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ORIGINAL PAPER

FUNGICIDES EFFECT ON THE HEART ROT INFESTATIONS AT POMEGRANATE FRUIT

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Abstract

The aim of present study was to determine the effects of four fungicide applications on Heart rot caused by Alternaria spp at pomegranate fruits. Heart root causes decay at pomegranate arils without obvious external symptoms. Slight change in shape and abnormal skin colour occur at infested fruits but it is highly difficult to comprehend fruits on the tree and even in pack houses. Studies conducted in 2015 on two different pomegranate orchards with Wonderful cv. located in Northern Cyprus. The experiment was planned in completely randomized block design and repeated in two orchards. Four replications were assigned for each treatment and five plants were selected for each replication. The treatments of present study are: Control; Cupper oxide; Azoxystrobin; Boscalid + Pyraclostrobin; and Propiconazole + Difenoconazol. Two repeated applications of copper oxide were performed before flowering and two repeated applications of other three fungicides performed during flowering and fruit set. Fruits of the each replication were harvested by hand at commercial maturity. All fruits were counted and put in different plastic creates and brought to pack house for analysis. Thus, all fruits were cut to determine if disease exist. Number of infected fruits by heart rot was noted and data from the experiments were subjected to the analysis of variance. Mean separations were done by using Tukey's multiple range test at $P < 0.05$. Results showed that there is a significant difference between the percent infestations of Heart rot in Orchard 1 and Orchard 2. However, the effects of tested chemicals are found to be similar in both orchards. According to the results obtained, as expected, the highest Heart rot infestation was found to be at the control treatment with 8.8% and the highest effect measured at Propiconazole + Difenoconazol application with only 2.4%. All treatments were found to be effective in reducing the infestations of Heart rot and significant differences were determined among the treatments. Percent infestation of Heart rot for Boscalid + Pyraclostrobin, Copper oxide and Azoxystrobin applications were measured as 3.7%, 4.2% and 6.9%, respectively.

Key Words: Alternaria spp., Copper oxide, Northern Cyprus, Propiconazole + Difenoconazol, Wonderful cultivar

INTRODUCTION

Pomegranate (*Punica granatum* L.) was one of the earliest domesticated fruit crops together with; figs, dates, olives and grapes; which was first planted during 4000 and 3000 BC even mentioned in the Quran and Bible (Lye, 2008). Pomegranate plants have their own botanical family: the Punicaceae. It is native to central Asia (Holland et al., 2009). Pomegranate fruits are traditionally known to be beneficial for human health and used as medical purposes. Numerous studies carried about pomegranates (Gil et al., 2000; Lansky et al., 2005; Jurenka, 2008; Turk et al., 2008; Haidari et al., 2009; Okatan et al., 2018; Korkmaz and Aşkın, 2017) and confirmed its beneficial effects on human health. Valuable findings of these studies caused an increase on the public awareness about pomegranates, and it increased the consumption and production of pomegranate fruits. Pomegranate tree is easily adaptable to different climatic conditions and it can be produced in many different geographical regions including Mediterranean and Asian countries, The United States, Brazil, Chile, South Africa, Australia and Israel (Kahramanoğlu and Usanmaz, 2016).

Pomegranate trees are susceptible to many pests and diseases. Among the pests and diseases, aphids (*Aphis punicae*), Mediterranean fruit fly (*Ceratitis capitata*), *Alternaria* black spot, pomegranate butterfly, (*Deudorix* '*Virachola*' *livia*), black heart and bacterial blight (*Xanthomonas axonopodis* pv. *punicae*) are the most devastating and loss causing agents to growers. However, perhaps the most important problem of the pomegranate is the Heart Rot (also known as: Black Heart) (Kahramanoğlu et al., 2014). Main agent of Heart rot is reported to be *Alternaria* spp. The damages of Heart rot has seed as decay of arils ranging from sections to all the arils, without obvious external symptoms except slightly abnormal skin colour or changes in shape. When a pomegranate has Heart rot, it is no longer marketable and the producer risks losing crop income. It was a big challenge for the producers and pack houses where this disease has not obvious external symptoms. Kahramanoğlu et al. (2014) reported that the density of Heart rot is 20.31% and 9.82% for the cultivars of Acco and Wonderful, respectively in 2013 in Cyprus.

