |
| Blueberries | 78960 | 77700 | USDA |
| Raspberries | 5600 | 5400 | USDA |
| Strawberries | 58190 | 55840 | USDA |
| Cranberries | 42000 | 40300 | USDA |
| Tomato (fresh market)[1] | 277,000 | 276,300 | USDA |
| Tomato (for processing)[1] | 99,600 | 101,000 | USDA |
| Peppers | 64,800 | 65,900 | USDA |
| Green onion[2] | 178,300 | 194,500 | USDA |
| Bulb onion[2] | 143,340 | 146,870 | USDA |
| Head Lettuce | 129,000 | 141,600 | USDA |

[1] Tomato (fresh/processing) are classified as separate minor use crops, but will be grouped together in document due to similarity in use pattern and pest pressure. We request they still be counted as 2 crops.

[2] Bulb onion and green onion are separate minor use crops, but will be grouped together in the document due to similarity in use pattern and pest pressure. We request they still be counted as 2 crops.

**DAS satisfies requirements II, III and IV (alternatives pose greater risk to environment/human health; managing pest resistance; and role in IPM) from FIFRA § 3(c)(1)(F)(ii) for the following 9 Crops:**

**Blueberry**

Spinetoram controls target pests through contact, ingestion and ovicidal activity in a wide variety of crops. One of the major pests is spotted wing drosophila (SWD), which is found in the minor use crop blueberry.

There are two types of blueberries grown in United States: Highbush blueberry (*Vaccinium corymbosum*) and lowbush blueberry (*V. angustifolium, V. myrtilloides*).

SWD (*Drosophila suzukii*) is an invasive species from Asia that has become a significant agricultural pest on blueberries in the United States. By 2014, the presence of SWD has become widespread throughout the western and eastern U.S., as well as in many European countries, Brazil, and Mexico (1). SWD are invasive vinegar flies (fruit flies) with multiple generations per year that can attack unripened fruit (2). Female SWD cut into intact fruit with their serrated ovipositor to lay eggs under the skin. This allows larvae of SWD to be present during ripening, leading to a risk of detection in ripe fruit after harvest. During egg-laying and larval feeding, sour rot and fungal diseases can also be introduced by SWD, further affecting fruit quality. There is a greater risk of fruit contamination at harvest from SWD compared with native species that lay eggs only in already-damaged and rotting fruit (3).

Several predatory insects feed on SWD adults and pupae, but not yet in sufficient quantities to provide significant control. A tiny predatory wasp that parasitizes SWD pupae is present in the Pacific Northwest and mid-Atlantic region and thus may be found in other regions as well. Thorough research is needed to fully understand whether and how this species may be utilized in long-term SWD management. As a result, blueberry growers cannot solely rely on natural enemies to manage SWD (4).

Successful spotted wing drosophila management programs should be focused on effective monitoring, cultural control and use of selective pesticides (5). An example of a cultural practice is to harvest all ripe and cull fruit from the planting and then dispose of the unwanted fruit to keep the entire planting completely clean. But this practice is very challenging and expensive, especially on larger acreages. In addition, SWD will multiply on wild fruit (raspberries or blackberries in hedgerows, mulberries, wild cherries, etc.) as well as cultivated fruit, and thus wild stands of these hosts can be reservoirs for SWD. Traps are typically used to detect adult SWD and determine whether control measures are needed, and are not intended to provide control (3). Extremely fine mesh (0.039 inches) screens can be used to protect plantings from SWD in high tunnels or greenhouses, but this practice reduces air flow and restricts access of pollinators during bloom (6). These types of cultural practices that are recommended by universities can be useful, however, most growers have found them to be insufficient to provide good control of annual and numerous populations of SWD.

Use of selective chemistry along with cultural practices for IPM program is important for managing SWD. Pesticides in three MOA groups – pyrethroids (IRAC, MOA Group 3), *spinosyns (*MOA Group 5*)*, and organophosphates (MOA Group 1B) have demonstrated good efficacy against SWD adults. Neonicotinoids (MOA Group 4A) have very low efficacy and are not recommended by universities (7).

To prevent developing resistance in SWD, rotation of chemical families with different Modes of Action is essential for effective management of this pest **(6, 8)**. Depending on environmental conditions, SWD populations can be very high with multiple generations per year, conditions which contribute to a high level of risk of resistance development. There is already documented resistance of SWD to pyrethrins in West Coast production **(6)**.

Alternating insecticides with different MOAs is a very important part of IPM programs. To manage SWD during the season, a 7-14 day retreatment cycle is recommend, and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program **(22)**. Spinetoram is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate for SWD per season.

In numerous university studies across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of SWD **(3, 7, 9, 10,11,12,13,14, 15, 16, 27)**. Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as acetamiprid, azinphos-methyl, lambda cyhalothrin, methomyl and phosmet; spinetoram clearly demonstrates reduced risk to human health and non-target organisms **(17)**. The rapid environmental degradation of spinetoram, combined with low rates needed for control **(Appendix1)** reduces the overall load of chemicals in the environment. Spinetoram, as a selective **(18)** reduced risk insecticide, plays a key role in adoption of IPM strategies as it has unique MOA and minimal impact on beneficial arthropod species such as and including big-eyed bugs (*Geocoris* sp.), damsel bugs (*Nabis* sp.), ladybird beetles (Coccinellidae) and lacewings (*Chrysopa* sp.) **(Appendix 1)**.

Furthermore, there are products that are labeled in blueberries for SWD control such as Diazinon, Danitol, Mustang, Asana, Brigade and Lannate that are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxicity to fish, birds and aquatic organisms **(19)**. Organophosphate insecticides within this list as well as Imidan, Diazinon and Malathion, have higher application rates and greater impacts on beneficial arthropods as compared to spinetoram. While pyrethroid insecticides are used at lower doses, they are broad spectrum and thus active on both beneficial and pest insects. Predator insects may be susceptible to lower dose than the pest, thus disrupting the predator-prey relationship, which leads to flaring up of mites and knock down of beneficial insects **(18, 20, 21)**.

When compared to other registered products for SWD control in blueberries, spinetoram offers the shortest re-entry interval (REI), which is very important for U-pick farm operations, and also has a lower PHI at 7 days, compared to Asana **(Appendix 1)**. Further work is being done by IR-4 to reduce the PHI on blueberries for SWD as it is a desired use pattern for the growers.

Spinetoram is a significant tool for IPM programs for control of SWD in blueberries, and has the following benefits:

- It is a selective insecticide with a low use rate
- It has a favorable toxicological profile and is soft on beneficial arthropods
- The unique mode of action of spinetoram makes it effective against SWD that become resistant to other insecticides as well as providing an alternate mode of action for managing against pesticide resistance.

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**Raspberry**

Spotted wing drosophila (SWD) is also a major pest in raspberry (*Rubus idaeus*), another minor use crop. SWD (*Drosophila suzukii*) is an invasive species from Asia that has become a significant agricultural pest on raspberries in the United States. By 2014, the presence of SWD has become widespread throughout the western and eastern U.S., as well as in many European countries, Brazil, and Mexico (1). SWD are invasive vinegar flies (fruit flies) with multiple generations per year that can attack unripened fruit (23, 24). Female SWD cut into intact fruit with their serrated ovipositor to lay eggs under the skin. This allows larvae of SWD to be present during ripening, leading to a risk of detection in ripe fruit after harvest. During egg-laying and larval feeding, sour rot and fungal diseases can also be introduced by SWD, further affecting fruit quality. There is a greater risk of fruit contamination at harvest from SWD compared with native species that lay eggs only in already-damaged and rotting fruit (24).

Several predatory insects feed on SWD adults and pupae, but not yet in sufficient quantities to provide significant control. A tiny predatory wasp that parasitizes SWD pupae is present in the Pacific Northwest and mid-Atlantic region and thus may be found in other regions as well. Thorough research is needed to fully understand whether and how this species may be utilized in long-term SWD management. As a result, caneberry growers cannot solely rely on natural enemies to manage SWD (4).

