Wilt epidemiology of pigeonpea (Cajanus cajan (L.) Millsp.) in organic farming system

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Abstract: Pigeonpea (Cajanus cajan (L.) Millsp.) is widely cultivated in hill slopes of Manipur under organic farming system for multipurpose use as fuel, fodder, vegetable, pulse etc. The growing sites where survey was conducted showed different degree of disease incidence and severity of wilt in pigeonpea caused by Fusarium udum. Maximum disease incidence (58.77 %; early maturing (V1) & 42.74 %; late maturing (V2)) and severity (55.22 %; V1 & 40.96 %; V2) were found at sampling sites (Motbung; V1 & Kanglatongbi; V2) where pigeonpea is grown continuously. Disease progress is slow during the early phases of growth but accelerates during the flowering and podding stage. Rate of infection was highest in flowering and podding stage and there was slight variation in area under disease progress curve between the sampling sites. Significant positive and negative correlations were observed between disease incidence and severity and meteorological factors.

Keywords: Apparent rate of infection, AUDPC, Epidemiology, Fusarium udum, Wilt

I. INTRODUCTION

In Manipur pigeonpea is mostly cultivated in the sloppy hills particularly in the Sadar hills (Senapati District). It is not much cultivated in the valley of Manipur due to waterlogging condition except in some elevated and isolated areas. Wilt disease caused by Fusarium udum is a major problem in the production of pigeonpea in the state. The disease can attack at any stage of the plant but highest mortality occurs at flowering and podding stage. The apparent rate of infection ‘r’ and AUDPC for wilt is helpful in evaluation of pigeonpea for wilt resistance and for studying the influence of crop seed mixtures, rotations and pathotypes on wilt incidence [1]. The present investigation was therefore aimed to analyze the epidemiology of wilt disease of pigeonpea using different disease parameters under Manipur climatic conditions as such not much work is done on the epidemiology of wilt disease.

II. Materials And Methods

2.1 Survey

Extensive survey was conducted for three consecutive year during the cropping season (2008-2010) on two local varieties of pigeonpea viz., early maturing variety (V1) and late maturing variety (V2) for the quantification of wilt of pigeonpea caused by Fusarium udum Butler at different organic fields. Surveys were conducted following two methods. (i) Roving survey and (ii) Site specific fixed location

2.1.1 Roving survey: Survey was conducted at Senapati District (93.40⁰ E and 94.29⁰ E longitudes and between 24.37⁰ and 25.37⁰ N latitudes, 1061-1788 m above sea level) of Manipur covering 45 Km regularly at monthly interval. The selected sites include Kanglatongbi, Motbung, Spermeina, Toribari and Kangpokpi.

2.1.2 Fixed location survey: Survey was conducted regularly at monthly interval at monthly interval at Senjam Chirang, Imphal West (24.30⁰ N and 25.00⁰ N latitudes and 93.45⁰E and 94.15⁰ E 790 m above mean sea level) 16 km away from Imphal and Uyumpok, Imphal East (92⁰59’ to 93⁰50’E longitude and 23⁰55’ to 24⁰30’ N latitude, 790 m above mean sea level) 21Km away from Imphal.

2.2 Disease measurement

Epidemiological study of Fusarium wilt of pigeonpea was studied by analyzing different disease parameters. The disease parameters include: percent disease incidence (DI%), percent disease severity (DS%) following 0-9 rating scale [2], disease progress curve, area under disease progress curve (AUDPC) in accordance to [3], apparent rate of infection (r) as per the formula given by [4] and simple correlation for ascertaining the relationship between disease parameters and meteorological factor.

\[
(1) \text{DI} \% = \frac{\text{Number of plants infected by wilt disease}}{\text{Total number of plants observed}} \times 100
\]

\[
(2) \text{DS} \% = \frac{\text{Sum of all numerical ratings}}{\text{Total number of plants examined} \times \text{Maximum rating scale}} \times 100
\]
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Plotting the disease progress curves: Disease incidence (pooled data) were plotted on the ordinate (Y axis) and the time on the abscissa (X axis).

\[
(3) \text{AUDPC} = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{(y_{i+1} + y_i)}{2} \right] \left[ x_{i+1} - x_i \right]
\]

(Shaner and Finney, 1977)

Where \( y_i \) and \( y_{i+1} \) are the severity in the \( i^{th} \) observations and \((i+1)^{th}\) observations, \( x_i \) and \( x_{i+1} \) are the time (in week) in the \( i^{th} \) and \((i+1)^{th}\) observations, and \( n \) is the total no of observations.

(4) Apparent rate of disease infection \((r)\) is worked out as per Van der Plank (1963)

\[
r = \frac{2.3}{t_2 - t_1} \left( \log \frac{x_2}{1 - x_2} - \log \frac{x_1}{1 - x_1} \right)
\]

Where \( t_2 - t_1 \) is the time interval of consecutive observations. \( x_1 \) and \( x_2 \) are the disease severity in time \( t_1 \) and \( t_2 \) respectively.

