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THE STUDIES ON EFFECTIVENESS OF CONVENTIONAL AND ORGANIC SPRAYING PROGRAMS AGAINST BLACKBERRY CANE AND LEAF RUST CAUSED BY *KUEHNEOLA UREDINIS* (LINK) ARTHUR

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Abstract

Market demand for blackberry fruit (*Rubus fruticosus L.*), that's production is more and more being widespread both in the world and Turkey, is increasing. The most important factor negatively affecting blackberry yield is fungal diseases but there are not any approved fungicides in Turkey to combat those diseases. This study was carried out in Bursa, Turkey's leading raspberry and blackberry production region, to develop organic and conventional management programs for controlling blackberry cane and leaf rust caused by *Kuehneola uredinis* (Link) Arthur, which was prevalently observed in blackberry orchards. Copper fungicides (20% copper calcium sulfate) were used to determine the efficacy against the disease as an organic spraying program. An IPM program recommended to control of blackberry cane and leaf rust disease in the State of California in the United States of America was applied to blackberry orchards in Bursa conditions as a conventional spraying program (by using fungicides with active substances Pyraclostrobin + boscalid and myclobutanil). The evaluations made within the scope of the study were done before the harvest in early June 2016, when the severity of the disease increased to 26% in the control parcels. In the evaluation, the effectiveness of the organic spraying program that was applied in the same way as the producers do was determined just as 7.69%, while the effectiveness of the conventional spraying program was found as 75%. It was observed that the applied organic spraying program did not reach sufficient efficiency. However, it is thought that conventional spraying program examined might be used in control of the disease with some improvement.

Keywords: Blackberry, Cane and leaf rust, *Kuehneola uredinis*, Fungicides

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1. Introduction

Blackberry (*Rubus fruticosus* L.), commonly has been cultivated in Europe and North America in recent years, has shown an rapid growth in its production by new applications in its production, developing new and high quality varieties, and addition of new cultivation areas

(Clark and Finn, 2014). Strik et al. (2007) reported the production areas of blackberry to have had an estimated worldwide increase of 45% between the years of 1995 and 2005. Since fruit of blackberry contains anthocyanins, flavonols, chlorogenic acid and pyrocyanidins, it has been found to have important positive effects on human health. As far as its compounds are concerned, fruit of blacberry includes significant numbers of phenolic compounds with high biological activity. Also, due to its positive effect on human health, the demand for blackberry fruit as a product has gradually been increasing (Reategui et al., 2014; Tosun and Yüksel, 2003). As are in all major manufacturer countries, because of increasing market demand in Turkey, blackberry cultivation has shown a significant increase in consequences of adaptation studies in recent years (Ağaoglu, 2003). Similar to growing of the blackberry production in the world and Turkey, blackberry production is gradually increasing in Bursa Province of Turkey where this study was done. Bursa, chosen as the study area, produces approximately 82% of the Country's production by itself. According to Turkish Statistical Institute's official figures for the year of 2017, in the last five years blackberry production quantities showed an increase of around 36% (Anonymous, 2019).

Significant diseases that cause economic losses in the cultivation of blackberry are the diseases caused by fungi. Even if cane and leaf rust disease caused by *Kuehneola uredinis* (Link) Arthur, one of those fungal disease, does not cause plant to die completely by severe infection, but causes significant yield loss (Ellis et al., 1991). The effect of cane and leaf rust disease on plant and yield varies according to the type of blackberry fruit (Gardner and Hodges, 1983). The first identification studies of cane and leaf rust caused by *K. uredinis* in blackberry orchards in Turkey was done by Erkan (2001). However, no studies have yet been carried out that suggest a method of controlling the disease in Turkey.

In a preliminary survey study conducted in 2015 in the scope of this study, it was seen that one of the major problems in blackberry cultivation experienced by the producers and that causing loss of productivity of blackberry was cane and leaf rust disease caused by *K. uredinis*. In the current situation, there is not any licensed fungicide against this disease in Turkey and therefore with this study it was aimed to develop a method for organic and conventional controlling cane and leaf rust disease. In this context, the efficacy of licensed fungicides, being used in the State of California in the USA against that disease, has been determined on controlling cane and leaf rust disease of blackberry cv. Jumbo in Bursa conditions.

