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# Epidemiological Study of Downy Mildew Disease of Opium Poppy

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

The downy mildew caused by *Peronospora*spp is a major disastrous disease of many plant species. The symptoms of downy mildew disease incidence on opium poppy (*Papaver somniferum* L.) were collected in three years from 2019-20 to 2021-22 for prediction of weather parameters on the progression of downy mildew disease. The downy mildew disease initiation was recorded in the 52$^{nd}$ SMW (10.0%DMI) when the maximum temperature was 19.43$^0$C. At 3$^{rd}$ SMW, the maximum temperature dropped 17.33$^0$C and DMI reached up to 20.00 percent depicting the progression and spread of downy mildew disease in opium poppy with the decrease of maximum temperature. The maximum disease incidence was recorded 92.53 percent in 10$^{th}$ SMW when maximum and minimum temperature were 29.03$^0$C and 13.53$^0$C. Regression analysis between dependent variable downy mildew disease incidence *Vs.* independent variables (*viz*., rainfall, maximum and minimum temperature and relative humidity) showed that all the weather parameters contributed more than 85 percent variation ($R^2$ = 0.869, 0.957, 0.859) in the downy mildew incidence of opium poppy. One unit change of maximum temperature, minimum temperature (1.0$^0$c), maximum and minimum relative humidity (1.0%) might cause to change 0.128, 0.70, 0.117 0.130 units in downy mildew incidence, respectively.

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## 1. INTRODUCTION

Downy mildew disease of opium poppy (*Papaver somniferum*L.) caused by biotrophic obligate parasite *Peronospora arborescens* (Berk), which is one of the most disastrous disease for the economically important crop of opium poppy [1]. Opium poppy is a strategic crop for the pharmaceutical industry and provides alkaloids such as morphine, codeine and thebaine for the formulation of several life saving drugs. The severity of downy mildew is affected by meteorological factors, i.e. high relative humidity, moderate temperature ($20^0$C) and rainfall [2]. During the high relative humidity large number of asexual spore s(sporangia) are producing by the downy mildew pathogen which are subsequently dispersed from few hundred meters to several kilometers by air currents and caused primary infection. These primary infectionscan causes secondary infection on the abaxial surface of leaves [3]. Moist leaf surface for 24hours after the primary infection showed prolific sporulation and rapid spread of the disease [4]. The aims of study to examine the optimal meteorological factors for predisposing the disease and its record disease progress in changing climatic scenario for recommendations and advisories to farmers for minimizing yield losses due to this devastating pathogen.

## 2. MATERIALS AND METHODS

The study was conducted in the experimental field at Medicinal and Aromatic plants research station, A.N.D University of Agriculture & Technology Kumarganj, Ayodhya, Uttar Pradesh, India, where the downy mildew disease of Opium poppy was frequently recorded under natural field condition. The trial was conducted during *Rabi* 2019-20 to 2021-22. The data of downy mildew disease was recorded under natural conditions; however, standard agronomical management practices were adopted. Observations for disease incidence were recorded at weekly interval from 30 days after sowing (DAS) till to maturity. Disease incidence was expressed as percentage of diseased plants over total plants. Weather data namely temperature, relative humidity and rainfall were recorded at weekly interval during the opium poppy growing season, it was obtained from the meteorological observatory of ANDUAT, Kumarganj, Ayodhya. Correlation and regression coefficients between disease incidence and weather variables *viz*.,rainfall maximum and minimum temperature and relative humidity prevailing during the crop growing periods was derived.

## 3. RESULTS AND DISCUSSION

The pooled data for weekly mean values of weather variables and downy mildew incidence in the Opium poppy variety Kirtman for the Rabi 2019-20 to 2021-22 revealed that downy mildew incidence (DMI) occurred from 52$^{nd}$ to 10$^{th}$ standard meteorological week(SMW) during all three growing years (Table 1). The average maximum and minimum temperature ranged from 17.33 $^0$C to 29.03 $^0$C and 6.76 $^0$C to 13.53$^0$C respectively with 95.6 and 53.95 percent maximum and minimum relative humidity during the study. The downy mildew disease initiation was recorded in the 52$^{nd}$ SMW (10.0%DMI) when the maximum temperature was 19.43 $^0$C. In the 3$^{rd}$ SMW, the maximum temperature dropped to 17.33$^0$C and DMI reached upto 20.00 percent. This favoured a progression and spread of downy mildew disease in opium poppy with the progressive decrease of maximum temperature. The maximum disease incidence was recorded at 92.53 percent in 10$^{th}$ SMW at maximum and minimum temperature were 29.03$^0$C and 13.53$^0$C respectively. Sangeetha and Siddaramaih [5] reported maximum downy mildew incidence in mustard when minimum and maximum temperature were 26$^0$C and 29$^0$C respectively. This result are in partial agreement to the previous report.

