Vol. 3, No. 4, 2018

THE EFFECT OF PYRETHRUM AND BACILLUS THURINGIENSIS AGAINST THE BROWN MARMORATED STINK BUG HALYOMORPHA HALYS (STAL) (HEMIPTERA: PANTATOMIDAE) IN GEORGIA

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Received: 26.10.2018

Abstract. The study was conducted for the purpose to determine the efficiencies of alternative biopesticides to be used in the control against *Halyomorpha halys.* NeemAzal® and water were used for the control. The most commonly-seen efficiency rates were determined to be 72 % with NeemAzal® in the nymph stage. Seen efficiency rates were determined to be 38.5 % with 600 ml/100l dose of Pyrethrum and 42 % with 500 g/100l dose of *Bacillus thuringiensis.* The impact rate of the biopesticides performed against the adults, on the other hand, was found to be 42.3 % with 600 ml/100l dose of Spruzit®Neu and 33 % with 500 g/100l dose of Dipel®DF. As a result, in the present study, it was observed that both pesticides were not to be much effective on the nymphs and adults of *H. halys* but NeemAzal® is effected for control.

Key words: Halyomorpha halys, biopesticides, Pyrethrum, Bacillus thuringiensis

1. Introduction

Invasive alien species adversely affect biodiversity and ecosystem, cause many negative impacts on natural and agricultural ecosystems, and cause severe heavy economic losses worldwide [1].

Among the invasive insect species, the brown marmorated stink bug (BMSB), Halyomorpha halys ((Stål), 1855) (Heteroptera: Pentatomidae), is among the most threatening pests for many agricultural crops. The brown marmorated stink bug is native to Asia, mostly to China, Korea, Japan, Myanmar, Vietnam, and Taiwan [2]. In recent years, increasing global trade and travel has led to the rapid distribution of H. halys from Asia to North America and Europe. H.halys was reported for the first time outside of its native area in USA in the mid-1990s [3]. In recent years, it was also reported from many European countries, such as Liechtenstein, Germany, France, Hungary, Greece, Romania, Austria, Italy, Serbia, Switzerland, Russia, Spain, Bulgaria [4–10]. This species was recorded for the first time in Georgia in 2015 and spread very quickly.

The polyphagous H. halys feeds on numerous vegetable and tree fruit crops, lowers quality and production [11]. Adults and nymphs feed on tree fruit, which has more than 300 reported hosts, including important horticultural crops [12]. Halyomorpha halys is dangerous pests, primarily fruit trees and woody ornamentals, but also field crops. Fruit crops: Citrus spp., Diospyros spp., Malus domestica, Morus spp., Prunus armeniaca, P. avium, P. domestica, P. persica, Pyrus communis, Rubus idaeus and Vitis vinifera. Field crops: Asparagus spp., Glycine max, Phaseolus vulgaris and Zea mays. Forest and ornamental trees/shrubs: Abelia, Acer, Aralia elata, Buddleia davidii, Cryptomeria, Cupressus, Decaisnea fargesii, Hibiscus, Lonicera, Paulownia tomentosa, Rosa rugosa, Salix, Stewartia pseudocamellia, Tropaeolum majus and Actrium spp. [5, 12, 13, 14].

Damage to host plants is caused by both adults and nymphs by piercing the surface injecting digestive enzymes and sucking plant fluids [12]. In addition, H. halys adults are also a household nuisance pest due to its massive overwintering aggregations inside buildings [15]

H. halys is widespread outbreak and caused economical lost in the all over the World. These crops include tree fruits, hazelnuts, winegrapes, blueberries, caneberries, and vegetables such as peas, snap beans, and sweet corn [16]. The U.S. Apple Association estimated H. halys cost $37 million in fruit loss in 2010 [17], and some stone-fruit growers lost >90 % of their crops [18]. During the season of 2016 the pest caused significant loss of the hazelnut harvest in the West Georgia (Samegrelo, Guria). According to the data of the National Food Agency of Georgiathe damage caused by H. halysmade approximately 70 % of the total cost of hazelnut harvest [19].

H. halys has two generations. Populations begin ovipositing in mid to late May. These overwintered adults, first generation adults begin to lay eggs from late June to early July or mid to lateJuly, with second generation adults observed between late August and early to mid-September [13, 20]. H. halys adults begin moving to overwintering sites in September. This activity was reported to increase by mid-October [20] and to continue into November [21].

