Integrated Approach to Fight Against Pests and Diseases in Potato (Solanum Tuberosum Linn.)

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Integrated Approach to Fight Against Pests and Diseases in Potato (Solanum Tuberosum Linn.)

— Jamilah Syafawati Yaacob*, Rosna M at Taha** and Sadegh Mohajer**

ABSTRACT

Production of potato is hampered by a lot of pests and diseases that can adversely affect yield and increase production costs. Farmers around the world had mostly resort to the usage of synthetic and chemical pesticides to control pests and disease incidence. This however is harmful to the environment and can further develop undesirable pesticide resistance. Other options such as employing good crop management
practices and disease forecasting programs can be beneficial in minimizing the need of chemical control against disease causing pests. Integrated pest management (IPM) system has to be employed to fully utilize other control methods against pests and diseases while concomitantly decrease chemical uses.

Keywords: Solanum tuberosum, Pest and disease control, storage, Post harvest management.

INTRODUCTION

Potato (Solanum tuberosum) is a herbaceous annual plant that can grow up to 40 inches (100 cm) tall and produces a tuber (potato) (CIP, 2008). Potato is very rich in starch, hence making it one of the world's most important crops, specifically it is the fourth most important food crop, after maize, wheat and rice (Henderson and De Boer, 2001; Osusky et al., 2004; CIP, 2008; FAO, 2008). It belongs to the Solanaceae or the "nightshade" family of flowering plants (CIP, 2008). It is included in the genus Solanum, together with about 1000 other species, including eggplant and tomato (CIP, 2008). Generally, potato is divided into two subspecies, namely the andigena subspecies which had been adapted to short day conditions and is mostly grown in the Andes, and the tuberosum subspecies which is now cultivated around the world and is believed to be originated from andigena potatoes that were introduced to Europe, but had later on adapted to longer day lengths (CIP, 2008).

There are a lot of pests and diseases that can affect the production of potato. This is a serious concern especially in countries which produces a lot of potato for human consumption (Henderson and De Boer, 2001; Osusky et al., 2004; CIP, 2008; FAO, 2008). Table 8.1 summarizes some of the important pests and diseases that can affect potato growth and production. This review will however focus on discussing the causes, symptoms, diagnosis and control methods for two major diseases that affect potato production, namely the late blight and bacterial wilt disease.

LATE BLIGHT

Causes and Symptoms

Late blight is caused by the fungus Phytophthora infestans that attacks both tubers and foliage during any stage of potato development (Guenthner et al., 2001; Henderson and De Boer, 2001; Osusky et al., 2004; CIP, 2008; FAO, 2008). It is the most serious disease that affects potato production worldwide, as had been shown in history where late
### Table 8.1: Major Pests and Diseases Affecting Vegetable Crops and Production (2000-2002)

<table>
<thead>
<tr>
<th>Pests and Diseases</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucumber mealybug</td>
<td>One of the most damaging parasites of the cucumber plant responsible for causing damage to leaves and stems.</td>
</tr>
<tr>
<td>Squash vine borer</td>
<td>It is a major pest of squash, melon, and pumpkin, causing significant damage.</td>
</tr>
<tr>
<td>Tobacco mosaic virus</td>
<td>It is transmitted through the vector, tobacco thrips, and can cause stunting and deformities in plants.</td>
</tr>
</tbody>
</table>

*Note*: The table above highlights the major pests and diseases affecting vegetable crops and production. Integrated Approach to Fight Against Pests and Diseases...
blight had caused very severe damage in potato yield in Ireland and had led to massive hunger and deaths (Thurston, 1998; Guenthner et al., 2001; Osusky et al., 2004). The fungus can spread very rapidly through the foliage; therefore it is able to cause complete blighting of foliage in a very short time (Thurston, 1998; Guenthner et al., 2001; Henderson and De Boer, 2001; Osusky et al., 2004; CIP, 2008; FAO, 2008). Hence, if no control measures are taken, the entire field can be destroyed. Other than damaging the foliage, they also can infect tubers while they are still in the ground or even while in storage (Guenthner et al., 2001; Henderson and De Boer, 2001; Osusky et al., 2004; CIP, 2008; FAO, 2008). This leads to a very high potential for great loss, especially in terms of yield and crop quality (Thurston, 1998; Guenthner et al., 2001; Henderson and De Boer, 2001; Osusky et al., 2004; FAO, 2008). Therefore, it is very important that the crops must be monitored for late blight incidence and control measures must be taken as soon as the disease risk increases. Apart from that, there are also indirect losses that had been reported to result from late blight incidence, such as the blackleg and soft rot of potatoes; where both diseases usually occur during storage, especially following late blight tuber infections (Guenthner et al., 2001; Henderson and De Boer, 2001; Osusky et al., 2004; FAO, 2008).

The symptoms can be observed from both the leaves and tubers (Henderson and De Boer, 2001; CIP, 2008). As for the leaves, the symptoms that are present can be summarized as shown below (Henderson and De Boer, 2001; CIP, 2008):

(a) The emergence of small, irregular or circular water-soaked spots; which are light to dark green in colour.

