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Application of Statistical Model for Forecasting Powdery Mildew of Grapes under Egyptian Conditions Based on Meteorological Data

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ABSTRACT

Powdery mildew caused by *Erysiphe necator* is the most serious diseases of grapes in Egypt and the world. Conidia of *Uncinula necator* are formed in a wide range of climatic conditions. Fungal growth, conidia formation and germ tube formation are mainly influenced by temperature. The prediction of occurrence of powdery mildew disease is one of the important processes in the fight against disease and reduces the losses of direct and indirect. Average temperatures which are obtained from meteorological stations located in places in Egypt and through the cultivation of grapes were possible to determine the month will be higher and lower rate of germination of conidial spores (GR), Penetration Rate (PR), reduction in the germination rate due to presence of liquid water on the host surface (GRM) and reduction in the number of conidia produced per day due to the presence of liquid water in the host (SRM). Studied were in the three Governorates viz. Alexandria, Giza and Aswan where it was getting on average temperatures for a period of fifteen years earlier and the application of equations of growth rate and the rate of penetration of the conidial spores of the fungus that causes conidia for white powdery mildew. The aim of this work improve control of powdery mildew disease by improving timing of biological control agents and soft fungicides sprays and possibly reducing the need for fungicide sprays during the growing season. Reducing fungicides application will also reduce exposure of the environment as well as farm workers and consumers to harmful pesticide residue. Fewer sprays also mean a lower consumption of fuels and lower labor costs which further reduces input costs and thereby increases the economic margin for grape growers. This is the first research study done in Egypt to study the effect of environmental conditions on the powdery mildew disease of grape.

Key words: Grape powdery mildew, prediction, forecasting models, Egypt

INTRODUCTION

Grapevine (*Vitis vinifera* L.) is one of the most important fruits grown in Egypt. The cultivated areas reached 64034 ha with a production of 1360250 tones (FAO., 2010). This area is rapidly increased in the desert areas every year for local market consumer and exporting as well. Powdery mildew caused by *Erysiphe necator* Schwein. Formally, *Uncinula necator* (Schwein), Burrill is an economically important disease of grapevine in Egypt and all over the world. Several asexual cycle of reproduction of the fungus occur during the growing season and may cause losses of fruit in quantity and quality (Stummer *et al.*, 2005). Epidemics can develop from mycelia surviving on infected buds (primary source of epidemic in Egypt) and/or over wintering cleistothecia surviving on infected leaves and exfoliating bark of grapevines and it is highly possible that powdery mildew epidemics are mainly initiated from conidia. These conidia are abundantly produced on flag shoots that are the first infected shoots, appearing early inn spring, derived from buds infected inn the

previous season (Rumbolz and Gubler, 2005). The favorable temperatures for conidial germination and disease development are 20-27°C (optimum 24-25°C) (Willocquet *et al.*, 1996), also germination can occur between 6-33°C (Delp, 1954). Temperatures above 32°C (Fessler and Kassemeyer, 1995) or 35°C (Delp, 1954) inhibit germination of conidia and temperature above 40°C will kill conidia (Delp, 1954). The fungus can adjust to temperature and a shift in germination rates occurs according to the temperature during conidial development (Fessler and Kassemeyer, 1995). Epidemiological models may facilitate studies in plant pathogen in several ways. They draw attention to areas in which information of the biology of the host/pathogen system is lacking (Waggoner and Horsfall, 1969) and they serve as excellent teaching aids by displaying epidemic development under a variety of chosen conditions (Blaise *et al.*, 1987). Applications of epidemiologic models include assessing the impact of host growth and environmental factors on disease development (Berger and Jones, 1985; Sall, 1980). They may also be used to optimize disease management strategies (Mackenzie, 1981). Thus, a warning system based on environmental factors affecting conidia could be a useful tool to assist farmers in control decisions. The aim of this study determine the month will be higher and lower rate of germination of conidial spores (GR), Penetration Rate (PR) of powdery mildew epidemics by using equations from (Delp, 1954; Chellemi, 1990) in simulation model with metrological data to determine the effect of temperature on germination and penetration rate under Egyptian conditions in governorates under studies.

