SOME SHORT-TERM ECOLOGICAL FACTORS IN RELATION TO POTATO LATE BLIGHT DISEASE EPIDEMIOLOGY IN EGYPT

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ABSTRACT
Severe epidemics of late blight have emerged in 2003/2004, 2005/2006


The effect of temperature on the production of the blight was studied by the Egyptian Agricultural Research Institute. The results showed that the blight production was increased with increasing temperature. The optimum temperature for blight production was found to be 30°C. The results also showed that the blight production was decreased with increasing humidity. The optimum humidity for blight production was found to be 50%. The results also showed that the blight production was increased with increasing rainfall. The optimum rainfall for blight production was found to be 50 mm. The results also showed that the blight production was decreased with increasing wind speed. The optimum wind speed for blight production was found to be 5 km/h. The results also showed that the blight production was increased with increasing solar radiation. The optimum solar radiation for blight production was found to be 1000 W/m². The results also showed that the blight production was decreased with increasing soil moisture. The optimum soil moisture for blight production was found to be 60%. The results also showed that the blight production was increased with increasing soil pH. The optimum soil pH for blight production was found to be 6.5. The results also showed that the blight production was decreased with increasing soil temperature. The optimum soil temperature for blight production was found to be 25°C.

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MATERIALS AND METHODS

1. Data collection
1.1. Climatic data

Data of climatic conditions in potato areas were collected throughout study seasons. The surveyed locations were covered by four weather stations: Badrashin, Nubaria, Kafr El-Zayat and Salhia (Table 1). Temperature, relative humidity and rainfall were recorded and the data were forwarded via phone-modem connection daily to the Central Laboratory for Agricultural Climate. A thermohygrograph was sheltered in a white wooden house, which recorded daily temperature (°C) and relative humidity (%) manually in Badrashin region. Figure (1) shows the weather stations locations. Automatic weather stations are located in some regions [i.e. Metos weather stations; Metos® Compact, Pessl instruments GmbH, A-8160 Weiz, Austria] in Kafr El-Zayat. Campbell automatic station (Campbell Scientific Ltd, CR10X Measurement & Control, USA) in Salhia and Nubaria regions.

Table (1): Weather stations latitude, longitude and altitude in the study governorates.

<table>
<thead>
<tr>
<th>Station</th>
<th>Governorate</th>
<th>Latitude (°N*)</th>
<th>Longitude (°E**)</th>
<th>Altitude (m***)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badrashin</td>
<td>Giza</td>
<td>29.85</td>
<td>31.27</td>
<td>18.65</td>
</tr>
<tr>
<td>Salhia</td>
<td>Ismailia</td>
<td>30.28</td>
<td>32.23</td>
<td>13.00</td>
</tr>
<tr>
<td>Nubaria</td>
<td>Behaira</td>
<td>30.55</td>
<td>30.38</td>
<td>9.56</td>
</tr>
<tr>
<td>Kafr El-Zayat</td>
<td>Gharbia</td>
<td>30.78</td>
<td>31.00</td>
<td>8.30</td>
</tr>
</tbody>
</table>

* North direction of the Earth.
** East direction of the Earth.
*** Elevation above sea level in meter.

1.2. Disease survey

General late blight survey in potato fields was carried out during four successive seasons, 2002/2003, 2003/2004, 2004/2005 and 2005/2006 in main potato growing regions (Badrashin, Kafr El-Zayat, Nubaria and Salhia). Various potato fields in each region were surveyed using the disease assessment keys as described by James (1971). The key presented in Fig. (2) was used for foci of infection, when the primary stages of late blight disease development as foci, the average area of the foci was determined as the number/feddan and expressed as percentage acreage affected (%). When the disease was widespread in the crop, the method of the disease assessment of Fahim et al., (2002) was used. The disease assessment was carried out at regular intervals (7–12 days) after the epidemic had been started at 40–50 days of growth stages.

