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Full Length Research Paper

Effects of shading and covering material application for delaying harvest on gray mold disease severity

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To delay the harvest of Sultani Cekirdeksiz grape variety and to reduce pre and post-harvest botrytis bunch rot severity, shading and covering material application were tested in 2009 to 2010 growing periods. In this study, grape vines were shaded with shading materials which had three different shading densities (35, 55, and 75% shading density) from veraison period to harvest. The grape vines were also covered with four different covering materials (transparent polyethylene, mogul, polypropen cross-stich and lifepack) before rainfall, at the end of August until harvest. The gray mold severity was recorded three times (before shading at unriped grape stage, veraison period, shortly after shading and twice at 20 day interval) during growing period. Based on the results of this study, the highest gray mold (*Botrytis cinerea*) severity was obtained in the control (uncovered and unshaded) treatment and the lowest disease severity was observed in lifepack treatment with or without shading. Since gray mold disease of grape was the main factor affecting harvest date of the crop lifepack, + 35 or 55% shading could be recommended to delay harvest and reduce the gray mold severity of grape in Manisa province-Turkey.

Key words: Sultani seedless, table grape, shading, cover material, delaying harvest disease severity, *Botrytis cinerea*.

INTRODUCTION

Annual grape production in the world is 66 935 199 tons and approximately 6.37% of the world grape production (4 264 720 tons) is produced in Turkey. Large amount of the grape produced in Turkey was used as table grape and raisin, and the remaining for making rakı, wine, vinegar, molasses, dried fruit pulp, sausage and dried foodstuff, etc. (Agaoglu, 2002; Fao 2010; Çelik et al., 2010). The climates of Turkey especially Aegean region are suitable for grapevine cultivation. Approximately 6% of the world table grape and 33% of raisin productions are provided by Turkey. A comparison with other grape producing countries throughout the world shows that Turkey was the 2nd largest seedless dry grape supplier after USA and has good progress in table grape exportation (Celik et al., 2010). Based on the 2008 year data, table grape export of Turkey was 202 114 tons/year and between 2004 and 2008, the rate of the seedless Sultani cultivar within the exported table grape was about 86 to 95% (Celik et al., 2010).

However, an important quantity of table grape is lost at various points between harvest and consumption. As with other fruits, the losses of quality are based on weight loss, colour changes and accelerated softening and decay due to diseases (Soylemezoglu, 2001). One of the most important post-harvest diseases of table grape is gray mold caused by *Botrytis cinerea.* This fungus is very common in nature and causes diseases on a variety of unrelated crops. Bunch rot can cause serious losses on highly susceptible grape varieties although, berries of all grape varieties are susceptible to bunch rot. Losses result from the rotting of berries in the vineyard or in storage (Yildiz et al., 2002). Infection of ripe berries is the most common and destructive phase of this disease. Infected berries first appear soft and watery. The berries of white cultivars become brown and shrivelled and those of purple cultivars develop a reddish colour. Under high relative

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humidity and moisture, infected berries usually become covered with a gray growth of fungus mycelium (Ari, 2002; Yildiz et al., 2002). The control of gray mold was obtained using sulphur and synthetic fungicides; anilinopyrinidines were found to be also effective against *B. cinerea*, although populations resistant to aniline-pyrinidines have been reported recently (Artes-Hernandez et al., 2003).

However, the associations of pesticide usage with the development of fungicide-resistant strains and the public's concern for the human health conditions and the environmental pollution have stimulated the search for new strategies as alternative means for controlling post harvest decay. Therefore studies focus on the use of cover materials and shading to prevent the decay of grape berries. In viticulture, full covering of grape vine with polyethylene cover aims to cause early ripening in early variety, delay harvest of moderately or late maturing varieties, and eliminate the negative effects of rain, hail, storm, snow and diseases during the flowering and maturation stages of vines (Agaoglu, 1977; Kimura and Kawabuchi, 1984; Uzun, 1988; Đshi et al., 1989; Uzun, 1993; Ergenoglu et al., 1999; Yuksel, 2001).

