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Insecticide applications with trunk injection method for reducing the damage level of *Leptoglossus occidentalis* (Heidemann, 1910) in stone pine stands

Abstract. *Leptoglossus occidentalis* was first detected in Turkey in 2009. The pest's damage to stone pine trees and its effects on seeds cause economic losses. In recent years, observations and predictions show that there is a significant threat not only to stone pine but also to other coniferous forests throughout country. In this study, pesticides were applied by trunk injection method in the experiment areas taken in stone pine stands of Bergama – Kozak region. In the systemic application carried out in 2020 and 2021, the Arborjet system was used and the insecticide with the active ingredient Azadirachtin (0.3 g/Lt) was used as an organic insecticide, as well as pesticide with the active ingredient Imidacloprid (200 g/Lt). In 2020, the highest seed filling rate was achieved after systemic Imidacloprid insecticide application with the Arborjet system. As a result of this application, the full seed rate reached 70.7% in Asagicuma, while this rate was 63.6% in the Karaveliler. The seed occupancy rate obtained from control trees in the Asagicuma was 37.96% and this rate reached 70.7% after systemic Imidacloprid application in the same field. Similarly, in the studies carried out in Asagicuma and Yukaribey experiment sites in 2021, only 35% of the seeds were filled in the cones taken from control trees, while the occupancy rate in the cones without insecticide application in the Yukaribey was determined to be 32.76%. In both trial sites, the highest seed fill rate was achieved after systemic Imidacloprid insecticide application with the Arborjet system. As a result of this application, the filled seed rate reached 67.89% in the Asagicuma and 69.86% in Yukaribey experiment sites.
Key words: *Leptoglossus occidentalis,* pine seeds, trunk injection, pesticides, Turkey.

Introduction

Climate change is one of the most effective factors on forests. In recent years, with the impact of climate change, invasive species have been causing significant destruction in forests of Turkey and are turning into natural species day by day. *Leptoglossus occidentalis* Heidemann (1910) (Hemiptera: Coreidae), which was first detected in Turkey in 2009, stands out with its damage to stone pine trees and economic losses due to its effects on seeds. It is noteworthy that it also poses a significant threat to the forests of other coniferous species throughout Turkey.

Since stone pine seed is an edible species with high economic returns, its damage is considered mostly from its economic perspective. But there is also a great danger for other forest tree seeds. Studies have shown that it also causes significant damage to the seeds of other species. In this respect, it is a pest that has a great potential to affect our forestry activities. As a result of the damage, problems such as rising stone pine nut prices and foreign market contractions in exports began to be encountered. If an effective and fast method of combating the pest cannot be introduced, significant negative consequences will occur, both in terms of economic losses and the natural forests in Turkey being affected by these damages.

The pest was first described by Heidemann in North America in 1910, and began to spread rapidly in central and eastern America after the 1950s. The insect, which was first seen in Italy in 1999, quickly spread to every part of the country and was also

found in Switzerland in 2005 [1,2]. Its spread after 2000 was very rapid, and in just ten years it colonized most of the continent, from Norway to Sicily, from Portugal to Turkey [3]. It was seen in Russia and Ukraine in 2012 [4]. The pest, which was first seen in our country in 2009, has attracted attention with its damage in a large part of our country in recent years, especially in coniferous forests. *Leptoglossus occidentalis* was found on *Pinus brutia, P. nigra, P. pinea, P. radiata, P. sylvestris, Abies nordmanniana* subsp. *bornmulleriana* and *A. concolor* in Turkey [5-11].

In the controlling of harmful insects, chemical control methods have not been a preferred method in recent years due to the damage they cause to the environment and their side effects. Instead, it is recommended to use biological and biotechnical control methods, which stand out as alternative methods. Chemical controlling is a method that requires the most care in its application in terms of the environment and human health. It appears as a method of control that can still be preferred today due to reasons such as seeing the results in a short time and preventing the high investment made in intensive cultures from being endangered, but it needs to be carried out with great care and should be carried out with selective pesticides that will not harm the nature.

Trunk injection is an alternative technique in chemical controlling of pest insects. The main advantages of trunk injection is providing a higher efficiency of product delivery, reduced risk for worker exposure, reduced risk to the environment, reduced harm to non-target organisms, and the possibility for use in populated areas where other methods are not an option [12-14].

In this study, systemic pesticides were applied by injection into the trunk in the trial areas taken in the stone pine fields of Bergama-Kozak region of Turkey. In this context, trials were carried out with products containing Azadirachtin and Imidacloprid actives.