III. Results And Discussions

Disease progress (Fig.1) was slow in spite of early appearance of disease symptoms during the vegetative phase and accelerates only in the flowering and podding stage. The survey sites showed different degree of disease incidence and severity. Maximum disease incidence (58.77% & 42.74%) and severity (55.22% & 40.96%) were found in sampling sites (Motbung: \( V_1 \) and Kanglatongbi; \( V_2 \)) where pigeonpea cultivation is practiced year after year. This is supported by [5] who reported the survival of the fungus on infected plant debris. Lower incidence of the disease was observed in sampling sites where pigeonpea is cultivated in alternate year (Table1,2). Varietal variation in disease parameters were observed between the two tested.

FIGURE AND TABLES

Fig.1. Disease progress curve

Table 1. Disease incidence and severity at different sampling sites for \( V_1 \).

<table>
<thead>
<tr>
<th>Year</th>
<th>DS%</th>
<th>DI%</th>
<th>Sampling sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>35.85</td>
<td>35.98</td>
<td>1. Kanglatongbi</td>
</tr>
<tr>
<td>2009</td>
<td>43.08</td>
<td>37.33</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>37.33</td>
<td>37.55</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>44.56</td>
<td>44.56</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>58.77</td>
<td>35.04</td>
<td>2. Motbung</td>
</tr>
<tr>
<td>2009</td>
<td>34.04</td>
<td>31.89</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>55.22</td>
<td>32.67</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>32.67</td>
<td>33.67</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>39.54</td>
<td>29.88</td>
<td>3. Spermeina</td>
</tr>
<tr>
<td>2009</td>
<td>33.67</td>
<td>34.56</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>30.89</td>
<td>30.89</td>
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</table>
Table 2. Disease incidence and severity at different sampling sites for \( V_2 \).

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>DI%</th>
<th>DS%</th>
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<th>2009-10</th>
<th>2010-11</th>
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<td>2. Motbung</td>
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<td>25.04</td>
<td>12.05</td>
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<td>25.04</td>
<td>28.30</td>
<td>25.04</td>
<td>20.89</td>
</tr>
<tr>
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<td>17.41</td>
<td>26.89</td>
<td>17.41</td>
<td>13.70</td>
</tr>
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<td>6. Senjam Chirang</td>
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<td>33.85</td>
<td>30.82</td>
<td>18.22</td>
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<td>7. Uyumpok</td>
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<td>27.41</td>
<td>33.26</td>
<td>27.41</td>
<td>24.44</td>
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Table 3. Apparent rate of infection (r) and area under disease curve (AUDPC) of Fusarium wilt of pigeonpea; \( V_1 \) (2008).

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Days after sowing</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kanglatongbi</td>
<td>195</td>
<td>1021.2</td>
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<tr>
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<td>1143.3</td>
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<td>0.518</td>
<td>490.05</td>
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<td>5. Kangpokpi</td>
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<td>0.549</td>
<td>365.55</td>
<td>0.370</td>
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<td></td>
<td>1693.5</td>
<td>0.630</td>
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<td>1.037</td>
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Table 4. Apparent rate of infection (r) and area under disease curve (AUDPC) of Fusarium wilt of pigeonpea; \( V_1 \) (2009).

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Days after sowing</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
<th>r</th>
</tr>
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</tbody>
</table>
Table 5. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; \( V_1 \) (2010).

<table>
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<tr>
<th>Sampling sites</th>
<th>Days after sowing</th>
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<th>165</th>
<th>135</th>
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<td>AUDPC</td>
<td>r</td>
<td>AUDPC</td>
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<td>2375.7</td>
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Table 6. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; \( V_2 \) (2008-2009).

<table>
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<tr>
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<th>255</th>
<th>225</th>
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<tbody>
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<td>AUDPC</td>
<td>r</td>
<td>AUDPC</td>
<td>r</td>
<td>AUDPC</td>
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<td>1595.55</td>
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<td>0.015</td>
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<td>1224.45</td>
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<td>1288.8</td>
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<td>1255.5</td>
<td>0.122</td>
<td>1116.3</td>
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<td>1114.5</td>
<td>0.104</td>
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<td>0.565</td>
<td>624.45</td>
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<td>1832.25</td>
<td>0.141</td>
<td>1567.8</td>
<td>0.256</td>
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</table>
Table 7. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; \(V_2\) (2009-2010).

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Days after sowing</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
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<tbody>
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<td>1.Kanglatongbi</td>
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<td>0.277</td>
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<td>0.245</td>
<td>1436.7</td>
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<td>2. Motbung</td>
<td>255</td>
<td>1803.45</td>
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<td>0.130</td>
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<td>3. Spermeina</td>
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<td>1415.55</td>
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<td>0.184</td>
<td>1142.25</td>
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<td>1.Kanglatongbi</td>
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<td>1470</td>
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Table 8. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; \(V_2\) (2010-2011).

