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Determination of the Effectiveness of Different Spraying Programs Against Powdery Mildew Disease (*Erysiphe necator* Schw.) in Vineyard

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Abstract
This study was carried out to determine the first spraying time and other spraying intervals in the chemical control against the disease and to establish a spraying program that will be effective in the control of the disease. The study was carried out in 2015 in a farmer's vineyard of 5 da of Razakı grape variety in Taşova district of Amasya province in a randomized block design with 4 treatments and 5 replications. In the study, treatments with different spraying times and intervals were applied for the control of the disease. At the end of the study, the effects of these treatments on the control of the disease were statistically evaluated and the most successful spraying program was determined. The same fungicide containing 100 g l^{-1} Kresoxim-Methyl+200 g l^{-1} Boscalid active ingredient was used in all treatments. According to the statistical analyses and evaluations, all treatments were found to be effective in the chemical control of powdery mildew on both leaves and clusters. However, due to reasons such as economic losses, environmental health and resistance problems in systemic drugs, it is thought that the application with the lowest number of sprayings and the highest effect of 91.96 % on panicle and 87.52 % on leaf should be considered.

Research Article

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1. Introduction

Türkiye, which is located on a favorable climate zone for viticulture in the, is one of the important viticulture centers in the world with its vineyard area and production values. While Spain ranks 1st in the world production with 922.920 ha. production area, Türkiye ranks 5th with 384.537 ha. production area after France, Italy and China respectively (FAO, 2022). The favorable ecological factors in our country increase the spread of viticulture over large areas. In 2023, grape production in the country was reported to be 3,400.000 tons. Amasya province has an important agricultural production potential. There is a total vineyard area of 8.064 da in Amasya province and 4.192 da in Taşova district (TUİK, 2023). *Erysiphe necator* Schw. is an obligate parasite of American ivy, wall ivy, wild grapevine and grapevine. It overwinters on the plant as cleistothecium and mycelium in the eyes. It starts its activity from the first moment when the shoots begin to elongate and continues to develop on all green parts (leaves, stems, shoots, panicles) (Built and Lafon, 1978, Pearson and Goheen, 1988). In vineyards affected by powdery mildew in the early stages, the growth of grains stops in all organs affected by the disease, and ash-like spore structures are seen on the leaf and cluster skeleton. If the grains are infected before they reach their full size, the grain cracks in the direction of the stem and the kernel is seen. If colored varieties are infected, they do not get their full color. The sale quality of table and wine varieties decreases and the taste of the wine deteriorates (Anonymous, 2015b).

Spraying is carried out according to the current Agricultural Control Technical Instructions (ACTI) (Anonymous, 2015a). However, it was observed that this program was insufficient to control the disease in some regions. This is due to the fact that the first spraying time recommended for the disease in the ACTI is late in our region according to the development of the disease and there is a time interval between the first and second spraying times, which can extend up to 30-40 days, depending on the region. For this reason, it was necessary to revise the agricultural control instruction of the disease and studies were initiated for the control of the disease. This study was carried out in order to determine the first spraying time and other spraying intervals in the chemical control against the disease and to establish the most effective spraying program in the control of the disease and as a result of the study, the most effective spraying program in the control of the disease was determined.

2.Materials and Methods

2.1. Material

The study previously examined the vineyard powdery mildew disease agent *E. necator*. The study was carried out in a 5-da farmer's vineyard with Razaki grape variety in the Taşova district of Amasya Province, which is known to be contaminated with. In the applications, fungicide containing 100 g l^{-1} Kresoxim-Methyl+200 g l^{-1} Boscalid active ingredient (Collis SC, BASF) was used at a dose of 30 ml 100 L^{-1} of water. The effective substance in question was included in the trial because it was licensed in the regions where the trial would be established and its effectiveness in the fight against the disease was known. During the spraying, a mechanical back sprayer suitable for providing uniform distribution in the entire trial area or for accurate regional spraying (partial branches, trunk, etc.) was used.

2.2. Method

2.2.1. Trial design and arrangement

The study was established in a randomized block design with 4 characters (Program A, Program B, Program C and Control) and 5 in the Taşova District of Amasya Province in 2015. The plots in the wired vineyard system consisted of 6 shoulders on the same row and the counts were made in the middle 4 shoulders. In the study, 6 shoulders were taken as a plot and one row was left as a safety strip between the plots during spraying. Sprayings were repeated taking into account the duration of the pesticide. No treatment was applied to the vines in the control plots. The same fungicide was used in all treatments and

necessary records were kept. The duration of action of the drug was accepted as 11-12 days considering the label of the drug. In the study, applications were made according to Program A, Program B and Program C for the control of the disease.

2.2.1.1. Applications

Program A

It was carried out according to the ACTI. 1st Spraying: Before flowering when the shoots are 25-30 cm; 2nd Spraying: When the flower petals fall off and the cores are the size of pellets; 3rd and other sprayings: After the second spraying, according to the duration of action of the drug used (11-12 days), until the time when the grains are covered with fresh water (mole fall).