In recent years, shading materials were used to protect the crops from hail damage and sunburn. The shading materials so-called net or network with different shading intensities are used in grapevine cultivation and vineyards. Shading applications has started to be implemented in practice in different regions of the world on viticulture while research on the topic continues to be done (Kliewer ve ark., 1967; Smart ve ark., 1988; Keller ve ark., 1998). In the study on Kyoho grape variety, it was reported that the vines were protected from adverse climate conditions especially from rain by shading (Kimura ve Kawabuchi, 1984). It also provided advent-ages such as extending the harvesting period and protection from the rain (Avenant and Loubser, 1993).

In Chile, especially late harvested grapes were adversely affected by rainfall. In this context, a study was conducted on Thompson Seedless grape cultivar to determine the effects of covering clusters on harvest period and grape quality. When the vines were covered with the polyethylene cover during adverse weather conditions, significant differences were obtained on harvest time and post-harvest storage (30 and 50 days) characteristics of the berries as compared to the control. The cracking and moulding rates of berries were lower in covering treatments than in the control both at harvesting time and post-harvest storage period. After 30 days of harvest, lost rates due to decay were 2.2 and 1.0% in the control and in the cover treatments, respectively while they were 2.1 and 1.0% in the control and in the cover treatments, respectively after 50 days of harvest. Cracking was not observed in both control and cover treatments after harvest (Soza ve ark., 2007). In another study, plastic cover treatments reduced the gray mold intensity on Riesling wine variety in Brazil (Anonymous, 2005). Additionally, plastic covers were used on Thomson seedless grape cultivar in Australia and on red globe variety in California-USA to protect the yields from rainfall (Anonymous, 2009a; Liberman, 2009).

Combined application of different shading and cover materials were performed in this study to determine the influence of different level of shading and cover materials on gray mold disease of Sultani seedless grape variety under *in vivo* conditions.

MATERIALS AND METHODS

Sultani seedless grape variety vines, were grafted on 41B rootstocks, grown at the Manisa Viticulture Research Station, Manisa-Turkey. Vineyard was established with 3 m spacing between rows and 2 m distance in rows in 2000. Vines were trained as head onto double Ŧ (4 rows wire) trellis system. The experiments were arranged in randomized split plot design. The main plot was shading and the sub-plot was the cover materials. There were 17 treatments and four replications (Table 1). During both seasons, natural inoculums occurred as a source of the disease and no extra inoculums was necessary. The green polyethylene net with three different shading rates (SR) (35, 55 and 75%) was placed over vines at veraison period (at the beginning of July). Close to harvest time (on 20 August), vines were covered with four different covering materials [transparent polyethylene, mogul (Agrimol), lifepack and polypropylene cross-stich] to protect the grape bunches from adverse effects of rain and to delay the harvest (Table 1). Properties of the cover materials used in this study were given as follows: Transparent polyethylene cover (TPC): transparent, 0.33 mm thick, 3% UV and 95% light transmission; mogul (Agrimol)(MG): white colour, 0.28 mm thick, weight, 30 g/m^2, 145 cm^3/cm^{2-}sc air transmission, 70% light transmission and 3% UV; olypropylene cross-stich (PCS): white cloth made of polypropylene by weaving; Lifepack (LP): consist of three layers (30 g/m^2 Spunbond+20 mc breathable layer+15 g/m^2 spunbond), waterproof, upper layer of it 8% UV.

Disease evaluation

Disease severity (rate of diseased berries/ cluster) was estimated three times during growing period (before shading at unripe berries, at veraison period soon after shading, after covering and twice with 20 days interval). Gray mold severity was etermined with the use of a 0 to 4 rating scale; 0 = no visible symptoms on cluster; 1 = up to five infected berries per cluster; 2 = 1/5 of the cluster diseased; 3 = 2/5 of the cluster diseased and 4 = 3/5 of the cluster diseased (Anonymous, 2009b). Percentage disease severity was calculated using Tawsend-Heuberger equation:

$$\text{Disease severity (\%)} = \frac{\sum (\text{category value x no. of plant in each category})}{\text{Total number of clusters x maximum category value}} \times 100$$

Data was analysed for variance and means were separated according to Duncan’s multiple range tests.

RESULT AND DISCUSSION

Harvest was delayed at cover applications and shade net x cover material treatments when compared with the

Table 1. Shading and cover applications tested in the study.

