Forecasting potato late blight in Morocco

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Abstract

A potato late blight forecasting system, Blitecast, was tested for possible adoption in Morocco. Late blight, caused by Phytophthora infestans (Mont.) de Bary is a major disease of potatoes and field-grown tomatoes because of the ubiquity of inoculum in some areas. In the absence of disease-free seed stock and resistant cultivars, disease management is based mainly on chemical control. The objective of this research was to reduce the number of fungicide applications needed for late blight control by predicting environmental conditions which favor pathogen development. Three cultivars ('Spunta', 'Desiree' and 'Nicola'), widely grown in Morocco, were planted in replicated plots in Larache (northern morocco). The Blitecast system, computerized in the Wisdom program, was implemented to verify its use under moroccan weather conditions and to determine the threshold for local " severity value ". Results from this research indicate that Blitecast can be successfully adapted for use in Morocco by decreasing the " severity value " of 18 (commonly used in the United States) to 14 or 12. Statistical analysis of the data using GLM of SAS, indicates that the cultivar 'Desiree' is more resistant to late blight than 'Nicola' or 'Spunta'. The quality of the fungicide application technique also affected the severity of the disease.

Key words : *Phytophthora infestans,* late blight, Blitecast, potato

Résumé : Prédiction du mildiou de la pomme de terre au Maroc

Un système de prédiction du mildiou de la pomme de terre, Blitecast, a été testé pour une adoption possible au Maroc. Le mildiou causé par Phytophthora infestans (Mont.) de Bary est une maladie importante de la pomme de terre et de la tomate à cause de l'omniprésence de l'inoculum dans certaines zones. Dans l'absence de semences saines et de cultivars résistants, la gestion de la maladie est basée surtout sur la lutte chimique. L'objectif de cette recherche est de réduire le nombre d'applications du fongicide nécessaire pour le contrôle du mildiou par la prévision des conditions environmentales qui favorisent le développement du pathogène. Trois cultivars (Spunta, Desiree et Nicola), largement cultivés au Maroc ont été plantés dans *des parcelles repliquées à Larache (nord du Maroc). Le système Blitecast, informatisé dans le programme Wisdom, a été mis en oeuvre pour vérifier son utilisation sous les conditions d'environnement marocain et déterminer le seuil pour une « valeur locale » de sévérité. Les résultats obtenus montrent que Blitecast peut être adapté avec succès pour son utilisation au Maroc pour réduire la valeur de sévérité 18 (communément utilisée aux USA) à 14 ou 12. L'analyse statistique des données, en utilisant GLM de SAS, indique que le cultivar « Desiree » est plus résistant au mildiou que « Nicola » ou « Spunta ». La qualité de la technique d'application du fongicide a aussi affecté la sévérité de la maladie.*

Mots-clés : *Phytophthora infestans,* mildiou, blitecast, pomme de terre

ملخص : توقع مرض ميلديو البطاطس بالمغرب

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تنظيم توقع مرض ميلديو البطاطس ، Blitecast ، قد جرب من أجل تبنّيه بالمغرب. إن مرض الميلديو المسبب من طرف فيطوفطورا إنفستنس *P. infestans* يعد مرضا مهما للبطاطيس والطماطم و ذلك راجع لتواجده الكلي في بعض المناطق. في غياب بذور نقية وأصناف مقاومة، فإن إدارة هذا المرض ترتكز على استعمال المبيدات. إن موضوع هذا البحث هو حصر عدد استعمال المبيد الكافي لمحاربة الميلديو و ذلك بتكهن الشروط البيئية التي تساعد نمو المرض. ثلاثة أصناف «سبونتا» ، «ديزري» و«نيكولا» ، كثيرة الاستعمال بالمغرب ، تم زرعها في حقول مجزئة ومضاعفة بالعرائش. إن تنظيم Blitecast المبرمج بالحاسوب في برنامج Wisdom تم وضعه حيز التطبيق من أجل التأكد من استعماله تحت الظروف البيئية المغربية ، النتائج المحصل عليها أظهرت أن Blitecast يمكن تكييفه بنجاح من أجل الاستعمال بالمغرب لحصر قيمة حدة المرض من 18 إلى 14 أو 12. إن التحليل الإحصائي للمعطيات باستعمال SAS/GLM ، بين على أن صنف «ديزري» مقاوم لمرض الميلديو أكثر من صنفي «نيكولا» و«سبونتا». إن نوعية استعمال المبيد قد أثرت هي الأخرى على حدة المرض.

