J. Turk. Phytopath., Vol. 45 No. 2-3, 45-52, 2016 ISSN 0378 - 8024

Effects of Soil Application and Cultivation Methods on the Development of Powdery Mildew (*Erysiphe necator* Schwein.) and Yield in Sultanina Grape

Nedim ÇETİNKAYA[1] Fadime ATEŞ[2]

[1] E.Ü. Ziraat Fakültesi, Bitki Koruma Bölümü, 35100 Bornova, Izmir, TURKEY
[2] T.C. Gıda Tarım Hayvancılık Bakanlığı, Bağcılık Araştırma İstasyonu, Manisa, TURKEY
Corresponding author e-mail: nedim.cetinkaya@ege.edu.tr

Accepted by November 1, 2016

ABSTRACT

The rapid increase in the development of world population and industrialization have brought many problems for human and environmental health. The widely use of chemicals in order to increase agricultural production is one of the main problems in this sense. To take into consideration this common problem, environmentally friendly production methods of organic farming as an alternative to conventional agriculture in different countries are put forward and accepted by both manufacturers and consumers, as well. In this study, the effects of different soil application forms and soil tillage techniques on the disease output of powdery mildew (*Erysiphe necator*) and grape yield in an organically managed vineyard with variety "Sultanina" were investigated. Soil applications were consisted of zeolite, farmyard manure, green manure, liquid fertilizer Bioplazma and E2001, a commercial organic biological suspension. The soil cultivation methods were mulching, use of chisel and the combination of plow + harrow. All the specified applications were conducted in combination with each other in the organically managed vineyard of the Research Institute of Viticulture, Manisa, for a period of three years. A vineyard in the vicinity of experimental vineyard which was managed with conventional cultivation methods was chosen to compare the results between organic and conventional systems. As in experimental organic vineyard, this vineyard was also visited at corresponding time intervals for disease monitoring and recording. The study has shown that zeolite application, depending upon the years, increased the incidence of powdery mildew. Application of organic fertilizers, due to stronger vegetative development, has resulted with more disease severity, changing with years, compared to the control. In the plots cultivated with chisel and mulching, a reduced disease severity was recorded in comparison with plow cultivation in both of organic and conventional plots.

Keywords: Grape powdery mildew, organic cultivation, zeolite, organic fertilizer, soil tillage.

Toprak Uygulamaları ve Yetiştirme Yöntemlerinin Sultani Çekirdeksiz Üzümde Külleme Hastalığı (*Erysiphe necator* Schwein.) ve Verim Üzerine Etkileri

ÖZET

Dünya nüfusunun ve sanayileşmenin hızlı artışı-gelişmesi insan ve çevre sağlığı ile ilgili birçok sorunu da beraberinde getirmiştir. Tarımsal üretim artışını sağlamak amacıyla yaygın kimyasal kullanımı bu sorunların en başında gelmektedir. Bu amaçla çevre dostu üretim şekli olan organik tarım konvansiyonel tarıma alternatif olarak ortaya konmuş ve değişik ülkelerde hem üreticiler ve hem de tüketiciler tarafından kabul görmektedir. Bu çalışma ile organik çekirdeksiz üzüm yetiştiriciliğinde farklı toprak uygulama ve işleme şekillerinin bağın en önemli sorunlarıdan olan bağ küllemesi (*Erysiphe necator*) hastalığı çıkışı üzerine olan etkisini araştırmak amaçlanmıştır. Toprak uygulamaları olarak zeolit uygulaması, çiftlik gübresi, yeşil gübre, sıvı biyolojik süspansiyon Bioplazma ve bir ticari organik gübre olan E2001 kullanılmıştır. Toprak işleme şekilleri ise malçlama, sadece çizel, pulluk+diskaro olarak şekillenmiştir. Belirtilen tüm uygulamalar birbirleriyle kombinasyonlar halinde Manisa

Bağcılık Araştırma enstitüsüne ait organik deneme bağında 3 yıl süre ile yürütülmüştür. Deneme bağının yakınında olan konvansiyonel olarak üretim yapılan bir bağda, organik uygulamaların kıyaslanması amacıyla hastalık gelişimi açısından kontroller ve sayımlar yapılmıştır. Bağ küllemesi hastalığı, zeolit uygulaması ile yıllara göre değişmekle birlikte artış göstermiştir. Organik gübre uygulamasında yıllara göre, asmalarda vejetatif aksamın kontrole göre daha kuvvetli gelişmesi sonucu hastalık şiddetinde artış kaydedilmiştir. Toprak işleme yöntemleri içinde yer alan çizel ve malçlama, hastalık şiddetini pulluk ile işlenen organik bağ parselleri ve konvensiyonel mukayese bağına göre azaltmıştır.