Successful spotted wing drosophila management programs should be focused on effective monitoring, cultural control and use of selective pesticides (5). An example of a cultural practice is to harvest all ripe and cull fruit from the planting and then dispose of the unwanted fruit to keep the entire planting completely clean. But, this practice is very challenging and expensive, especially on larger acreages. In addition, SWD will multiply on wild fruit (raspberries or blackberries in hedgerows, mulberries, wild cherries, etc.) as well as cultivated fruit, and thus wild stands of these hosts can be reservoirs of SWD. Traps are typically used to detect adult SWD and determine whether control measures are needed, and are not intended to provide control (25). Extremely fine mesh (0.039 inches) screens can be used to protect plantings from SWD in high tunnels or greenhouses, but this practice reduces air flow and restricts access of pollinators during bloom (6). Early harvest of fruit can be important in reducing exposure of fruit to the pest. These types of cultural practices recommended by universities can be useful, however, most growers have found them to be insufficient to provide good control of SWD populations.

Use of selective chemistry along with cultural practices for IPM program is important for managing SWD. Pesticides in three MOA groups – pyrethroids (IRAC, MOA Group 3), *spinosyns (MOA Group 5)*, and organophosphates (MOA Group 1B) have demonstrated good efficacy against SWD adults. Neonicotinoids (MOA Group 4A) have very low efficacy and are not recommended by universities (7).

To prevent developing resistance in SWD, rotation of chemical families with different Mode of Action is essential for effective management of this notorious pest (6, 8, 26). Depending on environmental conditions, SWD populations can be very high with multiple generations per year, which most likely will lead to resistance development. There is already documented resistance of SWD to pyrethrins in the West Coast (6).

Alternating insecticides with different MOAs is a very important part of IPM programs. To manage SWD during the season, a 7-14 day retreatment cycle is recommend, and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program (22). Spinetoram is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate for SWD per season.

In numerous university studies across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of SWD **(3, 7, 9, 10,11,12,13,14, 15, 16)**. Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as acetamiprid, azinphos-methyl, lambda cyhalothrin, methomyl and phosmet, spinetoram clearly demonstrates reduced risk to human health and non-target organisms **(17)**. The rapid environmental degradation of spinetoram, combined with only needing low rates for control **(Appendix1)** will reduce the overall load of chemicals in the environment. Spinetoram, as a selective **(18)** reduced risk insecticide, plays a key role in adoption of IPM strategies. It has a unique MOA and induces little or no disruption of beneficial arthropod species such as and including big-eyed bugs (Geocoris sp.), damsel bugs (Nabis sp.), ladybird beetles (Coccinellidae) and lacewings (Chrysopa sp.) **(Appendix 1)**.

Furthermore, there are products that are labeled in raspberries for SWD control such as Diazinon, Danitol, Mustang, Asana, Brigate and Lannate that are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxic to fish, birds and aquatic organisms **(19)**. In addition, the pyrethroid class of chemistry is toxic to all insects, both beneficial and pests. Predator insects may be susceptible to a lower dose than the pest, disrupting the predator-prey relationship, which leads to flaring up of the mites and overall reduction in beneficial arthropod densities **(18, 20, 21)**.Other registered products such as Imidan, Diazinon and Malathion are organophosphates, which compared to spinetoram have much higher application rates, and are extremely toxic to humans, beneficials and the environment **(25)**.

Additionally, compared to other registered products for SWD control in raspberries, spinetoram offers the lowest REI, which is very important for U-pick farm operations, and low PHI compared to Asana that offers extended fruit protection in the storage. Growers need to spray up to harvest to help protect the fruit from SWD infestations.

Spinetoram is a significant tool for IPM programs for control of SWD in blueberries, and has the following benefits:

- It is a selective insecticide with a low use rate
- It has a favorable toxicological profile and is soft on beneficial arthropods
- The unique mode of action of spinetoram makes it effective against SWD that become resistant to other insecticides as well as providing an alternate mode of action for managing against pesticide resistance.

**Strawberry**

A major pest in the minor use crop, strawberry (*Fragaria* x *ananassa*), is western flower thrips *Frankliniella occidentalis* (Perganda) (WFT). WFT are widely distributed throughout the United States, feed on a wide variety of plants and have multiple, overlapping generations per year on a broad range of plant species. WFT are slender, small insects that rasp the surface of the fruit and feed on strawberry blossoms, which causes the stigmas and anthers to turn brown and decline prematurely **(30, 31)**. Typically, WFT adults insert bean-shaped eggs into leaf, flower, or fruit tissues and can survive for 4-5 weeks and oviposit about 50 eggs per one generation.

Pre-bloom feeding deforms blossoms and leaves, reducing fruit set or weakening the fruit so it is more susceptible to frost and temperature stresses. In addition, as fruit develops, thrips feeding may cause a russeting **(30)**. Significant crop damage leading to severe yield losses can be caused by thrips that act as a vector of *Tospoviruses* **(32)**. Thrips-transmitted tospoviruses (genus *Tospovirus*, family *Bunyaviridae*) are a major group of plant viruses affecting at least 1,090 host-plant species in 15 monocotyledonous and 69 dicotyledonous families worldwide **(33, 34, 35, 36)**. Strawberry plantations often have a mixed population of thrips that includes a low percentage of onion thrips,

*(Thrips tabaci)*, among other species that do not cause economic damage. By properly identifying WFT, unnecessary insecticide applications can be avoided. (38).

Natural predators such as adults and nymphs of the minute pirate bug, green lacewings and certain parasitic wasps are known to pray on plant feeding thrips. The naturally occurring minute pirate bugs, *Orius insidiosus*, are effective predators of thrips in fruiting vegetable crops and strawberries. Their effectiveness is predictable based on the number of the predator relative to the number of thrips prey (118). However, releasing beneficial insects and predatory mites against thrips in most cases will not provide sufficient control of this pest on their own (37). Spinosad and spinetoram are the most effective insecticides to suppress WFT, and they are reduced risk selective insecticides that do not suppress populations of *O. insidiosus* at labeled rates (40, 41, 42, 118). The use of selective insecticides that have minimal effects on natural enemy populations, is vital in the control of WFT and preservation of predators.

Successful WFT management programs should be focused on cultural controls, effective monitoring and identification of the thrips species and use of selective pesticides (37, 38). IPM encompasses the simultaneous management of multiple pests, regular monitoring of pests, their natural enemies and antagonists, use of economic or treatment thresholds when applying pesticides, and integrated use of multiple suppressive tactics. Integrated Pest Management practices that combine use of cultural and biological control as well the use of the most selective or least-toxic insecticides is essential for effective management of thrips. Choosing the right site and planting date for cultivars susceptible to WFT may help to decrease the crops susceptibility to thrips damage. Removal and disposal of spent flowers that can harbor thrips may also be helpful, although the general benefit of this practice in landscapes is unknown; and old blossoms also commonly shelter beneficial predators of thrips. Timely pruning of injured and infested terminals may help to promote the increase of predaceous mite populations. Another option is to increase the use of mulches that reflect light, which can interfere with certain flying insects' ability to locate plants and can delay or reduce the extent to which young plants become infested by thrips (44). These types of cultural practices that are recommended by universities can be useful, however, most growers have found them to be insufficient to provide good control of the numerous yearly populations of WFT on their own and that a selective insecticide is required.

Integrated resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications and product per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings.

Pesticides in four activity groups – pyrethrins (IRAC, MOA Group 3), *spinosyns* (MOA Group 5), neonicotinoids (MOA Group 4A), sulfoximines (Group4C), and organophosphates (MOA Group 1B) have varied activity against WFT ranging from suppression to control (43). Insecticides continue to have an important role to play in WFT management, although the use of insecticides must be judicious. Decisions regarding which insecticides are to be used and the timing should be made in the context of both short term and long-term management goals. Minimizing resistance development and avoiding the flaring of WFT populations by their release from natural enemies are critical factors in insecticide use decisions (44). Behavior and ecology of WFT can minimize exposure to insecticides, due to the species being well suited to evolve resistance to multiple classes of insecticides. There have been numerous incidences of resistance reported to all major classes of insecticides from all regions of the world (102, 103, 104, 105, 106, 107, 108). In addition to pest management failures and resistance development, there is a limited pool of efficacious insecticides for use against WFT (47), which further increases the selection pressure on the remaining chemistries.