الكلمات المفتاحية : فيطوفطورا أنفستنس، بلايط كسط، ميلديو، البطاطس

Introduction

In Morocco, late blight is the most important disease on potato and field-grown tomato. These crops are grown year-around. The pathogen, *Phytophthora infestans* can survive in potato seeds and on potato and tomato plants from one crop to another. In Larache (northern region of Morocco), the fungus is always present in potato fields and is favored by climatic conditions (high humidity and moderate temperatures) which make late blight difficult to manage. Another factor that contributes to the development of the disease is the poor potato seed quality in Morocco. It is rare to find a disease-free seed in either imported or locally produced seed tubers. This makes management of late blight through chemical control very important (Beamont, 1947 ; Dotes and al., 1989).

Epidemiological information has been an important basis for forecasting plant disease (Fry and Dostes, 1990). Earlier forecasting systems were designed just to determine the first occurrence of late blight in a season (Beamqnt, 1947 ; Van Everdigen, 1926). Such forecasts were based on the correlation between weather patterns and disease presence. Forecasts for potato late blight have been in development for well over 60 years and their use has helped disease management.

According to some research (Dostes et al., 1989), the appearance of late blight on foliage when the source of inoculum is an infected seed tuber is rare. However, in the northeastern U.S ; when foliar symptoms of late blight develop as a result of planting infected seed tubers, they typically appear very soon after the time predicted by Blitecast (Dostes et al., 1989 ; Krausse and al., 1975 ; Wallin, 1962). Blitecast is the combination of the Hyre (Hyre, 1954) and Wallin (Wallin 1962 ; Wallin & Waggoner, 1950) prediction methods.

The objective of this study, conducted in Larache was to determine the level of resistance to the new genotype of *P. infestans* (M1 or US-6) of the most commonly grown moroccan potato cultivars and to verify the use of Wisdom (computerized Blitecast system) as a forecasting tool to predict the appearance of late blight. It was also important to determine the timing and frequency of fungicide applications necessary for chemical control and to verify if a threshold severity value of 18 (Krausse et al., 1975 ; Wallin 1962) is applicable under Larache potato-growing conditions.

Materials and Methods

Three commonly grown cultivars ('Nicola','Desiree'and 'Spunta') were provided by SONACOS (National Company for Seed Production). A 100 kg sample of each cultivar was planted on september 4th, 1996, in a field with a history of late blight and surrounded by other potato fields (to create an environment for natural inoculation). A field monitor developed by Sensor Instruments Co., Inc., was placed in the field to record temperature and relative humidity utilized in the Wisdom program to predict late blight and to recommend the initiation of chemical control. Three different types of fungicide combinations were used in this experiment : a protective (Dithane, mancozeb), a mixture of a protective and systemic (Sandofan M, oxadixyl+ mancozeb) and a mixture of a protective, systemic and locally systemic (Ripost M, oxadixyl+ cymoxanil + mancozeb). They were utilized in rotation starting with the protective, followed by the mixture and ending with the triple mixture. Each plot consisted of eight 50 m rows (40 cm between rows). Four rows of each plot were treated based on the spray calendar used in the area and the other four rows were treated following the Wisdom recommendation. The chemical application technique was the same used by growers in other nearby potato fields and commonly employed in Morocco, which is strictly an upper leaf surface application. A total of six applications were used up to the flowering stage. A nearby field with the same cultivars was used as a control and was never treated with chemical fungicides. The same cultural practices with regard to fertilization and irrigation were applied to the entire experiment.

The experimental design was a randomized complete block (RCB) with the following factors : Experiment (based on spray calendar or Wisdom), cultivar three, the date of the observation and replication (four rows for each treatment). Analysis of data was done using the GLM procedure of SAS.

Results

Based on data recorded from the field monitor and computed into the Wisdom program, it was shown that the threshold of 18 severity values was reached in the beginning of september of 1996 (Fig.1), before the emergence of the plants used in our experiment. Late blight was already observed in the neighboring potato fields. As a consequence, growers started fungicide application based on calendar sprays (every five days) to control the disease. Since conditions for late blight were also favorable in this experiment (Fig.2) we followed the Wisdom recommendation and applied fungicides in rotation (protective first, then mixtures) every five days. Based on the statistical analysis, there was no significant difference between the means (Table 1) and the number of fungicide applications was the same whether following Wisdom or a spray calendar.