Anahtar sözcükler: Bağ küllemesi, organik bağcılık, zeolit, organik gübre, toprak işleme.

INTRODUCTION

Viticulture has an important place in Turkey's agricultural profile. There is a great demand for the seedless variety of Sultanina as fresh consumption, as well as raisins in domestic and foreign markets. Turkey has produced totally 3,918,442 tons of table grapes, raisins and vine grapes on a total of 48278.87 hectares of vineyards in the year 2008 (Anonymous, 2009). Turkey has the second place in terms of raisin production and first place of raisin exportation in the world and also ranks first in production and exportation of organic raisins in the world (Altındişli, 1997).

Powdery mildew (*Erysiphe necator*) is the most serious disease of vineyards threatening the production, as well as the quality of grapes in Turkey. Disease severity and incidence can change over the years, affected mainly by environmental conditions. Although a general statistic on the yearly yield losses for the whole country is lacking, it is registered that, in case of neglecting chemical and cultural control methods, the pathogen can cause locally up to 35 % yield loss and quality decline of raisins (Delen, et al., 1987).

Powdery mildew infections can cause reduced berry size and sugar content due to decreased photosynthetic activity (Thomas and Gubler 1994). Scarring and cracking of berries may be so severe as to make fruit unfavorable for any purpose. Such infections impair (damage) the quality of vine, thus research has shown that infection levels as low as 3% can taint the wine and produce off-flavors. Disease control is mainly carried out by following the phenological shoot and berry development and chemicals are periodically sprayed with intervals.

MATERIALS AND METHODS

Materials

The experimental vineyard and properties

This study was conducted at the Alaşehir-Yeşilyurt vineyards of Viticulture Research Station in Manisa, Turkey. The vineyard, having the self-rooted 'Round Seedless' (Sultanina) cultivar was planted with 2,4 m x 3,3 m spacing. The vines were trained with "T" formed trellis system. The total area which the research conducted was 13 da.

These vineyards are managed according to the organic growing principles after a period of 3 years standby time and organic raisins were harvested during the 2 years (Anonymous, 2010). The soil showing a slight alkaline reaction did not cause any problem related with structure in terms of salinity; the amounts of total nitrogen and available phosphorus were sufficient whereas potassium level was insufficient. Among the micro nutrients analyzed, zinc level was found to be inadequate. Since the applications between the vine rows in the research area may have possible side effects, vine rows from control were placed to prevent such interactions.

A vineyard in the vicinity of experimental vineyard which was managed with conventional cultivation methods was chosen to compare the results between organic and conventional systems. The cultivation practices in

the conventional vineyard were planned and applied by the owner, without any advice being given. As in the experimental organic vineyard, this vineyard was also visited at corresponding time intervals for disease monitoring and recording.

Material used in the study of plant nutrition

Zeolite (Clinoptiloit mineral. Agro-clino (NMF 900)

Depending on the loose skeletal structure, natural Zeolite (clinoptilolite), has exchangeable cations and this property provides its successful use in terms of absorption, ion exchange and dehydration used successfully. Zeolite was provided from Enli Mining Co., Manisa-Gordes,

EM Bio-gel solution of polymer (E2001)

A preparation consisting of nitrogen binding bacteria provides plants' nitrogen by binding atmosferic nitrogen to the soil, thus enhances root growth. E2001 is supplied from İntar Tarım.

Bioplasma

It is an organic fertilizer in liquid form having the algal cells as biological suspension. Distributor company is Denge Tarım.

Machines used for soil tillage and plant protection

Soil tillage is carried through by chisel, plow, disc harrow or rotary tiller. A PTO driven sprayer with 400 liters capacity was used for routine applications of liquid fertilizers and chemicals for plant protection.

Methods

Plant nutrition and general viticulture practices in the experimental organic vineyard

All the organically managed plots in the vineyard were provided 1.5 tons / ha farmyard manure once in every two years and with green manure each year (vetch + barley + beans: 2.5 +3.5 +7.5 kg / ha) in November as a standard practice by mixing them into the soil using a rotary tiller.