2. Materials and Methods

2.1. Research Area and Plant Material

Kestel, a district of Bursa and leading blackberry production place of Turkey, was selected as research area. As a result of a survey earlier conducted by us in 2015 in the villages of Kestel, a blackberry orchard where cane and leaf rust disease identified was determined as fungicide trial area. Following the survey study for determination of the trial area, fungicide trials were carried out in 2016. The research was carried out in a 2–decare blackberry orchard. The orchard consisted of rows with 2 m row (block) spacing and 15 m row lenght. In this study, blackberry cv. Jumbo which are cultivated in the research area were used as plant material. Cane and leaf rust disease seen on the blackberry was the other material of the study.

2.2 Used Pesticides and Spraying Equipments

The fungicides were used in the study to determine the effectiveness of both organic and conventional spraying methods. Only 20% copper calcium sulfate (Ertar Bordoeaux 20 WP, 1.500g/100 L) was used in the organic spraying program. In the conventional spraying program, 20% copper calcium sulphate and then alternatively fungicides with active substances pyraclostrobin + boscalid (Bellis 12.8%+25.2% WG, 20 g/100L) and myclobutanil (Miclothane 24 E, 15 mL/100 L) were used. In order to control cane and leaf rust disease caused by *K. uredinis*, spraying was carried out in certain developmental periods of the plant. In this context, while the blackberry plant had not yet grown sufficiently, the hand sprayer (AQUATIC SX-CS2B) and in the following stage, the knapsack pulverizer (HB GARDEN TOOLS 16 L) were used for purpose of spraying the plant.

2.3. Method

2.3.1. Trial plan

In the 2-decare blackberry orchard used for fungicide trials, 5 consecutive rows were selected and each row named as one block. According to the randomized block design, each block had control, organic and conventional spraying parcels and there were 5 replications for each parcel type. Also, each replication (parcel) had 10 fruiting cane (floricane) (Table 1).

Table 1. Distribution of spraying programs in blocks according to the trial plan

1. Block	Organic Spraying	Conventional Spraying	Control
2. Block	Conventional Spraying	Control	Organic Spraying
3. Block	Control	Organic Spraying	Conventional Spraying
4. Block	Organic Spraying	Conventional Spraying	Control
5. Block	Conventional Spraying	Control	Organic Spraying

2.3.2. Application of spraying programs

20% copper calcium sulphate was used once only in the 1st spraying period in the organic spraying parcels. In the conventional (chemical) spraying parcels, firstly, 20%

copper calcium sulphate was used in the 1st spraying period, and then in the following spraying periods fungicides with active substances pyraclostrobin + boscalid (Bellis) and myclobutanil (Miclothane) were used intermittently. No fungicide was used in the control plots in the experimental design and only water was applied to these plots. The spraying process was terminated approximately one month before the harvest period. In the early stages of the spraying, since the canes of blackberries were newly grown and the canes could be easily sprayed, hand sprayer was used as spraying equipment. Due to the increase of leaf and fruit burden and by the growth of the primocanes, the knapsack pulverizator was used for the treatment of canes that bear fruit and disease. Detailed spraying program is given in Table 2.

Table 2. Names, doses and application periods of fungicides used in conventional spraying program

Application periods	Active substance and formulation of Fungiside Applied	Usage dose (in 100 L water)
1. Spraying	Copper Calcium Sulfate 20% WP	1500 g
2. Spraying	Myclobutanil 245 g/L	15 mL
3. Spraying	Pyraclostrobin+Boscalid 12.8%+25.2% WG	40 g
4. Spraying	Myclobutanil 245 g/L	15 mL
5. Spraying	Pyraclostrobin+Boscalid 12.8%+25.2% WG	40 g

2.3.2. Determination of prevalence and severity of the disease

Since any standard fungicide test method has not yet been created for blackberry cane and leaf rust disease in Turkey, the disease evaluation method for vine anthracnose disease proposed by the Ministry of Agriculture and Forestry of Turkey (Anonymous, 2016a) was used in this study for blackberries as they are bramble fruits. The counting for the evaluation of the disease were terminated after the last treatment, following the time when the duration of action of the fungicide and the duration of the incubation period of the disease agent passed and when the rate of disease in the control parcels exceeding 20%. In order to evaluate the disease, number of rust lesions on each of ten fruit-bearing canes in each block in the control, organic and classic spraying parcels were counted one by one, and the results were adjusted to the scale given in Table 3 and then severity of the disease was determined.

