
DISEASE HAZARDS IN POTATO CULTIVATION

I.—Late Blight caused by *Phytophthora infestans* (Mont) de Bary

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INTRODUCTION

LATE Blight is undoubtedly the most serious disease of potato in humid and wet areas of the hill country. It attacks the foliage of potato plants and invades the tubers causing a wet rot. It has been amply demonstrated that spraying for blight pays in areas where the disease is an important factor (1,2). The disease is endemic in Ceylon and epiphytotics may occur at any time during certain growing seasons. The weather is rather variable in the Nuwara Eliya area with cool nights, frequent rains and high relative humidity, conditions under which the disease can be serious. The source of the primary inoculum does not necessarily depend on infected tubers as potato, tomato and other solanaceous crops grow spontaneously the year round. The occurrence of epiphytotics of late blight in the hill country areas, is, therefore, attributed to the endemism of *Phytophthora infestans* and to the generally favourable local environment. In the Nuwara Eliya area there are many unsuspected micro climates apparently adequate for the year round existence of the pathogen.

The question of controlling late blight is an important requisite for the successful potato culture in the hill country areas. In addition to the control achieved by fungicidal spraying, it was considered necessary, that adjustments in cultural practices and the use of resistant varieties are factors which may contribute to the prevention of the disease, more specially in the hands of peasant cultivators.

SYMPTOMS AND EFFECTS

LATE blight appears on the leaves where it causes brown, dead spots or large dead areas until the leaves are killed. In moist conditions and with susceptible varieties the entire leaf may be killed

in 1-4 days. With the intervention of dry weather, progress of infection is retarded and blighted leaves soon curl and shrivel, while under moist conditions they decay rapidly. The disease results in blackening and wilting of entire tops followed by a wet rot involving the stems as well as the foliage. The lesions produce a delicate whitish or greyish fungus on the under surfaces of leaves. The effect of Late Blight on tubers may be primary or secondary. The early blighting of the foliage will reduce the size and number of tubers. The primary infection of tubers, on the contrary, causes a dry or wet rot according to the prevailing conditions.

It has been clearly demonstrated (2) that an increase of nearly 4 tons per acre of harvested tubers has been obtained in experimental plantings where the disease was effectively controlled. The loss of crop due to the disease can be enormous in severe blight weather and with highly susceptible varieties.

RESISTANCE OF POTATO TO LATE BLIGHT

THE genetics of resistance to Late Blight in potato has been clearly understood during the last few decades (3, 4, 5). There are basically two types of resistance, namely, field immunity or major gene resistance and field resistance or minor gene resistance. The former type of resistance is conferred by 4 major genes labelled by Black (5) as R1, R2, R3 and R4. Each gene was found to be inherited independently and conferred resistance to the common physiologic race of the pathogen as well as certain specialised races. Sixteen different genotypes including the recessive have been obtained from crosses involving the 4 major genes. On the contrary, the minor gene or field resistance appears to be equally effective against the races of the pathogen. This type of resistance is characterised by continuous variation and its inheritance is attributed to a polygenic system.

IDENTITY OF RACES OF *P. INFESTANS*

WITH the object of exploiting major gene resistance in potato culture, especially, as large scale cultivation is new to the country, an investigation was undertaken to ascertain the physiologic races of *P. infestans* present in the potential potato growing areas. Fifteen different genotypes obtained through the courtesy of Black (personal communication) consisting of the individual major genes or in combination and the recessive were used for the identification of the races of *P. infestans*. The different genotypes and the recessive were submitted to trial at Nuwara Eliya, Bopatalawa and Horton Plains.

Late Blight did not appear in the last named test area; the results of the tests at Nuwara Eliya and Bopatalawa are collectively summarised in Table 1. In both test areas none of the genotypes were completely immune, those lacking lesions with active sporulation exhibited hypersensitivity. The races of *P. infestans* found to be most virulent in both test areas were 0, 1, 2, 4 and 1, 2. In the test at Bopatalawa the race 3, 4 was also present in a less virulent form; the same race of the pathogen was identified in subsequent tests at Nuwara Eliya. It has been shown (4) that specialisation of the fungus normally progresses by steps from one order to another towards a wider host range; the mode of origin of new races being attributed either to physiological adaptation or mutation.

