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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

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تأثير التدفئة المتقطعة على خفض أضرار البرودة والاحتفاظ بجودة ثمار برتقال فالنشيا المعدة للتصدير

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أجريت هذه الدراسة خلال موسمي ٢٠٠٤، ٢٠٠٥ على ثمار برتقال فالنشيا الصيفي المعدة للتصدير بهدف معرفة أفضل معاملات التدفئة المتقطعة على خفض أضرار البرودة والاحتفاظ بجودة الثمار.

كانت المعاملات كالآتي:

أ. تخزين مستمر على درجة حرارة ٥ °م (مقارنة).

تخزين باستخدام دورات تدفئة متقطعة بأن تخزن الثمار على درجة حرارة ٥°م لفترات معينة ثم تتعرض لتدفئة على درجة حرارة ٢٠°م لمدة محددة ثم العودة ثانية لدرجة حرارة ٥°م وهكذا في دورات لنهاية فترة التخزين (١٥ أسبوعا) كالآتي:

ب. ١٨ يوم على درجة ٥°م + ٣٦ ساعة على ٢٠ °م
ت. ١٨ يوم على درجة ٥°م + ٤٨ ساعة على ٢٠ °م
ث. ١٨ يوم على درجة ٥°م + ٦٠ ساعة على ٢٠ °م
ج. ١٨ يوم على درجة ٥°م + ٧٢ ساعة على ٢٠ °م
ح. ١٣ يوم على درجة ٥°م + ٢٤ ساعة على ٢٠ °م
خ. ٦ يوم على درجة ٥°م + ١٢ ساعة على ٢٠ °م
د. ٦ يوم على درجة ٥°م + ٢٤ ساعة على ٢٠ °م

وكانت الرطوبة النسبية لكل المعاملات ٨٥-٩٠%.

بعد انتهاء فترة التخزين وضعت ثمار جميع المعاملات على درجة حرارة ٢٠ °م ورطوبة (٨٠-٩٠%) لمدة أسبوع لتماثل فترة العرض في محلات السوبر ماركت.

وقد أوضحت النتائج مايلي:

١. التغيرات الطبيعية والكيميائية أثناء التخزين
- بتقدم فترة التخزين زادت النسبة المئوية للثمار الغير قابلة للتسويق وفقد الوزن والمواد الصلبة الذائبة ونسبة المواد الصلبة الذائبة إلى الحموضة بينما انخفضت النسبة المئوية للحموضة والعصير وكذلك محتوى الثمار من فيتامين C وكانت التغيرات معنوية في كلا موسمي الدراسة.

٢. تأثير استخدام معاملات التدفئة المتقطعة
- أدى استخدام معاملات التدفئة المتقطعة إلى خفض معنوي للنسبة المئوية للثمار الغير قابلة للتسويق (أثناء فترة التخزين وأثناء فترة العرض وكذلك فقد الوزن)، بينما لم يكن لها تأثير واضح على القياسات الكيميائية (النسبة المئوية للمواد الصلبة الذائبة والحموضة والعصير ونسبة المواد الصلبة الذائبة إلى الحموضة ومحتوى الثمار من V.C).

٣. مقارنة معاملات التدفئة المتقطعة
- أفضل معاملة (خ) (٦ أيام على درجة ٥ °م + ١٢ ساعة على درجة ٢٠ °م) لتأثيرها الواضح على خفض النسبة المئوية للثمار الغير قابلة للتسويق خاصة أثناء فترة التخزين. بينما كان أقلها تأثيرا المعاملة (ح) (١٣ يوم على درجة ٥ °م + ٢٤ ساعة على درجة ٢٠ °م) وأظهرت باقي المعاملات تأثيرات متوسطة.
- عموما لا يوجد فروق واضحة بين معاملات دورات التدفئة المتقطعة الطويلة (١٨ يوم على درجة ٥ °م + ٣٦، ٤٨، ٦٠، ٧٢ ساعة على ٢٠ °م) في تأثيرها على خفض النسبة المئوية للثمار الغير قابلة للتسويق وفقد الوزن. وكذلك بين معاملات دورات التدفئة المتقطعة القصيرة (٦ أيام على درجة ٥°م + ١٢ أو ٢٤ ساعة على ٢٠°م) في تأثيرها على خفض النسبة المئوية لفقد الوزن.