Alternaria spp. was reported to be the major source of Heart rot (Barkai-Golan, 2001, Crites, 2004, Michailides et al., 2008, Stein et al., 2010, Zhang and McCarthy, 2012, Ezra et al., 2014, Kahramanoğlu et al., 2014). This fungus enters the blossom and then grows in resulting fruit rot. The infection process is not completely understood, and the type of *Alternaria* resulting in the infection is still being isolated. Moreover, there is no efficient control for this disease. Removal of old fruit from the tree is suggested to eliminate the potential source of the fungus. This study aimed to determine the effects of four different fungicides (Copper oxide, Azoxystrobin, Boscalid+Pyraclostrobin and Propiconazole+Difenoconazol) on the Heart Rot infestation at pomegranate fruits cv. Wonderful.

MATERIALS AND METHODS

Studies conducted in 2015 on two different pomegranate orchards with Wonderful cv. located in Northern Cyprus. Mediterranean climate is dominant in the region with relatively mild winters and hot summers. During the studies, trees were 7-years old, planted with 5 x 3 m distance and pruned as globe shape with one stem. Irrigation and fertilization were performed according to the basic needs of plants (Usanmaz et al., 2014) with drip irrigation. Rather than tested fungicides, 141 g/l Thiamethoxam + 106 g/l Lambda-cyhalothrin 20% (40 ml / 100 L water) application was done against Aphids on 14th March 2015. Field experiments were conducted to determine the effects of four fungicides on Heart Rot caused by *Alternaria* spp. The experiment was planned in completely randomized block design and repeated in two orchards. Four replications were assigned for each treatment and five plants were used in each replication. The treatments of present study were:

[1] Control [no any copper oxide or fungicide applications]
[2] Copper oxide 75% [Nordox 75 WG, Cupper oxide equivalent to 75% metallic cupper, DOĞAL KİMYA, dose: 125 g/100 L water];
[3] Azoxystrobin [Quadris SC, 250 g a.i. L^{-1}, SYNGENTA, dose: 75 cc/100 L water];
[4] Boscalid + Pyraclostrobin [Bellis WG, 25.2 g a.i. & 12.8 g a.i. kg^{-1}, BAYER, dose: 50 cc/100 L water];
[5] Propiconazole + Difenoconazol [Pronto 300 EC, 150 g a.i. & 150 g a.i. L^{-1}, AGROFARM, dose: 50 cc/100 L water].

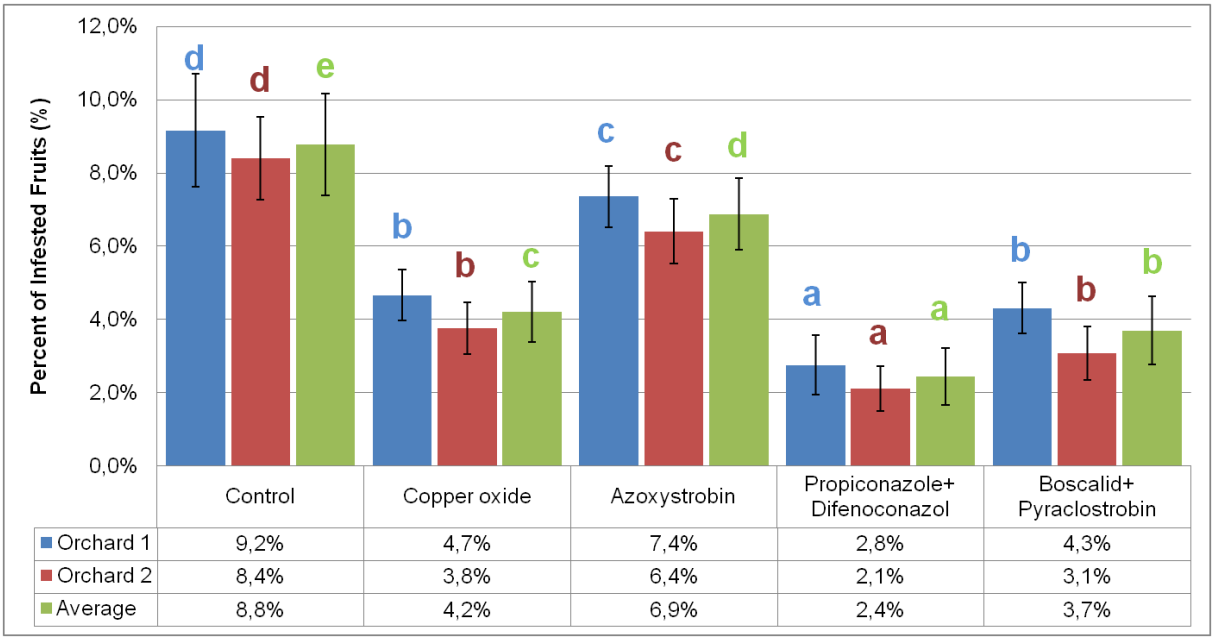
Heart Rot infection is known to begin in the orchard especially following rain during flowering and early fruit development. However, copper oxide is known to have some negative effects on the flowers and fruit set. For this reason, application of copper oxide is performed two times, both before flowering. First application performed on 7th of February 2015 during hibernation and second application on 28th of March 2015 just before flowering. Applications of other fungicides also performed two times, first on 9th of May 2015 (at the time of 50% bloom) and second application 14 days later. Hand atomizer with fan type nozzles used to apply fungicides where a total of 2.25 L of water was required to spray 1 tree. Fruits of the each replication were harvested by hand at commercial maturity. All fruits were counted and put in different plastic creates and brought to pack house for analysis. Thus, all fruits were cut to determine if disease exist (Picture 1.).