In view of the existing races of *P. infestans* and the possible appearance of new races, large-scale cultivation of these genotypes may be temporary. In Tanganyika, however, a genotype known to show hypersensitivity has been cultivated for several years without any signs of blight attack. (6).

TESTS ON VARIETAL RESISTANCE

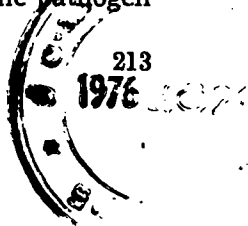
EARLY attempts to determine the varietal resistance to late blight infection were made at the Agricultural Research Station, Rahangala. Different potato varieties were submitted to natural infection in the monsoon season when epiphytotics usually occur on a field scale. The varieties evaluated are grouped below, according to the level of resistance shown in the experiments.

(a) Varieties with 100 per cent. foliage infection. Up to Date, Craigs Defiance, Hybrid 9, Home Guard, Craigs Royal, Kerrs Pink, Arran Pilot, Arron Banner, King Edward, Majestic, Alpha, Arran Peak and British Queen. The variety British Queen succumbed with 100 per cent. leaf blight in 6 weeks whereas the other varieties required 8-10 weeks to reach the same grade of infection.

(b) Varieties with 50 per cent. foliage infection. Japanese No. 4, Japanese No. 6 and Meerster showed this rating in 12 weeks.

(c) Varieties with no active infection. Ulster Torch. This variety had hypersensitive spotting on foliage.

Later tests on resistance were conducted at Nuwara Eliya, where the prevailing cool nights, frequent rains and constant high relative humidity were conducive to severe infection. Each variety was evaluated for the degree of susceptibility to infection by the pathogen



and to the field resistance shown after infection. The potato varieties listed according to the degree of susceptibility to infection are given below.

(a) **Highly Susceptible Varieties.** Voran, Maritta, Alpha, Prof. Broekema, Poet, Profijt, King Edward, Tedria, Up to Date, Local Selection *S. tuberosum* sub species *andigenum* (8), Delus, Ashworth, Courtland, Saco, Harford, Placid, Pungo, Essex, Prisca, Gineke, Phulwa, Darjeeling Red Round, Indian Seedlings ON 2236 and ON 1360 and Ambassadeur. Of the varieties in this category King Edward, Tedria, Up to Date and Indian Seedling ON 1360 produced active sporulating lesions in less than 7 weeks whereas in other varieties sporulation was delayed to 8-9 weeks.

(b) **Moderately Susceptible Varieties.** On Rival, Virgil and Indian Seedling ON 45 sporulating lesions appeared after 9 weeks.

(c) **Resistant Varieties.** Dekama, Dutch Seedlings GB 5269-22, GB 5210-5-9 and GB 5244-8 produced hypersensitive type of spotting on the leaves.

Perhaps the most important consideration in determining resistance is the rapidity with which potato varieties succumb to infection under natural epiphytotic conditions. The potato varieties evaluated have been listed in Table 2 on the basis of resistance shown after attack by the pathogen.

The varieties Delus, Up to Date and King Edward though highly susceptible to late blight and exhibiting poor field resistance showed relatively good yield potential, a condition attributable to early tuberisation of these varieties. Gineke, Prof. Broekema and Profijt while being highly susceptible to infection exhibited a useful degree of field resistance enabling the crop to succumb gradually. These varieties, in contrast, to others of the same category, have the ability to tuberise relatively early. The variety Tedria is highly susceptible to initial infection and has poor field resistance. Unlike Gineke it succumbs to infection rapidly. Voran, Ambassadeur and the local selection *S. tuberosum* sub species *andigenum* are highly susceptible to infection but do not break down with disease rapidly, thus possessing a high degree of field resistance. The varieties Voran and Ambassadeur tuberise relatively early whereas the local selection exhibited a poor yield potential under blight conditions. The seedling GB 5269-22 and Dekama produced hypersensitive reaction and were the least affected by the disease. The loss of crop caused by late blight being negligible in these varieties they would be safe in the hands of peasant cultivators.

