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The effect of insecticides used against the cherry fly *Rhagoletis cerasi* L. (Diptera: Tephritidae) at different cherry fruit colouring periods on fruit worm rates

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Abstract
The cherry fly *Rhagoletis cerasi* L. (Diptera: Tephritidae) is a pest that causes yield losses and reduces the market value of the fruit. It is the key pest of cherry orchards both in Turkey and in other countries. Since the pest causes damage directly on cherry fruits, its economic loss is great. It is known that pest adults emerge at the end of the flowering period or before the mole fall period in nature, their populations increase during the mole fall period, and reach the highest population density in the pre-ripening or ripening period. In technical instructions, one of the most commonly used methods in the fight against cherry fly is the phenological and pomological prediction method. This method belongs to short-term forecasting. This method, which is based on determining the moment when the insect starts laying eggs, is important in terms of determining the exact timing of the pest control. Namely; the period when the cherry fly starts to lay eggs is specified as the cherry mole fall period, and spraying according to pomology is important in terms of revealing its history. In this study, Malathion 650 g/l, Cypermethrin 250 g/I, Azadiractin 10 g/I insecticides were used in 5 different coloring periods of cherry to determine the effects of the control on the wormy fruit rates. Chi-square test was performed to determine the statistical differences of three different insecticide applications according to different coloring periods of cherry plants. As a result of the study, it was determined that the most successful applications of all insecticides in the 2nd period phenological coloration of cherry were the most successful applications and the lowest values in the number of wormy fruits were observed in this fruit colouration. As a result of the Chi-square test of Malathion application according to the periods, the calculated Chi-square value was calculated as χ^2=31.184. The relationship between the periods was found statistically significant (p<0.01). According to this analysis, it was observed that the number of worms decreased from the 1st to the 2nd period, while the number of worms increased statistically from the 2nd to the 5th period. As a result of the Chi-square test performed according to the periods of Cypermethrin application, the calculated Chi-square value was calculated as χ^2=24.772. The relationship between the periods was found to be statistically significant (p<0.01). According to this analysis, it was observed that the number of worms decreased from period 1 to period 2, and the number of worms increased statistically from period 2 to period 5. As a result of the Chi-square test performed according to the periods of azadiractin application, the calculated Chi-square value was calculated as χ^2=25. 964. The relationship between the periods was statistically significant (p<0.01). According to this analysis, it was observed that the number of worms decreased from period 1 to period 2, while the number of worms increased statistically from period 2 to period 5. The results of this study are important for determining the effect of fruit coloration cycles in the control of cherry fly and contain basic data for cherry IPM studies.

Keywords: *Rhagoletis cerasi*, insecticide application time, fruit colouring period

Introduction
The cherry fly feeds on the fleshy part of the cherry fruit, spoiling its taste and appearance, and reducing its market value. The cherry fly damage is quite high, mostly in mid-season and especially in temporary varieties that ripen in June. It is reported that in places and years where its population is dense, the damage exceeds 90% (Aktürk, 1997) [1]. The different damage levels are due to phenological differences in cherries due to cherry varieties and different climatic conditions during oviposition. Lower infestation levels are observed in early-ripening fruit varieties because the fruits are harvested before the first flies are ready to lay eggs.

In general, the later a cherry variety is harvested, the higher the potential infestation level (Stamenkovic *et al*., 1996) [5]. Sunny weather conditions during oviposition lead to high infestation levels. Rainy conditions during early ripening stages prevent oviposition and mating (Prokopy and Boller, 1971) [4]. Since the quality of the harvested worm-infested fruits is low, their market value also decreases (Anonim, 2020) [2].