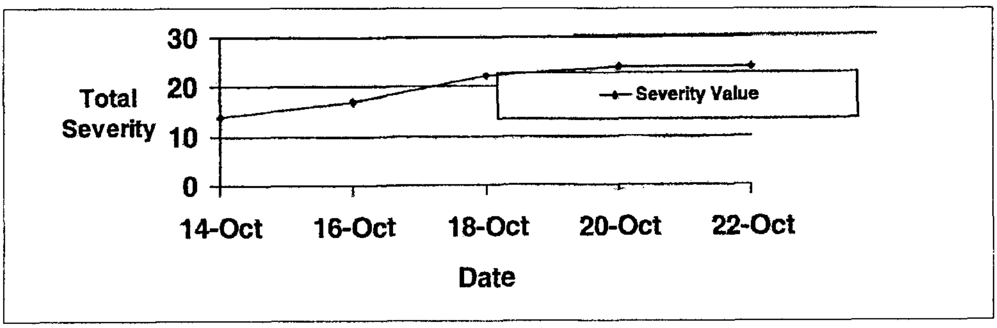

Figure 1. Total severity value recorded in the experimental plots in Larache (starting at emergence of the plants)

Table 1. Continued

3	Resistant	H898-8-5	*a, f/fs, St, Tl, 6pgd-c*(S)
	Susceptible	A83-22(11)6	*A, F/Fs, st, tl, 6pgd-c*(F)
4	Resistant	PL2318	*f/fs, Tl, Aat-p*(S), *Aat-m*(F), *Est-2*(F), *6pgd-c*(S), *Lap1*(S)
	Susceptible	A83-22(11)6	*F/Fs, tl, Aat-p*(F), *Aat-m*(S), *Est-2*(S), *6pgd-c*(F), *lap-1*(F)
5	Resistant	Kodiak	*le, N, V, i, R, 6pdg-c*(S), *Skdh*(F), *Lap-1*(S)
	Susceptible	C77-323-2a	*Le, n, v, I, r, 6pgd-c*(F), *Skdh*(S), *Lap-1*(F)
6	Resistant	RP95126	*i, R, Aat-p*(S), *Lap-1*(S), *Skdh*(S), *Est-2*(F)
	Susceptible	C77-323-2b	*I, r, Aat-p*(F), *Lap-1*(F), *Skdh*(F), *Est-2*(S)

Table 2. Description of the morphological* and isozymic** genes used to study possible linkage with *er*

Genes	Chr	Description
A	1	General plant anthocyanin pigmentation
F/Fs	5	More or less sharp and evenly distributed, small violet spots on the seed testa.
Gp	5	Recessive *Gp* produces yellow pods; dominant *Gp* produces green pods.
i	1	Green cotyledons when recessive, dominant *I* givesyellow cotyledons.
le	4	Short internodes, *Le* gives long internodes
n	4	Recessive *N* conditions thick and fleshy pod walls; whereas, dominant *N* conditions thin pod walls.
Oh	2	Dominant *Oh* produces reddish-brown testa; whereas, recessive *Oh* produces green testa.
r	7	Recessive *r* produces wrinkled seeds. Dominant *R* produces round seeds.
st	3	Recessive *st* produces stipules that are lanceolate, slightly bent and greatly in size. Dominant *St* has normal sized stipules.
tl	7	Recessive *tl* converts tendrils to leaflets (acacia) the heterozygote, *Tl/tl* causes flattened tendrils and homozygous dominant *Tl* produces normal tendrils.
	4	Recessive *v* removes most of the sclerenchymatous membrane from the inner pod wall. Dominant *V* has fibrous pod walls.
was	4	Recessive *was* has no wax on both sides of stipules, on the underside of the leaflets or on the pods.
Aat-p	1	Aspartate aminotransferase-plastidic
Aat-m	7	Aspartate aminotransferase-mitochondrial
Lap-	3	Leucine aminopeptidase-1
Skdh	7	Shikimate dehydrogenase
Est-2	7	Methyl-umbelliferyl esterase-2
Idh	1	Isocitrate dehydrogenase
6pgd-c	5	6-Phosphogluconate dehydrogenase-cystolic
6pgd-p	7	6-Phosphogluconate dehydrogenase-plastidic