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, Noubaria, 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 Noubaria regions].

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

Station	Governorate	Latitude (°N*)	Longitude (°E**)	Altitude (m***)
Badrashin	Giza	29.85	31.27	18.65
Salhia	Ismailia	30.28	32.23	13.00
Noubaria	Behaira	30.55	30.38	9.56
Kafr El-Zayat	Gharbia	30.78	31.00	8.30

* North direction of the Earth.
** East direction of the Earth.
*** Elevation above sea level by 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, Noubaria 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.

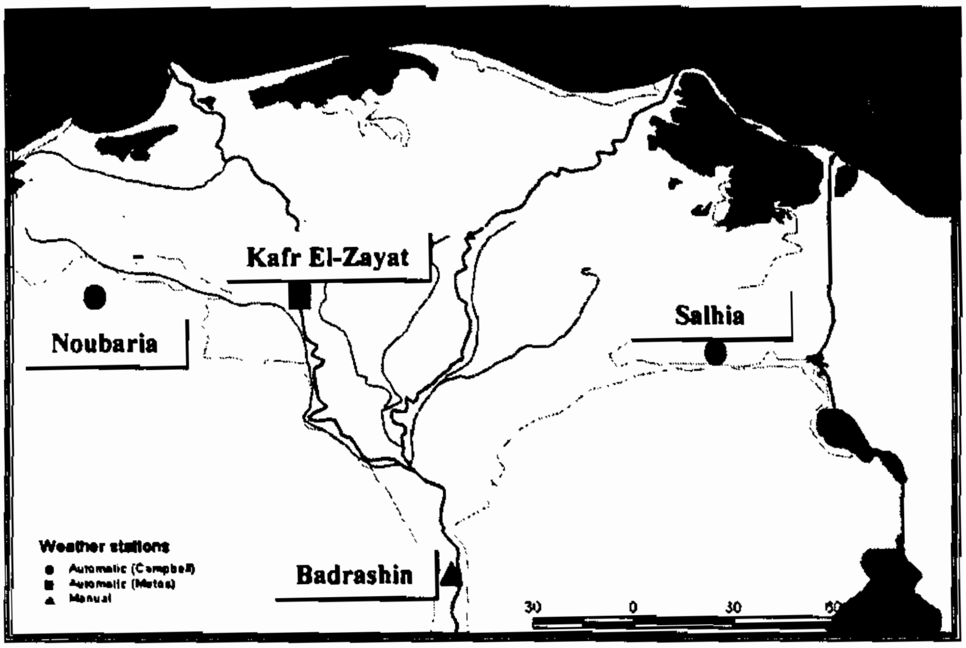

Fig. (1): The weather stations of Badrashin, Noubaria, Kafr El-Zayat and Salhia

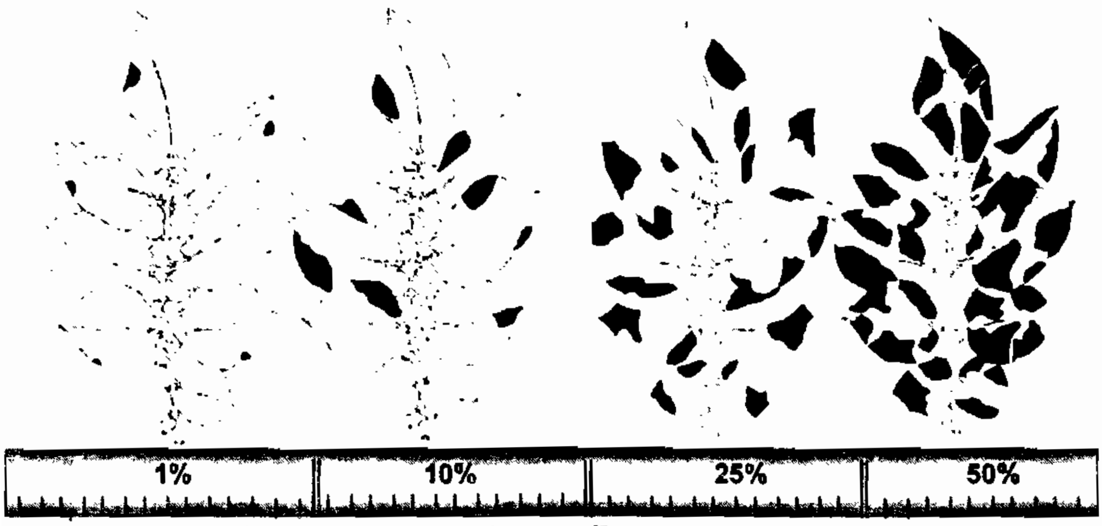

Fig. (2): Assessment of leaf area affected by late blight within the foci (James, 1971).