In the fight against cherry fruit fly, chemical compounds are mainly used. It has become a method used more than other methods due to its features such as easy application, immediate results and easy supply of drugs from the market (Uygun *et al*., 2015) [6]. Intensive chemical pesticide applications are not only negatively affecting human health, but also effective in the extinction of plant and animal species. While it creates residue in soil and water resources, it also creates economic losses with the resistance and durability that develop over time (Birişik, 2018) [3]. Although it is important to specify the period when the cherry fruit fly starts to lay eggs as the cherry coloration period in terms of revealing the date of spraying according to pomology, it is not sufficient in terms of timing. It has been revealed by observations and damage situations during the harvest period that the insecticides applied during this period are often not sufficient to reduce the pest population. The term for the period when the cherry begins to redden, therefore, has not been set forth with clear criteria, and is important in terms of determining important phenological, pomological and pest biology relationships, such as the degree of reddening, the level of color and biochemical content. There are many insecticides used licensed against cherry flies. The timing of use of these insecticides is very important and is important for the success of the fight. This study was carried out in Harput, Elazığ Province in 2024 in order to determine the cherry fly damage of insecticide applications made in different phenological periods and colorations of the cherry fly.

Materials and Methods

The material of the study consisted of cherry fruit flies, insecticides and cherry fruits of different colors. In the study conducted to determine the effects of insecticide applications against cherry fruit flies in different color scales on cherry fruit fly damage rate, the drugs used and spraying dates are given in Table 1 and Figure 1 (Figure 1). Sprayings were carried out according to a repeated randomized block trial plan. The coloration periods taken into account in spraying are given in Figure 2. After the application, cherry fruits were taken according to the sprayings of each coloration period at harvest and worm percentages were calculated (Figure 3).

Fig 1: Spraying Against Cherry Maggot Fly

Fig 2: Fruit coloration periods considered in Cherry Plant Spraying (Left to Right, 1, 2, 3, 4,5)

Table 1: Active Ingredients Used, Doses, Scale Values and Spraying Dates

Insecticide	No Color (1 scale) (Spraying Date: 25.04.2024)	Little Pink (2 scale) (Spraying Date: 14.05.2024)	Medium Pink (3 scale) (Spraying Date: 22.05.2024)	Red (4 scale) (Spraying Date: 27.05.2024	Full Red (5 scale) 07.06.2024
Malathion 650 g/I	100 ml to 100 lt water	100 ml to 100 lt water	100 ml to 100 lt water	100 ml to 100 lt water	100 ml to 100 lt water
Cypermethrin 250 g/I	30 ml to 100 lt water	30 ml to 100 lt water	30 ml to 100 lt water	30 ml to 100 lt water	30 ml to 100 lt water
Azadiractin 10 g/I	500 ml to 100 lt water	500 ml to 100 lt water	500 ml to 100 lt water	500 ml to 100 lt water	500 ml to 100 lt water
Kontrol	No insecticide	No insecticide	No insecticide	No insecticide	No insecticide

Fig 3: Taking Samples for Spraying Effectiveness Impact Calculations

Results and Discussion

In the examinations of the fruits taken during the Harvest Period, the most effective spraying period was the 2nd coloration according to the number of hits and percentages according to the times of insecticide use (Figure 4). The effects of the drugs applied in all periods on the wormy fruit rates (%) are given in Figures 5-9.

Fig 4: Fruit Coloration Where Spraying Is Most Effective

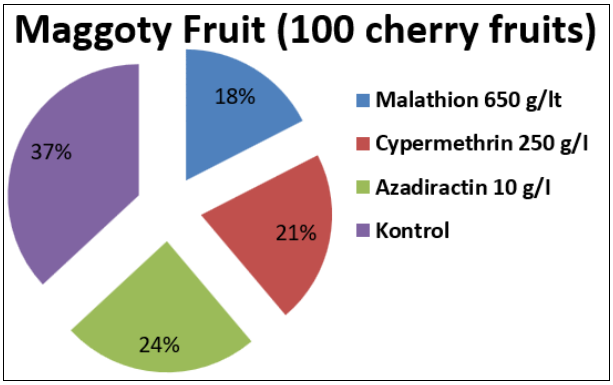

Fig 5: Fruit damage percentages of insecticide applications at the firsth stage of fruit colouration