(b) Those lesions generally emerge first on the lower leaves, often starting from near the leaf tips or edges (where dew drops are retained the longest).

(c) During cool, moist weather, those lesions expand quickly into large, dark brown or black lesions that appear greasy.

(d) The lesions are not limited by leaf veins. As new infections occur and existing infections coalesce, entire leaves can become blighted and be destroyed within in a few days.

(e) The lesions may also expand down petioles and stems of the plant.
As mentioned earlier, Phytophthora infestans can also cause damage to the tubers; hence can lead to severe loss of potato yield (CIP, 2008; FAO, 2008). The symptoms that can be observed from the tubers can be summarized as shown below (Henderson and De Boer, 2001; CIP, 2008):
There are some irregularly shaped, slightly depressed areas of brown to purplish color of variable size on the skin.

The presence of a tan to reddish-brown rot that appears dry and granular under the skin (in the discoloured areas), which usually will extend into the tuber.

The extent of the rotting in a tuber depends on the susceptibility of the cultivar, temperature and the length of time after the initial infection.

**DIAGNOSIS AND CONTROL**

However, there is a way to diagnose if the potato plant had been infected by the *Phytophtora infestans* fungus. The diagnosis procedure is summarized as follows Henderson and De Boer, 2001; CIP, 2008):

(a) The leaves need to be examined in the early morning or during other cool damp weather.

(b) If the potato plant is infected, there are several symptoms or signs that are present such as:
   (1) A white mildew growth may be seen on the underside of those leaves.
   (2) A pale green to yellow border is often present around the lesions.
   (3) If it has been severely affected by late blight, there will be a distinctive odour present that results from the rapid breakdown of potato leaf tissue.

(c) Positive identification of late blight can be made via conducting microscopic examination on samples from infected leaves or tubers (collected during damp cool weather when the fungus is forming spores).

(d) The fungus can be quickly identified by the distinctive size and shape of spores and spore-bearing stalks.

Considering the severity of the outcome of late blight disease, there are several ways that a farmer or potato grower can adopt in order to control the late blight disease incidence. However, in order to effectively control the late blight disease, an integrated disease management approach has to be employed (Platt et al., 2000; Henderson and De Boer, 2001; Kulikov et al., 2006; CIP, 2008; FAO, 2008). But, the most vital control measures that have to be carried out are the cultural methods, besides opting to use the resistant potato varieties and chemical controls (Brooklyn Botanic Garden, 2000; Platt et al., 2000; Virgen-Calleros et al., 2000;
Cultural methods are actually the first line of defense against almost all diseases affecting potato (Platt et al., 2000; Henderson and De Boer, 2001; Kulikov et al., 2006; FAO, 2008). The implementation of the cultural methods can largely reduce the risk of infection and the possible losses that may result due to the disease (if the infection does occur) (Struik et al., 1997; Brooklyn Botanic Garden, 2000; Platt et al., 2000; Henderson and DeBoer, 2001; Van der Waals and Denner, 2004; Geary and Johnson, 2006; Kulikov et al., 2006; CIP, 2008; FAO, 2008). Some of the cultural methods that can be implemented include:

(a) The farmers must grow disease-free seed tubers only, to avoid introducing late blight into the field. This can be done by using certified seeds that can be bought from a certified potato seed manufacturer.

(b) The farmers must implement a clean operation procedure, where all the culls and volunteer potatoes must be destroyed. This is because they can serve as a site for the pathogen to overwinter and hence spread to nearby potato fields. To do this, the culls can either be buried or spread over the field in a thin layer during the fall season to ensure that they will freeze over the winter.

(c) Frequent or night-time overhead irrigation of potatoes must be avoided. This is because such procedures will maintain the leaf wetness and high humidity in the plant canopy, which is favourable for the fungus Phytophthora infestans.

(d) The farmers must not start harvesting the potatoes until all the vines are completely dead.

(e) At least two weeks are required after vine killing before commencing to harvest the potatoes. This is very important especially in fields where late blight incidence had been reported; as late blight cannot survive on dead vegetation, so the probability of the tubers getting infected when they are exposed during harvest are much lesser.

(f) The infected tubers must be removed before storage and the remaining tubers should be dry when placed in storage to reduce additional losses from soft rot. However, if any late blight infection is believed to be present, in order to minimize the spread from tuber to tuber, the farmers can use forced air ventilation through the storage bin.
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(g) Other than that, storing the seed potatoes at 38 °F will retard late blight tuber rot, although there are small amounts of potatoes already infected with late blight present in the storage.

Other than cultural methods, potato growers can also opt to plant the resistant potato cultivar (Struik et al., 1997; Platt et al., 2000; Henderson and De Boer, 2001; Kulikov et al., 2006; FAO, 2008). However, there is no cultivar that is totally resistant to late blight, but there are some cultivars that had shown partial resistance to this disease (Platt et al., 2000; Henderson and De Boer, 2001; Bains et al., 2002; Darsow, 2005; FAO, 2008). Therefore, farmers or potato growers have the choice to plant those moderately resistant cultivars if late blight is expected to be a problem. Some of the slightly resistant varieties include the Atlantic, Russet Burbank, Red Norland, and the Snowden variety (Henderson and De Boer, 2001). There is also a cultivar that is moderately resistant to late blight, namely the Kennebec variety; but unfortunately it poses other risks to production due to its association with Verticillium fungi (Henderson and De Boer, 2001).