The key to managing resistance is to reduce selection pressure by rotating between insecticides with different modes of action and reducing the number of insecticide applications. It may be necessary to use nonchemical control methods and rotate to insecticides that may not provide the highest level of control.
The negative impacts of broad-spectrum insecticides, such as pyrethroids, on natural enemies and competitor species, in addition to continuous, overlapping generations typical for WFT populations in crops makes it especially challenging to implement IRM strategy **(45)**.

The most efficacious insecticides for WFT, at present, are in the spinosyn class. No other insecticide class provides a similar level of effectiveness against WFT **(44, 46)**. Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling WFT and widely used for this purpose **(39)**. Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinetoram represents a unique mode of action (Group 5 insecticides) and is one of the most effective insecticides to suppress WFT because it provides excellent control and it is a reduced risk insecticide that does not suppress beneficial populations, including minute pirate bug (*O. insidiosus*), at labeled rates **(40, 41, 42)**. Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the WFT while mitigating the development of resistance to all insecticides in the rotation. Other insecticides registered for suppression of WFT may not be as efficacious as spinosyns, however, they should be included as part of IPM program **(44)**.

As mentioned, alternating insecticides with different MOAs is a very important part of IPM programs **(44, 50)**. To manage WFT during the season, a 3-7 day retreatment cycle is recommended and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program **(44)**.

In numerous university studies across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of WFT **(40, 41, 42, 44, 46, 50)**. Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as acetamiprid, naled, malathion, pyrethrins + piperonyl
butoxide and clothianidin, spinetoram clearly demonstrates reduced risk to human health and non-target organisms **(17)**. The rapid environmental degradation of spinetoram, combined with only requiring low rates for control of WFT, reduces the overall load of chemicals in the environment.

For the Southeastern United States, there are only two products registered for WFT, spinosad and spinetoram **(48)**. For California and Florida, there are a number of registered insecticides available with variable efficacy. Dibrom and Malathion are organophosphates that have much higher application rates than Spinetoram, and are more toxic to humans, beneficial arthropods and the environment **(25, 31)**. In addition, Dibrom and Malathion provide only 50% control or less of WFT and can induce spider mite outbreaks **(37)**. If registered in the state, neonicotinoids such as Belay and Assail can be a good rotation partner for spinetoram as a different class of chemistry and MOA. However, neonicotinoid insecticides have reported effects on predaceous arthopods and can have variable activity on WFT **(37, 46, 49)**. Horticultural oil, natural pyrethrins (plus piperonyl butoxide), or insecticidal soap have very low efficacy and require multiple applications.

When compared to other registered products for WFT control in strawberries, spinetoram offers one of the lowest REI, which is very important for U-pick farm operations.

Spinetoram is a significant tool for IPM programs for control of WFT in strawberries, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile and is soft on beneficial arthropods.
- The unique mode of action of spinetoram makes it effective against WFT as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 3 applications at the labeled rate per calendar year in strawberries.

**Cranberry**

One of the major pests in the minor use crop, cranberry (*Oxycoccus microcarpus*), is the blackheaded fireworm (BHFW) (*Phopobota naevana).* Proper identification plays a major role in achieving control of this pest. Larvae are approximately 7-9 mm in length and have a distinct shiny black head. The body is a greenish, greenish-yellowish, or grayish color. BHFW is one of the most significant cranberry pests because of the damage it is able to inflict on cranberry (88). BHFW are widely distributed throughout the United States and have 2- 3 generations per year. Females of both generations lay about 70-80 eggs (89). BHFW overwinters in the egg stage and the hatching period in the spring can last up to 6 weeks. Newly hatched larvae burrow into cranberry leaves or mine into unopened terminal buds as they swell. On new growth, the larva uses silk to gather 2 or more leaves in the tip area and then feeds within. Older caterpillars use webbing to construct up to 5-6 tents during the course of development (90). The primary damage caused by BHFW on cranberries is larval feeding on foliage and fruit. The foliage turns brown over time as a result of larval feeding. BHFW larva feed on the surface of the fruit as well. Second generation of BHFW usually reduce the crop for the following year because the feeding on the tips of the upright results in a failure to form normal fruit buds.

Minimizing damage to the plants and crop by insect pests is one of the most important challenges in cranberry production. Failure to manage pest insects properly can result in severe crop loss, vine damage, or in extreme cases, the death of large areas of the bog.

Predators and parasitoids which coexist in the bog environment play an important role in regulating cranberry pest populations. Natural predators such as adults and nymphs of the ladybird beetles, green lacewings, spined soldier bug, praying mantis and certain parasitic insects are known to prey on plant feeding BHFW (93). However, maintaining naturally occurring populations of these beneficials may be difficult. If there is low presence of insects for ladybeetles to feed on, they will disperse to more productive hunting grounds. Although the green lacewing adults also feed on insects, they require other food sources such as many soft insects and mites, and if any necessary type of food is not available, they will fly elsewhere. Spined soldier bug also feed on a variety of slow-moving, soft-bodied insects that live on plants. However, no research has been done to fully evaluate the full benefit of this predator in cranberries (92). As of today, limited research-based information is available on effectiveness of beneficials. Releasing beneficial insects to manage BHFW in most cases will not provide sufficient control of this notorious pest and can be very costly (92). Furthermore, bio-control is often too late, as the crop damage occurs before the predators and parasites can build up to adequate numbers.

Successful BHFW management programs should be focused on effective monitoring, cultural control and use of selective pesticides (91, 93). IPM encompasses the simultaneous management of multiple pests, regular monitoring of pest and their natural enemies and antagonists, use of economic or treatment thresholds when applying pesticides, and integrated use of multiple suppressive tactics. Integrated Pest Management practices that combine use of cultural and biological control as well the use of the most selective or least-toxic insecticides is essential for effective management of BHFW. Use of IPM traps for monitoring the flight pattern and peak catch is an important part of monitoring for BHFW. Scouting is difficult, particularly for small larvae. However, this stage is very critical for successful management of this pest due to increased sensitivity to chemical treatments (88). Ecological management such as sanding and flooding may help to reduce the number of larvae, but will not eliminate all larvae.

Providing appropriate cultural care to keep plants vigorous may help to increase their tolerance to BHFW damage. Use of more tolerant cranberry varieties may be helpful as well. Although -these types of cultural practices recommended by universities can be useful, most growers have found them to be insufficient to provide good control of BHFW (94). Spraying chemical pesticides is the most common practice to manage herbivorous insects in cranberries.

Insecticide resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications of products per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings. The use of selective insecticides that have minimal effects on natural enemy populations is important in the control of BHFW. Pesticides in three major activity groups - *spinosyns* (MOA Group 5), neonicotinoids (MOAGroup 4A), sulfoximines (Group 4C) and organophosphates (MOAGroup 1B) have varied activity against BHFW ranging from suppression to control (93, 95, 97). However, the use of insecticides must be judicious. Decisions regarding the proper insecticide to use and timing need to be made in the context of both short term and long-term management goals. Critical factors in insecticide use decisions for BHFW include minimizing resistance development and minimizing effect on natural enemies (94). Current control methods for the management of BHFW include the repeated use of insecticides which can lead to resistance (96).

Alternating insecticides with different MOAs is a very important part of IPM programs (44, 50). To manage BHFW during the season, it is recommended to use a 7-14 day retreatment cycle and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program (44).

The most efficacious insecticides for BHFW, at present, are in the spinosyn class. Spinetoram is one of the most efficacious synthetic insecticides against BHFW. Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling BHFW and widely used for this purpose (39). Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinosyn insecticides represent a unique mode of action (Group 5 insecticides). Spinosad and spinetoram are the most effective insecticides to suppress *Phopobota naevana*, and they are reduced risk insecticides that do not suppress populations of predatory insects at labeled rates (40, 41, 42).

Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the BHFW while mitigating the development of resistance to all insecticides in the rotation. Other insecticides registered for suppression of BHFW may not be as efficacious as spinosyns, however, they should be included as part of IPM program (97).

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In numerous university studies conducted across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of BHFW (**98, 99, 100, 101**). Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as acetamiprid, diazinon, clothianidin, carbaryl and phosmet, spinetoram clearly demonstrates reduced risk to human health and non-target organisms (**17, 97**). The rapid environmental degradation of spinetoram, combined with low application rates, reduces the overall load of chemicals in the environment when managing BHFW. Spinetoram, as a selective (**18**) reduced risk insecticide, plays a key role in adoption of IPM strategies as it has unique MOA and little or no disruption of beneficial arthropod species such as and including big-eyed bugs (Geocoris sp.), damsel bugs (Nabis sp.), ladybird beetles (Coccinellidae) and lacewings (Chrysopa sp.).

There is list of registered insecticides available to manage BHFW on cranberries with variable efficacy. Diazinon, phosmet and acephate are organophosphate insecticides that have much higher application rates when compared to spinetoram, and are more toxic to humans, beneficial arthropods and the environment (**25, 31**). Also, organophosphate and carbamate insecticides are considered "high risk" by FQPA and may be unavailable for use in the near future (**66**).

Furthermore, Diazinon and Actara that are labeled in cranberries for BHFW control are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxic to fish, birds and aquatic organisms (**19**). Neonicotinoids such as Belay, Assail, Scorpion and *Bt* products can be a good rotation partner for spinetoram due to its different class of chemistry. However, these classes of chemistry may not effectively reduce overall infestations of BHFW.

When compared to other registered products for BHFW control in cranberries, spinetoram offers the lowest REI (4 hours) compared to Assail, Avaunt, Belay, Diazinon, Imidan, Orthene and Sevin and the lowest PHI (1day) compared to Avaunt and Orthene (**97**).

Spinetoram is a significant tool for IPM programs for control of BHFW in cranberries, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile and is soft on beneficial arthropods.
- The unique mode of action of spinetoram makes it effective against BHFW as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate per calendar year in cranberries.

**Tomatoes (fresh market and processing)**

One of the major pests in the minor use crop tomatoes (*Solanum lycopersicum L.*), is western flower thrips, *Frankliniella occidentalis* (Perganda), (WFT). WFT is one of the most significant agricultural pests globally because of the damage it is able to inflict on a wide range of crops (**47**). WFT are widely distributed throughout the United States and have multiple, overlapping generations per year on a broad range of plant species. Adults and larvae feed by piercing plant tissues with their needle-shaped mandible and draining the contents of punctured cells (**47, 54**). Feeding by adults and larvae produces scarring on foliage, flowers and fruits, which results in aesthetic crop damage and disrupts plant growth and physiology. Also, oviposition can produce a wound response in fruiting structures, which reduces the marketability of certain horticultural produce (**47, 55**). Typically, WFT adults insert bean-shaped eggs into leaf, flower, or fruit tissues and can survive for 4-5 weeks and oviposit about 50 eggs per one generation.

The primary damage caused by WFT to tomatoes is the vectoring of tomato spotted wilt virus, genus *Tospovirus*. The virus can only be acquired by the immature stage of thrips, whereas plant-to-plant transmission primarily occurs by adults. The adult thrips can transmit the virus for the remainder of their lives, which can last 30 to 45 days.

Tomato plantations often have a mixed population of thrips that includes a low percentage of the onion thrips, *Thrips tabaci.* Thrips feeding on plants can damage fruit, leaves, and shoots and very noticeably affect plants' cosmetic appearance. In addition, as fruit develops, thrips feeding may cause a russeting **(30)**. Significant crop damage leading to severe yield losses can be caused by thrips that serve as vectors of *Tospoviruses* **(32)**. Thrips-transmitted tospoviruses (genus *Tospovirus*, family *Bunyaviridae*) are a major group of plant viruses affecting at least 1,090 host-plant species in 15 monocotyledonous and 69 dicotyledonous families worldwide **(33, 34, 35, 36)**. The actual amounts of economic losses attributable to tomato spotted wilt virus alone caused over US$1 billion in losses annually on a global basis. This estimate did not include the direct damage also caused by WFT **(56, 57)**.

Natural predators such as adults and nymphs of the minute pirate bug, green lacewings and certain parasitic wasps are known to pray on plant feeding thrips. The naturally occurring minute pirate bugs, *Orius insidiosus* (Say), are effective predators of thrips in fruiting vegetable crops. Their effectiveness is predictable based on the number of the predator relative to the number of thrips prey **(118)**. Spinosad and spinetoram are the most effective insecticides to suppress WFT, and they are reduced risk selective insecticides that do not suppress populations of *O. insidiosus* at labeled rates, making the spinosyns extremely useful for thrips control **(40, 41, 42, 118)**. Unfortunately, minute pirate bug species, which preferentially preys on WFT, do not have an affinity for tomato **(44, 60, 61)**. Releasing beneficial insects and predatory mites against thrips in most cases will not provide sufficient control **(37)**. Furthermore, biocontrol is often too late, as the crop damage is already present before the predators and parasites can build up to adequate numbers **(59)**.

Successful WFT management programs should be focused on effective monitoring, cultural control and use of selective pesticides **(37)**. IPM encompasses the simultaneous management of multiple pests, regular monitoring of pests and their natural enemies and antagonists, use of economic or treatment thresholds when applying pesticides, and integrated use of multiple suppressive tactics. Integrated Pest Management practices that combine use of cultural and biological control as well the use of the most selective or least-toxic insecticides is essential for effective management of thrips. Choosing the right site for planting WFT susceptible plants and providing appropriate cultural care to keep plants vigorous may help to increase their tolerance to thrips damage. Removal and disposal of spent flowers that can harbor thrips may also be helpful. However, the general benefit of this practice in landscapes is unknown; and old blossoms also commonly shelter beneficial predators of thrips. Timely pruning of injured and infested terminals may help to promote increases in predaceous mite populations **(37)**. Additional cultural practices include increasing the use of mulches that reflect light, which can interfere with certain flying insects' ability to locate plants and can delay or reduce the extent to which young plants become infested by thrips **(44)**. These types of cultural practices that are recommended by universities can be useful; however, most growers have found them to be insufficient to provide good control of the numerous yearly populations of WFT by themselves.

Integrated resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications and product per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings.

Pesticides in four activity groups – pyrethrins (IRAC, MOA Group 3), *spinosyns* (MOA Group 5*)*, neonicotinoids (MOA Group 4A), sulfoximines (Group 4C), and organophosphates (MOA Group 1B) have varied activity against WFT ranging from suppression to control **(43)**. Insecticides continue to have an important role to play in WFT management, although the use of insecticides must be judicious. Decisions regarding which insecticides are to be used and the timing should be made in the context of both short term and long-term management goals. Minimizing resistance development and avoiding the flaring of WFT populations by their release from natural enemies is a critical factor in insecticide use decisions **(44)**. Behavior and ecology of WFT can minimize exposure to insecticides, due to the species being well suited to evolve resistance to multiple classes of insecticides. There have been numerous incidences of resistance reported to all major classes of insecticides from all regions of the world **(47, 62, 63, 64, 65)**. In addition to pest management failures and resistance development, there is a limited pool of efficacious insecticides for use against WFT **(47)**, which further increases the selection pressure on the remaining chemistries.

The key to managing resistance is to reduce selection pressure by rotating between insecticides with different modes of action and reducing the number of insecticide applications. It may be necessary to use nonchemical control methods and rotate to insecticides that may not provide the highest level of control.
The negative impacts of broad-spectrum insecticides, such as pyrethroids, on natural enemies and competitor species, in addition to continuous, overlapping generations typical for WFT populations in crops makes it especially challenging to implement IRM strategies **(45)**.

As mentioned, alternating insecticides with different MOAs is a very important part of IPM programs **(44, 50)**. To manage WFT during the season, a 3-7 day retreatment cycle is recommended, and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program **(44)**.