MATERIALS AND METHODS

Equation used: The effect of temperature degrees on Germination Rate (GR) and penetration rate (PR) were estimated from Delp (1954), by using the polynomial regression equations:

$$[GR = -2.641+0.256T-0.00528T^2]$$

Whereas, GR is germination rate and T is average daily temperature:

$$[PR = -0.639+0.108T-0.00254 T^2]$$

Whereas, PR is penetration rate and T is average daily temperature. While the effect of liquid water on germination was estimated from Delp (1954) by using the regression equation:

$$[GRM = 1.155-0.014*T]$$

Whereas, GRM is reduction in the germination rate due to presence of liquid water on the host surface and T is average daily temperature. The effect of liquid water on sporulation was estimated from and Chellemi (1990) by using the polynomial regression equation:

$$[SRM = -10.998+(0.939*T)-(0.019*T^2)]$$

Whereas, SRM is reduction in the number of conidia produced per day due to the presence of liquid water on the host surface and T is average daily temperature.

Meteorological data: Meteorological data were collected from three local Agricultural weather station located in three governorates under studied from (1997-2011). Alexandria in North Egypt

(Elev: 7 m, Longitude: 30.0°E, Latitude: 31.2°N), Giza Middle Egypt (Elevation: 19 m, Longitude: 31.2°E, Latitude: 30.0°N) and Aswan South Egypt (Elevation: 194 m, Longitude: 32.8°E, Latitude: 24.0°N). Meteorological data collected from each weather station includes: Maximum temperature, optimum temperature and minimum temperature.

Statistical analysis: Data analyzed using software Costat version 6.4-CoHort software. The mean was compared by the Least Significant Difference (LSD) at 5% according to Oehlert (2010).

Model output: Outputs of the model describe changes over time and location in:

- Optimum temperature of conidia germination and penetration rate
- Expected germination and penetration rate of conidia in different months of the year
- Predicted the incidence of epidemic disease in the governorates under study

RESULTS

Optimum temperature of conidia germination and penetration rate: Optimum temperature for germination rate was 24°C, while minimum temperature was 15°C and maximum temperature was 33°C (Fig. 1). The Optimum temperature for penetration rate was 20°C, while minimum temperature was 8°C and maximum temperature was 35°C (Fig. 2).

Expected germination and penetration rate of conidia in different months of the years: Temperature degrees were found significantly affected germination rate of conidia in different months of year's studied.

Alexandria governorate

Expected germination rate: Epidemics simulated using meteorological data from 1997-2011 were characterized by increasing germination rate with increasing the temperature degrees in

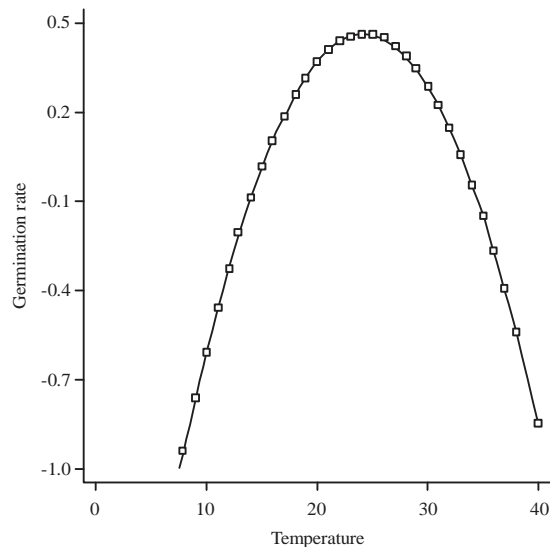


Fig. 1: Optimum temperature on conidia germination rate

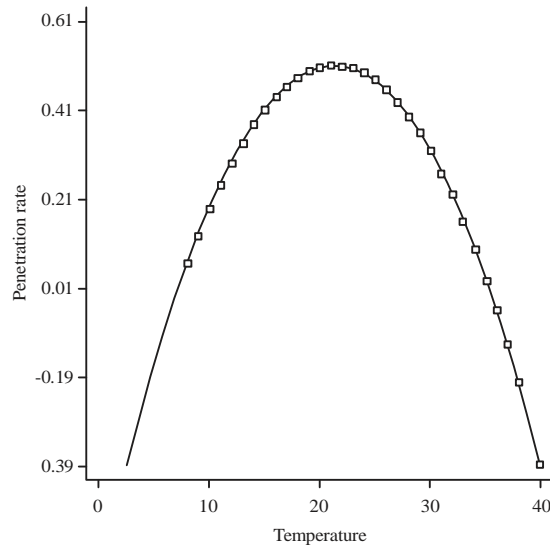


Fig. 2: Optimum temperature on conidia penetration rate

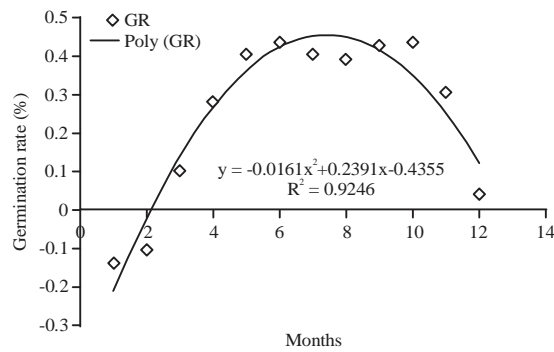


Fig. 3: Germination rate of conidia in different months of Alexandria Governorate