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, Kafr 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 severed 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.

Cultivated areas	Cultivar	Growing seasons	Disease (%)*	AUDPC**	RAUDPC (%)***	Progress rate (r)****
Badrashin	Spunta Burren Diamant	2002/2003	6.3	124.45	1.49	0.10
		2003/2004	35.0	691.65	8.30	0.64
		2004/2005	10.3	163.85	1.97	0.18
		2005/2006	80.0	2256.00	27.07	1.39
Nubaria	Nicola Spunta Valor	2002/2003	3.8	103.45	1.24	0.08
		2003/2004	61.0	1768.70	21.22	1.21
		2004/2005	4.5	122.05	1.46	0.08
		20052006	92.5	2494.00	29.93	1.60
Kafr El-Zayat	Spunta Cara Burren	2002/2003	5.0	103.90	1.25	0.10
		2003/2004	46.6	1105.45	13.27	1.00
		2004/2005	8.6	234.50	2.81	0.15
		20052006	76.0	2065.40	24.78	1.33
Salhia	Leady-Rosita Nicola	2002/2003	4.1	88.35	1.06	0.07
		2003/2004	55.2	1355.75	16.27	1.01
		2004/2005	6.0	161.60	1.94	0.11
		20052006	83.4	2414.00	28.97	1.45

*** 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 Rosita) and moderately resistant cultivars (Spunta, Nicola and Cara) than the resistant ones (Valor and Burren).

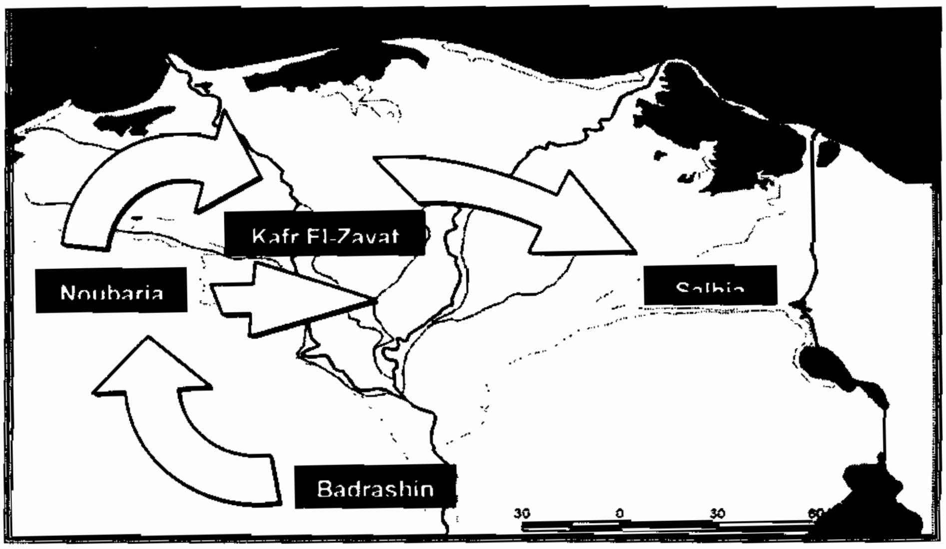

Fig. (3): Disease distribution in the Delta regions during the winter seasons.

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 $y = b0 + b1x + b2\,x^2 + \ldots\, bqx^q$, 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 (1986) 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.

$$\text{AUDPC} = \int_{n=1}^{120} (-0.0306x3 + 0.5536x2 - 1.6587x + 1.1714) = 124.45 \qquad (1)$$

$$= 124.45/120*100 = 0.0149 = 1.49\ \%$$

$$\text{AUDPC} = \int_{n=1}^{120} (-1.3333x3 + 16.571x2 - 43.381x + 29.429) = 2265.00 \qquad (2)$$

$$= 2265.00/120*100 = 0.2707 = 27.07\ \%$$

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.*, (1975) 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).