EM Bio-polymer gel solution was applied into soil 5 times as 0,5-1 lt/da, beginning before the flowering (Veraison) stage in 15 - 20 days periods.

Bioplasma, as of the beginning of shoot growth was sprayed 5 times in 0,4-0,6 l /da onto leaves with 10-15 day intervals during the whole phenology.

Zeolite was mixed into soil between rows every year in November as dosage of 3 kg/vinestock.

The whole vineyard including the experimental site was irrigated by watering the pans between the rows.

Soil Cultivation

Soil applications were made on both sides of the respective row and two inter rows were left as side-effect rows in order to avoid the side effects of other applications

Three different soil tillage methods were used, i.e; mulching (none tillage), tillage only with a chisel and tillage only with a plow. During the tillage, half of the rows have obtained Zeolite, the other half none. The rows (plots) treated with Zeolite were also treated with organic agriculture certificated products E2001 and Bioplasma. The remaining plots were not treated with these fertilizers.

Table 1. The summary of fertilizer applications on the main floor of three different soil tillage methods.

Zeolite application (+)		Zeolite application (-)	
E2001+Bioplasma	No application	E2001+Bioplasma	No application

Disease Management

Disease development and severity were followed by the weekly monitoring and scaling in the test plots. Management of dead-arm disease (*Phomopsis viticola* Sacc.) was carefully conducted by removing out the canes with typical symptoms during the winter pruning followed by winter wash of the vines with Bordeux mixture. The spraying schedule for managing the False mildew (*Plasmopara viticola* "B.et C." Berlese et de Toni) was depended on the announcements of Early Warning System and copper oxychloride was used when necessary.

During the study, powdery mildew infections exceeded the economic damage level, due to the suitable weather conditions in the test plots, thus it was necessary to follow up the disease development and control. Spraying program was planned and conducted by considering the official technical instructions of plant protection for powdery mildew based on phenology starting after flowering and continuing with intervals of 12-14 days. Organic plots were treated only with sulfur, whereas the conventional plots alternately were treated with sulfur and systemic fungicides (Table 1). All the plots were sprayed for 6 times.

Table 1. The active ingredients of fungicides and the doses used for the control of powdery mildew.

Active ingredient and rate	**Formulation**	**Dose (%)**
Triadimenol+Folpet % 1,5+70	WP	0,200
Penconazole 100 g/l	EC	0,025
Hexaconazole 50 g/l	SC	0,030
Sulfur % 80	WP	0,400

Powdery Mildew disease assessment was conducted according to the method proposed by the Ministry of Agriculture and Rural Affairs (Anonymous, 1996). Instead of the 0-4 scale proposed in this method, a modified 0-5 disease scale with a higher accuracy at low disease severity was used. The disease severity in each plot was evaluated on the total of 36 clusters gathered from 12 vines/plot with each 3 clusters using the 0-5 disease scale. Disease counts were done for three years in phenological growth stages 79-81 (Lorenz et al., 1994).

The experimental design and statistical analysis

The experiment designed according to a split-split-plot system was consisted of three replications, each with 36 vines. The statistical analysis was performed by using a SPSS Program package, version 15.0 (software) and the mean values of the data obtained were compared by using the Duncan test at confidence level of $p \leq 0.05$. The mean values in the same statistical group were indicated with the same letter.

RESULTS AND DISCUSSION

The vines in research plots, treated with different soil application and cultivation methods were regularly sprayed with sulfur which is permitted to use in organic agriculture with 2-week intervals before the outcome of the disease.

Disease incidence in zeolite treated and conventional plots declined in the first 2 years and increased in third year of investigation. Severity of disease in the zeolite plots statistically increased in the first 2 years, however no difference was recorded in these plots compared with conventional plots ($p<0.05$). However, in the second year, where the disease incidence was generally lower, zeolite application reduced the disease outcome in comparison with conventional plots.

Table 2. The comparative values of disease severity (%) and yield parameters in Zeolite treated and untreated control plots and in conventional managed vineyard.