Program B

Spraying was carried out by adding one more application between the first two sprayings made according to the ACTI.
1st Spraying: Before flowering, when the shoots are 25-30 cm; 2nd Spraying: Before flowering, when the flower buds are separated; 3rd Spraying: When the flower petals fall off and the cores are the size of a pellet; 4th and other sprayings: After the third spraying, according to the duration of the effect of the drug used (11-12 days), until the time when the grains are covered with fresh water (mole fall).

Program C

Early Spraying
1st spraying: Before flowering, when the shoots are about 10 cm; 2nd and other sprayings: According to the duration of action of the pesticide used (11-12 days), until the time when the grains are covered with fresh water (mole fall).

Control

No treatment was applied in the control.

2.2.2. Counting and assessments

Evaluations were carried out on leaves and panicles on 4 of the middle 4 of the 6 shoulders on each plot.

2.2.2.1. Leaf count and evaluation

Counting and evaluations were made on 25 leaves randomly taken from the shoots around each vine to be counted, from the leaves after the 3rd leaf from the bottom, and a total of 100 leaves taken from 4 vines. The evaluation scale for leaves in vineyard powdery mildew disease is given in Table 1 (Anonymous, 2015b).

Table 1. 0-3 evaluation scale for leaves in vineyard powdery mildew disease

Scale Value	Disease Description
0	There are no spots on the leaf
1	There are 1-2 spots on the leaf
2	There are 3-10 spots on the leaf
3	There are more than 10 spots on the leaf

2.2.2.2. Counting and evaluation in bunches

The number of diseased and healthy grains in the parcel was determined by counting the number of diseased and healthy grains in a total of 20 clusters taken from 4 vines, 5 clusters from each of the vines subject to counting in each parcel.

2.2.3. Counting time

Leaf and panicle counts were made after the last spraying, taking into account the sum of the pesticide's duration of action and the incubation period (5-6 days).

2.2.4. Evaluation of data

Percentage disease severity was calculated according to the Towsend-Heuberger formula (Townsend and Heuberger, 1943) from the values obtained according to the scale used in the leaf evaluation, and the percentage effect of the treatments was calculated from the disease severity with the Abbott formula. In the evaluation of the panicles, the percentage of the disease of the grains separated as sick and healthy at the end of the count was found and the percentage effects of the treatments were calculated by evaluating with the Abbott

formula (Abbott, 1925). ArcSin transformation was applied to the obtained values and analysis of variance was performed. Multiple comparison test (LSD) was applied to the results and treatments were grouped. The evaluations were made in JMP statistical program.

3. Results and Discussion

In the study, phenological follow-ups were carried out and phenological records are given in Table 2.

Table 2. Phenological follow-ups and dates in the experimental area

Phenological Periods	Date
Beginning of Bud Burst Period	24.04.2015
First Detection of the Disease	20.05.2015
Beginning of Mole Fall Period	14.08.2015
Evaluation of the Project	28.08.2015
Harvest Period	07.09.2015

In the experimental vineyard, the disease symptom was detected on the leaves on 20.05.2015. The first spraying in Program A application was made when the shoots reached an average of 25-30 cm. In Program A, 6 sprayings were made until the pre-molescence period. In Program B, the first spraying was started when the shoots reached approximately 25-30 cm. According to this program, 7 sprays were applied. In Program C, the first spraying was started when the shoots reached an average of 10 cm and 9 sprayings were made until the mole fall period. The number, date and phenological period of spraying of Program A, B and C in the experiment are given in Table 3.

Table 3. Spraying programs applied against vineyard powdery mildew, application times and phenological periods

Spraying Program			Spraying Dates	Phenological Period
Program A	Program B	Program C		
		X	11.05.2015	Shoots 10 cm long
X	X	X	22.05.2015	Shoots 25-30 cm long
		X	03.06.2015	Shoots 60-70 cm long
	X		08.06.2015	Separation of flower buds
		X	15.06.2015	Beginning of flowering
X	X	X	26.06.2015	The berries in the size of a pellet
X	X	X	07.07.2015	The grains in the size of chickpeas
X	X	X	20.07.2015	Beginning of cluster tightening
X	X	X	03.08.2015	Cluster tightening
X	X	X	14.08.2015	Beginning of the spot fall period

Counts and evaluations were made on leaves and panicles taken from the experimental vineyard on 28.08.2015. As a result of the counts made on the leaves, the percentage effects of the treatments compared to the control: Program A 77.35 %, Program B 87.52 % and Program C 86.13 %. As a result of the counts made on the panicle, the percentage of diseased grains was 87.35 % in the control, 19.97 % in Program A, 7.02 % in Program B and 7.61 % in Program C. Spraying was discontinued with at the beginning of the mole fall period in the experimental vineyard and counting and evaluation were carried out 11-15 days after the last application. Percentage effects and statistical groupings of pesticide applications on leaves and panicles compared to the control are given in Table 4.

