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Influence of Pruning Seasons and Weather Parameters on Powdery Mildew (*Erysiphe necator* Schw.*)* Disease Incidence of Grapes (*Vitis vinifera* L.) var. Muscat Hamburg

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KEYWORDS

Disease, grapes, powdery mildew, pruning, weather, season, etc

ABSTRACT:

Grapes (*Vitis vinifera* L) powdery mildew caused by the obligate fungus *Erysiphe necator* Schw. is one of the most important diseases causing considerable losses in grapes. The incidence of powdery mildew disease was assessed from July, 2022 to April, 2023 at Grapes Research Station, Anaimalayanpatty, Theni at weekly interval revealed that the highest incidence of 62.73 per cent was observed during second week of October, 2022 after summer pruning, which coincides after harvest period. Similarly, the disease incidence of 66.26 per cent was noticed during second week of February, 2023 after winter pruning which coincided in the fruiting period. Correlation studies with weather parameters on disease incidence revealed that maximum temperature (0.670^{**}), sunshine hours (0.513^{*}) and soil temperature (0.604^{**}) registered significantly positive correlation on powdery mildew incidence whereas average relative humidity reported with significant negative correlation (-0.602^{*}) both during summer and winter pruning. Further, disease incidence was positively correlated with wind velocity (0.476^{*}) after winter pruning. Rainfall was negatively correlated for powdery mildew disease incidence both summer and winter pruning.

1. Introduction

Grapes (*Vitis vinifera* L.), a delicious fruit, rich in sugars and vitamins, particularly vitamin C. Grapes contains high flavonoids content which are powerful antioxidants that removes free radicals and prevent ageing (Choudhary *et al.*, 2014). The tropical climate of peninsular India, where the winter is mild and the vines do not undergo dormancy and evergreen throughout the year. Grapes prefer dry humid weather condition during its growth and fruiting stage. Grapes is highly susceptible to a number of fungal, bacterial and viral diseases, which have a substantial impact on its yield and quality (Nimbalkar *et al.*, 2005). Grapes powdery

Journal of Chemical Health Risks

www.jchr.org

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mildew caused by *Erysiphe necator* is prevailed in the majority of grapes-growing locations across the world. The disease has the potential to impair vine growth, development and productivity. Powdery mildew infection also decreases the yield, quality of berries and wines. Conidia dispersal is critical in polycyclic, aerially disseminated diseases like grapes powdery mildew because it influences both the temporal and geographical spread of epidemics (Aylor, 1990). Conidia dispersal in powdery mildew is a passive process induced by a variety of climatic variables. Powdery mildew can infect any green succulent tissue under favourable climatic circumstances and this disease is most easily identified by the dusty look or white powdery growth developing as spots on fruits, leaves and vines. During hot and dry weather, severely diseased leaves may curl upward. Diseased vines develop dark brown to black blotchy blemishes. Berries that have been infected are frequently deformed or have rusty patches on the surface. The fungus reduces the photosynthetic activity of the vines, resulting in indirect yield and quality losses (Moriondo *et al.*, 2005). Environmental variables have a significant impact on the disease's development. Temperature, humidity, rainfall, sunlight, wind speed and the number of wet days are the most important weather parameters because they impact the pathogen, host or host-pathogen interaction during pathogenesis. As a result, it is critical to investigate the relationship between weather parameters and disease severity, as these factors influence disease development and dissemination.

2. Materials and method

The current investigation was carried out from July, 2022 to April, 2023 at the Grapes Research Station, Anaimalayanpatty, Theni, Tamil Nadu which is located between 9° 45' 26.685" N and 77° 20' 50.737" E at a height of 435 m above mean sea level. The grapes var. Muscat Hamburg was established by *in situ* grafting on dogridge rootstock and trained over bower system with the spacing of 3 x 2 m were chosen to evaluate the seasonal occurrence powdery mildew disease. This research was carried out during June, 2022 to October, 2022 (summer pruning) and November, 2022 to April, 2023 (winter pruning). During the study period, no fungicides were applied to the crop. Infected leaves were chosen at random and graded using the disease grading chart (Fig 4). The prevalence of powdery mildew disease incidence on leaves was determined across two seasons using Jamadar and Desai's (1997) scoring table (Table 1). The Percent Disease Index (PDI), was calculated using Mc Kinney's (1923) formula,

$$PDI = \frac{\text{The sum of all numerical ratings}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Maximum grade}}$$

Weather data was collected from "A" class meteorological observatory at the Grapes Research Station, Theni includes maximum and minimum temperature, average relative humidity, sunshine hours, total rainfall, wind speed, soil temperature and evaporation. To assess the impact on powdery mildew incidence, the standard week averaged over a week was used (except for rainfall, which was summarized for a week). The mean per cent of powdery mildew incidence was recorded for correlation with the prevailed weather data. The powdery mildew disease incidence and correlations coefficients were worked out as suggested by Snedecor and Cochran, 1967. All the statistical analyses were performed using the GRAPES (General R based Analysis Platform Empowered by Statistics) software.