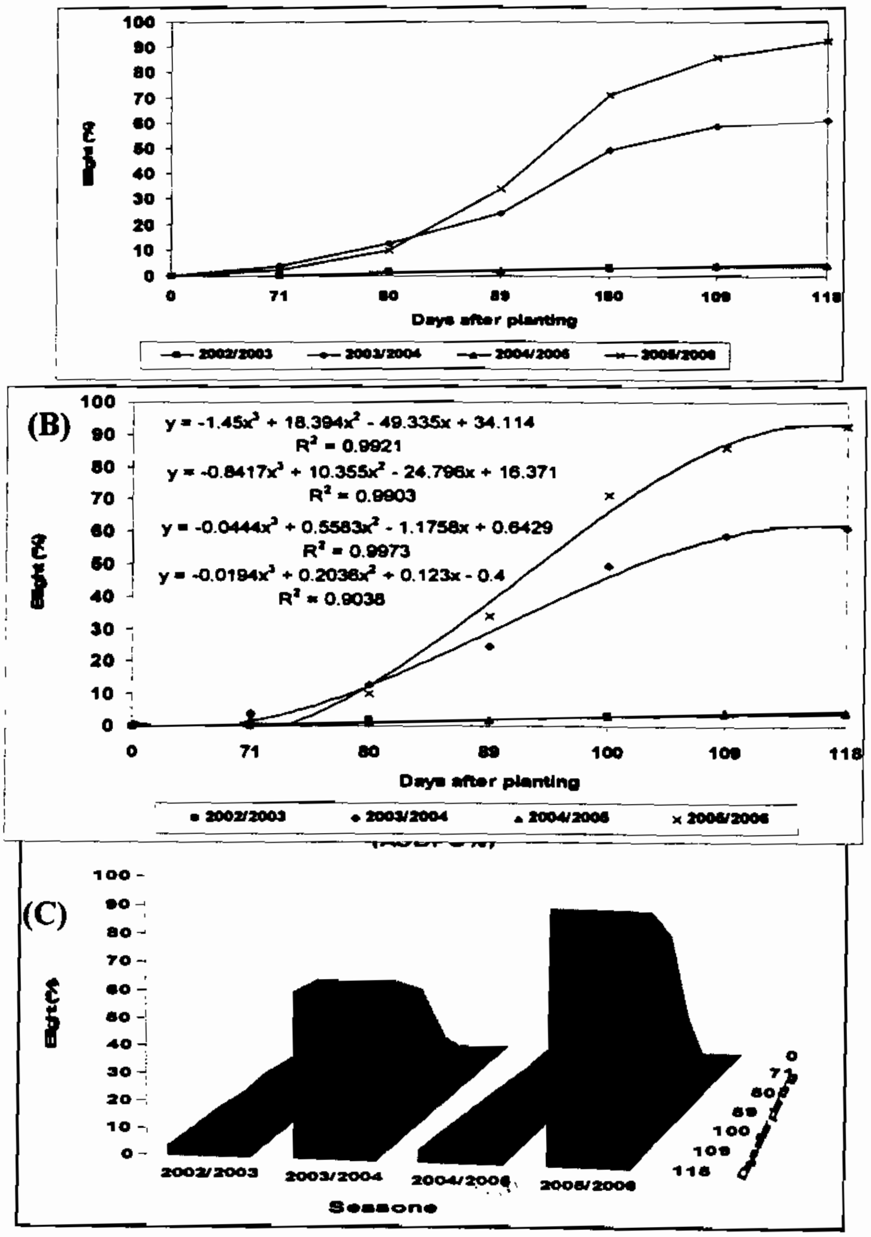

Fig. (4): Potato late blight fitting graph (A); disease progress curve (B) and area under disease progress curve (C) for Nubaria area on potato cultivars of Nicola, Valor and Spunta.

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 Noubaria region was 18-24°C.