Table 4. Effect of different pesticide applications on powdery mildew disease on leaves and bunches

Applications	Disease Severity on Leaf (%)	Effect of Applications on Leaf (%)	Diseased Grain Rate (%)	Effect of Applications on Cluster (%)
Program A	17,97 b	77,35	19,97 b	77,14
Program B	9,9 d	87,52	7,02 c	91,96
Program C	11 c	86,13	7,61 c	91,29
Kontrol	79,34 a*	-	87,35 a*	-

Significant at P≤0.01 according to Duncan multiple comparison test in leaves and panicles. Means with the same letter are in the same statistical group.

In this study, the first spraying time and other spraying intervals in the chemical control to be applied against grape powdery mildew disease were determined and a spraying program that will provide efficiency in the control of the disease was established. In the study, applications were made according to Program A, Program B, Program C with different spraying times and intervals for the control of the disease. In Program A, in which applications were made according to the ACTI, 6 sprayings were made and 77.35 % efficiency was determined in leaves and 77.14 % efficiency was determined in panicles. It was determined that a period of 35 days elapsed between the first and second spraying time and when the average period of 10-14 days, which is the efficacy period of the pesticide, was subtracted from the 35-day period, it was determined that at least 21 days passed without spraying. In the study carried out to determine the appropriate control method against powdery mildew of the vineyard, the period between the first two spraying times (20-30 cm shoot period and pellet size period) in the application made according to the ACTI was found to be 38 days in Arpaçsakarlar, 30 days in Akdam and Sarıçukur and 34 days in Fındıklı (Turan and Tokgönül, 1994). This unsprayed period covers the pre-bloom and post-bloom period when the vineyard is most susceptible to powdery mildew disease (Gadoury et al., 2006). In a study conducted by Uddin et al. (2023), Bordeaux slurry was applied in the first spraying as a preventive, followed by Elite 45 as a therapeutic and Quintec as a systemic during the dormant period, at the separation of flower buds, one week before flowering and during fruit formation. A preventive fungicide was applied before flowering, followed by a systemic fungicide on the fruit, which was reported to effectively control *E. necator* and resulted in healthier and higher grape yields. In our study, the fact that the 1st spraying time in Program A was late in preventing the first infections and the time between the 1st and 2nd spraying times was longer than the duration of action of the fungicides used against the disease, in years when the seasonal conditions were favorable for the development of the disease, were effective in the course of the disease during the vegetation period and the amount of crop losses it caused. The lowest percentages of disease on leaves and panicles were observed in B and C treatments. Although 9 sprayings were made in C and 7 sprayings were made in B, the results were very close. It has been reported in many studies that grape berries are susceptible to powdery mildew during the 4-5 weeks before and after flowering, i.e. during the grain set period, and if the disease is not controlled during this period, serious crop losses occur (Gadoury et al. 2000, Gubler et al. 1999, Reuveni 2010). Hartman and Beale (2008) reported that applications in the control of powdery mildew should start just before flowering and early control of primary infections, especially in susceptible varieties, is important in the treatment of this disease. In programs A and B, the sensitive period before and after flowering was kept under constant control by following the duration of the drug's effect. It is thought that the results were very close and successful because the vineyard was protected by spraying during the sensitive period. Due to the high frequency of application of the C program, it is thought that it may create risks in terms of human and environmental health in the product. In addition, it was the program with the highest economic burden on the producer. When the available data are evaluated in all aspects such as producer, product and human health, the B

program can be recommended for use in the control of vineyard powdery mildew disease. According to this program, we believe that it would be appropriate to start spraying when the shoots are 25-30 cm, followed by the 2nd and 3rd applications when the flower buds are separated and the petals are shed. Considering the effective substances used, climatic conditions and disease development, it may be recommended that the producers continue spraying.

4. Conclusions

In this study, it was aimed to determine the appropriate time and a more effective spraying program for chemical control of grape powdery mildew disease. The study was carried out in 2015 in a farmer's vineyard of 5 da Razakı grape variety in Taşova district of Amasya province with 4 treatments and 5 replications in a randomized block design. Three programs with different spraying times were tested: Program A (spraying according to ACTI), Program B (spraying by adding one more application between the first two sprayings made according to ACTI) and Program C (spraying starting in the early period when the shoots are 10 cm). In the applications, fungicide containing 100 g l^{-1} Kresoxim-Methyl+200 g l^{-1} Boscalid active ingredient (Collis SC, BASF) was used at a dose of 30 ml 100 L^{-1} of water. As a result of the counts made on the leaves, the percentage effects of the treatments compared to the control: Program A 77.35 %, Program B 87.52 % and Program C 86.13 %. As a result of the counts made on the panicle, the percentage of diseased grains was 87.35 % in the control, 19.97 % in Program A, 7.02 % in Program B and 7.61 % in Program C. Programs B and C were the most effective programs. When the available data are evaluated in all aspects such as producer, product and human health and spraying cost, program B can be recommended for the control of vineyard powdery mildew disease. According to this program, it was concluded that it would be appropriate to start spraying when the shoots are 25-30 cm, followed by the 2nd and 3rd applications when the flower buds are separated and the petals are shed.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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