There are many methods used control for H.halys. Chemical control has been the most widely used strategy for H. halys. In general, pyrethroids and neonicotinoids are recommended for control [22, 23]. Other control method for H. halys, using of pheromone traps. Khrimian et al. [24] reported that the two main components of the aggregation pheromone for this species. Recently, the aggregation pheromone (PHER) of H. halys was identified and synthesized [24]. In cultural control for H.halys; mechanical removal of eggs and nymphs from crops [25], construction of overwintering traps [20], and bagging fruit [26] as potential control techniques.

In biological control; the parasitoids, predators and entomopathogens that have been reported as potential biological control agents of H. halys [27]. Among these control methods, the most effective chemical control, but these insecticides are often the broad spectrum in their activity; Reduce natural enemy populations and damage integrated pest management programs [28].

Therefore, alternative control methods are needed. The importance of biological control, which is included in Integrated Pest Management (IPM) has increased in recent years. Applying entomopathogen organisms in biological control has an important part. Among these organisms, it was proved in many studies that Bacillus thuringiensis was effective against many pests [29]. B. thuringiensis have not been used before. Plant based insecticides are widely used in organic farming applications. Among these are the best known are azadirachtin, pyrethrum, rotenone, nicotine, ryania, sabadilla, quassine and plant oils [30]. Reported here are results from investigate the effect of Pyrethrum and B. thuringiensis biopesticides on H. halys and to its applicability.

2. Materıals and methods

The main material of the present study, consisted of H. halys nymphs and adults collected on beans, hand pump, tulle cages, and biopesticides. The bio pesticides referred to as Pyrethrum (Spruzit®Neu) and Bacillus thuringiensis (Dipel®DF) were used, during the spring and summer of 2017, the period when nymphs and adults are found profoundly in the city of Batumi – Georgia.

Neemazal and water were used for the control. It was that the most effective practices for nymphs and adults would be through NeemAzal®. Practices by means of pesticides in different doses were performed on the nymphs and adults of Halyomorpha halys, and the results were evaluated according to One-Way Variance Analysis and Duncan Test. Different doses of biopesticides were applied against the nymphs and adult in in-vitro conditions (Table 1).

Table.1

Sampling organization

Trade name of the pesticide & dose usage	Number of cages	Number of nymph/cages	Number of adult/cages
Pyrethrum (Spruzit Neu 150ml/100lt)	10	20	20
Pyrethrum (Spruzit Neu 300ml/100lt)	10	20	20
Pyrethrum (Spruzit Neu 600ml/100lt)	10	20	20
Bacillus thuringiensis (Dipel DF 100gr/100lt)	10	20	20
Bacillus thuringiensis (Dipel DF 300gr/100lt)	10	20	20
Bacillus thuringiensis (Dipel DF 500gr/100lt)	10	20	20
NeemAzal (100gr/100lt)	10	20	20

Foto. 1–2. Laboratory application of biopesticides

Following the biopesticides, 5 controls were made in every 2 days, and the alive and dead individuals were counted. In the present study, nymphs of H. halys were collected in the 3st week of May. Adults of H. halys were collected in the 3st week of Agust and brought to the Laboratory. Nymphs and adults were brought with beans were placed in wire mesh cages with a size of 20x20x30cm as 20 nymphs and adults in each cage.

3. Results and discussion

It was observed that all the dosages used in the applications had effects at various levels, and it was determined that there were differences between the six different slides applied to H.halys nymphs and adults (Table 2).

Table 2

One way ANOVA Results showing the effects of the pesticides and the doses applied on the nymphs and adults of Halyomorpha halys

Period of development	The degree of freedom (DOF)	F value	Significance level (p)
Nymphs	5	35.03	.001
Adults	5	68.10	.001