different years under studied. The first germination rate (Fig. 3) was recorded in March then little increased in the next month April. The maximum germination rate were recorded in May-October then decreased rapidly in November and December. On the other hand, no germination rate recorded in both month January and February in all years under studied. Germination rate was found not significant between different years (Fig. 4).

Expected penetration rate: Penetration rate (Fig. 5) was significantly in all months of year. The maximum penetration rate was recorded in May followed in April, October and November. On the other hand, the moderate PR was in June followed in March and September. While, the weak PR were in July and December followed in August. The very weak PR was in January and February in all years under studied. Penetration rate was found not significant between different years (Fig. 6).

Aswan governorate

Expected germination rate: The first germination rate (Fig. 7) was recorded in Jan and the same GR in May and September then little increased in the next month February and the same GR

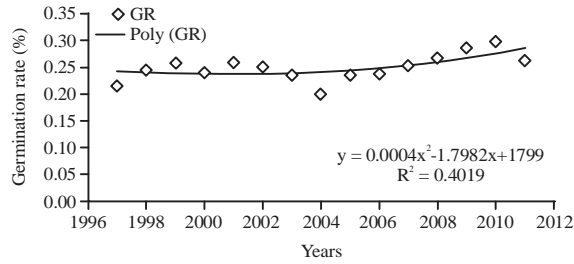


Fig. 4: Germination rate of conidia in different years of Alexandria governorate

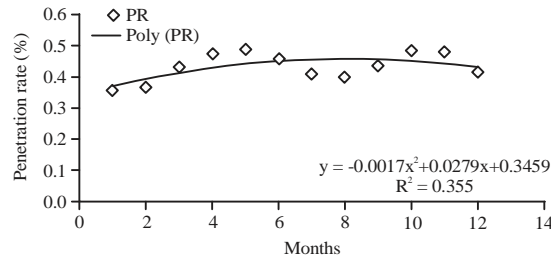


Fig. 5: Penetration rate of conidia in different months of Alexandria governorate

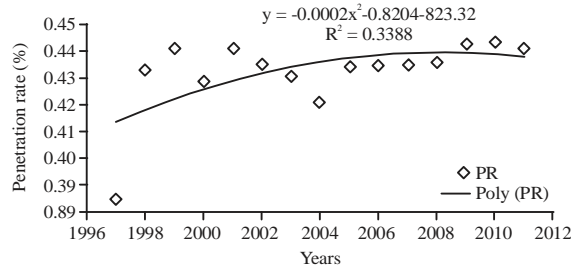


Fig. 6: Penetration rate of conidia in different years of Alexandria governorate

in December. The maximum germination rate was recorded in March and November, followed in April. On the other hand, no germination rate was recorded in months June, July and August in all years under studied. Germination rate was found not significant between different years (Fig. 8).

Expected penetration rate: Penetration rate (Fig. 9) was significantly in all months of year. The highest PR was recorded in November followed in February, March and December, while the moderate PR was in Jan followed in March and September. On the other hand, PR decreased in April, October, May, September, July and the latest in August. Penetration rate was found not significant between different years (Fig. 10).

Giza governorate

Expected germination rate: The first germination rate (Fig. 11) was recorded in the month February and December then little increased in the month March. The maximum GR was recorded