Picture 1. View of Heart rot (*Alternaria* spp.) damage.

Number of infected fruits by heart rot was noted. Thus, the data were subjected to analysis of variance and efficacy of treatments was determined. Mean separations were done by using Tukey's multiple range test at $P < 0.05$.

RESULTS AND DISCUSSION

The first appearance of Heart rot in pomegranate orchards observed after 2010 in some of the European countries [i.e. Cyprus (Kahramanoğlu et al., 2014), Spain (Berbegal et al., 2014), Italy (Faedda et al., 2015)]. One of the main causal agents of Heart rot is *Alternaria alternata* which also causes some spots on fruits or leaves. Symptoms included black spots on leaves and fruits, as well as chlorosis and premature abscission of leaves. The causal agent of Heart rot in present study was also *Alternaria* spp. The results of present study are in accordance with the findings of Kahramanoğlu et al. (2014) where they reported that the density of Heart rot is 9.82% for the Wonderful cultivar in 2013 in Cyprus. Results for the effects of fungicides are given in Figure 1. Control trees found to have 8.8% of *Alternaria* infestation and the least effective application was found as the Azoxystrobin with 6.9% infestation. It is clear from the results that the highest efficacy obtained from the application of Propiconazole + Difenoconazol as 2.4% infestation. Previously Kumar et al. (2017) reported that Azole group fungicides (Tebuconazole and Propiconazole) are effective to inhibit the growth of *Alternaria alternata*. The second best effect obtained from the application of Boscalid + Pyraclostrobin where the *Alternaria* infestation was measured as 3.7%. When comparing the orchards individually, no difference was obtained between the applications of Boscalid + Pyraclostrobin and Copper oxide. However, when considering the averages of both orchards, Boscalid + Pyraclostrobin application was found to be more effective.



	Control	Copper oxide	Azoxystrobin	Propiconazole+ Difenoconazol	Boscalid+ Pyraclostrobin
Orchard 1	9,2%	4,7%	7,4%	2,8%	4,3%
Orchard 2	8,4%	3,8%	6,4%	2,1%	3,1%
Average	8,8%	4,2%	6,9%	2,4%	3,7%

Figure 1. Effects of different fungicides on the percent infestation of *Alternaria* spp. on pomegranate fruits.

Barkai-Golan (2001) reported that *Alternaria* spp. enters the fruit during bloom and early fruit set. The spores of fungus are mostly found on organic materials, weeds and fruit wastes, and transmission of fungus from host to the bloom needs some biotic or abiotic factors to be transmitted. Transmission of *Alternaria* spp. to the heart of the fruits in other plant types can be by: wind (Bashen et al, 1991; Timmer et al., 2003), rain (Chen et al., 2003) and various pests (Köhl and van der Wolf, 2005). Results of present study showed that application of copper oxide, which performed before flowering, prevents the infestation of *Alternaria* spp. This might be as a result of the elimination of *Alternaria* spp. spores in the environment and on the plants.

CONCLUSIONS

The control of Heart rot caused by *Alternaria* spp. is the major problem of pomegranate growers and pack houses. The results of present study showed that the infestation of *Alternaria* spp. at the pomegranate fruit might be reduced with early applications of Copper oxide (before flowering) or be reduced with the applications of Propiconazole + Difenoconazol (during full bloom). Results of the experiments suggest that two repeated applications of Propiconazole + Difenoconazol might reduce infection of *Alternaria* spp. to around 2.5% where the natural control is around 8.8%. Combined applications of Copper oxide and Propiconazole + Difenoconazol had not tested in the present study but results suggest that combined applications of these two fungicides (one in winter period and the other one is full bloom period) might give best results but needs clarification.

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