Table 1. Score chart for assessment of powdery mildew disease incidence in grapes var. Muscat Hamburg

Disease grade	Per cent leaf area covered
0	No infection
1	0 to 10
3	10.1 to 15
5	15.1 to 25
7	25.1 to 50
9	> 50

3. Results and discussion

The effect of various weather parameters on disease development was studied to correlate the periodic disease severity with the maximum and minimum temperature, average relative humidity, sunshine hours, total rainfall, wind speed, soil temperature and evaporation from July, 2022 to April, 2023. The weekly data on the per cent disease index was furnished in Table 2.

Effect of weather parameters on grape powdery mildew during summer pruning from July, 2022 to October, 2022

During the summer pruning (Table 2), symptoms of powdery mildew appeared on 28th standard week. The

Journal of Chemical Health Risks

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disease's severity significantly increased from the 39th to the 41st standard week. The weather conditions that prevailed during these standard weeks with the average maximum temperature of 30.00^{0}C, average minimum temperature of 21.57ºC, average relative humidity of 70.5 per cent, wind velocity of 12.28 kmph, sunshine hours of 6.9 hours and low rainfall of 27 mm (Figure.1). These conditions favoured the powdery mildew disease development. The disease severity gradually increased and reached a peak of 62.73 per cent during 41st standard week (October, 8 to 14). The weather parameters prevailed during this period with maximum temperature of 30.29ºC, minimum temperature of 21.57ºC, average relative humidity of 69.79 per cent, wind velocity of 10.13 kmph, sunshine hours of 5.36 hrs, total rainfall of 27 mm, evaporation of 19 mm and the soil temperature of 25.83ºC. Because the causative agent's growth rate of powdery mildew is primarily temperature driven coupled with low rainfall resulted adverse to conidia germination (Gadoury *et al*., 2012) and compared to previous standard weeks. Powdery mildew disease is most easily identified by the dusty look or white powdery growth developing in spots on fruits, leaves and vines (Fig. 3). The effect on highest wind velocity also passively stimulated conidia dispersal during this week. However, when the disease's severity declined to a low of 5.80 per cent in the 35th standard week, rain fall of 139 mm over the week. Low wind velocity and excessive rainfall have an impact on disease severity. Findings of present investigation on disease incidence are consistent with those of Chavan *et al.* (1995), who found that temperature ranged from 11.8 to 32.4°C and relative humidity of 58.4 per cent favoured the development of grape powdery mildew disease.

Effect of weather parameters on grape powdery mildew during winter pruning from December, 2022 to April, 2023,

During the winter pruning a period of December, 2022 to April, 2023, indications of powdery mildew began during the 51st standard week and progressively increased from the 2nd to 5th standard week. During this standard week, the weather parameters *viz.*, average maximum temperature of 29.43ºC, average minimum temperature of 18.82ºC, average relative humidity of 70 per cent, average sunshine hours of 6.89 hours, total rainfall of 13.0 mm, average wind velocity of 7.16 kmph and average soil temperature of 22.37ºC favoured maximum disease development (Figure. 2). Disease severity increased slowly and reached its peak of 66.26 per cent during 5th standard week (29th January to 4th February, 2023). During this period maximum temperature of 29.00ºC, minimum temperature of 19.43ºC, relative humidity of 72.14 per cent, sunshine hours of 5.25 hours, total rainfall of 3.00 mm, wind velocity of 6.26 kmph and soil temperature of 23.54ºC, but after 5th standard week the disease severity had decreased slowly. As a result, after the fifth week, there were very few showers with an extended period of maximum temperature above 30ºC. Because of the high temperature, even when it rains, powdery mildew does not form on grapevines. Studies by Kareppa *et al.* (2004) indicated that the most ideal conditions for the greater occurrence of powdery mildew of grapes were a mean maximum temperature of 28.0 to 29.0^{0}C and a mean relative humidity of 79-84 per cent. It was also found that the chill and humid conditions from the last week of December to the first week of February were also most conducive for the peak incidence of powdery mildew. Shahri *et al.* (2006) investigated the germination of conidial and ascospores of *Erysiphe necator*, the causative agent of grape powdery mildew, at various temperature and relative humidity at the temperature 25°C, ascospore germination was found to be the highest (37 %). The optimal temperature for ascospore germination was found to be between 20 and 30°C. Conidia grew on dry microscopic slides or grape leaves at a variety of temperature and relative humidity levels.