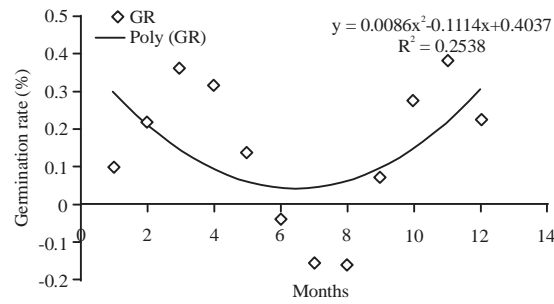


Fig. 7: Germination rate of conidia in different months of Aswan governorate

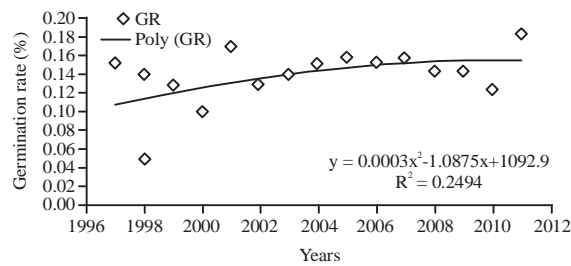


Fig. 8: Germination rate of conidia in different years of Aswan governorate

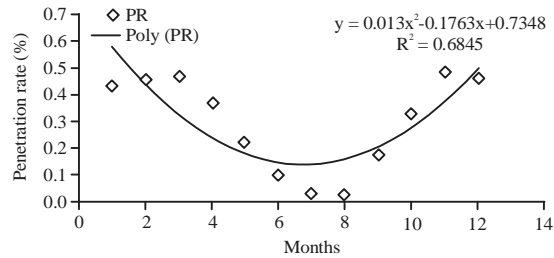


Fig. 9: Penetration rate of conidia in different months of Aswan governorate

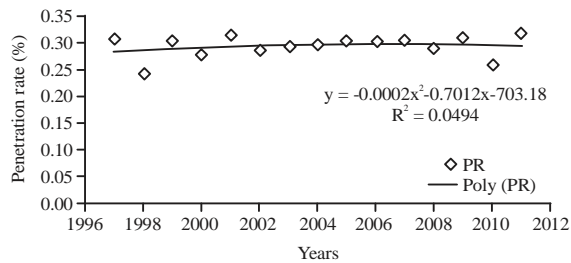


Fig. 10: Penetration rate of conidia in different years of Aswan governorate

in October and May, followed in September, April and June. The moderate GR was in November, August and July. On the other hand, no GR recorded in the month January in all years under studied. Germination rate was found not significant between different years (Fig. 12).

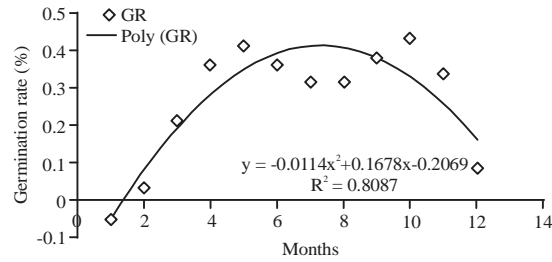


Fig. 11: Germination rate of conidia in different months of Giza governorate

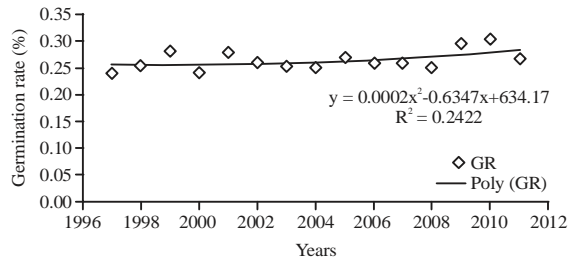


Fig. 12: Germination rate of conidia in different years of Giza governorate

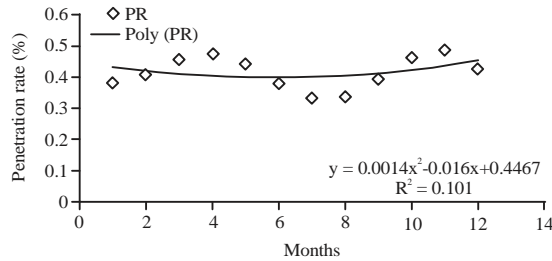


Fig. 13: Penetration rate of conidia in different months of Giza governorate

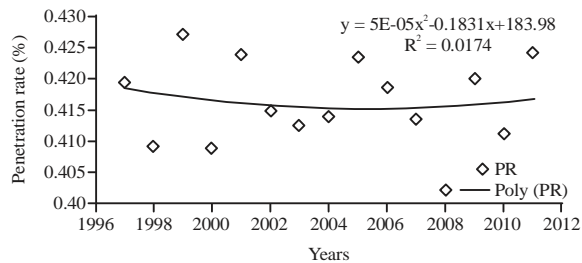


Fig. 14: Penetration rate of conidia in different years of Giza governorate

Expected penetration rate: Penetration rate (Fig. 13) was significantly in all months of year. The highest PR was recorded in November followed in April, October and March, while the moderate PR was in May followed in December, February and September. On the other hand, PR decreased in January, June, August and the latest in July Penetration rate was found not significant between different years (Fig. 14).