The most efficacious insecticides for WFT, at present, are in the spinosyn class. No other insecticide class provides a similar level of effectiveness against WFT **(44, 46)**. Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling WFT and widely used for this purpose **(39)**. Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinetoram represents a unique mode of action (Group 5 insecticides) and is the most effective insecticide against WFT, as it provides excellent control and is a reduced risk insecticide that does not suppress populations of natural predators, including minute pirate bugs, at labeled rates **(40, 41, 42)**.

Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the WFT while mitigating the development of resistance to all insecticides in the rotation. Other insecticides registered for suppression of WFT may not be as efficacious as spinosyns, however, they should be included as part of IPM program **(44)**.

In numerous university studies across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of WFT **(40, 41, 42, 44, 46, 50)**. Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects.
Compared to other registered chemicals such as acetamiprid, bifenthrin, beta-cyfluthrin, clothianidin, fenpropathrin, lambda cyhalothrin, zeta-cypermethrin, dinotefuran, methomyl and dimethoate, spinetoram clearly demonstrates reduced risk to human health and non-target organisms **(17)**. The rapid environmental degradation of spinetoram, combined with only needing low rates for control of WFT will reduce the overall load of chemicals in the environment.

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There is list of registered insecticides available to manage WFT on tomatoes with efficacy that varies widely. Dimethoate is an organophosphate, which compared to spinetoram has much higher application rates, and higher levels of toxicity to humans, beneficials and the environment (**25, 31**). Also, organophosphate and carbamate insecticides are considered "high risk" by FQPA and may be unavailable for use in the near future (**66**). In addition, dimethoate has low efficacy on WFT and can cause spider mite outbreaks (**67**). Furthermore, there are large number of pyrethroids that are labeled in tomato for WFT control such as Danitol, Mustang, Hero, Asana, Brigate, Karate, Leverage, Proaxis, Warrior II, Athena, Baythroid and Lannate (carbamate) that are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxic to fish, birds and aquatic organisms (**19**). In addition, the pyrethroid class of chemistry is not highly selective and is toxic to both beneficials and pests. Predator insects may be susceptible to a lower dose than the pest, disrupting the predator-prey relationship, which leads to flaring up of the mites and reduction in beneficial insect populations (**18, 20, 21**).

If registered in the state, neonicotinoids such as Belay and Assail can be a good rotation partners for spinetoram because they are from a different class of chemistry with a different MOA. However, neonicotinoid insecticides have reported effects on predaceous arthopods and can have variable activity on WFT (**37, 46, 49**). Horticultural oil, natural pyrethrins, or insecticidal soap have very low efficacy and require multiple applications.

Additionally, compared to other registered products for WFT control in tomatoes, spinetoram offers one of the lowest REI, which is very important for fresh market farm operations and the lowest PHI (1 day) compared to Asana, Assail, Platinum, Athena, Gladiator, Karate, Proaxis, Belay, Danitol, Sevin, Warrior II and Durivo (**68**) .

Spinetoram is a significant tool for IPM programs for control of WFT in tomatoes, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile and is soft on beneficial arthropods.
- The unique mode of action of spinetoram makes it effective against WFT as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate per calendar year in tomatoes.

## Peppers

One of the major pests in the minor use crop peppers (*Capsicum annuum L*) is western flower thrips, *Frankliniella occidentalis* (Perganda), (WFT). WFT are widely distributed throughout the United States, feed on a wide variety of plants and have multiple, overlapping generations per year on a broad range of plant species. Thrips feeding on plants can damage fruit, leaves, and shoots and very noticeably affect plants' cosmetic appearance. Adults and larvae feed by piercing plant tissues with their needle-shaped mandible and draining the contents of punctured cells (**47, 54**). Feeding by adults and larvae produces "flecking" on fruits, which results in aesthetic crop damage and disrupts plant growth and physiology. Peppers display a range of symptoms, and the ring spots are not always present on the leaves. Typically, WFT adults insert bean-shaped eggs into leaf, flower, or fruit tissues and can survive for 4-5 weeks and oviposit about 50 eggs per one generation.

The primary damage caused by WFT to peppers is the vectoring of tomato spotted wilt virus, groundnut ringspot virus and tomato chlorotic spot virus (**71**). The virus can only be acquired by the immature stage of thrips, whereas plant-to-plant transmission primarily occurs by adults. The adult thrips can transmit the virus for the remainder of their lives, which can last 30 to 45 days. . Significant crop damage leading to severe yield losses can be caused by thrips that act as a vector of *Tospoviruses* **(32)**. Thrips-transmitted tospoviruses (genus *Tospovirus*, family *Bunyaviridae*) are a major group of plant viruses affecting at least 1,090 host-plant species in 15 monocotyledonous and 69 dicotyledonous families worldwide **(33, 34, 35, 36)**.

Across the US, pepper plantations often have a mixed population of thrips that can includes a percentage of one or more of the following: *Thrips tabaci, F. Tritici, F. bispinosa* and *F. fusca*. Large populations of *F. occidentalis, F. tritici*, and *F. bispinosa* migrate into the spring crop of flowering peppers, causing reduced-marketability from thrips feeding damage and from their vectoring of tomato spotted wilt virus **(69, 70)**.

Natural predators such as adults and nymphs of the minute pirate bug, green lacewings and certain parasitic wasps are known to pray on plant feeding thrips. The naturally occurring minute pirate bugs, *Orius insidiosus*, are very effective predators of thrips in peppers, as pepper is a better reproductive host for minute pirate bugs than tomato. Adults of minute pirate bugs are highly mobile, and can rapidly invade pepper and eggplant fields to control the WFT adults and larvae **(42, 45, 118)**. Their effectiveness is predictable based on the number of the predator relative to the number of thrips prey **(118)**. Spinosad and spinetoram are the most effective insecticides to control WFT, and they are also reduced risk selective insecticides that do not suppress populations of minute pirate bugs at labeled rates **(40, 41, 42, 45, 118)**. Conversely, pyrethroids are known to suppress populations of minute pirate bugs, while increasing populations of the WFT in pepper **(45)**. The use of selective insecticides that have minimal effects on natural enemy populations is vital in the control of WFT and preservation of predators.

Releasing beneficial insects and predatory mites against thrips in most cases will not provide sufficient control of this key pest **(37)**. Furthermore, bio-control is often too late, as the crop damage occurs before the predators and parasites can build up to adequate numbers **(59)**. In northern Florida, minute pirate bugs are not active during the winter and early spring. There is usually a lag time in spring pepper and eggplant during which populations of thrips increase before natural populations of the minute pirate bugs invade in sufficient numbers to suppress the pests **(40, 41)**.

Successful WFT management programs should be focused on effective monitoring, cultural control and use of selective pesticides **(37)**. IPM encompasses the simultaneous management of multiple pests, regular monitoring of pests and their natural enemies and antagonists, use of economic or treatment thresholds when applying pesticides, and integrated use of multiple suppressive tactics. Integrated Pest Management practices that combine use of cultural and biological control as well the use of the most selective or least-toxic insecticides is essential for effective management of thrips. Choosing the right site for planting peppers and providing appropriate cultural care to keep plants vigorous may help to increase their tolerance to thrips damage. Removal and disposal of spent flowers that can harbor thrips may also be helpful. However, the general benefit of this practice in fields is unknown; and old blossoms also commonly shelter beneficial predators of thrips. Timely pruning of injured and infested terminals may help to promote increases in predaceous mite populations **(37)**. An additional cultural practice includes increasing the use of mulches that reflect light, which can interfere with certain flying insects' ability to locate plants and can delay or reduce the extent to which young plants become infested by thrips **(44)**. These types of cultural practices that are recommended by universities can be useful, however most growers have found them to be insufficient to provide good control of the numerous yearly populations of WFT on their own.