Table 2. Influence of weather parameters on occurrence of grapes powdery mildew during June, 2022 to April, 2023

Summer pruning			**Winter pruning**		
Standard Week	**Period**	**PDI (%)**	**Standard Week**	**Period**	**PDI (%)**
26	25th of June – 01st of July, 2022	0	49	03rd – 09th of December	0

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 1786-1791 | ISSN:2251-6727

27	2nd – 8th of July, 2022	0	50	10th – 16th of December	0
28	9th – 15th of July, 2022	2.08	51	17th – 23rd of December	0
29	16th – 22th of July, 2022	5.15	52	24th – 31st of December	2.30
30	23rd – 29th of July, 2022	12.90	1	1st - 07th of January, 2023	9.27
31	30th of July – 5th of August, 2022	20.5	2	8th – 14th of January	18.45
32	6th – 12th of August, 2022	12.09	3	15th – 21st of January	29.64
33	13th – 19th of August, 2022	15.26	4	22nd – 28th of January	48.82
34	20th – 26th of August, 2022	17.49	5	29th of January - 4th of February	66.26
35	27th of August – 02nd of September, 2022	5.80	6	5th – 11th of February	60.40
36	3rd – 9th of September	7.22	7	12th – 18th of February	56.91
37	10th – 16th of September, 2022	10.64	8	19th – 25th of February	51.13
38	17th – 23rd of September, 2022	24.18	9	26th of February – 4th of March	45.51
39	24th – 30th of September, 2022	37.67	10	5th – 11th of March	41.80
40	01st – 07th of October, 2022	48.32	11	12th – 18th of March	44.19
41	8th – 14th of October, 2022	62.73	12	19th – 25th of March	49.25
42	15th – 21st of October, 2022	9.21	13	26th – 1st of April	52.65
43	22nd – 28th of October, 2022	22.95	14	2nd – 8th of April	36.82

***PDI – Percent Disease Index**

Figure 1. Standard week weather data prevailed during the summer pruning season from June, 2022 to October, 2022

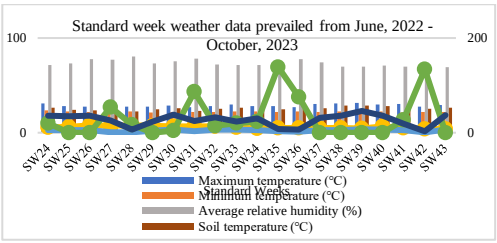
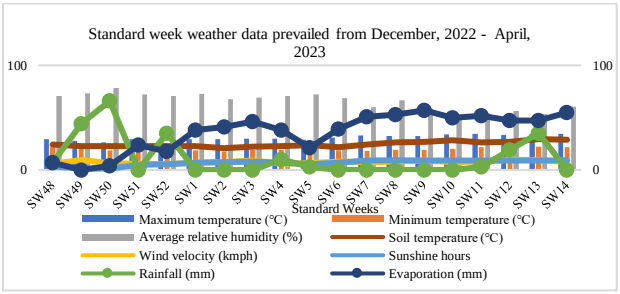


Figure 2. Standard week weather data prevailed during the winter pruning from December, 2022 to April, 2023



4. Correlation studies

A simple correlation coefficient was worked out with the weather parameters recorded during the study period of powdery mildew in grapes over the pruning seasons from June, 2022 to April, 2023. A simple correlation studies (Table 3) revealed that during summer pruning, maximum temperature, sunshine hours and soil temperature had a positively significant correlation with disease severity, but average relative humidity had a considerably negative correlation. However, the disease severity was negatively but not significantly correlated with minimum temperature, rainfall and wind velocity. Further, there was a positive correlation noticed with evaporation but it was non-significant. As a result, prevailed weather conditions had a key impact on the development of powdery mildew during summer pruning. Mane *et al.* (1996) reported that higher incidence of grape powdery mildew disease was observed in the months of December and January, which were aided by temperature from 11.6 to 30.4°C and relative humidity 53 to 97 per cent.