Treatment	Shading (%)	Cover material
0+ Control (un covered)	0	-
SR 35% +TPC	35	Transparent polyethylene
SR 55% + TPC	55	Transparent polyethylene
SR 75% + TPC	75	Transparent polyethylene
TPC (prevent rain)	0	Transparent polyethylene
SR 35% +MG	35	Mogul
SR 55% +MG	55	Mogul
SR 75% + MG	75	Mogul
0+MG (prevent rain)	0	Mogul
SR 35% +PCS	35	Polypropylene cross-stitch
SR 55% + PCS	55	Polypropylene cross-stitch
SR 75% + PCS	75	Polypropylene cross-stitch
0+PCS (prevent rain)	0	Polypropylene cross-stitch
SR 35% + LP	35	Lifepack
SR 55% + LP	55	Lifepack
SR 75% + LP	75	Lifepack
0+LP (prevent rain)	0	Lifepack

control (open field), in both years. While the harvesting date of the control was August 14th 2009 growing season, the harvesting date of 75% shading+LP treatment was 20th October. Similarly, in 2010 growing season, 55% shading+LP treatment provided 13 days delay in harvest as compared with the control. The delayed harvest time changed from 44 and 60 days in 2009, to 22 and 44 days in 2010 for shade nets and cover material combination treatments. In the study, it was showed that shade net and cover material treat-ments delayed the harvest time. 35.55 and 75% shade nets with LP cover gave the best results.

Long term maintenance of the quality of fresh grapes is becoming increasingly significant as the supply of high quality commodities constantly exceed demand. The consumer expectation in the supply of fresh produce is partly matched by long term storage which is not profitable for the producers in Manisa province. In table grape, gray mold caused by *B. cinerea* is also considered the most important limiting factor for the maintenance of the quality of fresh grapes. The uncontrolled infections result in the development of aerial mycelium spreading rapidly to adjacent berries with severe economical repercussions even in storage. The alternative way for the maintenance of the quality of fresh grapes without storage was keeping the clusters on vine until late season. To eliminate the effects of adverse weather conditions and decay caused by *B. cinerea* during these periods, combined applications of different shading and cover materials were performed.

In this study, Botrytis bunch rot was reduced by combined application of the different shading and cover materials. Bunch rot severity was significantly lower in the combined application of cover materials and shading treatments compared to the control during both seasons ($P \leq 0.05$). Cover materials application significantly affected the development of Botrytis bunch rot during pre-harvest period in 2008 to 2009 and 2009 to 2010 especially in lifepack treatment used as cover material (Table 1). Among the cover materials used in this study, transparent polyethylene cover and lifepack did not passed precipitation underneath, while mogul and polypropylene cross-stich allowed rainfall to pass through the lower section. While moisture condensation occurred at the inner surfaces of the transparent polyethylene cover and polypropylene cross-stich, the moisture condensation was not observed at the inner surface of lifepack and mogul. These features of the cover materials affected the gray mold severity and amount of the marketable yield. Higher marketable yield and lower disease severity were observed, when lifepack was used as the cover material, while lower marketable yield and higher disease severity was observed, when transparent polyethylene and polypropylene cross-stich were used as the cover materials. In the vineyard, the severity of Botrytis bunch rot during 2009 growing period ranged from 17.7 to 46.6% in 0% shading combined with the covering treatments, from 9.4 to 35.7% in 35% shading combined with covering treatments, from 7.3 to 28.6% in 55% shading combined with covering treatment and from 3.9 to 12.0% in 75% shading combined with covering treatments. Similarly, the severity of Botrytis bunch rot during 2010 growing period ranged from 40.4 to 59.6% in 0% shading combined with covering treatments, from 26.8 to 53.4% in 35% shading combined with covering treatments, from 21.1 to 43.0% in 55% shading combined with covering treatment and from 28.4 to 41.2% in 75% shading combined with covering treatments (Tables 2

Table 2. Effects of cover materials treatment on gray mold disease severity (%) in 2009.