Table 3. Scale used to determine the severity of disease

Scale value	Definition
0	Disease-free canes
1	Canes with 1 – 2 infection lesion
2	Canes with 3– 4 infection lesion
3	Canes with 5– 6 infection lesion
4	Canes with 7 or more infection lesion

In the counting process, only rust lesions on canes were counted and it was not taken into account because counting of the rust in leaves was not possible. The prevalence rates of the disease in the parcels were determined as non-existent regardless of the number of rust signs in each plant body (= replication).

Towsend-Heuberger (1943) formula was applied to the scale values obtained as a result of counting and percent cane and leaf rust severity scores in blackberry were determined. The percentage effects of fungicides on cane and leaf disease were calculated according to the formula of Abbott (1925). One-way analysis of variance was performed by using ANOVA. The difference between the disease level was determined by Least Significant Differences (LSD) ($P < 0.05$).

3. Results

3.1. Symptoms of *Kuehneola uredinis* in Trial Area

As described by Ellis et al (1991), cane and leaf rust caused by *K. uredinis* in blackberry has made itself clear by the end of April with lemon-yellow pustules in the lesions formed by splitting the bark on the canes that hold fruits (Figure 1 a, b). With the impact of the rainy season, the increase in severity of the disease can be seen on the lower surfaces of the leaves of the plants in the fruit holding canes as of the end of May (Figure 1 c, d).

In the studies carried out in the blackberry orchards, there were no signs of cane and leaf rust disease on mature and yet unripe fruits or on the non-fruiting new canes (primocanes). Pustules with a lemon-yellow color on floricanes in the spring and summer period were observed to have been partially white after harvest in the fall period (Figure 1 e, f).

3.2. Effectiveness of Spraying Programs

The prevalence rates of the disease and the effectiveness of the fungicide spraying according to the spraying programs are shown in Figure 2, while the severity of the disease and the effectiveness of the fungicide spraying are given in Figure 3.

As it can be seen in Figure 2, the effectiveness of the conventional spraying program was 75% and was found significantly more effective than organic spraying. This result was obtained when the prevalence rate was 56% in the control parcels, 50% in the organic spraying parcels and 14% in the conventional spraying parcels.

As it can be seen from Figure 3, the effect of the conventional spraying program on the severity of the disease was found to be quite high compared to the organic spraying program. In this study, the severity of the disease was 26% in the control parcels, 24% in the parcels where the organic spraying program was applied

and in the parcels where the conventional spraying program was applied, a severity of 6.5% was detected.

Figure 1. The appearance of spores of *Kuehneola uredinis* on the cane and leaves of the blackberry

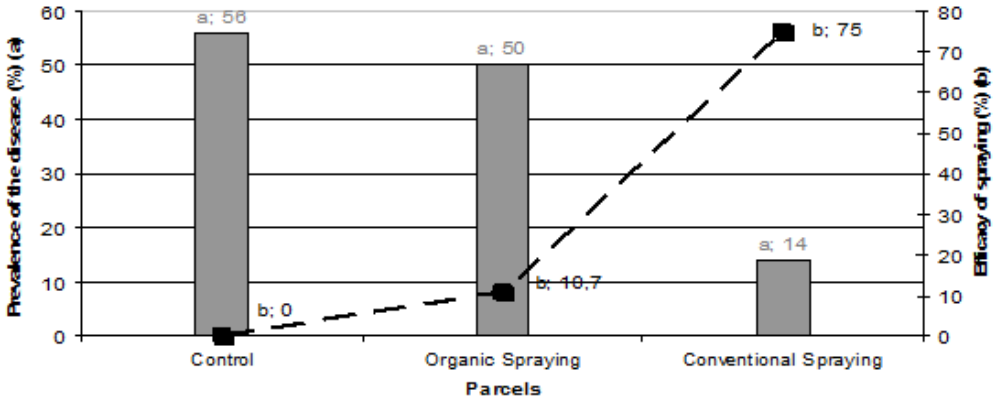

Figure 2. The prevalence rates (%) of *Kuehneola uredinis* in blackberry cv. Jumbo and the effectiveness of fungicide spraying in parcels according to spraying programs