Table 3. Correlation between incidence of powdery mildew with weather parameter prevailed during July, 2022 to April, 2023

Pruning season	**Correlation coefficient**							
	Max temp. (°C)	Min temp. (°C)	Average Relative humidity	Wind velocity (kmph)	Sunshine hours	Rainfall (mm)	Evaporation (mm)	Soil temp. (°C)

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 1786-1791 | ISSN:2251-6727

			(%)					
Summer pruning	0.67**	-0.066	-0.602**	-0.328	0.513*	-0.253	0.316	0.604**
Winter pruning	0.604*	0.292	-0.457	0.476*	0.595*	-0.379	0.397	0.408

The present studies on correlation of weather parameters on powdery mildew disease incidence (Table 3) indicated that during winter pruning, the maximum temperature, wind velocity and sunshine hours had a substantially positively correlattion with disease severity, but the minimum temperature, evaporation and soil temperature had a non-significant positive correlation. Similarly, the average relative humidity and rainfall exhibited a non-significant negative correlation. Powdery mildew severity in grapes rose with maximum temperature, minimum temperature and sunshine hours and higher rainfall has an influence on disease incidence. Sonawane (2013) reported that a substantial positive link between powdery mildew severity and temperature (maximum and minimum) and a significant negative correlation between humidity and disease development supported the present study.

Table 4. Multiple regression between incidence of powdery mildew and weather parameters prevailed during July,2022 to April, 2023

Pruning season	Intercept (A)	Max temp. (°C)	Min temp. (°C)	Average Relative humidity (%)	Wind velocity (kmph)	Sunshine hours	Rainfall (mm)	Evaporation (mm)	Soil temp. (°C)	R^2
Summer pruning	-27.42	6.87	-0.36	-1.91	1.44	2.03	0.07	-0.24	-1.02	0.53
Winter pruning	2.54	3.58	-4.72	-0.39	3.46	10.30	-0.113	-1.29	-0.36	0.52

The regressing on incidence of grapes powdery mildew data with all the weather parameters prevailed after summer pruning, the following multiple regression equation was obtained (Table 4).

$$Y= -27.42 + 6.87 (X_1) -0.36 (X_2) -1.91 (X_3) +1.44 (X_4) + 2.03 (X_5) + 0.07 (X_6) -0.24 (X_7) - 1.02 (X_8)$$

Where, Y= Disease incidence
X_1 = Maximum temperature (°C)
X_2 = Minimum temperature (°C)
X_3 = Average relative humidity (%)
X_4 = Wind velocity (kmph)
X_5 = Sunshine (hours)
X_6 = Rainfall (mm)
X_7 = Evaporation (mm)
X_8 = Soil temperature (°C)

The multiple regression equation indicated that for every unit increases in maximum temperature, wind velocity, sunshine hours and total rainfall would ultimately result in higher incidence of powdery mildew by 6.87, 1.44, 2.03 and 0.07 times respectively. Whereas, every unit increase in minimum temperature, average relative humidity, evaporation and soil temperature would decrease the incidence of powdery mildew by 0.36, 1.91, 0.24 and 1.02 times respectively. The study indicated that weather parameters influenced the incidence of powdery mildew to the extent of 53.0 per cent ($R^2 = 0.53$).

The regression analysis on the incidence of powdery mildew data prevailed with all the weather parameters after winter pruning, the following multiple regression equation was obtained (Table 4).

$$Y= 2.54 + 3.58 (X_1) -4.72 (X_2) -0.39 (X_3) +3.46 (X_4) + 10.30 (X_5) + -0.11 (X_6) -1.29 (X_7) – 0.36 (X_8)$$

The multiple regression equation indicated that for every unit increase in maximum temperature, wind velocity and sunshine hours would result in the higher incidence of powdery mildew by 3.58, 3.46 and 10.30 times respectively. Whereas, every unit increase in minimum temperature, average relative humidity, rainfall, evaporation and soil temperature would decrease the incidence of powdery mildew by 4.72, 0.39, 0.11, 1.29 and 0.36 times respectively. The weather parameters influenced the incidence of powdery mildew to the extent of 52.0 per cent ($R^2 = 0.52$).

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 1786-1791 | ISSN:2251-6727

5. Conclusion

The severity of grapevine powdery mildew disease incidence (*Erysiphe necator*) was predominantly influenced by weather parameters that were positively correlated with the maximum temperature and sunshine hours. As a result of the favourable conditions, disease incidence ultimately lower the grape yield and quality. The findings of this research would also be utilized for the development of location-specific models and decision support systems (DSS) for weather-based forecasting and advisory services for an effective management of powdery mildew disease in grapes to enhance the yield and quality for the benefit of grape farming community.

Fig 4.

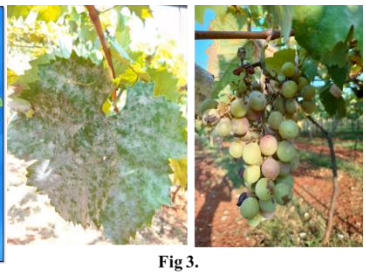


Fig 3.

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