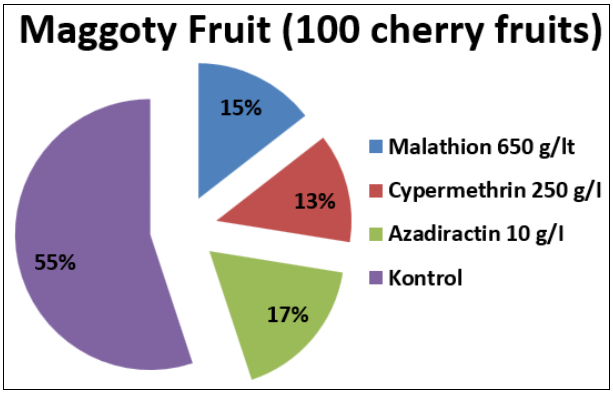

Fig 7: Fruit damage percentages of insecticide applications at the third stage of fruit colouration

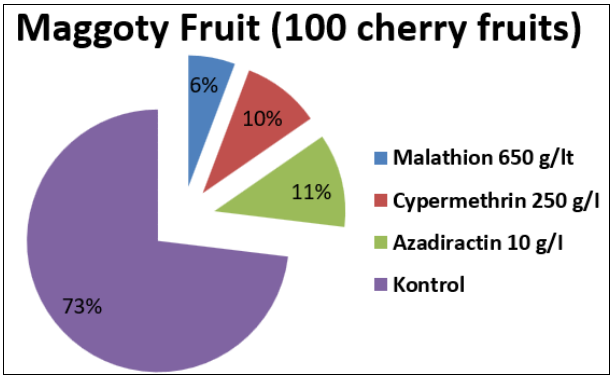

Fig 6: Fruit damage percentages of insecticide applications at the second stage of fruit colouration

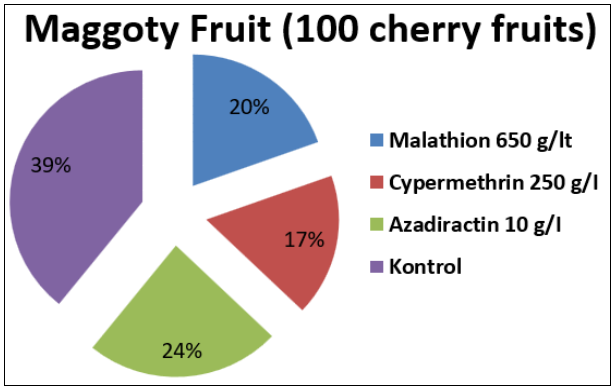

Fig 8: Fruit damage percentages of insecticide applications at the fourth stage of fruit colouration

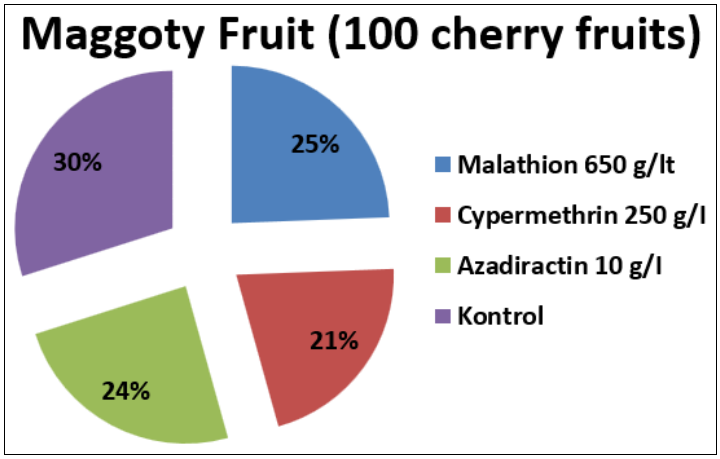

Fig 9: Fruit damage percentages of insecticide applications at the fifth stage of fruit colouration

Chi-square test was performed to determine the statistical differences between three different drug applications according to different coloring periods of the cherry plant. Chi-square test results are shown in Tables 2, 3 and 4. In addition, graphical representations of these differences are shown in Figures 10, 11 and 12.