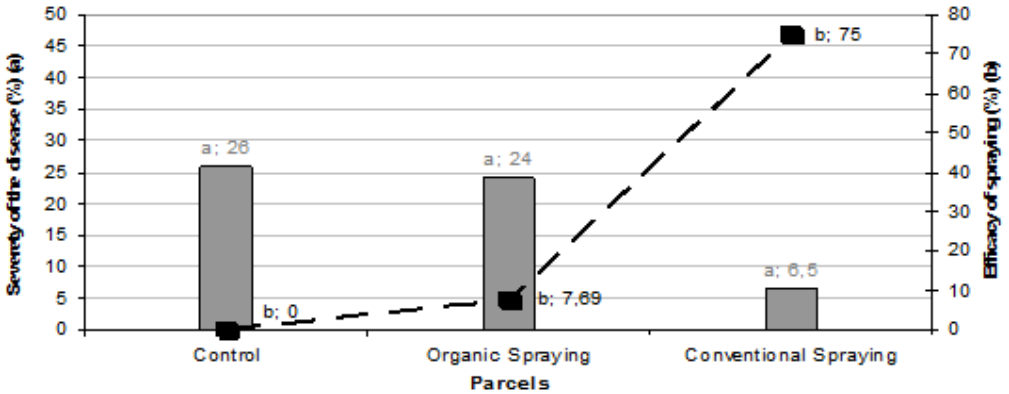

Figure 3. The severity of disease (%) of *Kuehneola uredinis* and the effectiveness of the fungicide spraying in blackberry cv. Jumbo in the parcels according to the spraying programs

4. Discussions

In this study, macroscopic symptoms in blackberries caused by *K. uredinis* were observed macroscopically on the canes and leaves in the trial area as indicated in the sources related to this disease (Ellis et al., 1991; Erkan, 2001). In addition, rust pustules of the pathogen were clearly observed at the end of April and although teliospores were not encountered, the width and length measurements of the uredospores were found and those sizes were found to be between 19-27 µm. The width and length measurements were found to be consistent with the literature (Ellis et al., 1991).

Different fungicides have been tested in different countries for controlling this disease and there are different suggestions (Boskovic, 1986; Ellis et al., 1991; Anonymous, 2016b; Anonymous, 2016c). In a study by Boskovic (1986), the effectiveness of 12 different fungicides against cane and leaf rust was evaluated on Thornless blackberries. It was observed that the fungicides with bitertanol active substance were highly effective (ensuring 95.5% protection) and the fungicides with triadimefon and benomyl active substances were sufficiently good level (85.4% and 84.4%, respectively. However, the usage of any fungicide with triadimefon, bitertanol and benomyl active substances are banned in Turkey.

Therefore they can not be seen a solution to cane and leaf rust caused by *K. uredinis*. According to Anonymous (2016b), Fischer and Johnson (1950) suggested various fungicide applications for prevention of cane and leaf rust disease in addition to cultural practices such as; usage of lime sulfur application in dormant period in winter, and alternatively usage of fungicides with pyraclostrobin, copper fungicides, fungicides with myclobutanil and fungicides with propgenazole + lambda-cyhalothrin at green budding stage and then again immediately before blooming stage.

Ellis et al. (1991) reported that in order to reduce the inoculums on the cane and leaf rust disease, infected old canes (floricanes) should be removed from the orchard immediately after the fruit harvest. It is stated that a 3-pesticide spraying program for cane and leaf rust disease control was applied in the Oregon State of the USA. According to this program, following the application of lime sulfur in winter, two different copper leaf spraying were applied immediately after the green budding. Then the same process was repeated before the flowering. However, it is stated that this application does not provide enough effect for controlling the disease.