* Source : Blixt *and al.* 1978
** Source : Weeden and Marx 1987

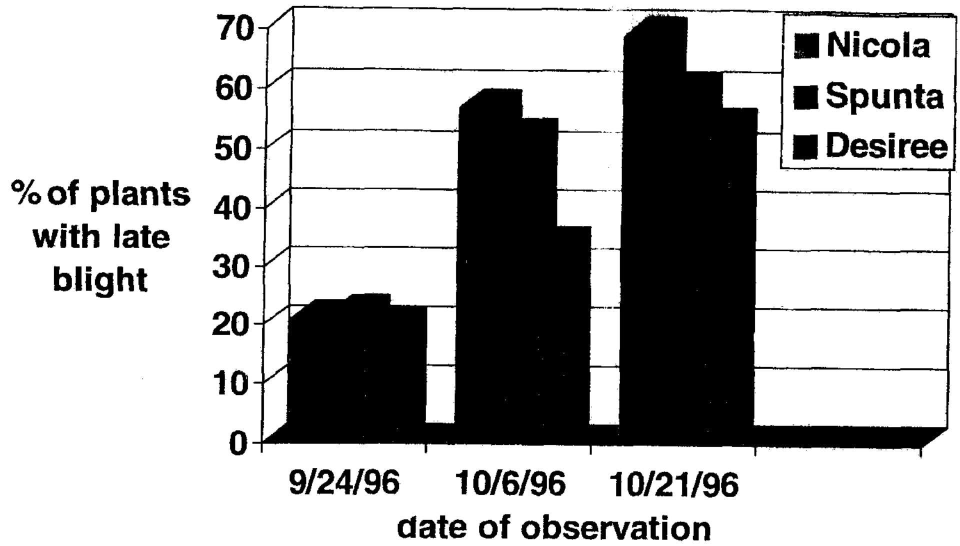

Figure 3. Resistance of three potato cultivars to late bloght

In spite of chemical control based on either a calendar spray system or Wisdom, disease progress was significant (Table 3) and climatic conditions during the growing season were always favorable for the development of the pathogen. In the area where our experiment was conducted, a total severity value of 62 was reached just two months after planting.

Table 3. The progress of disease severity values during different growth stages of potatoes evaluated for late blight in Larache, Morocco.

Source of variation	Number of observations	Mean of severity	Standard deviation	Pi^x
9/24/96	24	$20.66a^y$	2.77	0.0001
10/6/96	24	48.01b	12.37	
10/21/96	24	61.45c	8.42	

^{x} P value from analysis of variance at 0.05 level.

^{Y} Means with the same letter are not significantly different at P = 0.05 according to Fisher's test based on the percentage of plants with symptoms of late blight.

Discussion

The number of plants that developed late blight was high for all three cultivars used in this experiment. A number of factors were involved :

❐ First, the presence of the disease in the neighboring fields before the plants in our experiment even emerged from the soil provided early inoculum ;

❐ Second, the climatic conditions based on Wisdom were totally favorable for disease development (we had reached 18 severity values early in the season, starting in september) ;

❐ Third, was the poor quality of the potato seeds (already infected). This meant that in addition to sporangia being blown by the wind from other infested fields, there was systemic infection in the tubers that also provided more primary inoculum.

Another major problem that could have also contributed to the lack of late blight control was the fungicide application technique that growers generally utilize. They treat only the upper surface of the leaves when using a protective spray. It is desirable to cover all leaf surfaces (including underside) where the fungus could also penetrate the plant. Failure to do so can allow the fungus to become established and cause damage to the plant before application of any systemic that could eliminate the fungus or prevent the fungus from being disseminated to other plants.

Finally, we may have to review this Wisdom threshold (severity value of 18) based on the climatic conditions in Larache. In the area where the experiment was conducted, a severity value of 12 or 14 may be more realistic. Properly timed early fungicide applications may be useful in preventing early infection and reduce the total number of subsequent applications needed for late blight control. This would be especially true if disease-free seed tubers were planted.

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