Integrated resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications and product per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings. Pesticides in four activity groups – pyrethrins (IRAC, MOA Group 3), *spinosyns* (MOA Group 5), neonicotinoids (MOA Group 4A), sulfoximines (Group 4C) and organophosphates (MOA Group 1B) have varied activity against WFT ranging from suppression to control **(43)**. Insecticides continue to have an important role to play in WFT management, although the use of insecticides must be judicious. Decisions regarding which insecticides are to be used and the timing should be made in the context of both short term and long-term management goals. Minimizing resistance development and avoiding the flaring of WFT populations by their release from natural enemies are critical factors in insecticide use decisions (44). Behavior and ecology of WFT can minimize exposure to insecticides and increase risk of risistance due to the species being well suited to evolve resistance to multiple classes of insecticides. There have been numerous incidences of resistance reported in WFT to all major classes of insecticides from all regions of the world (47, 62, 63, 64, 65). In addition to pest management failures and resistance development, there is a limited pool of efficacious insecticides for use against WFT (47), which further increases the selection pressure on the remaining chemistries.

The key to managing resistance is to reduce selection pressure by rotating between insecticides with different modes of action and reducing the number of insecticide applications. It may be necessary to use nonchemical control methods and rotate to insecticides that may not provide the highest level of control.
The negative impacts of broad-spectrum insecticides, such as pyrethroids, on natural enemies and competitor species, in addition to continuous overlapping generations typical for WFT populations in crops makes it especially challenging to implement IRM strategies (45).

As mentioned, alternating insecticides with different MOAs is a very important part of IPM programs (44, 50). To manage WFT during the season, a 3-7 day retreatment cycle is recommended, and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program (44).

The most efficacious insecticides for WFT, at present, are in the spinosyn class. No other insecticide class provides a similar level of effectiveness against WFT (44, 46). Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling WFT and widely used for this purpose (39). Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinetoram represents a unique mode of action (Group 5 insecticides), and is one of the most effective insecticides to control WFT, as it provides excellent control and is a reduced risk insecticide that does not suppress beneficial populations, including minute pirate bug, at labeled rates (40, 41, 42).

Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the WFT while mitigating the development of resistance to all insecticides in the rotation. Other insecticides registered for suppression of WFT may not be as efficacious as spinosyns, however, they should be included as part of IPM program (44).

In numerous university studies conducted across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of WFT (40, 41, 42, 44, 46, 50). Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects.
Compared to other registered chemicals such as dimethoate, acetamiprid, azinphos-methyl, lambda cyhalothrin, methomyl and phosmet, spinetoram clearly demonstrates reduced risk to human health and non-target organisms (17). The rapid environmental degradation of spinetoram, combined with only needing low rates for control of WFT will reduce the overall load of chemicals in the environment.

There is list of registered insecticides available to manage WFT on peppers with efficacy that varies widely. Dimethoate is an organophosphate that has much higher application rates, and higher levels of toxicity to humans, beneficials and the environment when compared to Spinetoram (25, 31). Additionally, dimethoate has low efficacy on WFT and can cause spider mite outbreaks (67). In general, organophosphate and carbamate insecticides are considered "high risk" by FQPA and may be unavailable for use in the near future (66).

Furthermore, there are a large number of pyrethroids labeled in peppers for WFT control such as Danitol, Endigo, Hero, Asana, Brigate, Proclaim, Warrior II, Athena, Baythroid and Lannate (carbamate) that are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxicity to fish, birds and aquatic organisms (**19**). In addition, the pyrethroid class of chemistry is toxic to all insects, both beneficial and pests. Predator insects may be susceptible to a lower dose than the pest, disrupting the predator-prey relationship, which leads to flaring up of mites and knocking down of beneficial insects (**18, 20, 21**).

If registered in the state, neonicotinoids such as Belay and Assail can be a good rotation partner for spinetoram because they are in a different class of chemistry with a different MOA. However, neonicotinoid insecticides have reported effects on predaceous arthropods and can have variable activity on WFT (**37, 46, 49**). Horticultural oil, natural pyrethrins, or insecticidal soap have very low efficacy and require multiple applications.

When compared to other registered products for WFT control in peppers, spinetoram offers one of the lowest REI, which is very important for fresh market farm operations and the lowest PHI (1 day) compared to Asana, Assail, Plutinum, Athena, Gladiator, Belay, Danitol, Sevin, Warrior II and Durivo (**68**) .

Spinetoram is a significant tool for IPM programs for control of WFT in peppers, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile and is soft on beneficial arthropods.
- The unique mode of action of spinetoram makes it effective against WFT as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate per calendar year in peppers.

**Onion (green and bulb)**

A major pest in the minor use crop onion, *Allium cepa L,* is onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) (OT). Onion thrips is the key insect pest in most onion production regions of the world and can reduce yield by 30-50%. Losses can be even more severe if thrips infest the crop with Iris yellow spot virus (**72, 73**). OT causes both direct and indirect damage to onion by feeding and ovipositing on leaves that may cause green onions (scallions) to be unmarketable and dry bulb onion size to be reduced. To prevent many unnecessary insecticide applications to control nonthreatening thrips, proper identification of thrips species is an essential part of IPM. OT may not be the only thrips species present in the field (**80**).

OT are widely distributed throughout the United States and have multiple, overlapping generations per year on a broad range of plant species, and have an ability to disperse rapidly with short generation time (**71, 74, 75**). OT can reproduce asexually (parthenogenesis) and sexually, where females are produced from fertilized eggs and males are produced from unfertilized eggs. Adults and nymphs feed by piercing plant tissues with their needle-shaped mandible and draining the contents of punctured cells (**74, 75**). Feeding by adults and larvae produces silvery patches or streaks on the leaves, which also create entry points for pathogens. Typically, OT feed mainly within the sheaths of newly emerging onion leaves. This feeding habit makes the insects difficult to detect unless the inner leaves are examined. The damage may cause leaves to dry up, wither, turn brown, and eventually lodge (bend or break the stalk). Adults insert bean-shaped eggs into leaf tissues and can oviposit about 50 eggs per one generation, with 5-8 generations per year (**75**).

The primary damage caused by OT to onions is the vectoring of iris yellow spot virus (IYSV), genus *Tospovirus*, that causes significant economic losses for both onion seed and bulb crops produced in the United states (**74, 75, 76**). IYSV can be propagated in the vector's body and transmitted in a persistent and circulative manner and adults are capable of transmitting IYSV for life (**77, 78**). Large populations of OT adults move from overwintering sites to onion fields over several months beginning in early May, causing reduced-marketability from thrips feeding damage and from their vectoring of IYSV.
Thrips-transmitted tospoviruses (genus *Tospovirus*, family *Bunyaviridae*) are a major group of plant viruses affecting at least 1,090 host-plant species in 15 monocotyledonous and 69 dicotyledonous families worldwide (**33, 34, 35, 36**).

Natural predators such as adults and nymphs of the minute pirate bug, green lacewings and certain parasitic wasps are known to prey on plant feeding thrips. Predators of onion thrips can be numerous, but are not usually in abundance until late summer, after the majority of thrips feeding injury has occurred (**74, 79**). Releasing beneficial insects and predatory mites against thrips in most cases will not provide sufficient control of this pest (**37**). In addition, biological controls seldom reduce thrips populations below the economic injury level (**74**).

Successful onion thrips management programs should be focused on effective monitoring, cultural control and use of selective pesticides (**73, 80**). IPM encompasses the simultaneous management of multiple pests, regular monitoring of pests and their natural enemies and antagonists, use of economic or treatment thresholds when applying pesticides, and integrated use of multiple suppressive tactics. Integrated Pest Management practices that combine use of cultural and biological control, as well the use of the most selective or least-toxic insecticides, is essential for effective management of thrips.

Choosing the appropriate field location that will not be in close proximity to alfalfa, small grain fields and other onions will decrease the likelihood of OT migration into the onion fields (**75**). Inspecting onion transplants for thrips infestation and discarding infested plants may be helpful. Use of straw or mulch may help to reduce thrips populations and reducing nitrogen applications and using overhead irrigation may also reduce thrips densities (**73**). Removing or destroying debris and volunteer onion plants after harvesting may reduce overwintering sites of OT. Although these types of cultural practices recommended by universities can be useful, most growers have found them to be insufficient to provide good control of the numerous yearly populations of OT on their own.