Materials and methods

Experimental areas were selected in the areas of stone pine with different elevation levels in the Bergama-Kozak region. The project studies were carried out in the trial areas (Figure 1) in the Karaveliler, Yukaribey and Asagicuma provinces, which are located at different altitudes where stone pine (*Pinus pinea*) is distributed in the Bergama region. In the experiment, 10 trees (Figure 2) were taken as a parcel, with the number of replications being 3.

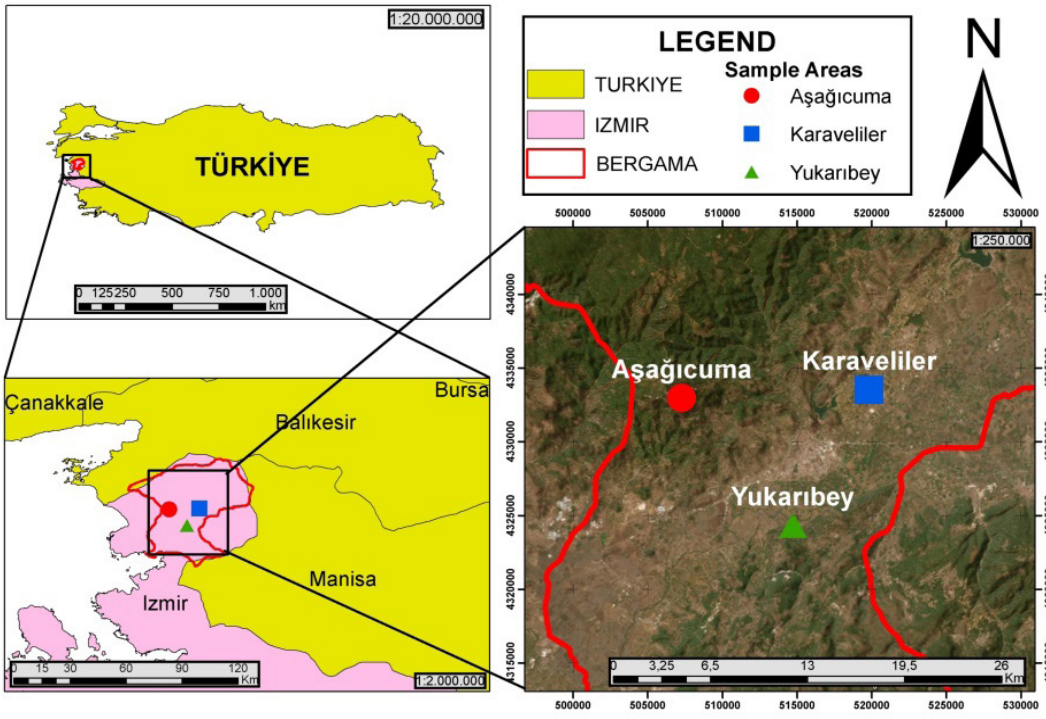

Figure 1 – Research area and experiment sites

Figure 2 – Stone pine trees in research area

Chemical applications were carried out twice on the same trees in 2020 and 2021, in the first week of April and the second week of July when he first and second generation of *L. occidentalis* adults were occurred. Arborjet system was used in systemic spraying and application was carried out with the insecticide containing the active ingredient Azadirachtin (0.3 g/Lt) as an organic pesticide, as well as the pesticides containing the active ingredient Imidacloprid (200 g/Lt). In systemic application, the injection method applied directly to the tree trunk was used. The main reason for this is that this method is seen as a more effective, environmentally friendly and safe systemic application than the systemic application method from the soil. Unlike spraying and applying pesticides through soil, Arborjet does not harm the person applying, other people in the environment, or non-target creatures, as the product is applied directly to the trunk of the tree.

In the systemic application with the Arborjet system, the pesticides were injected into the tree at the rate of 50 ml per tree. For this purpose, 6-10 arbor plugs per tree (Figure 3) were placed on the trees where the application would be made, after drilling the bark with a cordless drill, depending on the diameter and thickness of the tree. These plugs are used in different sizes, with a length of at least 15 mm and a width of at least 6 mm, and can be applied to all trees. Its special structure ensures fast and consistent release by holding the plug tightly to the tree, ensuring that the pressure is not lost during the injection process, and the special gasket inside prevents product leakage and "rebound" of the applied insecticide. In practice, a 1/1 solvent-insecticide mixture was injected into each plug as 5 ml (Figure 4). Solvent formulation is a mixture as Surfactant System – 31.20%, Organic Solvent 1- 24.40%, Organic Solvent 2- 24.40% and water 20.00%.