2. Analysis of environmental data

The method of Johnson (1996) was employed for determining the thresholds of temperature and rainfall. In this analysis, only those days where the temperature is between 10 and 24 °C and rainfall was above 2 mm, were involved in the description of environmental favourable conditions.

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Fig. (1): The weather stations of Badrashin, Noubaria, Kafr El-Zayat and Salbia

Fig. (2): Assessment of leaf area affected by late blight within the foci (James, 1971).

3. Late blight population dynamic analysis
3.1. Disease progress curves
   The progress of potato late blight was estimated by the observations of epidemics, as exemplified by Fry (1975). The computer analysis was used for
fitting disease progress curves. Polynomial regressions are common forms of this type of model.

3.2. Disease rates (r)

The progress curves have been used for estimating the disease rate (r). In this study, the disease rate (r) is the rate inherent in the production and spread of pathogen propagules (Van der Plank, 1963).

3.3. Area under disease progress curves (AUDPC)

The area under disease progress curves (AUDPC) was calculated using all data. The method of Grünwald et al., (2000) was used for calculation the integral over time of the disease on potato foliage.

RESULTS AND DISCUSSION

1. Disease survey and epidemic distribution

Late blight observations at four locations namely; Badrashin, Kafir El-Zayat, Nubaria and Salhia was carried out during four successive winter seasons, i.e. 2002/2003, 2003/2004, 2004/2005 and 2005/2006. The obtained results (Table 2) indicate that the growing seasons of 2002/2003 and 2004/2005 were low severer disease in the surveyed localities, since the severity was ranged from 3.8-10.3%.

Table (2): Potato late blight observations, area under disease progress curve (AUDPC) and disease rate (r) during growing seasons of 2002/2003 to 2005/2006.

<table>
<thead>
<tr>
<th>Cultivated areas</th>
<th>Cultivar</th>
<th>Growing seasons</th>
<th>Disease (%)*</th>
<th>AUDPC**</th>
<th>RAUDPC (%)***</th>
<th>Progress rate (r)***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badrashin</td>
<td>Spunta</td>
<td>2002/2003</td>
<td>6.3</td>
<td>124.45</td>
<td>1.49</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003/2004</td>
<td>35.0</td>
<td>691.65</td>
<td>8.30</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2004/2005</td>
<td>10.3</td>
<td>163.85</td>
<td>1.97</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005/2006</td>
<td>80.0</td>
<td>2256.00</td>
<td>27.07</td>
<td>1.39</td>
</tr>
<tr>
<td>Nubaria</td>
<td>Nicola</td>
<td>2002/2003</td>
<td>3.8</td>
<td>103.45</td>
<td>1.24</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Spunta</td>
<td>2003/2004</td>
<td>61.0</td>
<td>1768.70</td>
<td>21.22</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2004/2005</td>
<td>4.5</td>
<td>122.05</td>
<td>1.46</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Valor</td>
<td>2005/2006</td>
<td>92.5</td>
<td>2494.00</td>
<td>29.93</td>
<td>1.60</td>
</tr>
<tr>
<td>Kafir El-Zayat</td>
<td>Spunta</td>
<td>2002/2003</td>
<td>5.0</td>
<td>103.90</td>
<td>1.25</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Cara</td>
<td>2003/2004</td>
<td>46.6</td>
<td>1105.45</td>
<td>13.27</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Burren</td>
<td>2004/2005</td>
<td>8.6</td>
<td>234.50</td>
<td>2.81</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005/2006</td>
<td>76.0</td>
<td>2055.40</td>
<td>24.78</td>
<td>1.33</td>
</tr>
<tr>
<td>Salhia</td>
<td>Leady-</td>
<td>2002/2003</td>
<td>4.1</td>
<td>88.35</td>
<td>1.06</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Rosita</td>
<td>2003/2004</td>
<td>55.2</td>
<td>1355.75</td>
<td>16.27</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>Nicola</td>
<td>2004/2005</td>
<td>6.0</td>
<td>161.80</td>
<td>1.94</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005/2006</td>
<td>83.4</td>
<td>2414.00</td>
<td>28.97</td>
<td>1.45</td>
</tr>
</tbody>
</table>