During the disease initiation high variation was observed in maximum (93.05%) and minimum (55.2%) relative humidity due to rainfall (2.10mm) which had influence on spore build up in the 52$^{nd}$ SMW.. The high rainfall (6.8mm) and maximum (92.53%) and minimum (58.05%) relative humidity were also recorded; when the downy mildew disease incidence was reached at the peak (10$^{th}$SMW). The similar results were found by Daunde et al. [6] and Arti and Singh [7] in downy mildew disease of cucumber and pearl millet respectively, up to 28$^{th}$ SMW with high morning and evening relative humidity. The rains received during standard meteorological weeks were in 52$^{nd}$ (2.10mm), 1$^{st}$ (4.6mm) 2$^{nd}$ (4.12mm), 3$^{rd}$ (4.15mm) and 4$^{rth}$ (1.25mm) with relative humidity in the range of 91.4 to 95.6% resulted to fast build up of downy mildew disease incidence (22.33%). However, variation in an

amount of rainfall did not significantly affected to disease development. These results are similar with the findings of Ghule et al. [8].

The correlation coefficients between downy mildew incidence (DMI) and weather parameters over the three consecutive cropp season are computed (Table2). The results shown a significant positive correlation between DMI and temperature (minimum temperature (r=0.86), maximum temperature (r= 0.95) as well as relative humidity ( maximum relative humidity (r= 0.86)). Whereas minimum relative humidity was found negative significant correlation (r= -052%). However, the effect of rainfall was not significant with DMI. Dhaliwal et al. [9] also reported negative and significant correlation with temperature and rainfall in maize stem borer incidence.

The regression analysis of all crop season 2019-20 to 2021-22 is presented in Table 2. Findings of the regression analysis between dependent variable (Downy mildew disease incidence) *Vs.* independent variables (*viz*., rainfall, maximum and minimum temperature and relative humidity) showed that all the weather parameters accounted for more than 85 percent variation ($R^2$ = 0.869, 0.957, 0.859) in the downy mildew incidence of opium poppy. One unit change of maximum temperature, minimum temperature (1.0 $^0$C), maximum and minimum relative humidity (1.0%) might cause to change 0.128, 0.70, 0.117 0.130 units in downy mildew incidence, respectively. Saharan and Saharan [10] reported that a multiple regression analysis of data which revealed minimum temperature, high relative humidity in the evening and sunshine and cumulative rainfall played major role in *Alternaria* leaf blight disease development of cluster bean. Das and Raut [11] investigated that relative humidity was one of the most important weather parameters, which determine strip disease development in sorghum.

**Table 1. Mean weather variable and per cent downy mildew disease incidence inopium poppy during (2019-20,2020-21 and 2021-22 Pooled mean)**

| Month | Standard Met. Week (SMW) | Temperature ($^0$C) | | Relative humidity (%) | | Rainfall(mm) | Per cent downy mildew incidence |
|---|---|---|---|---|---|---|---|
| | | Minimum | Maximum | Minimum | Maximum | | |
| Dec. | 52 | 6.76 | 19.43 | 55.2 | 93.05 | 2.10 | 10.00 |
| Jan. | 1 | 9.3 | 20.96 | 57.55 | 91.4 | 4.6 | 15.00 |
| | 2 | 9.2 | 19.33 | 68.8 | 92.6 | 4.12 | 16.50 |
| | 3 | 7.76 | 17.33 | 72.1 | 94.75 | 4.15 | 20.00 |
| | 4 | 7.23 | 18.2 | 76.2 | 95.6 | 1.25 | 22.33 |
| | 5 | 7.2 | 20.83 | 63.45 | 94.35 | 0.00 | 30.00 |
| Feb. | 6 | 8.06 | 22.93 | 60.95 | 91.1 | 0.00 | 45.00 |
| | 7 | 9.4 | 24.66 | 57.3 | 91.15 | 0.00 | 62.00 |
| | 8 | 12.53 | 26.4 | 53.95 | 90.0 | 5.3 | 70.50 |
| | 9 | 12.86 | 28.03 | 55.1 | 83.3 | 0.00 | 85.00 |
| March | 10 | 13.53 | 29.03 | 58.05 | 83.6 | 6.8 | 92.53 |