Figure 3 – Plug settled in stem for injection

Figure 4 – Pesticide injection

Figure 5 – Separation of full and empty seeds

The cones were collected and the necessary counts were carried out in January of the year following the years of applications. Seeds obtained from trees that received systemic injection by injection in 2020 and 2021 were also subjected to residue analysis for both years.

Results and discussion

In the studies carried out in Asagicuma and Karaveliler experiment sites in 2020; in the cones taken from the control trees where no application was made, only 37.96% of the seeds were filled in Asagicuma experiment site, while the occupancy rate was determined as 48.44% in the cones without any insecticide application in the Karaveliler experiment site. In both sites, the highest seed filling rate was achieved after systemic Imidacloprid insecticide application with the Arborjet system. As a result of this application, the full seed rate reached 70.7% in Asagicuma, while this rate was 63.6% in the Karaveliler. The seed occupancy rate obtained from

control trees in the Asagicuma was 37.96% and this rate reached 70.7% after systemic Imidacloprid application in the same field (Table 1).

Table 1 – Comparison of seed filled percentages in Asagicuma and Karaveliler experiment sites at the end of 2020

2020	Experiment Sites	
	Asagicuma	Karaveliler
Application / Active Ingredient	Seed occupancy (%)	
Azadirachtin	46.06%	43.8%
Imidacloprid	70.7%	63.6%
Control trees	37.96%	48.44%

In the studies carried out in Asagicuma and Yukaribey experiment sites in 2021, only 35% of the seeds were filled in the cones taken from control trees, while the occupancy rate in the cones without insecticide application in the Yukaribey was determined to be 32.76%. In both trial sites, the highest seed fill rate was achieved after systemic Imidacloprid insecticide application with the Arborjet system. As a result of this application, the filled seed rate reached 67.89% in the Asagicuma and 69.86% in Yukaribey (Table 2).

Table 2 – Comparison of seed filled percentages in Asagicuma and Yukaribey experiment sites at the end of 2021

2021	Experiment Sites	
	Asagicuma	Yukaribey
Application / Active Ingredient	Seed occupancy (%)	
Azadirachtin	37.23%	42.29%
Imidacloprid	67.89%	69.86%
Control trees	35%	32.76%

"Residue Analysis" was also performed on the seeds collected in December 2021 from the trees to which imidacloprid was applied. According to the Residue Analysis Report, no Imidacloprid residue was found in the seeds. According to the control results of both years, the use of the insecticide containing the active ingredient Imidacloprid in systemic application by trunk injection gave the most successful results.

In previous studies regarding the chemical control of *Leptoglossus occidentalis*, it has been reported that there is no chemical preparation registered for the pine cone sucking insect so far. Mostly, there are recommendations for combating the insect in closed areas where it enters for wintering and is used by humans or pets.

Jacobs [15] states that the most effective insecticides against *Leptoglossus occidentalis* are broad-spectrum ones such as permethrin and pyrethroid-based ones such as deltamethrin, cyfluthrin, lambda-cyhalothrin, cypermethrin. Summers and Ruth [16] report that dimethoate and permethrin are successful against *L. occidentalis*, and diatom soil is successful under laboratory conditions, but they are ineffective under field conditions. Grossman et al. [17] state that a single systemic pesticide mixture of thiamethoxam with benzoate administered by injection in the USA reduced seed loss by 72%.

In a limited number of studies on the use of chemical insecticide against *Leptoglossus occidentalis*, results show that systemic application by injection is successful. In our study, we observed that the insecticide, especially with the active ingredient Imidacloprid, reached a significant success rate on trees where it was applied systemically.

Conclusion

It is important and a priority to choose methods such as mechanical or biotechnical controling methods, especially biological control, which does not harm to nature, instead of chemical applications against *Leptoglossus occidentalis*. In addition, systemic application by injection into trees, which has a higher success rate compared to others in our studies, is not considered easy to prefer in forest areas, both in terms of economy and labor force. However, our results reveal that it is possible to use systems such as arborjet instead of contact chemical spraying, and that systemic application through injection into the tree can be used as an alternative method in regions or seed stands that make their living entirely from stone pine nut production, as in the Bergama-Kozak region. Applying the insecticide directly to the tree by injection can eliminate the negative effects on the environment and other living things that the contact effect may cause. The most important concern is the possible negative effects on human health if the pesticide penetrated into the seed

leaves residue. Starting from this point, after the systemic applications of Imidacloprid, the most successful insecticide in our study, in the obtained seeds in April and August, residue analyzes were made in the following January, which is also the month of harvest, and no residue was found.

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