Table 2: Chi-square test results of Malathion application according to periods

Malathion	Period					Total
	1st Period	2nd Period	3rd Period	4th Period	5th Period	
Clean	82	96	89	80	68	415
Wormy	18	4	11	20	32	85
Total	100	100	100	100	100	500

When Table 2 is examined, as a result of the Chi-square test performed for Malathion application according to the periods, the calculated Chi-square value was calculated as χ^2=31.184. The relationship between the periods was found to be statistically significant (p<0.01). According to this analysis, it is seen that the number of worms decreased statistically from the first period to the second period, and the number of worms increased statistically from the second period to the fifth period.

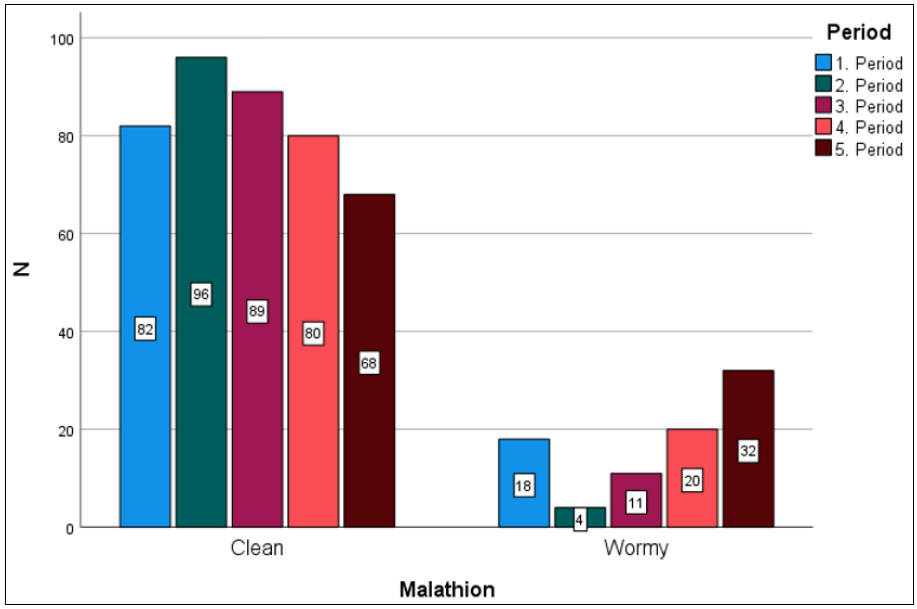

Fig 10: Seasonal Differences of Malathion Application in Clean and Wormy Cherries

Table 3: Chi-square test results of Cypermethrin application according to periods

Cypermethrin	Period					Total
	1st Period	2nd Period	3rd Period	4th Period	5th Period	
Clean	78	95	89	81	71	414
Wormy	22	5	11	19	29	86
Total	100	100	100	100	100	500

When Table 3 is examined; As a result of the Chi-square test performed according to the periods of Cypermethrin application, the calculated Chi-square value was calculated as χ^2=24.772. The relationship between the periods was found to be statistically significant (p<0.01). According to this analysis, it is seen that the number of worms decreased statistically from the first period to the second period, and the number of worms increased statistically from the second period to the fifth period.

