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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 (V_1) & 42.74% ;late maturing (V_2)) and severity (55.22% ; V_1 & 40.96% ; V_2) were found at sampling sites (Motbung ; V_1 & Kanglatongbi ; V_2) 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 (V_1) and late maturing variety (V_2) 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 (93.40 ^{0} and 94.29 ^{0}E longitudes and between 24.37 ^{0} and 25.37 ^{0}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 (24.30 ^{0} N and 25.00 ^{0} N latitudes and 93.45 ^{0}E and 94.15 ^{0} E 790 m above mean sea level) 16 km away from Imphal and Uyumpok, Imphal East (92^{0}59′to 93^{0}50′E longitude and 23^{0}55′ to 24^{0}30′ 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.

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

$$(2)\ DS\% = \frac{\text{Sum of all numerical ratings}}{\text{Total number of plants examined} \times \text{Maximum rating scale}} \times 100$$

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) *AUDPC* = $\sum_{i-1}^{n}[(y_{i+1}+y_i)/2][x_{i+1}-x_i]$ (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

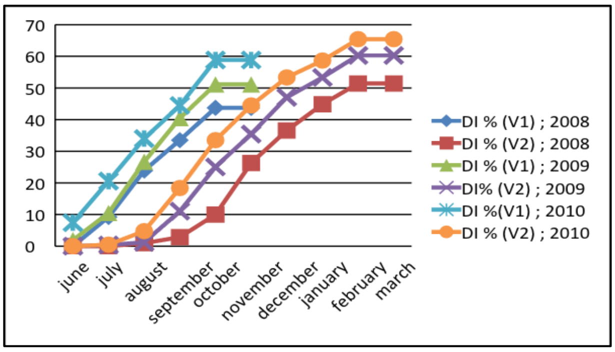

Fig.1. Disease progress curve

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

				DS%	DI%	**Sampling sites**
2010	2009	2008	2010	2009	2008	
35.85	35.98	43.08	37.33	37.55	44.56	**1. Kanglatongbi**
55.22	32.67	34.04	58.77	31.89	35.00	**2. Motbung**
39.54	33.67	29.88	40.67	34.56	30.89	**3.Spermeina**

16.88	11.10	10.64	17.45	11.89	11.56	**4. Toribari**
22.36	19.15	15.18	23.89	19.67	15.89	**5. Kangpokpi**
39.87	33.52	11.47	41.22	35.44	11.89	**6. Senjam Chirang**
40.88	39.95	28.89	42.22	41.11	30.00	**7. Uyumpok**

Table 2. Disease incidence and severity at different sampling sites for V_2.

				DS%	DI%	**Sampling sites**
2010-11	2009-10	2008-09	2010-11	2009-10	2008-09	
40.96	29.79	22.91	42.74	31.04	24.22	**1. Kanglatongbi**
24.28	23.79	12.05	25.04	25.04	12.74	**2. Motbung**
25.61	23.96	19.01	26.96	25.11	20.29	**3.Spermeina**
26.39	23.23	18.66	28.30	25.04	20.89	**4. Toribari**
25.81	16.55	13.01	26.89	17.41	13.70	**5. Kangpokpi**
33.85	30.82	18.22	33.85	30.82	18.22	**6.Senjam Chirang**
32.33	27.00	23.53	33.26	27.41	24.44	**7. Uyumpok**

Table 3. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; V_1 (2008).

					Days after sowing	**Sampling sites**
			195	165	135	
AUDPC	r	AUDPC	r	AUDPC	r	
2091.3	0	1827.9	0.747	1421.1	0.384	**1.Kanglatongbi**
1539.9	0	1354.33	0.502	1143.3	0.072	**2. Motbung**
1384.5	0	1308.9	0.205	1129.95	0.294	**3. Spermeina**
626.7	0	596.7	0.125	331.2	1.953	**4. Toribari**
875.7	0	733.5	0.518	490.05	0.499	**5. Kangpokpi**
666.6	0	545.55	0.549	365.55	0.370	**6. Senjam Chirang**
1693.5	0	1459.05	0.630	906.74	1.037	**7. Uyumpok**

Table 4. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; V_1 (2009).

					Days after sowing	**Sampling sites**
			195	165	135	
AUDPC	r	AUDPC	r	AUDPC	r	
2022.3	0	8249.05	0.871	1021.2	0.227	**1.Kanglatongbi**
1593.3	0	1517.85	0.201	1051.2	0.237	**2. Motbung**

1544.4	0	1404.45	0.375	1198.95	0.036	**3. Spermeina**
600	0	536.7	0.288	399	0.087	**4. Toribari**
1062.3	0	927.75	0.422	661.05	0.104	**5. Kangpokpi**
1806.6	0	1519.95	0.773	1025.55	0.124	**6.Senjam Chirang**
1822.2	0	1695.6	0.344	1382.25	0.101	**7. Uyumpok**

Table 5. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea;V_1 (2010).