Integrated resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications and product per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings. The use of selective insecticides that have minimal effects on natural enemy populations is vital in the control of OT. Pesticides in six activity groups – pyrethrins (IRAC, MOA Group 3), *spinosyns* (MOA Group 5), spirotetramat (MOA Group 23), neonicotinoids (MOA Group 4A), sulfoximines (Group 4C), diamides (Group 28), and organophosphates (MOA Group 1B) have varied activity against different life stages of OT ranging from suppression to control (**43, 72, 75, 81, 82**). However, the use of insecticides must be judicious. Decisions regarding which proper insecticides to use and timing need to be made in the context of both short term and long-term management goals. Minimizing resistance development and avoiding the flaring of onion thrip populations by their release from natural enemies need to be critical factors in insecticide use decisions. Behavior and ecology of thrips can minimize exposure to insecticides and increase risk of resistance due to species being well suited to evolve resistance to multiple classes of insecticides and because OT feed in protected areas of the plant. There have been numerous incidences of resistance reported to all major classes of insecticides from all regions of the world (**47, 62, 63, 64, 65, 75**). In addition to pest management failures and resistance development, there is a limited pool of efficacious insecticides for use against OT, which further increases the selection pressure against the remaining chemistries (**81, 82**).

The key to managing resistance is to reduce selection pressure by rotating between insecticides with different modes of action and reducing the number of insecticide applications. Insecticides are the most common tactic for onion thrips management and their effectiveness against the pest vary based on inherent toxicity to the pesticide, as well as evolving resistance due to overdependence on a single insecticide or class of insecticides (**73, 75**).

As mentioned, alternating insecticides with different MOAs is a very important part of IPM programs (**44, 50, 75**). To manage OT during the season, a 7-10 day retreatment cycle is recommend (based on weather and pest pressure) and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program (**44**). Spinetoram is an ideal and widely used rotation partner, allowing up to 5 applications at the labeled rate for OT per season.

The most efficacious insecticides for onion thrips at the present time are in the spinosyn class. No other insecticide class provides a similar level of effectiveness against onion thrips (**75, 80, 81, 82**). Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling onion thrips and widely used for this purpose (**39**). Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinetoram represents a unique mode of action (Group 5 insecticides) and is one of the most effective insecticide to suppress OT due to the excellent control, and the fact it is a reduced risk insecticide that does not suppress beneficial populations, including minute pirate bug, *O. insidiosus*, at labeled rates (**40, 41, 42**).

Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the onion thrips while mitigating the development of resistance to all insecticides in the rotation. Other insecticides registered for suppression of OT may not be as efficacious as spinosyns, however, they should be included as part of IPM program (**44, 75**).

In numerous university studies conducted across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of OT (**72, 73, 74, 75, 80, 81, 82** ). Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as oxydemeton methyl, diazinon, methyl parathion, acetamiprid, lambda cyhalothrin, methomyl and permethrin , spinetoram clearly demonstrates reduced risk to human health and non-target organisms (**17**). The rapid environmental degradation of spinetoram, combined with only requiring low rates for control of OT reduces the overall load of chemicals in the environment.

There is list of registered insecticides available to manage OT on onions with wide ranging efficacy. Oxydemeton methyl (MSR), diazinon, and methyl parathion are organophosphates, which have much higher application rates when compared to spinetoram, and are more toxic to humans, beneficials and the environment (**25, 31**). Also, organophosphate and carbamate insecticides are considered "high risk" by FQPA and may also be unavailable for use in the near future (**66**).

Pyrethroids labeled in onions for OT control include Ambush, Ammo, Proaxis, Mustang Max, Pounce, Warrior II and Lannate (carbamate). These are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxicity to fish, birds and aquatic organisms (**19**). In addition, the pyrethroid class of chemistry is broad spectrum and controls both beneficial and pest insects. Predator insects may be susceptible to a lower dose than the pest, disrupting the predator-prey relationship, which leads to flaring up of mites and knocking down of beneficial insects (**18, 20, 21**). Furthermore, there is documented resistance of OT to organophosphate (e.g., azinphosmethyl, diazinon, and methyl parathion) and synthetic pyrethroid (e.g., cypermethrin, and permethrin) insecticides across the United States (**75, 83, 84, 85, 86**). Managing resistance to insecticides is critical and can be mitigated by limiting the frequency of insecticide applications, rotating insecticides used in a sequence, and maintaining thorough coverage to prolong the effectiveness of insecticides (**75, 87**).

Neonicotinoids such as Assail can be a good rotation partner for spinetoram due to its different class of chemistry. Agri-Mek (MOA Group 6) and Exirel (MOA Group 28) provide variable control of onion thrip larvae and adults, and have short residual activity (5–7 days). Movento (MOA Group 23) is highly efficacious against larval OT infestations, but it does not provide satisfactory control against adults or late in the season when plants are maturing (**75**). Horticultural oil, natural pyrethrins (plus piperonyl butoxide), or insecticidal soap have very low efficacy (**75**).

When compared to other registered products for OT control in onions, spinetoram offers the lowest REI and the lowest PHI (1 day) compared to Penncap-M, Diazinon, Assail, Warrior II and Lannate (**68, 80**).

Spinetoram is a significant tool for IPM programs for control of OT in onions, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile and is soft on beneficial arthropods.
- The unique mode of action of spinetoram makes it effective against OT as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 5 applications at the labeled rate per calendar year in peppers.

**Lettuce**

One of major pests in the minor use crop lettuce (*Lactuca sativa*), is western flower thrips, *Frankliniella occidentalis* (Perganda), (WFT). WFT are widely distributed throughout the United States, feed on a wide variety of plants and have multiple, overlapping generations per year on a broad range of plant species (71). Adults and larvae feed by piercing plant tissues with their needle-shaped mandible and then draining the contents of the punctured cells (**47, 54, 109**). Feeding by adults and larvae produces silvery appearance that eventually turns to brown scarring and can be confused with windburn or blown sand damage. Typically, WFT adults insert bean-shaped eggs into leaf tissue and can survive for 4-5 weeks, and ovipositing approximately 50 eggs per generation. Thrips also cause damage on outside leaves of head lettuce and can contaminate the inside of heads at harvest.

The primary damage caused by WFT to lettuce is the vectoring of tomato spotted wilt virus and impatiens necrotic spot virus, genus *Tospovirus* (**109**). The virus can only be acquired by the immature larva stage of thrips, whereas plant-to-plant transmission primarily occurs by adults. The adult thrips can transmit the virus for the remainder of their lives, which can last 30 to 45 days. Large populations of WFT migrate into the spring crop of lettuce from weeds and other vegetation, causing reduced-marketability from thrips feeding damage and from their vectoring of tomato spotted wilt virus (**69, 70**). On lettuce plants, adults reproduce and rapidly colonize into large populations (**109**).

Thrips feeding on plants can damage leaves and noticeably affect plants' cosmetic appearance. Significant crop damage leading to severe yield losses can be caused by thrips that act as a vector of Tospoviruses (**32**). Thrips-transmitted tospoviruses (genus *Tospovirus*, family Bunyaviridae) are a major group of plant viruses affecting at least 1,090 host-plant species in 15 monocotyledonous and 69 dicotyledonous families worldwide (**33, 34, 35, 36**). The actual amount of economic losses attributable to tomato spotted wilt virus alone was over US$1 billion in losses annually on a global basis. This estimate did not include the direct damage caused by WFT (**56, 57**).

Insect control in high value fresh market lettuce grown in the desert southwest have relied almost exclusively on insecticides to control a complex of mobile pests such as WFT. Because lettuce is a short season annual crop with no tolerance for insect damage or contamination, biological control is generally considered unacceptable. Western lettuce growers cannot rely on beneficial insects and predatory mites against thrips in most cases as it will not provide sufficient control of this pest to meet marketing demands for fresh produce. Additionally, fresh market grading standards do not allow for contaminants such as pest or predatory species in fresh produce (**120**).Thus any insect species including natural predators found on marketable lettuce crops at harvest is not tolerated (**120**).