Among the seven different applications performed against the nymphs and adults of *H. halys*, significant differences were found both for the nymphs and for the adults. The impact rate of the biopesticides were found alittle low in this study. In the results of the analysis of the data obtained from the bio pesticide practices performed on *H. halys* nymphs. For biopesticides were determined that the most effective practices for nymphs would be through the use of 150 g/100 l, 300 g/100 l and 500 g/100 l Dipel®DF. The efficiencies of 150 ml/100 l dose and 300 ml/100 l dose of Spruzit®Neu were seen to be the same. Also, the efficiency of 600 ml/100 l dose of Spruzit®Neu and the efficiency of 300 g/100 l dose of Dipel®DF were found to be similar, as well. For biopesticides were determined that the most effective practices for adults would be through the use of 600ml/100 l Spruzit®Neu and 500g/100 l Dipel®DF. The efficiencies of 150 ml/100 l dose, 300 ml/100 l dose of Spruzit®Neu and 300 g/100 l Dipel®DF were seen to be the same (Table 3).

As the results of the practice performed against *H. halys* nymphs, the impact/effectiveness rates of Spruzit®Neu were determined as 29 % in 150 ml/100 l dose, 30 % in 300 ml/100 l dose, and 38.5 % in 600 ml/100 l dose. The impact/effectiveness rates of Dipel®DF, on the other hand, were determined as 35 % in 100 g/100 l dose, 38 % in 300 g/100 l dose, and 42 % in 500 g/ 100 l dose.

As the results of the practice performed against *H. halys* adults, the impact rates of Spruzit®Neu were determined as 34 % in 150 ml/100 l dose, 35 % in 300 ml/100 l dose, and 42.3 % in 600 ml/100 l dose. The impact rates of Dipel®DF were determined as 27.5 % in 100g/100 l dose, 28.5 % in 300 g/100 l, and 33 % in 500 g/100 l dose (Fig. 1, 2).

NeemAzal® has been identified as the most effective application for both 72 % with nymph and 54 % with adults. It was observed in the applications that the death rates increased especially on the 6th and 8th days, and similarly, it was also determined that as the dosage increased, so did the death rates

A management strategy for H. halys that could be implemented in the nowadays is an attract-and-kill system. The most common method for this is insecticides. An unfortunate side effect of aggressive insecticide usage in fruit orchards has been the disruption of natural biological control by eliminating or decreasing natural enemies. Organic production utilizes a diverse array of cultural and biological control tactics as alternatives to synthetic insecticides to reduce the level of crop injury by arthropod pests [31].

Table 3

Effects of the pesticides and the doses applied on the nymphs and adults of *H. halys*

Trade name of the pesticide & dose usage	Nymph		Adult	
	Mean	Standard deviation	Mean	Standarddeviation
Pyrethrum (Spruzit Neu® 150ml/100lt)	5.8[e]	±1.2	6.8[c]	±1.1
Pyrethrum (Spruzit Neu® 300ml/100lt)	6.0[e]	± 1.3	7.0[c]	± 1.2
Pyrethrum (Spruzit Neu® 600ml/100lt)	7.7[c]	± 1.3	8.5[b]	± 0.7
Bacillus thuringiensis (Dipel® DF 100gr/100lt)	7.0[d]	± 0.8	5.5[d]	± 1.0
Bacillus thuringiensis (Dipel® DF 300gr/100lt)	7.6[c]	± 0.6	5.7[d]	± 0.8
Bacillus thuringiensis (Dipel® DF 500gr/100lt)	8.4[b]	± 0.5	6.6[c]	± 0.9
NeemAzal® (100gr/100lt)	14.4[a]	± 0.5	10.8[a]	± 0.9

Note: In each column, there is no significant difference between the averages with the same small letter above them ($p < 0.05$).