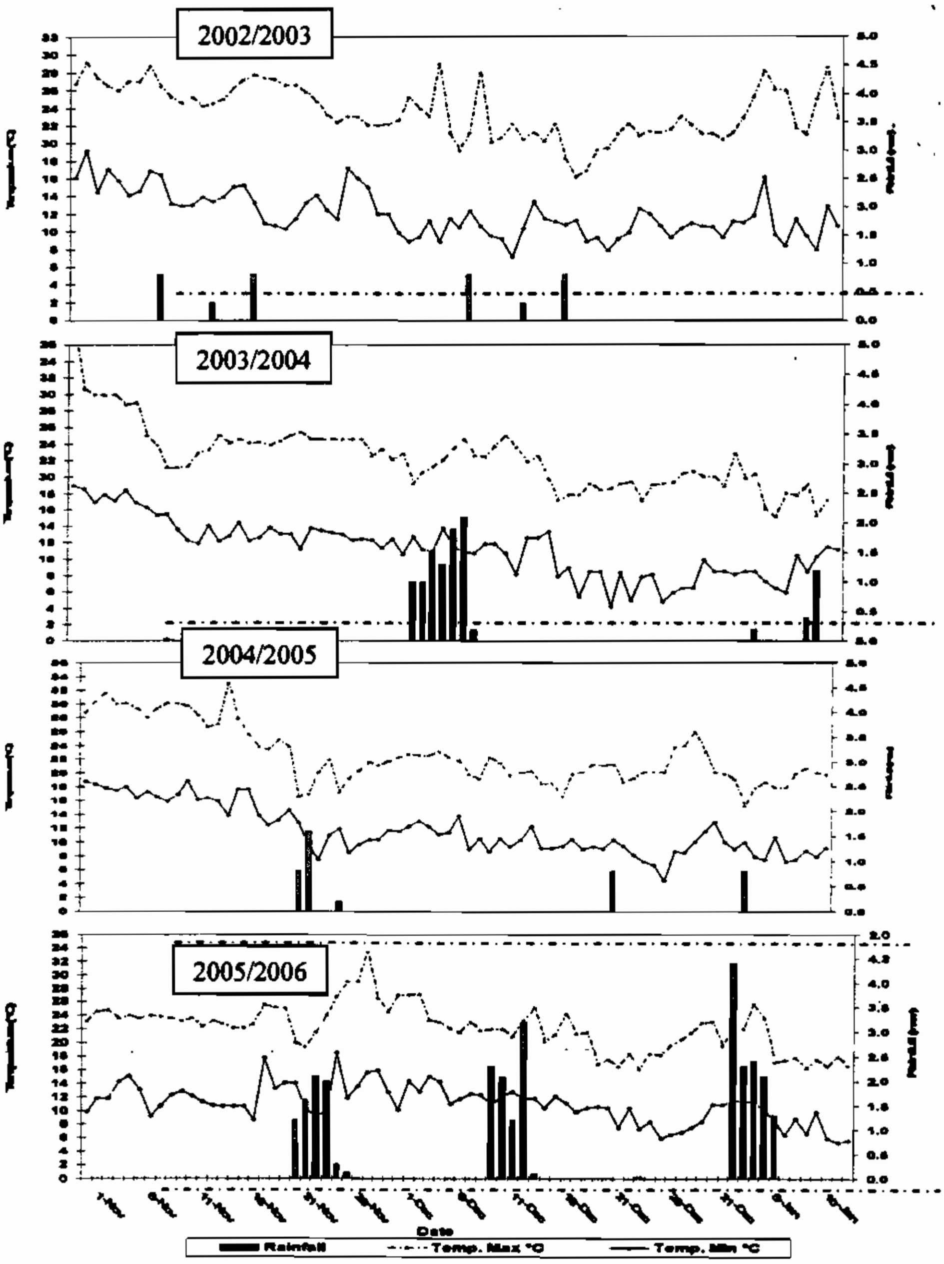

Fig. (5): Daily rainfall (mm), maximum & minimum daily temperature (°C), for consecutive growing seasons of 2002/2003 to 2005/2006 in Nubaria region.

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 temporally 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

Agrios, G. N., 1987. Plant Pathology 3 rd. Edition. Translated into Arabic by Abou-Arkoub M. M. Acad. Press 1994. Cairo.

Beaumont, A. 1947. The dependence on the weather of the dates of outbreak of potato blight epidemics. Trans. Br. Mycol. Soc. 31: 45-53.