DISCUSSION

Powdery mildew caused by *Uncinula necator* (*Erysiphe necator*) is the most serious diseases of grapes in Egypt and the world (Pearson and Gadoury, 1992) Conidia of *Uncinula necator* (Schw.) Burr are formed in a wide range of climatic conditions. Fungal growth, conidia formation and germ tube formation are mainly influenced by temperature (Gadoury *et al.*, 2001b). The prediction of occurrence of powdery mildew disease is one of the important processes in the fight against disease and reduces the losses of direct and indirect. The aim of forecasting to improve control of powdery mildew disease by improving timing of biological control agents and soft fungicide sprays and possibly reducing the need for fungicide sprays during the growing season. The aim of this study determine the month will be higher and lower rate of germination of conidial spores (GR), Penetration Rate (PR) of powdery mildew epidemics by using equations from (Delp, 1954; Chellemi, 1990) in simulation model with metrological data to determine the effect of temperature (Campbell *et al.*, 2007) on germination and penetration rate under Egyptian conditions in governorates under studies.

The first expected GR was recorded in Mar in Alexandria governorate. While was recorded in Jan in Aswan and in Giza was recorded in Feb. On the other hand, the maximum expected PR was recorded in May in Alexandria governorate. While was in Nov in both governorates Aswan and Giza. These results are compatible with the views and observations recorded in the provinces under study for the onset of symptoms of powdery mildew disease on different varieties of grapevine. The results obtained, we find that in Egypt cultivated different grape varieties of early and middle and late maturity, it is known that the varieties of early escape from injury in powdery mildew and losses are in fruits fewer but of the results obtained, the varieties of early might happen to her injury if planted in areas suitable for the growth of conidia spores when changing environmental conditions become suitable for the growth of conidia spores and causing injury. While middle and late varieties fruiting exposed to disease, powdery mildew and vary the proportion of crop losses due to weather conditions which affect the growth of conidia spores and severity of the disease as well as other factors. Predict disease of the important factors in the fight against the disease powdery mildew is possible to enter predict disease in IPM programs for powdery mildew disease as well as in organic agriculture programs (Mackenzie, 1981). Monitoring air temperature from the start of bud burst to veraison would be highly advisable. Nevertheless, early infection periods which could possibly be detected, using this warning system can occur (Campbell *et al.*, 2007).

The model developed in California, based on *in situ* air temperature, it is possible to estimate the risk of powdery mildew infection of grapes under Chilean conditions (Chellemi and Marois, 1991; Braun *et al.*, 2002; Bendek *et al.*, 2007). The other warning systems (Sall, 1980; Kast, 1997; Jarvis *et al.*, 2002; Carroll and Wilcox, 2003), are based on only monitoring on-site air temperature, assuming that the rate of conidia production is increased by temperatures between 20 and 30°C.

This is the first research study done in Egypt to study the effect of environmental conditions on the powdery mildew disease of grape. The results obtained from models predict disease powdery mildew may be useful Early Warning System in the suitable time for the spread of the disease in different governorates in Egypt, so we can therefore follow the disease and spread depending on the weather conditions in the governorates leading to reduce the spread of the disease and minimize the loss of direct and indirect as well as reduces the pollution of the environment with pesticides and maintain the safety of workers and increase the income of farmers and by means of

reduce input and increase output, as well as increase the quality of the final product of the fruits of the grape (Madden and Nutter, 1995; Gadoury *et al.*, 2001a; Jarvis *et al.*, 2002; Calon nec *et al.*, 2004).

CONCLUSION

The effects of climate change on plant diseases have been the subject of intense debate in the last decade; research in this sense has been carry out, however, more information is needed. Elevated temperatures associated with climate change will have a substantial impact on plant-disease interactions. Changes in temperature affect both the host and the pathogen; thus, risk analyses must be conducted for each pathosystem to determine the effects of climate change. Powdery mildew (*U. necator*) is a major fungal disease that affects a wide variety of grapes negatively. Leaves and grapes of many *Vitis vinifera* varieties are highly susceptible to this pathogen. Weather parameters play an important role in initiation and development of these diseases. Powdery mildew requires relatively dry conditions and moderate temperature. Plant pathogenic fungi require specific environment conditions of temperature and relative humidity/wetness to cause infection. By monitoring these conditions as they occur, it is possible to identify infection periods and respond with eradicate sprays. By predicting weather conditions, it is possible to protect the vine before the infection period occurs. In advanced research we should monitoring vineyard fields at the various locations in Egypt for validation of disease prediction models of primarily powdery mildew disease.

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