	Shading rate			
	0%	**35%**	**55%**	**75%**
Polypropylene cross-stitch	46.4^{b}	32.0^{b}	12.8^{ab}	3.9^{a}
Lifepack	17.7^{a}	9.4^{a}	7.3^{a}	8.1^{a}
Mogul	46.1^{b}	21.6^{ab}	23.2^{bc}	12.0^{a}
Transparent polyethylene	46.6^{b}	35.7^{b}	28.6^{c}	$9 .9^{a}$
Control	60.2^{b}	60.2^{c}	60.2^{d}	60.2^{b}

* In column, means followed by a same letter are not significantly different at 5% level.

Table 3. Effects of cover materials treatment on gray mold disease severity (%) in 2010.

Cover materials	Shading rate			
	0%	**35%**	**55%**	**75%**
Polypropylene cross-stitch	43.2^{a}	53.4^{ab}	43.0^{a}	40.6^{a}
Lifepack	40.4^{a}	26.8^{a}	21.1^{a}	28.4^{a}
Mogul	47.1^{a}	33.3^{a}	35.7^{a}	37.5^{a}
Transparent polyethylene	59.6^{ab}	52.6^{ab}	35.4^{a}	41.2^{a}
Control	75.6^{b}	75.6^{b}	75.6^{b}	75.6^{b}

* In column, means followed by a same letter are not significantly different at 5% level.

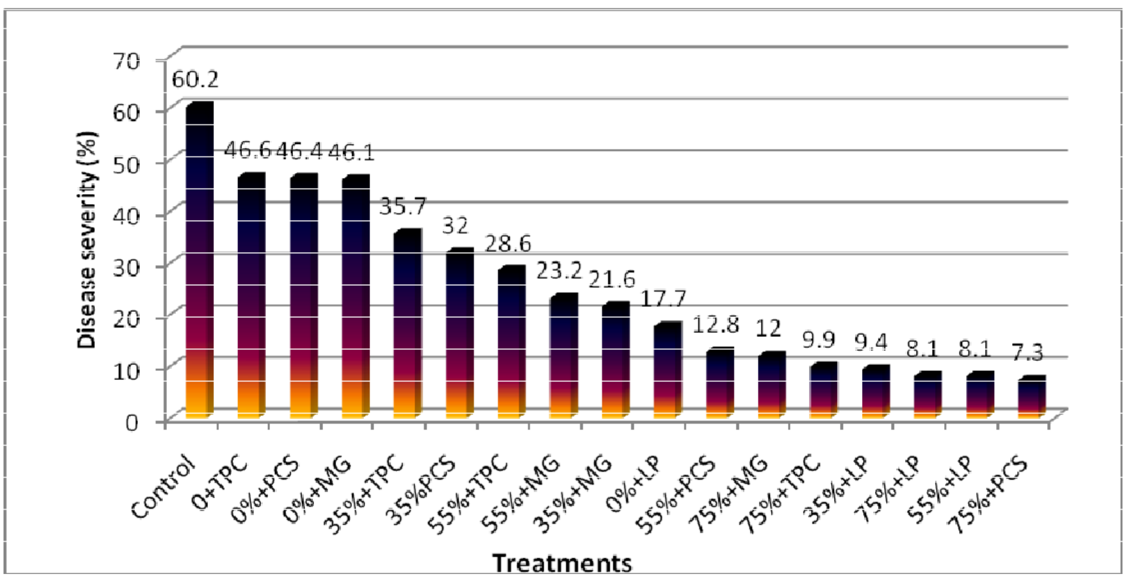

Figure 1. Effects of combined applications of shading and cover materials on disease severity of gray mold disease of grape in 2009 growing period.

and 3).

The incidence of Botrytis bunch rot severities in the untreated controls were 60.2 and 75.6% in 2009 and 2010, respectively. The severity of Botrytis bunch was significantly affected by treatment. Due to the higher disease pressure in 2010 growing period, bunch rot severities were found higher in 2010 than in 2009 (Figures 1and 2). Thus, occurrence of decay was 75.6% in the control grapes and significantly reduced by the combined applications of 35% shading + lifepack (9.4%), 55% shading + lifepack (8.1%) and 75% shading + lifepack (8.1%) in 2009. Similar results were obtained in 2010 with the results of the previous year bunch rot severities as 26.8, 21.1 and 28.4% in 35% shading+lifepack, 55% shading+lifepack and 75% shading+lifepack applications, respectively (Figure 2).