Year	Parameter	Treatment		
		Zeolite	Control	Conventional
1	Disease severity (%)	11,98 a	7,38 b	12,26 a
	Fresh grape yield/ (kg/vine)	11,74 a	11,03 a	11,41 a
	Raisin yield (%)	25,00 a	24,19 b	21,34 c
2	Disease severity (%)	9,16 b	3,38 c	19,74 a
	Fresh grape yield/ (kg/vine)	19,49 a	20,56 a	25,42 a
	Raisin yield (%)	23,06 a	22,83 a	23,08 a
3	Disease severity (%)	31,18 b	28,18 b	27,62 a
	Fresh grape yield/ (kg/vine)	8,58 c	11,50 b	15,00 a
	Raisin yield (%)	28,91 a	29,41 a	29,38 a
Average	Disease severity (%)	17,44 a	12,98 a	19,87 a
	Fresh grape yield/ (kg/vine)	13,27 a	14,36 a	17,28 a
	Raisin yield (%)	25,66 a	25,48 a	24,60 a

As the average of three years, no statistically significant difference in disease severity was found between the plots with zeolite application, the control and the conventional vineyards ($p<0.05$). A significant ($p<0.05$) reduction in the average fresh grape yield was observed in zeolite treated plots in the third year of investigation, compared with the control and the conventionally managed plots.

Raisin yield was increased with the zeolite application during the first year compared with control and conventional plots, whereas no significant difference was recorded in the following years. There weren't any significant ($p<0.05$) differences which were found by evaluating the average yield parameters of zeolite plots in terms of 3 years (Table 2).

Disease severity in plots treated with organic fertilizer varied according to years as a result of a general increase during the first 2 years and decline in the last year, compared to the control. There was no difference between organic and conventional systems in terms of disease severity (Table 3). Organic fertilizer application in organically managed plots has decreased fresh grape yield significantly in the third year, compared with control as well as conventional applications. However, three-year averages of these 3 applications indicates that no significant difference ($p<0.05$) was observed both in terms of yield and disease severity.

Table 3. The comparative values of disease severity (%) and yield parameters in organic plots fertilized or not fertilized with organic amendments compared to conventional managed vineyard.

Year	Parameter	Treatment		
		Organic fertilizer	Control	Conventional
1	Disease severity (%)	11,88 a	7,46 b	12,26 a
	Fresh grape yield/ (kg/vine)	11,56 a	11,21 a	11,41 a
	Raisin yield (%)	24,53 a	24,66 a	21,34 a
2	Disease severity (%)	8,18 b	4,36 b	19,74 a
	Fresh grape yield/ (kg/vine)	19,00 a	21,04 a	25,42 a
	Raisin yield (%)	23,33 a	22,56 a	23,08 a
3	Disease severity (%)	27,62 a	30,16 b	27,62 a
	Fresh grape yield/ (kg/vine)	8,87 c	11,20 b	15,00 a
	Raisin yield (%)	29,03 a	29,28 a	29,38 a
Average	Disease severity (%)	15,89 a	13,99 a	19,87 a
	Fresh grape yield/ (kg/vine)	13,14 a	14,48 a	17,28 a
	Raisin yield (%)	25,63 a	25,50 a	24,60 a

As a result of organic fertilizer applications, a strong negative linear relationship between the disease severity and raisin yield were determined (Figure 1), whereas only a mild interaction was detected in other plots.

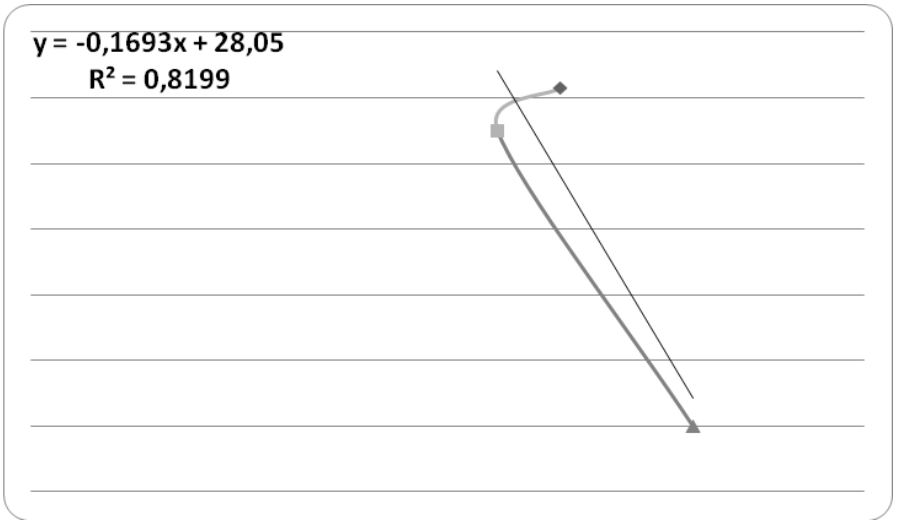

Figure 1. Relationship between disease severity and raisin yield under conditions of organic fertilizer application.