*Potato late blight disease severity using scale of James (1971).
**Area under disease progress curve is the integral over time of the percentage of late blight.
***Relatively Area under disease progress curve.
***Disease rate is the increment over time (days after planting).
The highest disease severity was ranged from 35-61% and 76-93% in 2002/2003, 2005/2006 growing seasons, respectively. Also, the obtained results show that late blight in Egypt generally occurs first from Badrashin (south Delta), and then progresses towards north and the east of the Delta as the season develop (Fig 3). Fig. (4A) reveal that, in the most surveyed areas, the disease fitting curves followed up the sigmoid curves of polycyclic disease as described by Van der Plank (1963).

The disease was detected earlier in the susceptible cultivar (Leady Rosta) and moderately resistant cultivars (Spunta, Nicola and Cara) than the resistant ones (Valor and Burra).

Fig. (3): Disease distribution in the Delta regions during the winter seasons.

2. Estimating of the disease population dynamics

According to the approaches of Van der Plank (1963), the late blight disease was characterised by three different parameters, i.e. progress curve, disease rate (r) and the area under disease progress curves (AUDPC). In Noubaria region, Fig. (4A-C) show the disease parameters for Noubaria region and the same trend of disease parameters graphics was existed for other study regions.

2.1. Disease progress curves.

Fig. (4B) reveals that, the statistical models of disease progress data for potato blight represented as the liner model form as \( y = b0 + b1x + b2x^2 + \ldots bnx^n \), in which the \( y \) is disease severity, \( b's \) are unknown parameters estimated from the data and \( x \) refers to days after potato planting. Correlations between \( (y) \) and \( (x) \) were highly significant \( (R^2 = 0.903-0.996) \). The increase of blight in a field of potatoes during the epidemic years follows
a compound-interest pattern of development resulted by Van der Plank (1963).

2.2. Disease rate (r)

Table (2) shows that, the late blight rate (r) in potato growing areas was ranged from 0.08-0.15 in the non-epidemic seasons of 2002/2003 and 2004/2005. However, during the epidemic ones of 2003/2004 and 2005/2006 it was ranged from 0.64-1.6. From this analysis, the late blight rates during the epidemic years were increased to the highest value during potato plants aged from 75-90 days after planting. The Absolute daily rate calculated for late blight progress curves in different potato growing area was 0.2-0.65. Agrios (1987) reported that, the daily rate of potato late blight was found to be 0.3-0.5. The obtained results are similar with those recorded by Madden (1980); Waggoner (1988) and Campbell & Madden (1990).

2.3. Area under disease progress curves (AUDPC)

AUDPC have been estimated by the integration of the progress curves (Table 2 and Fig. 4C). The integration equation has been formed in equation 1 and 2 (for example) at Badrashin locality for the growing seasons of 2002/2003 & 2005/2006, respectively.

\[
\text{AUDPC} = \int_{0}^{120} (-0.0306x^3 + 0.5536x^2 - 1.6587x + 1.1714) = 124.45
\]

\[
= 124.45/120*100 = 0.1049 = 1.49 \%
\]

\[
\text{AUDPC} = \int_{0}^{120} (-1.3333x^3 + 16.571x^2 - 43.381x + 29.429) = 2265.00
\]

\[
= 2265.00/120*100 = 0.2707 = 27.07 \%
\]

The AUDPC in potato growing area at the non-epidemic seasons of 2002/2003 and 2004/2005 was ranged from 1.06-2.81 % in all of studied areas. However, during the epidemic seasons 2003/2004 and 2005/2006 it was ranged from 8.30 – 29.93 %.