					Days after sowing	**Sampling sites**
			195	165	135	
AUDPC	r	AUDPC	r	AUDPC	r	
1853.4	0	1533.45	0.866	1084.5	0.374	**1.Kanglatongbi**
2375.7	0	2047.8	1.040	1612.2	0.289	**2. Motbung**
1899.8	0	1713.3	0.365	1214.4	0.235	**3. Spermeina**
997.8	0	815.55	0.621	513.3	0.572	**4. Toribari**
1051.2	0	980.1	0.216	778.95	0.400	**5. Kangpokpi**
1962.3	0	1728.9	0.642	1302.15	0.527	**6. Senjam Chirang**
1899.8	0	1713.3	0.504	1214.4	0.885	**7. Uyumpok**

Table 6. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; V_2 (2008-2009).

					Days after sowing	**Sampling sites**
			285	255	225	
AUDPC	r	AUDPC	r	AUDPC	r	
1595.55	0.238	1501.05	0.015	1218.9	0.774	**1.Kanglatongbi**
1224.45	0.524	820.05	0.736	402.3	1.260	**2. Motbung**
1288.8	0.224	1086.6	0.347	857.7	0.357	**3. Spermeina**
1255.5	0.122	1116.3	0.271	906.3	0.365	**4. Toribari**
1114.5	0.104	901.2	0.565	624.45	0.407	**5. Kangpokpi**
1389.9	0.516	1189.95	0.188	919.95	0.240	**6.Senjam Chirang**
1832.25	0.141	1567.8	0.256	1344.45	0.392	**7. Uyumpok**

Table 7. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; V_2 (2009-2010).

					Days after sowing	**Sampling sites**
			285	255	225	
AUDPC	r	AUDPC	r	AUDPC	r	
1818.9	0.277	1628.85	0.245	1436.7	0.270	**1.Kanglatongbi**
1803.45	0.703	1504.5	0.130	1183.35	0.770	**2. Motbung**
1415.55	0.142	1294.5	0.184	1142.25	0.239	**3. Spermeina**
1427.85	0.252	1241.7	0.252	1057.8	0.267	**4. Toribari**
1493.4	0.172	1192.2	0.665	656.7	1.237	**5. Kangpokpi**
1880.1	0.516	1630.05	0.188	1470	0.240	**6.Senjam Chirang**
1762.35	0.141	1615.65	0.256	1374.45	0.392	**7. Uyumpok**

Table 8. Apparent rate of infection (r) and area under disease curve (AUDPC) of *Fusarium* wilt of pigeonpea; V_2(2010-2011).

					Days after sowing	**Sampling sites**
			285	255	225	
AUDPC	r	AUDPC	r	AUDPC	r	
2136.75	0.156	2059.95	0.089	1979.85	0.152	**1.Kanglatongbi**
32499.9	0.462	1576.8	0.169	1280.1	0.641	**2. Motbung**
1945.65	0.365	1794.6	0.341	1604.55	0.234	**3. Spermeina**
1538.85	0.252	1361.1	0.224	1204.35	0.203	**4. Toribari**
1681.05	0.147	1527.75	0.264	1267.8	0.442	**5. Kangpokpi**
2010	0.393	1780.05	0.277	1500	0.482	**6. Senjam Chirang**
1945.65	0.322	1794.6	0.114	1604.55	0.400	**7. Uyumpok**

Table 9. Simple correlation coefficients between disease parameters and weather variables for three years.

											*Correlation coefficients	***Weather variables**
									2010-2011	2009-2010	2008-2009	
						V_2	V_1	V_2	V_1	V_2	V_1	
DS%	DI%	DS %	DI%	DS%	DI%	DS%	DI%	DS%	DI%	DS%	DI%	
-0.88	-0.88	-	-	0.93	0.93	-	-	0.89	0.89	-	-	**Max.temp.**
-0.96	-0.95	-	-	-0.96	-0.96	-	-	-0.98	-0.98	-	-	**Min.temp.**

-0.89	-0.89	-	-	-0.89	-0.88	-	-	-0.93	-0.93	-	-	**Max.RH**
-	-	-	-	-0.89	-0.89	-0.85	-0.86	-	-	0.93	0.93	**Min.RH**
-0.82	-0.82	-	-	-0.77	-0.77	-	-	0.88	0.88	-0.87	-0.87	**Rainfall**

*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 V_1 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 V_1 at different sampling sites. In V_2 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 (V_1) in 2008 as well as significant negative correlation with minimum relative humidity (2009). In V_2, 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.

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