CLIMATIC FACTORS IN RELATION TO DISEASE DEVELOPMENT

FACTORS which define the growing seasons in each climatic zone in the hill country are rainfall, temperature, wind and frost. Both high humidity and rainfall play an important part in the development and spread of late blight. Rain provides the moisture necessary for the germination of sporangia on the leaves and also raises the humidity within the crop. Sporangia are produced liberally (7) in an atmosphere with more than 91 per cent. relative humidity and at a temperature range of 46°-59°F. The sporangia have been found to lose their viability in 1-2 hours exposure to dry air. It has been described (7) that free water or dew on the leaves is an essential requirement for sporangial germination. Direct sporangial germination occurs at 48°-79°F whereas indirect germination by zoospores require both free moisture and low temperatures 58°-59°F. Ideal humidity and temperature requirements both for indirect sporangial germination and rapid field spread of the disease are found during certain seasons in the hill country areas. It is, therefore, necessary that the growing seasons should be restricted with the view to escaping blight epiphytotics or raising crops with the minimum infection. The climagrams (Figs. 1 & 2) show the different growing seasons in respect of each climatic zone. In areas receiving predominantly the South-West Monsoon rains the crops which fully or partly escape blight are in the October and January sowing seasons. While the temperatures are satisfactory for economic tuberisation all the year round, blight epiphytotics would be specially serious in the monsoon rains from May to September. In parts of the hill country influenced by the North-East Monsoon the crops which fully or partly escape blight would be in the January, April and July sowing seasons. Accordingly the cropping seasons for escaping late blight epiphytotics could be outlined as follows for each climatic zone. In the climatic zone influenced by the North-East Monsoonal rains. (Fig. 1), viz., Bandarawela, Welimada, Ragalla, Maturata, etc., the recommended seasons for disease escape are—

(a) **January-April Season.** With a variety like Gineke which is susceptible to infection but possessing considerable field resistance, 1-4 protective fungicidal sprays would be necessary with the increase of rainfall and relative humidity towards the close of the season.

(b) **April-July Season.** During this season potato crops are grown in protected locations due to the strong and desiccating winds experienced. The humidity is relatively low and unfavourable for

blight development. Spraying is unnecessary in most areas except in regions where the local climate or microclimate necessitated fungicidal protection.

(c) **July-October Season.** With Gineke 1-4 sprays would be necessary particularly with the advance of the season when both atmospheric relative humidity and the rainfall increase, thereby causing conditions favourable for development of blight.

In the climatic zone, influenced by the South-West Monsoonal rains (Fig. 2), viz., Nuwara Eliya, Bopatalawa, Hatton, Kuda Oya, etc., the seasons recommended for blight escape are the following:—

(a) **October-January Season.** With Gineke, about 1-5 protective sprays are required mostly in the first half of the growing season when both rainfall and relative humidity are conducive to disease development.

(b) **January-April Season.** Protective spraying, about 1-6 spray applications, may be necessary both in the first half and towards the close of the season when the relative humidity and rainfall appear favourable for disease development.

DISCUSSION

EVIDENCE is presented on the methods of field control of late blight by any one or combination of the following methods:—(a) fungicidal spraying, (b) the use of hypersensitive or resistant varieties, and (c) restriction of cropping seasons in each climatic zone to escape blight epiphytotics.

In view of the existence of a number of physiologic races of *P. infestans* and of the possibility of the appearance of new races the use of major gene resistance may be short lived. The evaluation of potato varieties on the basis of susceptibility to attack and the degree of resistance exhibited after infection, revealed that there are hypersensitive varieties and those incorporating both good field resistance and high yield potential which can be successfully cultivated under local conditions.