Evaluation of soil cultivation methods in terms of powdery mildew outbreak indicates that mulching and chisel tillage were the best practices. The plots treated with these techniques had lower disease incidence compared with organically managed plots cultivated with plow and plots with conventional practices, except the third year, in which disease severity was relatively high. Considering the severity of the disease in terms of overall averages, there was no statistical significance ($p<0.05$) between these practices.

In the plots with chisel and mulch applications a reduction in the fresh grape yield was recorded although low disease severity was low. But a difference did not emerge in the dried grape yield.

When the three-year average data is taken into account, except with dried raisin yield, a non-significant decrease was recorded in disease severity and fresh grape yield.

Table 4. The comparative values of disease severity (%) and yield parameters in different soil cultivated plots.

Year	Parameter	Treatment			
		Plow	**Chisel**	**Mulching**	**Conventional**
1	Disease severity (%)	11,80 a	8,64 b	8,30 b	12,26 a
	Fresh grape yield/ (kg/vine)	11,64 a	11,94 a	10,57 a	11,41 a
	Raisin yield (%)	24,46 a	24,36 a	24,96 a	21,34 a
2	Disease severity (%)	7,20 b	4,80 c	6,80 b	19,74 a
	Fresh grape yield/ (kg/vine)	20,65 b	22,35 b	17,07 c	25,42 a
	Raisin yield (%)	24,08 a	22,25 b	22,50 b	23,08 ab
3	Disease severity (%)	27,26 a	27,18 a	27,62 a	27,62 a
	Fresh grape yield/ (kg/vine)	8,83 a	10,80 a	10,48 a	15,00 a
	Raisin yield (%)	30,80 a	27,77 b	28,91 ab	29,38 ab
Average	Disease severity (%)	15,42 a	13,54 a	14,24 a	19,87 a
	Fresh grape yield/ (kg/vine)	13,71 a	15,03 a	12,71 a	17,28 a
	Raisin yield (%)	26,45 a	24,79 a	25,46 a	24,60 a

Powdery mildew attacks could not reach to an epidemic level in the vineyards where the research was carried out. This situation can be explained that climatic conditions and especially high temperatures could directly influence the infection pressure, i.e the development of the pathogen on the vines. Particularly under suitable weather conditions, i.e. at temperatures of 21-30° C during the day at least 6 hours and at the maximum temperatures not exceeding 33° C, the pathogen can reach the case of high infection pressure (Thomas *et.* a*l*., 1994). Under these conditions, *E. necator* can build a new generation in every 5 days and can cause high levels of disease severity on its host. Thus, one can state that the high temperatures exceeding especially 33° C during the experiment, could significantly damage the population increase of the pathogen. In addition, quite inadequate maintenance procedures were applied in the pre-trial years in the vineyard and as a result of this poor vegetative development which is not suitable for the disease development, the outcome of the disease could have been indirectly hindered.

In the first year of study, powdery mildew attack showed a higher rate in the plots with zeolite application and in conventional control plots than the plots without zeolite treatment. The reason for this may be that the more intense vegetative vine growth which was supported with optimal cultural conditions in conventional production plots and zeolite application providing a sufficient water economy, created better conditions for the pathogen development. The same situation was also observed in the second year to a certain extent. Disease severity was again higher in zeolite treated plots compared untreated plots and the vines in conventionally managed vineyard had the highest values of disease incidence.

Zeolite helps plants by increasing the water uptake and nutrient availability (Li et al., 2000). This situation can be explained by the increased vegetative growth in conventional plots. In the third experiment year infection pressure was higher than in previous years and no difference was observed in this year in terms disease severity compared to first years. Making a general assessment on the zeolite implementation, it can be concluded that, significant differences between zeolite variants comes out when the infection pressure is low whereas it had no effect on the disease outbreak in terms of years with higher infection pressure ($p<0.05$).

In the plots with organic fertilizer application, a higher disease incidence was recorded than in nonfertilized plots during the first year. In the conventional managed vineyard also similar levels of disease severity was determined as in organically fertilized plots. In the second year, both in the organic fertilizer treated and an untreated plot, a lower level of infestation was recorded in comparison to conventionally managed vineyard. In the third year, because of higher disease development in all the experimental plots, no difference was found among them in terms of disease severity ($p<0.05$). A negative linear relationship between disease severity and raisin yield was determined as a result of the increased vegetative activity created by organic fertilizer application.