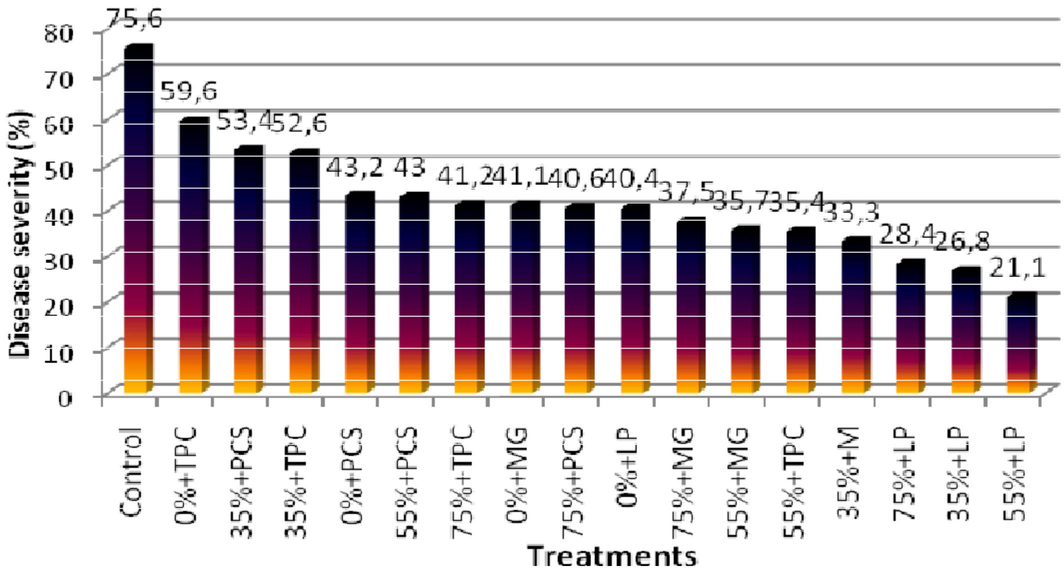

Figure 2. Effects of combined applications of shading and cover materials on disease severity of gray mold disease of grape in 2010 growing period

These treatments were the most effective in reducing decay. Bunch rot severity decreased with increasing shading rate. The lowest bunch rot severity was obtained when the lifepack was used as cover material. These results are consistent with the report that the grape vines grown under polypropen cover material gave the higher yield compared with the vines grown in the open vineyard (Kara and Coban, 2001).

In another study conducted in Chile, especially late harvested grapes were adversely affected by rainfall. In this context, a study was conducted on Thompson seedless grape cultivar to determine the effects of covering clusters on harvest period and grape quality. When the vines were covered with the polyethylene cover during adverse weather conditions, significant differences were obtained on harvest time and post-harvest storage (30 and 50 days) characteristics of berries as compared to the control. The cracking and moulding rates of berries were lower in covering treatments than in the control both at harvesting time and port-harvest storage period. After 30 days of harvest, lost rates due to decay were 2.2 and 1.0% in the control and in the cover treatments, respectively whileit was were 2.1 and 1.0% in the control and in the cover treatments, respectively after 50 days of harvest. Cracking was not observed in both the control and cover treatments after harvest (Soza et al., 2007).

In this study, covering the clusters with different covering materials in vineyard made it possible to delay the harvest and reduce the gray mold disease. In similar studies, it was reported that application of covering materials delayed harvest of grapes and also was found to increase the rate of marketable yield by reducing the disease severity (Kara and Coban, 2001; Soza et al., 2007).

Conclusion

Considering the overall findings with regard to the control of gray mold disease of grape, combined application of shading and cover material (lifepack) could be proven as a powerful method at present. The results of this study show that the gray mold severity of grape could be used as a parameter of harvest criteria when the cover materials are used for delaying harvest. This result is very encouraging, because it showed that it is possible to delay harvest by the combined application of shading and cover material under vineyards conditions. This will enable grape producers to market fresh grapes during October and November without cold storage in Manisa and this is a target for the local growers.

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