The University of California has proposed a proposal for both organic spraying and conventional spraying to control cane and leaf rust disease. In the blackberries highly sensitive to *K. uredinis*, in additon to cultural practices it is recommended to use protective fungicides before the symptoms of the disease seen. In Anonymous (2016c), it has been suggested to remove the infected canes from the orchard after harvesting and to treat them with lime sulfur or copper mixtures for organic production. As the conventional method of spraying; it is recommended to use alternatively lime sulfur (8 L / 100 L water, 187 L water / da) in the dormant period in winter, copper mixtures (in the ratios indicated on the label) and lime sulfur (8 L / 100 L water) in the delayed dormant period, copper mixtures (in the ratios indicated on the label), and fungicides with myclobutanil (35 - 85 g), pyraclostrobin + boscalid (525 - 652 g) and pyraclostrobin (397 g) active substances in the first flowering.

In Turkey there is not any suggestion for management of cane and leaf rust disease caused by *K. uredinis* except cultural practices like removing infected old fruiting canes by pruning from orchard immediately after harvest. The competent authority on plant protection, the Ministry of Agriculture and Forestry of Turkey (MAFT), has no suggestion on licensed fungicides to use for controlling cane and leaf rust that is a serious problem in blackberry cultivation in Turkey (Anonymous, 2018). In this study, the effectiveness of the spraying programs was tried to be revealed in two different ways according to the prevalence rate and disease severity in the parcels. In Figure 2 and Figure 3, according to the disease prevalence and disease severity, respectively when looked at effectiveness of the treatment programs, it can easily be seen that there is no significant difference and change in the effectiveness of the spraying programs by calculating the prevalence rate or disease severity. In the study, the efficacy of the conventional spraying program (Figure 2) is 75% in terms of the prevalence of the disease, while the efficacy of the conventional spraying program is also found to be 75% according to disease severity (Figure 3). In the organic spraying program, efficacy according to the prevalence rate of the disease is 10.7%, while it is found to be slightly lower 7.69% in terms of disease severity (Figure 2 and 3) when compared to the prevalence rate of the disease. This situation can be considered insignificant. This result suggests that it may be sufficient to conduct studies by taking into account the prevalence rates of the disease in plants, without using the scale values that require intensive labor in the later fungicide trials.

Within the scope of this study, the effect of both organic and conventional spraying methods on cane and leaf rust in the blackberry cv. Jumbo orchards, which is one of the common cultivar of blackberry in Turkey, was tried to be determined. According to the results of the study; in the trial orchard, it was found that the severity of the disease increased to 26% in the control parcels one month before the harvest. The incidence of disease in organic parcels in the counting period was determined as 24%. The efficacy of the copper fungicide on cane and leaf rust disease, which applied once for organic spraying, was determined as 7.69%. According to this result, it can be concluded that the method of applying copper fungicide, which is commonly used by farmers, cannot achieve sufficient results in the controlling the disease. A review of the spraying time and perhaps even twice a year by spraying with copper fungicides will help to achieve higher

efficiencies and make producers not to abandon organic blackberry cultivation promptly. However, it should be kept in mind that copper fungicides are protective fungicides.

In the study, the effectiveness of licensed fungicides and their application methods, being used in the State of California in the USA against cane and leaf rust disease of blackberries, were determined on blackberry cv. Jumbo orchards in Bursa conditions. The incidence of the disease was determined as 6.5% in the conventional spraying applied parcels. The efficacy of the fungicides used for conventional spraying was found to be 75%. Although 75% is a significant level of effectiveness, it is possible that MAFT does not consider this effectiveness level to be sufficient for a registration application for pesticides to be used against cane and leaf rust disease of blackberries. For this reason, in order to increase the effectiveness of the conventional spraying, it is considered that it would be beneficial to increase the range of spraying intervals or to give more place to the fungicides with myclobutanil active substance which have more systemic and curative properties.

In addition to cultural and chemical control methods, the cultivation of resistant varieties can be seen as an option for controlling Blackberry cane and leaf rust disease. However, necessity of taking some factors into consideration like adaptation to climate and soil conditions, differences in the harvest period, fruit size, aroma and taste, fruit durability, compatibility with fresh consumption or food industry and so on that will not always provide an opportunity for selecting cane and leaf rust disease-resistant blackberry cultivar. In this study, blackberry cv. Jumbo, which has been targeted for spraying experiments within the scope of this study, is one of the most popular blackberry cultivars in Turkey because of its taste, fruit size and compliance with the conditions. For these reasons, it is seen that there is a need for further development of the method of controlling cane and leaf rust disease of blackberry cv. Jumbo and of other blackberry cultivars which are preferred for cultivation in Turkey.