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Days after sowing</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
<th>r</th>
<th>AUDPC</th>
<th>r</th>
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</thead>
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<tr>
<td>1.Kanglatongbi</td>
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<td>32499.9</td>
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<td>1280.1</td>
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<td>3. Spermeina</td>
<td>285</td>
<td>1945.65</td>
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<td>1794.6</td>
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<td>1361.1</td>
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<td>5. Kangpokpi</td>
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Table 9. Simple correlation coefficients between disease parameters and weather variables for three years.

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<th><em>Weather variables</em></th>
<th><em>Correlation coefficients</em></th>
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<th>2008-2009</th>
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<td>V2</td>
<td>V1</td>
<td>V2</td>
<td>V1</td>
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<tr>
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<td>V2</td>
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<td>-</td>
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<tr>
<td>Min.temp.</td>
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<td>-0.95</td>
<td>-0.96</td>
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During the three year survey it was found that variation in highest rate of infection occurred at different days after planting at various sampling sites and year surveyed. Area under disease progress curve (AUDPC) showed that AUDPC was highest between 135 days to 165 days in V₁ at different sampling sites. In V₂ AUDPC was maximum between 225 to 255 days with slight variation at different sampling sites (Table 3-8). The disease incidence and disease severity (Table 9) showed highly significant positive and negative correlation coefficient with minimum relative humidity and rainfall (V₁) in 2008 as well as significant negative correlation with minimum relative humidity (2009). In V₃ significant positive correlation was observed with maximum temperature and rainfall (2008) and only maximum temperature (2009). Earlier workers also reported temperature as one of the important factors which favour the development of wilt disease [6 ; 7]. Other meteorological parameters showed significant negative and non significant correlation. In French bean [8] also observed non significant correlation between disease incidence and severity caused by Phaeoisariopsis griseola. Being a soil borne disease, negative correlation between the disease parameters and meteorological factors indicated the importance of soil inoculum. The relationship between the amount of initial inoculum of Fusarium oxysporum f. sp. dianthi and the severity of the resulting epidemic in susceptible crop was also reported [9]. The present investigation indicated the importance of r and AUDPC for evaluation of wilt disease of pigeonpea and it can be used for studying various factors influencing wilt disease.

### IV. Conclusion

_Fusarium_ wilt is an important disease of pigeonpea leading to significant yield losses. Various disease control measures have been developed but there is a need to study the epidemiology of wilt disease for developing an effective disease management practices in the context of present scenario of climate change. The present investigation also revealed the importance of studying epidemiology of wilt disease. But there is a need to develop a perfect model for disease development for controlling wilt disease.

### References


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<td>0.88</td>
<td>-0.87</td>
<td>-0.87</td>
</tr>
</tbody>
</table>

*average value ; * significant at p<0.05

varieties. This difference could be due to different degree of susceptibility of pigeonpea to wilt disease or it could be due to the continuous cropping in the same field without crop rotation. Data on apparent rate of infection showed that there was variation in apparent rate of infection between the sampling sites during the present investigation (Table 3-8). Rate of infection is highest at the flowering and podding stage and declines at the termination of the growing season. Highest rate of infection was observed at 135 days and 165 days in V₁ at different sampling sites. During the three year survey it was found that variation in highest rate of infection occurred at different days after planting at various sampling sites and year surveyed. Area under disease progress curve (AUDPC) showed that AUDPC was highest between 135 days to 165 days in V₁ at different sampling sites. In V₂, AUDPC was maximum between 225 to 255 days with slight variation at different sampling sites (Table3-8). The disease incidence and disease severity (Table 9) showed highly significant positive and negative correlation coefficient with minimum relative humidity and rainfall (V₁) in 2008 as well as significant negative correlation with minimum relative humidity (2009). In V₃ significant positive correlation was observed with maximum temperature and rainfall (2008) and only maximum temperature (2009). Earlier workers also reported temperature as one of the important factors which favour the development of wilt disease [6 ; 7]. Other meteorological parameters showed significant negative and non significant correlation. In French bean [8] also observed non significant correlation between disease incidence and severity caused by Phaeoisariopsis griseola. Being a soil borne disease, negative correlation between the disease parameters and meteorological factors indicated the importance of soil inoculum. The relationship between the amount of initial inoculum of Fusarium oxysporum f. sp. dianthi and the severity of the resulting epidemic in susceptible crop was also reported [9]. The present investigation indicated the importance of r and AUDPC for evaluation of wilt disease of pigeonpea and it can be used for studying various factors influencing wilt disease.

### IV. Conclusion

_Fusarium_ wilt is an important disease of pigeonpea leading to significant yield losses. Various disease control measures have been developed but there is a need to study the epidemiology of wilt disease for developing an effective disease management practices in the context of present scenario of climate change. The present investigation also revealed the importance of studying epidemiology of wilt disease. But there is a need to develop a perfect model for disease development for controlling wilt disease.

### References