**Table 2. Correlation and regression coefficient between three year (2019-20, 2020-21 and 2021-22) pooled per cent disease incidence of downy mildew disease of opium poppy and meteorological factors**

| S.No. | Environmental factor | Correlation coefficient | Regression coefficient | |
|---|---|---|---|---|
| | | | Regression equation | $R^2$ value |
| 1. | Minimum temperature | 0.86987** | Y= 0.070x+6.421 | 0.869483** |
| 2. | Maximum temperature | 0.957554** | Y=0.128x+16.98 | 0.957079** |
| 3. | Minimum relative humidity | -0.5187* | Y=-0.130x+67.24 | 0.518652* |
| 4. | Maximum relative humidity | 0.85951** | Y=0.117x+95.99 | 0.859069** |
| 5. | Rainfall | 0.08569 | Y=0.007x+2.270 | 0.083666 |

***** *Significant* *******Highly Significant*

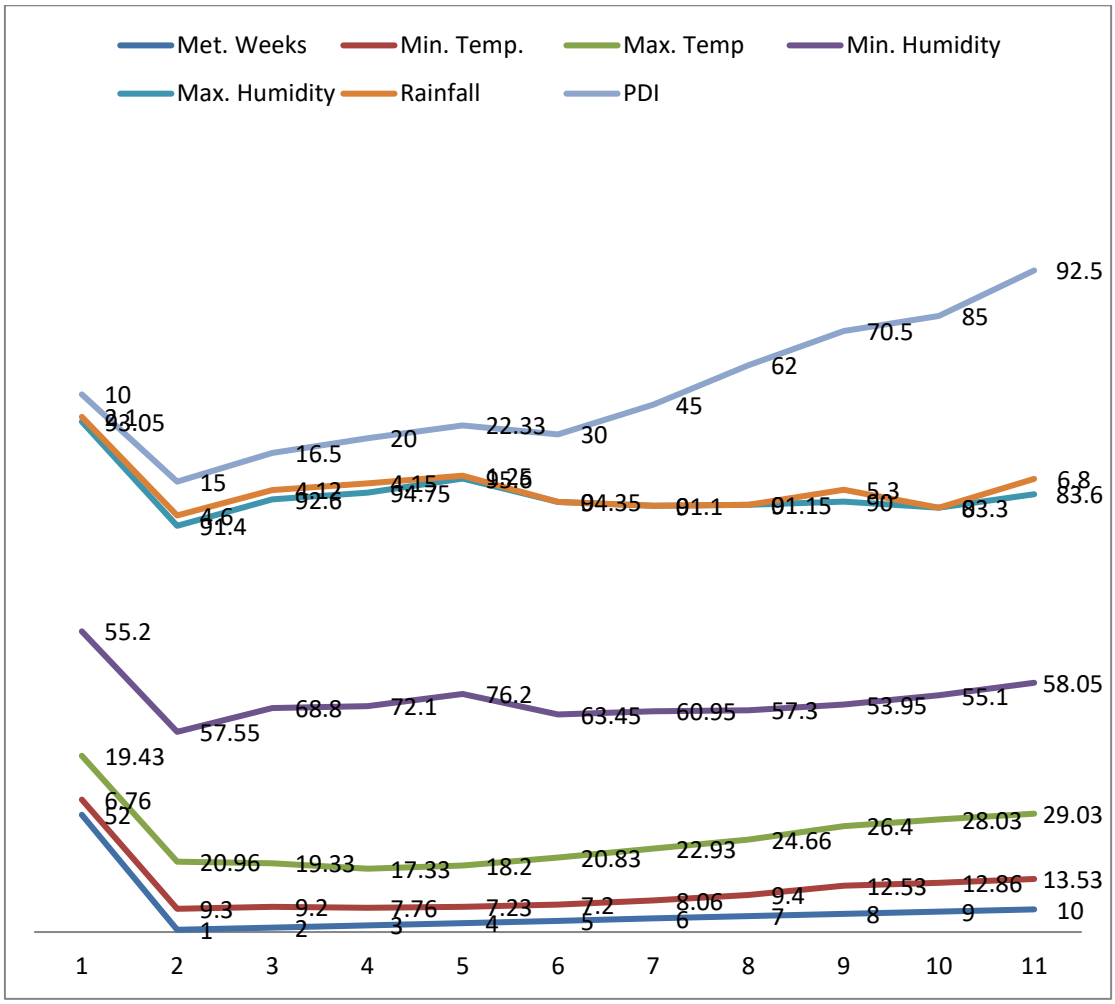


**Fig. 1. Graphical representation of per cent disease incidence and meteorological factors**

## 4. CONCLUSION

The results were shown significant positive correlation between DMI and minimum temperature(r=0.86), maximum temperature (r= 0.95) and maximum relative humidity (r= 0.86). Whereas minimum relative humidity was found negative significant correlation (r= -052%). The effect of rainfall was not significant with DMI.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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