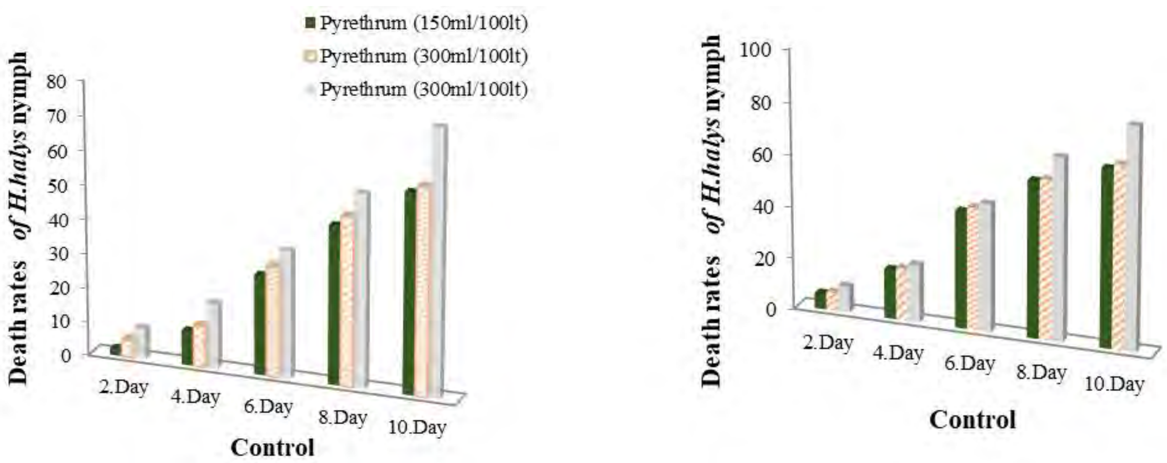

Fig. 1. The effectiveness of different doses of Pyrethrum on the nymph of *H. halys*

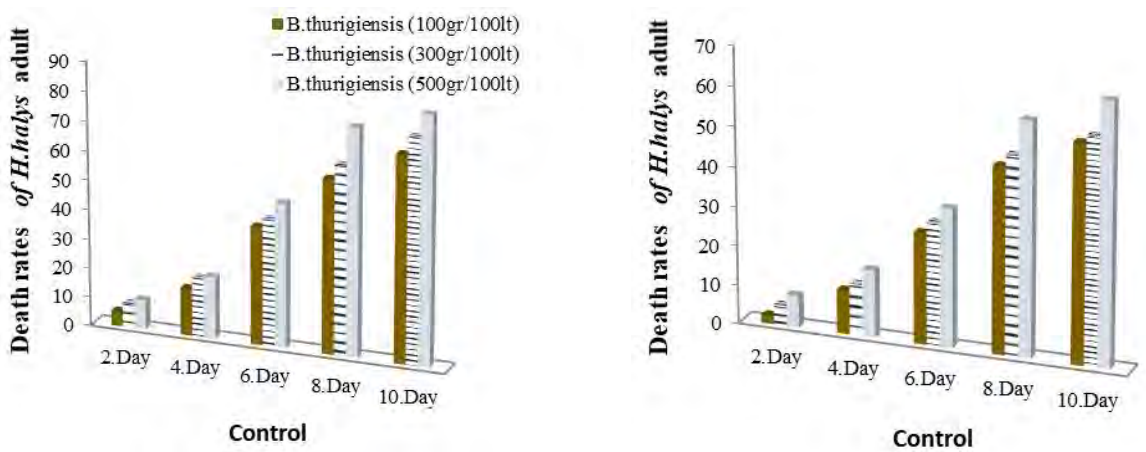

Fig. 2. The effectiveness of different doses of Dipel ® DF BT on the adult of *H. halys*

Few alternatives to synthetic insecticides are available to organic growers for management of H. halys and therefore, organic insecticides may play a key role until cultural and biological control tactics are developed and adopted. Limited information is available for organic insecticides for H. halys. Organic insecticide Azadirachtin is effective against H.halys [14].

Halyomorpha halys has become an important pest together with Ricania simulans in orchards in Eastern Black Sea Region in recent years. The brown marmorated stink bug is a recent example of a serious biological invasive species, especially in Georgia and described as an occasional or outbreak pest of several crops as well as a nuisance pest in the native region. Due to serious economic losses caused by H. halys for world agriculture, unprecedented group efforts have been made to study the biology of H. halys and develop management strategies.

Conclusion

In the present study, it was observed that both bio pesticides – Pyrethrum (Spruzit®Neu) and Bacillus thuringiensis (Dipel®DF) were not to be much effective on the nymphs and adults of H. halys but NeemAzal® is effected for control.

The nymphs of H. halys were influenced more by the applied biopesticides. The field research of these biopesticides must be well investigated before they are presented for active use.

It is important to follow-up the population of these species and to fight against them. Against H.halys nymph and adult, Pyrethrum (Spruzit® Neu) and B. thuringiensis (DiPel® DF) biopesticides were tested in laboratory conditions and it was determined that they were less effective.

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