Fertilization practices caused higher disease severity on the bunches than that of bunches in control plots. The vine variety “Sultanina” is known with its excessive vegetative growth and in addition to this trend, the fertilization, creating plenty of shoots and also a suitable microclimate for the sporulation of *E. necator* might have prevented the penetration of fungicides to the inner parts of vine and bunches. This observation coincides with the results of previous research (Cetinkaya and Onogur, 2006).

Powdery mildew infestation was generally lower in the first two years and in the plots treated with Chisel plowing and mulching disease severity was recorded to be lower than in the plots with plow tillage and conventionally managed vineyard. In the third year, in which disease intensity was higher than the first two years, no difference ($p<0.05$) was observed between all the variants. Fresh grape yield influenced by this severe powdery mildew attack was also lower. Dry grape yields were not affected by tillage practices. Berner et al., (2008), examined the effects of practices such as different tillage techniques (plow and chisel), fertilization with animal manure extract and animal manure compost and biodynamic preparations on soil fertility and crop yields. They found that, among the factors which were tested only tillage patterns were effective on soil fertility parameters. In the soil cultivated with Chisel, soil microbial biomass and dehydrogenase enzyme activity were respectively 28%

and 27% higher than the plow tillage application and the animal manure extract could increase wheat yield more than 5% in comparison with manure compost application.

LITERATURE CITED

Altındişli, A., 1997. Çekirdeksiz Kuru Üzümde Ürün Değerlendirme ve Tarımsal Sanayi. Ege Bölgesinde Çekirdeksiz Kuru Üzümün Bugünkü Durumu, Geleceği, Sorunları ve Çözüm Önerileri Paneli, 14. Ekim.1996, Ege Tarımsal Araştırma Enstitüsü, Menemen, İzmir. Yayın no: 94, 21- 32.

Anonymous, 2009. Bitkisel üretim istatistikleri (2008) raporu, TUİK, Ankara.

Anonymous, 2010. Organik Tarımın Esasları ve Uygulanmasına İlişkin Yönetmelik, 18 Ağustos 2010 tarih ve 27676 sayılı Resmi Gazete.

Berner, A., Hildermann, I., Fließbach, Pfiffner, L., Niggli, U., Mäder; P., 2008. Crop yield and soil fertility response to reduced tillage under organic management. Soil Till. Res., 101: 89-96.

Çetinkaya, N. ve E. Onoğur, 2006. Organik Yetiştiricilik Yapılan Yuvarlak Çekirdeksiz Üzüm Bağlarında Farklı Gübreleme Uygulamalarının Külleme Hastalığı Gelişimi ve Verime Etkileri. Ege Üniv. Ziraat Fak. Derg., 2006, 43(1):33-44, ISSN 1018-8851

Delen, N., E. Onoğur, M. Öncü, 1987. Bağ Küllemesi (Uncinula necator Sch.Burr.)'nin

kimyasal savaşımı üzerinde araştırmalar.Doğa, 11 (2): 303-309

Li, C, Li, H. Zhang X. 2000. Effects of Natural Zeolite on Soil Properties and Nutrient Efficiency. Soil and Environmental Sciences, DOI : cnki:ISSN:1008-181X.0.2000-02-020.

Lorenz, D. H., K. W. Eichorn, H. Blei-Holder, R. Klose, U. Meier und E. Weber, 1994: Phänologische Entwicklungsstadien der Weinrebe (*Vitis vinifera* L. ssp. *vinifera*). Vitic. Enol. Sci. 49, 66-70.

Thomas, C. S., W. D. Gubler and G. Leavitt. 1994. Field Testing of Powdery Mildew Disease Forecast Model On Grapes in California. Phytopathology 84:1070.

Yıldırım, I., E. Onogur and M. Irshad. 2002. Investigations on the efficacy of some natural chemicals against powdery mildew (*Uncinula necator* (Schw.) Burr.) of grape. J. Phytopathology, 150 : 697 – 702, 2002.

Yürüt, A. 1978. Orta Anadolu Koşullarında Bağ Küllemesi Fungusu (*Uncinula necator* "Schwein" Burr.)'un Kışlaması Üzerine Bir Araştırma. Ankara Bölge Zir. Müc. Araş. Enst. Yayınları: 41. Ankara.