Campbell, C. L., and L. V. Madden, 1990. Introduction to Plant Disease Epidemiology. John Wiely & Sons, New York City. 532 pp.

Clayton, R.C. and R.C. Shattock, 1995. Reduced fungicide inputs to control Phytophthora infestans in potato cultivars with high levels of polygenic resistance. Potato Res. 38: 399–405.

De Bary, A., 1876. Researches into the nature of the potato fungus Phytophthora infestans. Journal of the Royal Agricultural Society of England. 12: 239-269.

De Weille, G. A., 1964. Forecasting crop infection by the potato blight fungus. Koninklijk Nederlands Meteorologisch Institute, Mededlingen en Verhandelingen No. 82, 144 pp (c.f. Meteor. Res. Bull. 4 (1): 29-43).

El-Bakry, M. M.; N. H. Saad and A. A. Farahat, 1983. Relation between weather conditions and with potato late blight outbreak in Egypt. Meteor. Res. Bull. 15: 43-53.

El-Bedewy R. and A. Sharara, 1990. Potato production in Egypt. CIHEAM-CIP Potato Workshop of the Mediterranean Region 10–13 September 1990., Zaragoza, Spain. 7 p (c.f. Fahim et al., (2002). MSc. Thesis, Ain Shams university)

Fahim, M. A.; M. A. Medany; A. A. Mosa and M.H. Mostafa, 2002. Potato late blight forecasting under the Egyptian environmental conditions. M.Sc. Thesis, Ain Shams university.

FAOSTAT© 2006. Integrated database and satellite databases. http://faostat.fao.org/

Fry W.E; H.D. Thurston and W.R. Stevenson, 2001. Late blight. In: Stevenson W.R.; R. Loria; G.D. Francand D.P. Weingartner (eds) Compendium of potato diseases, 2 nd edition. American Phytopathological Society, St. Paul, p 28-30.

Fry, W.E. and E. S. Mizubuti, 1999. The Epidemiology of Plant Disease, (eds, D. Gareth Jones), Kluwer Publishers, Dordrecht. pp. 371-388.

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

Garrett, K. A., S. H. Hulbert, J. E. Leach, and S. E. Travers. In Press. 2006b. Ecological genomics and epidemiology. European Journal of Plant Pathology.

Grünwald, N. J., O. A. Rubio-Covarrubias and W. E. Fry, 2000. Potato late-blight management in the Toluca Valley: Forecasts and resistant cultivars. Plant Disease 84(4): 410-416.

Hansen, J.G.; B. Andersson and A. Hermansen, 1995. NEGFRY: a system for scheduling chemical control of late blight in potatoes. In: (Eds. Dowley, L.J., E. Bannon; L.R. Cooke; T. Keane and E. O'Sullivan) Proceedings "PHYTOPHTHORA 150 Sesquicentennial Scientific Conference, Dublin, Ireland, 201-208. Boole Press Ltd.

Harrison, J. G., 1992. The effect of aerial environments on late blight of potato foliage. Plant Pathology 41: 384-416.

Hirst, J.M. and Stedman, O.J., 1956. The effect of height of observation in forecasting potato blight by Beaumont's method. Plant Pathol. 5:135-140.

James, C.,1971. Potato late blight scale. In: British Mycological Society Manual, 60p.

Johnson, D. A., 1996. Using meteorological information to help manage late blight. Proc. Wash. State Potato Conf., Wash. State Potato Comm., Moses Lake. 10.

Kirk, W.W.; K.J. Felcher; D.S. Douches; J.M. Coombs; J.M. Stein; K.M. Baker and R. Hammerschmidt, 2001. Effect of host plant resistance reduced rates and frequencies of fungicide application to control potato late blight. Plant Disease 85: 1113-1118.

Kirk, W.W.; K.M. Baker; J. Andresen and J.M. Stein, 2005. A problem case study: Influence of climatic trends on late blight epidemiology in potatoes. Acta Hort (ISHS) 638:37-42.

Krause, R.A.; L.B. Massie and R.A. Hyre, 1975. Blitecast: a computerized forecast of potato late blight. Plant Disease Reporter 59: 95-98.

Madden, L. V., 1980. Quantification of disease progression. Port. Ecol. 2:159-176.