Successful WFT management programs should be focused on cultural controls, effective monitoring and identification of the thrips species, and use of selective pesticides (**37, 38, 121**). Crop placement can help if growers avoid planting lettuce crops near grain fields, weedy drains or fields or grassy areas. Overhead sprinkler irrigation has been shown to suppress WFT numbers in romaine and spinach by as much as 50%, but insecticide treatments are generally still necessary, particularly in late spring when WFT adult dispersal is high (**121**). Cultural methods do not provide effective control of thrip populations during the critical spring months (**113**).

Integrated resistance management (IRM) includes the rotation of insecticides from different chemical classes, the use of recommended rates, the limitation of maximum number of applications and product per acre per year or season, and the avoidance of sequential treatments within a single planting and across sequential crops/plantings.

Pesticides in four activity groups – pyrethrins (IRAC, MOA Group 3), *spinosyns (MOA Group 5)*, neonicotinoids (MOA Group 4A), sulfoximines (MOA Group 4C) and organophosphates (MOA Group 1B) have varied activity against WFT ranging from suppression to control (**43, 114, 115, 116**). Insecticides continue to have an important role to play in WFT management, although the use of insecticides must be judicious. Decisions regarding which insecticides are to be used and the timing should be made in the context of both short term and long-term management goals. Minimizing resistance development and avoiding the flaring of WFT populations by their release from natural enemies are critical factors in insecticide use decisions (**44**). Behavior and ecology of WFT can minimize exposure to insecticides and increase the risk of resistance due to the species being well suited to evolve resistance to multiple classes of insecticides. There have been numerous incidences of resistance reported to all major classes of insecticides from all regions of the world (**102, 103, 104, 105, 106, 107, 108**). In addition to pest management failures and resistance development, there is a limited pool of efficacious insecticides for use against WFT (**47**), which further increases the selection pressure on the remaining chemistries.

The key to managing resistance is to reduce selection pressure by rotating between insecticides with different modes of action and reducing the number of insecticide applications. It may be necessary to use nonchemical control methods and rotate to insecticides that may not provide the highest level of control.
The negative impacts of broad-spectrum insecticides, such as pyrethroids, on natural enemies and competitor species, in addition to continuous, overlapping generations typical for WFT populations in crops makes it especially challenging to implement IRM strategy (**45**).

The most efficacious insecticides for WFT, at present, are in the spinosyn class. No other insecticide class provides a similar level of effectiveness against WFT (**44, 46**). Spinosad insecticide products were first introduced in the late 1990s and have been highly effective in controlling WFT and widely used for this purpose (**39**). Spinetoram, a new and more active insecticide, was registered for use in 2008. Spinetoram represents a unique mode of action (Group 5 insecticides) and is one of the most effective insecticides to suppress WFT due to excellent control and softness of beneficial at labeled rates. Rotating highly active insecticides such as spinetoram with moderately active insecticides could achieve good levels of control of the WFT while mitigating the development of resistance to all insecticides in

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™®Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow the rotation. Other insecticides registered for suppression of WFT may not be as efficacious as spinosyns, however, they should be included as part of IPM program **(44)**.

As mentioned, alternating insecticides with different MOAs is a very important part of IPM programs **(44, 50)**. To manage WFT during the season, a 3-7 day retreatment cycle is recommended, and the same product should not be used more than two consecutive times before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program **(44)**.

In numerous university studies across the US, spinetoram demonstrated consistent performance in the field and provided excellent control of WFT **(40, 41, 42, 44, 46, 50)**. Spinetoram provides quick knockdown and residual control via contact and ingestion activity. It has a very favorable toxicity profile, with no evidence of teratogenicity, mutagenicity, carcinogenicity, or adverse reproductive effects. Compared to other registered chemicals such as dimethoate, acetamiprid, beta-cyfluthrin, zeta-cypermethrin and methomyl, spinetoram clearly demonstrates reduced risk to human health and non-target organisms **(120)**. The rapid environmental degradation of spinetoram, combined with only needing low rates for control of WFT reduces the overall load of chemicals in the environment. There is a list of registered insecticides available to manage WFT on lettuce with widely ranging efficacy. Dimethoate is an organophosphate, which has much higher application rates, and is more toxic to humans, beneficials and the environment when compared to Spinetoram(25, 31). Also, organophosphate and carbamate insecticides are considered "high risk" by FQPA and may be unavailable for use in the near future **(66)**. In addition, dimethoate and methomyl have low efficacy on WFT and can cause spider mite outbreaks **(67)**.

Furthermore, there are large number of pyrethroids that are labeled in lettuce for WFT control such as Ambush, Asana, Baythroid, Brigate, Mustang Max, Warrior II and Lannate (carbamate) that are "restricted use pesticides (RUP)" due to acute toxicity to humans with possible oncogenicity and/or toxicity to fish, birds and aquatic organisms **(19, 117)**. Neonicotinoids, such as Actara, Belay, Assail, and Scorpion, can be a good rotation partner for spinetoram because it is a different class of chemistry with a different MOA. Horticultural oil, natural pyrethrins (plus piperonyl butoxide), or insecticidal soap have very low efficacy and requires multiple applications **(109, 116, 119)**.

When compared to other registered products for WFT control in lettuce, spinetoram offers the lowest REI and the lowest PHI (1 day) compared to Asana, Assail, Mustang Max and Belay **(109)**.

Spinetoram is a significant tool for IPM programs for control of WFT in lettuce, and has the following benefits:

- It is a selective insecticide with a low use rate.
- It has a favorable toxicological profile.
- The unique mode of action of spinetoram makes it effective against WFT as well as providing an alternate mode of action for managing against pesticide resistance.
- It is an ideal and widely used rotation partner, allowing up to 6 applications at the labeled rate per calendar year in lettuce.

**Conclusion:**

For the reasons set forth above, DAS requests the Agency to grant an exclusive use period extension on Spinetoram of 3 years, making the end date September 28, 2020. Should you have any questions or wish to discuss this matter further, please do not hesitate to contact me. Thank you for your assistance.

Sincerely,

JHughes

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**Appendix 1.** Comparison of insecticides used in US blueberries and raspberries for managing of SWD ( **1, 3, 7, 8, 9, 29**)

| Trade name | Active ingredient | Class | MOA code[1] | SWD activity | Rate (Acre) | PHI (days) | REI (hours) | Max applic's | Safety on Beneficials |
|---|---|---|---|---|---|---|---|---|---|
| Imidan | phosmet | Organophos. | 1B | Excellent | 1.33lb | 3 | 24 | 5 | Very Poor |
| Malathion | malathion | Organophos. | 1B | Good | 2.5 pint | 1-2 | 12 | 3 | Very Poor |
| Diazinon* | Diazionon | Organophos. | 1B | Good | 0.5lb | 3 | 5 | 1 | Very Poor |
| Danitol* | fenpropathrin | Pyrethroid | 3 | Excellent | 16 oz | 3 | 24 | 2 | Poor |
| Mustang* | zeta-cypermethrin | Pyrethroid | 3 | Excellent | 4 oz | 1 | 12 | 6 | Poor |
| Asana* | estenvalerate | Pyrethroid | 3 | Excellent | 9.6 oz | 14 | 12 | 7 | Poor |
| Brigate* Bifenture* | bifenthrin | Pyrethroid | 3 | Excellent | 16 oz | 1 | 12 | 6 | Poor |
| Lannate* | methomyl | Carbamate | 1A | Excellent | 1lb | 3 | 48 | 4 | Poor |
| Exirel | cyantraniliprole | Diamide | 28 | Excellent | 13.5 oz | 3 | 12 | 4 | Good |
| Assail | acetamiprid | Neonicotinoid | 4A | Poor | 5.3 oz | 1 | 12 | 5 | Poor |
| Pyganic | pyrethrum | Pyrethtin | 3 | Poor | 64 oz | 0.5 | 12 | - | Very good |
| **Delegate** | **spinetoram** | **Spinosyn** | **5** | **Excellent** | **3-6oz** | **3** | **4** | **6** | **Good** |

[1] Mode of action group defined by IRAC = Insecticides Resistance Action Committee

* Restricted use material