As a general evaluation, it is thought in terms of organic agriculture that since copper-based fungicides can be sold without over-the-counter and they are suitable for organic agriculture, the current situation can be continued by some improvement. Commercial products are still lack for this disease in Turkey and thus producer's requests for providing better control of the disease make them use illegal fungicides or even face with residue problems. For these reasons, first of all, more effective spraying programs should be considered with the use of copper fungicides or other biological preparations recommended in organic agriculture. Furthermore, it can be considered that programs that include systemic fungicides with higher therapeutic properties may be developed in future studies. It can be expected that the effective control with the diseases seen in blackberry cultivars will contribute to the further spread of the production of the fruit in Turkey, which has an increasing importance in the world.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Abbott WS. 1925. A method of computing the effectiveness of an insecticide. J Econ Entomol, 18: 265-267.

Ağaoğlu YS. 2003. Bramble fruits production. In: Workshop on development of fruit production in Turkey; 2003 September 24; Ankara, TR, Fruit Juice Industry Asssociation of Turkey (Edition no:2).

Anonymous. 2016a. Plant diseases standard pesticide trial methods - Fruit and vine diseases, Vine anthracnose disease [*Elsinoe ampelina* (De Bary) Shear] standard pesticide trial method, http://www.tarim.gov.tr/TAGEM/Menu/28/Yayinlar_veriler - (Date of access: 01/09/2016).

Anonymous. 2016b. Pacifik Nortwest plant disease management handbook, http://pnwhandbooks.org/plantdisease/node/2792/print - (Date of access: 01/09/2016).

Anonymous. 2016c. UC pest management guidelines, http://ipm.ucanr.edu/PMG/ r71100311.html - (Date of access: 01/09/2016).

Anonymous. 2018. Turkish Ministry of Agriculture and Forestry Website, Plant protection products database, https://bku.tarim.gov.tr/Arama/Index, (Date of access: 01/01/2018).

Anonymous. 2019. Turkish Statistical Institute Website – Crop production statistics, https://biruni.tuik.gov.tr/bitkiselapp/bitkisel.zul - (Date of access: 01/01/2019).

BoskoviçI. 1986. Contribution to the possibility of protecting blackberries from the causal agent of yellow rust (*Kuehneola uredinis* (Link) Art.). Jugoslovensko Vocarstvo, 20: 95-97.

Clark JR, Finn CE. 2014. Blackberry cultivation in the world. Rev Bras Frutic, 36: 46-47.

Ellis MA, Converse RH, Williams RN, Williamson B. 1991. Compendium of raspberry and blackberry diseases and insects. 2nd ed. APS Press, The American Phytopathological Society, Ohio, USA.

Erkan M. 2001. New records fungi isolated from raspberry and blackberry plants from BursaProvince in Turkey. Journal of Turkish Phytopathology, 30 (1): 35-38.

Fischer G W, Johnson F. 1950. Cane and leaf rust (*Kuehneola uredinis* (Link) Arthur) of blackberries in western Washington. Phytopathology, 40: 199-204.

Gardner DE, Hodges CS. 1983. Leaf rust caused by *Kuehneola uredinis* on native and nonnative Rubus species in Hawaii. Plant Disease, 67: 962-963.

Reategui JLP, Machado F, Barbero G, Rezende C, Martinez J. 2014. Extraction of antioxidant compounds from blackberry (*Rubus*sp.) bagasse using supercritical CO_2 assisted by ultrasound. J Supercrit Fluids, 94: 223-233.

StrikBC, Clark JR, Finn CE, Banados MP. 2007. Worldwide blackberry production. Horttechnology, 17(2): 205-213.

Tosun İ, Yüksel S. 2003. Antioxidant capacity of bramble fruits. J Food, 28 (3): 305-311.

Townsend GR, Heuberger JW. 1943. Methods for estimating losses caused by diseases in fungicide experiments. Plant Disease Reporter, 27 (17): 340-343.