Short Communication

Influence of weather variables on morphological structures of *Pseudoperonospora cubensis* in cucumber

S. HEMBRAM¹, S. DUTTA *², I. BHATTACHARYA¹, A. SAHA³ and D. MAJUMDER⁴

¹Department of Plant Pathology, ²AICRP on Vegetable Crops, ³Department of Agricultural Meteorology, ⁴Department of Agricultural Statistics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India

*E-mail: subrata_mithu@yahoo.co.in

Downy mildew, powdery mildew, gummosis, anthracnose, *Phytophthora* blight, *Cercospora* leaf spot, root knot nematode and watermelon bud necrosis virus are becoming the most destructive diseases of cucurbits in India. Among these diseases, downy mildew, a foliar disease caused by the Oomycetous fungus, *Pseudoperonospora cubensis* (Berk and Curt) Rostow is one of the most destructive pathogens of cucurbits (Palti and Cohen, 1980). Weather variables, greatly influence the outbreaks of cucurbit downy mildew epidemics. The degree of infection of cucurbits by *P. cubensis* is greatly influenced by temperature and leaf wetness. Environmental conditions greatly influence sporangial production, liberation, dispersal, and survival. Sporangial production is affected by temperature, moisture, and light (Reuveni and Raviv, 1997; Rotem, et al. 1978). Morphology of *Pseudoperonospora cubensis* seems to be reliant on several factors viz., weather variables, hosts and nutritional factors (Cohen & Eyal, 1977; Kulkarni et al. 2009). Variability in morphological dimensions of *P. cubensis* may have some major impact on downy mildew disease and epidemic development. Thus, the objectives of this study were to identify the influence of weather variables on sporangial production and variation in morphological parameters of *P. cubensis*.

The field experiment was laid out in C-Block farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal under new alluvial zone (22.9°N latitude, 89°E longitudes at an elevation of 9.75 mamsl) in a cucumber field for 12 months during the growing season of 2009-10. The weather variables were collected from nearby observatory. The cucumber crop (local cultivar) was sown in February, May, September and December, 2009 and standard agronomic and plant protection techniques were followed except use of any fungicides. For this experiment infected lesions were collected from the downy mildew infected leaves of cucumber field and teased on glass slide with a drop of lacto phenol and mounted on the microscope throughout the year. The morphological characters examined were the length of the sporangiophores (n = 20), the height of the first branching (n = 20), the number of branching (n = 20) and the length and the width of the sporangia (n = 20). The morphological parameters of *P. cubensis* isolates of different host were observed through micrometric measurement in different season of the year and their average values were presented. The sporangial production was evaluated from the sporulating area of the infected leaf through haemocytometer as expressed as number of sporangia per cm² area. Correlation and regression analysis were carried out to find out the association between weather parameter and morphological structure of *P. cubensis*.

The significantly maximum length of sporangiophore of *Pseudoperonospora cubensis* on cucumber host was observed in the month of January and significantly minimum length of sporangiophore was recorded in the month of May. Significantly higher numbers of branches and spores per spot were observed during November to January and lower numbers of branches and spores per spot were observed during April-May (Table 1). The present findings, thus suggested that environmental factors had strongly influenced on the variation of morphological dimensions of *Pseudoperonospora cubensis*. The significantly lowest spore concentration of *P. cubensis* was observed during April-May period and lower sporulation during this period may be associated with hot and dry climatic spell and consequently low disease severity was recorded during this period. Higher temperature with dry spell during April-May months may affect the sporangiophore and sporangial developmental stages of *P. cubensis*. Sporangia and sporangiophores are greatly affected by changes in temperature and humidity. Temperature has been stated to be the most important external factors affecting the growth and development of sporangiophores (Iwata, 1953).
Table 1: Morphological structures of *Pseudoperonospora cubensis* on cucumber host during 2009-2010