Minogue, K. P. and W. E. Fry, 1981. Effect of temperature, relative humidity and rehydration rate on germination of dried sporangia of Phytophthora infestans. . Phytopathology 71: 1181-1184.

Raposo, R.; D. S. Wilks and W. E. Fry, 1993. Evaluation of potato late blight forecasts modified to include weather forecasts: a simulation analysis. Phytopathology 83: 103-108.

Rotem, J., J. Palti and J. Lomus, 1970. Effects of sprinkler irrigation at various times of the day on development of potato late blight. Phytopathology 60: 839-843.

Saad, N. H., 1978. Epiphytology of Potato Blight in Arab Republic of Egypt. Ph.D. Thesis, Faculty of Agriculture Cairo University, Egypt .104 pp.

Smith, L.P. (1956). Potato late blight forecasting. Plant Pathology, 5, 83-87.

Van der Zaag, D. E., 1956. Overwintering en epidemiologie van Phytophthora infestans, tevens enige nieuwe bestrijdingsmogelikheden. Tijdschrift over Plantenziekten. 62: 89-156.

Van der Plank, J. E., 1963. Plant Disease: Epidemic and Control. Academic Press, New York. pp349.

Waggoner, P. E., 1986. Progress curves for foliar diseases: their interpretations and use, in Plant Disease Epidemiology, Vol. 2, (eds, K.J. Leonard and W.E. Fry), MacMillan, New York, p.3-37.

Wallin, J.R., 1962. Summary of recent progress in predicting late blight epidemics in the United States and Canada. Am. Potato J. 39:306-312.

دراسة العلاقة بين بعض العوامل البيئية في المدى القصير ووبائية مرض اللفحة المتأخرة علي البطاطس في مصر

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[٢] المعمل المركزي للمناخ الزراعي – مركز البحوث الزراعية

العديد من وبائيات مرض اللفحة المتأخرة أصابت البطاطس خلال الأعوام القليلة الماضية وخاصة خلال المواسم الممتدة من ٢٠٠٣ إلى ٢٠٠٦. واجريت هذه الدراسة من اجل بحث العلاقة بين بعض الظروف البيئية على المدي القصير وبين وبائية وانتشار هذا المرض. حيث تم تسجيل بيانات الحرارة والمطر يوميا خلال مواسم الدراسة. وتم الحصول على علاقات رياضية باستخدام الحاسب الآلي تربط بين الظروف الجوية السائدة وبين زيادة دورات الحياة وانتشار ووبائية اللفحة المتأخرة. حيث وجد أن بداية ظهور المرض مرتبط بعدد من الأيام التي تلاءم المرض. وأمكن تحديد أن الفترات التي يسود فيها درجة حرارة دافئة ليلا (أكثر من ١٠°م) وفي وجود كمية مطر لا تقل عن ٢ مم/ يوم فان ظهور المرض يرتبط بتكامل هذه الظروف وان هذه الظروف تتوفر خلال أشهر ديسمبر ويناير وفبراير. كما أمكن تحليل وبائية المرض إحصائيا حيث تم حساب منحنيات تقدم المرض Disease progress curves ومعدل الزيادة Disease rate مع الزمن وحساب المساحة تحت منحنى الإصابة (AUDPC). حيث وجد ان المواسم الوبائية (٢٠٠٣/٢٠٠٤ ، ٢٠٠٥/٢٠٠٦) يتراوح معدل تقدم المرض من ٠,٦٤ – ١,٦ اى ٣ أضعاف المواسم غير الوبائية (٢٠٠٢/٢٠٠٣ ، ٢٠٠٤/٢٠٠٥) والتى يكون المعدل فيها من ٠,٠٨–٠,١٥ ، وكذلك وجد ان المساحة تحت منحنى الاصابة فى مواسم الوباء بين ٨,٣ – ٢٩,٢٣ والمواسم غير الوبائية بين ١,٠٦– ٢,٨١. وكل هذه المؤشرات الإحصائية يمكن الاعتماد عليها بشكل كبير في دراسة السلوك الوبائي للمرض وكذلك دراسة تأثير المبيدات الفطرية ومقارنة مقاومة الأصناف ضد مرض اللفحة المتأخرة ويمكن استخدامها في تحديد التوقيت المناسب لعمل الإجراءات الوقائية اللازمة قبل انتشار المرض بشكل وبائي خطير.