The analysis of climatic factors in relation to disease showed that the conditions prevailing in the hill country areas are for the most part suitable for disease development and spread. The climagrams

illustrate the cropping seasons in the major climatic zones with the object of escaping blight epiphytotics. While incorporating both inherent varietal resistance and fungicidal control the necessity for avoidance of disease by restricting growing seasons is emphasised.

SUMMARY

1. The physiologic races of *P. infestans* prevalent in the hill country areas have been identified.
2. A large number of potato varieties have been evaluated for both hypersensitive reaction and field resistance. Their relative yield potential in blight conditions is discussed.
3. Climagrams have been presented illustrating the cropping seasons with a view to escape blight epiphytotics.

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TABLE I

Races of *P. Infestans* identified in the hill country

| Genotype | Type of Leaf Lesion | | | | Physiologic race present |
|-------------------------------------------------------------|---------------------|---|----------------|---|-----------------------------|
| | Sporulated | | Hypersensitive | | |
| r | .. | + | .. | - | 0 |
| R ₁ | .. | + | .. | - | 1 |
| R ₂ | .. | + | .. | - | 2 |
| R ₃ | .. | - | .. | + | - |
| R ₄ | .. | + | .. | - | 4 |
| R ₁ R ₂ | .. | + | .. | - | 1,2 |
| R ₁ R ₃ | .. | - | .. | + | - |
| R ₁ R ₄ | .. | - | .. | + | - |
| R ₂ R ₃ | .. | - | .. | + | - |
| R ₂ R ₄ | .. | - | .. | + | - |
| R ₃ R ₄ | .. | + | .. | - | 3,4* |
| R ₁ R ₂ R ₃ | .. | - | .. | + | - |
| R ₁ R ₂ R ₄ | .. | - | .. | + | - |
| R ₁ R ₃ R ₄ | .. | - | .. | + | - |
| R ₂ R ₃ R ₄ | .. | - | .. | + | - |
| R ₁ R ₂ R ₃ R ₄ | .. | - | .. | + | - |

* Only identified at Bopatalawa.

+ Infection present.

- Infection absent.

TABLE II

Relative Yield and Resistance of Potato Varieties after infection by *P. Infestans*

| <i>Poor Resistance</i> | | <i>Moderate Resistance</i> | | <i>Good Resistance</i> | | <i>Hypersensitive</i> | |
|------------------------|-------------------------------------|----------------------------|-------------------------------------|-----------------------------------------------------------------------------|-------------------------------------|-----------------------|-------------------------------------|
| <i>Variety</i> | <i>Mean Yield per plant in ozs.</i> | <i>Variety</i> | <i>Mean Yield per plant in ozs.</i> | <i>Variety</i> | <i>Mean Yield per plant in ozs.</i> | <i>Variety</i> | <i>Mean Yield per plant in ozs.</i> |
| Delus .. | 10.51 | Gineke .. | 10.62 | Ambassador .. | 7.41 | GB. 5269-22 .. | 14.51 |
| Up to Date .. | 9.01 | Prof. Broekema .. | 10.30 | Voran .. | 7.09 | Dekama .. | 10.61 |
| King Edward .. | 7.01 | Profijt .. | 9.04 | Alpha .. | 4.90 | G.B. 5210-5-9 .. | 8.21 |
| Prisca .. | 6.40 | Maritta .. | 7.09 | Rival .. | 3.63 | GB. 5244-8 .. | 7.55 |
| Tedria .. | 5.57 | Pungo .. | 5.87 | <i>S. tuberosum</i> sub species <i>andigenum</i> (local selection) | 2.72 | | |
| Placid .. | 4.83 | ON 45 .. | 5.76 | | | | |
| Ashworth .. | 4.45 | Saco .. | 5.14 | | | | |
| Courtland .. | 4.37 | Essex .. | 4.70 | | | | |
| Virgil .. | 3.52 | ON 1360 .. | 4.66 | | | | |
| Darjeeling .. | | Harford .. | 2.42 | | | | |
| Red Round .. | 3.24 | ON 2236 .. | 2.16 | | | | |
| Post .. | 1.97 | Phulwa .. | 2.08 | | | | |