| Months | Total length of sporangiophore (A) (µm) | Height of branching started (B) (µm) | Ratio of B:A | Total number of branches | Spore size (Length µm) | Spore size (Breath µm) | Spore concentration per spot (in 10⁴/cm²) |
|--------|----------------------------------------|-------------------------------------|--------------|-------------------------|-----------------------|-----------------------|------------------------------------------|
| January| 323                                    | 245                                 | 0.76         | 15.04                   | 28.29                 | 18.41                 | 2.19                                      |
| February| 312                                   | 228                                 | 0.73         | 13.67                   | 28.09                 | 18.2                  | 1.99                                      |
| March  | 309                                    | 223                                 | 0.72         | 12.76                   | 27.93                 | 18.58                 | 1.75                                      |
| April  | 286                                    | 206                                 | 0.72         | 12.40                   | 28.06                 | 18.56                 | 1.42                                      |
| May    | 265                                    | 201                                 | 0.76         | 12.46                   | 28.04                 | 18.58                 | 1.47                                      |
| June   | 257                                    | 202                                 | 0.79         | 12.57                   | 28.04                 | 18.58                 | 1.69                                      |
| July   | 270                                    | 205                                 | 0.76         | 12.75                   | 28.06                 | 18.61                 | 1.75                                      |
| August | 277                                    | 208                                 | 0.75         | 12.94                   | 28.06                 | 18.6                  | 1.84                                      |
| September| 286                                   | 213                                 | 0.74         | 13.41                   | 28.04                 | 18.58                 | 1.92                                      |
| October| 287                                    | 216                                 | 0.75         | 13.49                   | 28.94                 | 18.17                 | 1.98                                      |
| November| 299                                   | 221                                 | 0.74         | 14.74                   | 29.68                 | 18.91                 | 2.01                                      |
| December| 312                                   | 229                                 | 0.73         | 14.87                   | 28.06                 | 18.15                 | 2.07                                      |
| SEM±1  | 3.65                                   | 4.27                                | 0.00         | 0.07                    | 0.11                  | 0.14                  | 0.09                                      |
| CD(5%) | 10.72                                  | 12.51                               | 0.01         | 0.20                    | 0.31                  | 0.41                  | 0.27                                      |

Table 2: Correlation analysis between morphological characteristics of *Pseudoperonospora cubensis* and weather variables

| Weather Parameter | Total length of sporangiophore | Height of branching started | Total no of branch | Spore concentration |
|-------------------|-------------------------------|-----------------------------|-------------------|--------------------|
| Max. Temp.        | -0.703*                       | -0.821**                    | -0.928**          | -0.934**           |
| Min. Temp.        | -0.902**                      | -0.912**                    | -0.837**          | -0.684*            |
| Max. RH           | 0.267                         | 0.360                       | 0.540*            | 0.726**            |
| Min. RH           | -0.631*                       | -0.483                      | -0.188            | 0.112              |
| Wind Speed(WS)    | -0.338                        | -0.445                      | -0.694**          | -0.846**           |
| Sun Shine hour    | 0.327                         | 0.229                       | 0.054             | -0.248             |
| Rainfall(RF)      | -0.674*                       | -0.602*                     | -0.514*           | -0.244             |
| Evaporation       | -0.527                        | -0.644*                     | -0.812**          | -0.932**           |

**Significant at 1% level, *Significant at 0.5% level**

Table 3: Multiple regressions equation using stepwise technique

| Equation                                      | R²     |
|-----------------------------------------------|--------|
| Total length of sporangiophore                | 362.197-3.342(min. temp.) | 0.813 |
| Height of branching started                   | 262.594-2.145(min. temp.) | 0.832 |
| Total no of branch                            | 21.961-0.258(min. temp.)-0.002(RF) | 0.921 |
| Spore concentration                           | 4.629-0.008(max. temp.)-0.02(WS) | 0.922 |
Morphological variations of the oomycete appear to be correlated with host and environmental conditions (Lebeda and Widrlechner, 2003).

**Correlation and multiple regression analysis**

The results of correlation analysis presented in Table 2 revealed that total length of sporangiopore was found to be significantly negatively correlated with maximum temperature ($r=-0.70$), minimum temperature ($r=-0.90$), minimum RH ($r=-0.63$) and rainfall ($r=0.67$), whereas branch length was found to be significantly negatively correlated with maximum temperature ($r=-0.82$), minimum temperature ($r=-0.91$), rainfall ($r=0.60$) and evaporation ($r=-0.64$). Also total number of branches was significantly negatively correlated with maximum temperature ($r=-0.93$), minimum temperature ($r=-0.84$), wind speed ($r=-0.69$), rainfall ($r=0.51$), and evaporation ($r=-0.81$) whereas total number of branches was found to be significantly positively correlated with maximum relative humidity ($r=0.54$) whereas spore concentration was significantly negatively correlated with maximum temperature ($r=-0.93$), minimum temperature ($r=-0.68$), maximum relative humidity ($r=-0.73$), wind speed ($r=-0.85$) and evaporation ($r=-0.93$). However, step-wise regression by considering all the weather variables as predictors to explain total length of sporangiophore, height of branching, total number of branches revealed that an increase in minimum temperature, rainfall and wind speed resulted in decrease in the respective morphological characteristics (Table 2&3). Temperature and rainfall were found to be the two most important weather variables associated with the variation in the morphological characteristics and sporulation of *P. cubensis* on cucumber. These identified weather variables may be further exploited under in field condition for development of cucumber downy mildew disease prediction model.

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