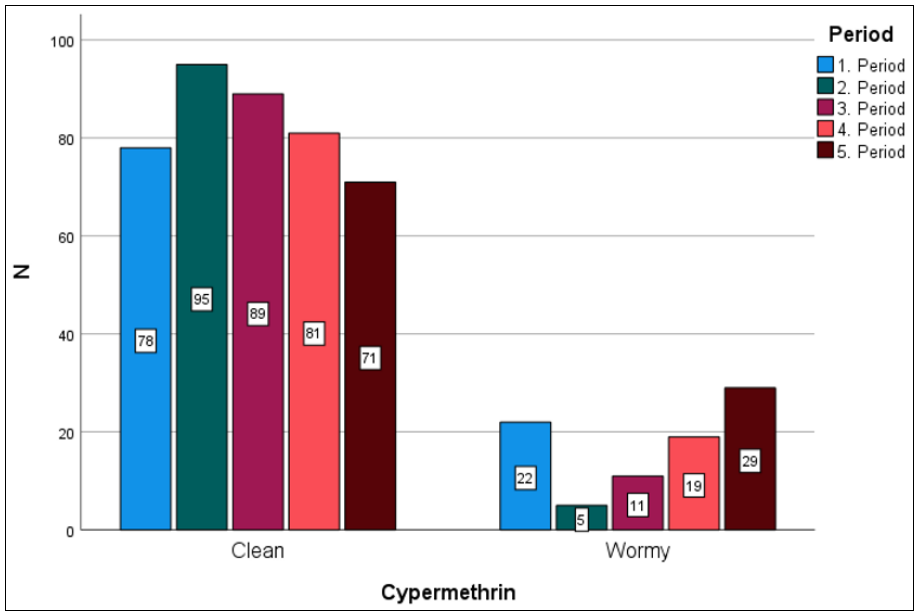

Fig 11: Periodic Differences of Cypermethrin Application in Clean and Wormy Cherries

Table 4: Chi-square test results of Azadiractin application according to periods

Azadiractin	Period					Total
	1st Period	2nd Period	3rd Period	4th Period	5th Period	
Clean	76	94	88	77	69	404
Wormy	24	6	12	23	31	96
Total	100	100	100	100	100	500

When Table 4 is examined, the Chi-square test result of Azadiractin application according to the periods, the calculated Chi-square value was calculated as χ^2=25.964. The relationship between the periods was found to be statistically significant (p<0.01). According to this analysis, it is seen that the number of worms decreased statistically from the first period to the second period, and the number of worms increased statistically from the second period to the fifth period.

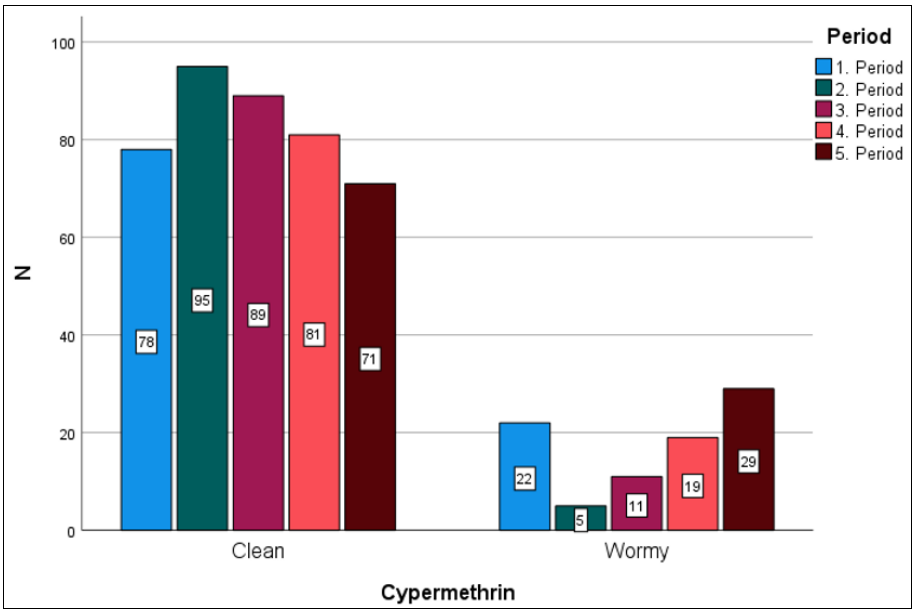

Fig 12: Seasonal Differences of Azadirachtin Application in Clean and Wormy Cherries

As a result; the best success in insecticide applications against cherry fruit fly was obtained in the second coloring period of the cherry. This result was obtained in all three insecticide applications, the success of the spraying decreased towards the fourth and fifth coloring periods of the cherry. And an increase was observed in the number of dented fruits. The results of this study are important for cherry IPM studies and the success of chemical control against cherry fruit fly.

Conclusion

The second coloration period of cherry fruit proved to be the most effective for insecticide applications against cherry fruit fly, as all three tested insecticides showed the highest success during this period. As the fruit approached later stages of ripening, insecticide efficacy decreased, leading to increased damage. This study highlights the importance of precise timing in chemical control measures for integrated pest management (IPM) strategies to mitigate cherry fruit fly damage and improve crop quality. The findings are significant for optimizing pest control in cherry farming.

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