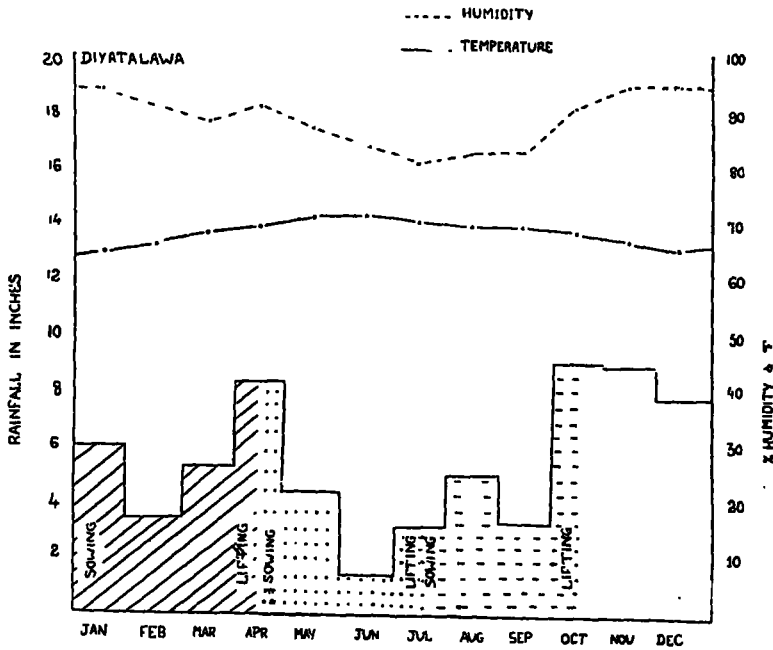


Figure 1.—Long-term average monthly rainfall, mean temperature and mean relative humidity in relation to potato cropping seasons for escaping late blight epiphytotics in the climatic zone influenced by the North-East Monsoon.

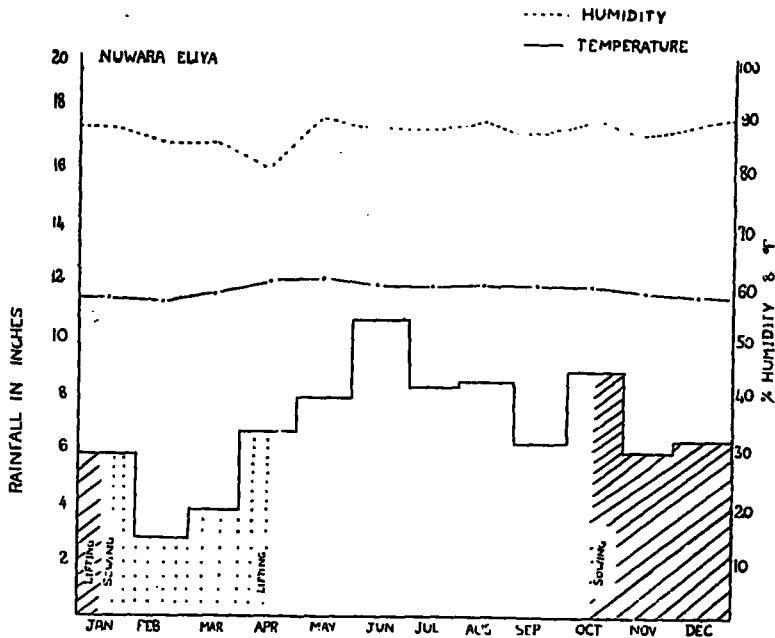


Figure 2.—Long-term average monthly rainfall, mean temperature and mean relative humidity in relation to potato cropping seasons for escaping late blight epiphytotics in the climatic zone influenced by the South-West Monsoon.