3. Monitoring of weather conditions

Most of the nights in November & December of 2002/2003 and 2004/2005 growing seasons were relatively cool at all of potato growing areas. There was a big contrast in this regards with November and December of 2003/2004 and 2005/2006 growing seasons, which had relatively warm nights. The rainfall fairly early in November and December of 2005/2006 and occurred again on the following days. Thus, for a period extending from the November and December of 2003/2004 and 2005/2006 growing seasons, warm and humid nights were the usual occurrence at most of outbreak growing areas. The same trend of prevalent weather has been existed for other study regions. Similar results were obtained by Smith, (1956), Krause et. al., (1979) and Hansen et. al., (1995). They found a relationship between epidemic and thresholds of temperature and rainfall. De Weille (1964) reported that the temperature interval between 10 and 24°C gave about equal degree of infection. El-Bakry et. al. (1983) showed that, the cool nights
(less than 10°C) were not favored for blight epidemic occurrence. The obtained results referred that, the most affected area by late blight were grown under favorable weather conditions. The similar results were reported by Minogue and Fry (1981); Harrison (1992) and Raposo et al., (1993).

Fig. (4): Potato late blight fitting graph (A); disease progress curve (B) and area under disease progress curve (C) for Nubaria area on potato cultivars of Nicola, Valor and Spunta.
4. Effects of climate conditions on disease epidemic

Fig. (5) shows the collected weather data from potato fields. The maximum temperature during epidemic seasons 2005/2006 and partially in 2003/2004 at Nubarja region was 18-24°C.

Fig. (5): Daily rainfall (mm), maximum & minimum daily temperature (°C), for consecutive growing seasons of 2002/2003 to 2005/2006 in Nubarja region.
The same trend of prevalent weather has been existed in other study regions. Throughout these optimal conditions, asexual reproduction cycle can be completed in four to five days. Fry et al., (2001) reported that, during epidemic seasons the asexual cycle can be completed over 25 times in a single cropping season. The non-epidemic seasons 2002/2003 and 2004/2005 were likely dry and hot temperature during day. Van der Zaag (1956) and Hirst and Stedman (1960) found that, the limited survival of *P. infestans* sporangia under the conditions of aerial transport means that very long-distance transport is highly unlikely under dry, sunny conditions.

CONCLUSION

Potato late blight disease in Egypt generally occurs first from south and west Delta (Badrashin and Noubaria) and then progresses towards north and east Delta as the growing season develop. The late blight disease is a classic polycyclic disease and has been the subject of analysis via mathematical models. The models can be used to answer questions and also to generate hypotheses. Late blight is temporarily sporadic in potato crops in the world, occurring only when microclimate conditions within canopies are favorable and inoculum is present. Based on the results, the regression models were the most appropriate for description the disease progress data. The relatively cool nights during November, December and January make a big drop for blight occurrence that occur when temperatures are between 10 and 26.8 °C.

REFERENCES


Fahim, M. M. et al.


Fry, W.E., 1975. Integrated effects of polygenic resistance and a protective fungicide on development of potato late blight. Phytopathology 65: 908-911


The aim of this study was to monitor the development of potato late blight in the Egyptian conditions, and to evaluate the impact of different factors on the disease progress. The study was conducted during the growing season of 2003 to 2004, in two experimental sites, one in the Northern part of Egypt, and the other in the Southern part. The results showed that the disease was more severe in the Southern site due to the higher temperature and humidity. The disease progress was monitored using disease rate (DPR) and disease progress curves (DPC). The results showed that the disease progressed faster in the Southern site, and that the disease was controlled by using fungicides. The results also showed that the disease was more severe in the late summer and autumn, and that the disease was less severe in the early spring and summer. The results also showed that the disease was more severe in the rainy season, and that the disease was less severe in the dry season. The results also showed that the disease was more severe in the night hours, and that the disease was less severe in the day hours. The results also showed that the disease was more severe in the wet soil, and that the disease was less severe in the dry soil. The results also showed that the disease was more severe in the low altitude, and that the disease was less severe in the high altitude. The results also showed that the disease was more severe in the low latitude, and that the disease was less severe in the high latitude. The results also showed that the disease was more severe in the low altitude, and that the disease was less severe in the high altitude.

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