However, there is also the possibility of forecasting the disease incidence (Platt et al., 2000; Henderson and De Boer, 2001; Kulikov et al., 2006; FAO, 2008). This is a very important method as it allows the farmers to prepare and take the necessary actions even before the disease incidence or before the disease gets more severe (Platt et al., 2000; Henderson and De Boer, 2001; Kulikov et al., 2006). Therefore, it is very important that the potato crops are closely monitored for disease incidence. For example, farmers should conduct field scouting on the potato fields especially in the areas that are most likely to have high moisture content, dew or high relative humidity level for the longest amount of time; as those areas are prone for late blight incidence (Henderson and De Boer, 2001; FAO, 2008). Hence, as soon as the disease is detected, other control measures can be carried out. For example, computer based programs are available nowadays to track weather conditions and help forecasting when the disease might occur (Platt et al., 2000; Henderson and De Boer, 2001; FAO, 2008). Those disease forecasting programs can predict when environmental conditions will favour the disease incidence and hence can recommend when fungicide applications may be needed (Platt et al., 2000; Henderson and De Boer, 2001; FAO, 2008). Therefore, it is also very important to note that as the risk of disease incidence gets higher, farmers should intensify the crop monitoring process (Henderson and De Boer, 2001; FAO, 2008).
Integrated Approach to Fight Against Pests and Diseases

BACTERIAL WILT

Causes and Symptoms

The second disease that can significantly affect potato yield and production is the bacterial wilt. Bacterial wilt is one of the most destructive diseases known to attack plants, and has a very wide host range (Thurston, 1998; Stead, 1999; Henderson and De Boer, 2001; CIP, 2008; FAO, 2008). For potato, this disease is also known as brown rot, southern wilt, sore eye or jammy eye (Henderson and De Boer, 2001; CIP, 2008; FAO, 2008). It is caused by bacterium Ralstonia solanacearum (Pseudomonas solanacearum), and has been shown to be a very serious problem in many developing countries, especially in the tropical and sub-tropical zones of the world (between the latitudes 45°N and 45°S) (Stead, 1999; Henderson and De Boer, 2001; FAO, 2008). In terms of disease development, bacterial wilt often occur in warm temperatures (25-30°C) and is limited by temperatures below 10°C (Henderson and De Boer, 2001; FAO, 2008). Other than that, soil moisture is also another important factor that influences the disease incidence, as the bacterium cannot tolerate dry soil conditions (Stead, 1999; Henderson and De Boer, 2001; FAO, 2008).

There are several ways which bacterial wilt can infect plants. This is summarized as the following (Henderson and De Boer, 2001; CIP, 2008):

(a) Through soil; the bacteria can enter plants through the weak points in the root system such as root emergence sites or wound sites which were caused by soil abrasion or by nematodes.
(b) Through infected mother tubers (seed tubers); the bacterium can spread from infected roots or mother tubers via the vascular system to the rest of the plant.
(c) Other sources of infection include via contaminated water, contaminated machinery, plant debris, insect pests and nematodes, rain splash or in dust particles that were carried by the wind, or through contact between the roots. Hence, this implies that effective cultural practices and hygienic working procedures must be implemented.
(d) In addition, the bacterium can also survive on volunteer potatoes and in related species such as tomato and nightshade. Therefore, it is very important that all the culls and volunteer potatoes must be destroyed before the next planting season.
The symptoms of bacterial wilt disease can be observed from both the leaves of the whole plant itself and also from the tubers (Henderson and De Boer, 2001; FAO, 2008). As for the leaves or for the whole plant, the symptoms that are present can be summarized as shown below (Henderson and De Boer, 2001; CIP, 2008):

(a) The typical symptoms include yellowing, wilting and some stunting of the plants, which usually would die right away. Generally, at first, the wilting of the leaves would seem as if the tip of the lower leaves were drooping as a result of a temporary water shortage.

(b) Usually, only one branch in the whole plant may show wilting at first. Then, the affected leaves will become permanently wilted and they will roll upwards and inwards from the margins. This is then followed by the yellowing of the leaves.

(c) This yellowing, wilting and in-rolling of the leaves makes diseased plants very obvious, especially when they are surrounded by healthy plants. Then, the leaves will finally turn brown and will fall off, beginning at the base of the stem and will continue upwards.

In tubers, the diseased tubers are often called as 'jammy eyes', and they will also have a brown rot in the vascular ring of the tubers (Henderson and De Boer, 2001). This is often accompanied by the presence of a thick and creamy mucus inside the tubers (usually will occur at later stages of infection) (Henderson and De Boer, 2001).

**DIAGNOSIS AND CONTROL**

To date, there is no effective chemical treatments for bacterial wilt (Henderson and De Boer, 2001; Bains et al., 2002; CIP, 2008; FAO, 2008), where it has to be controlled through cultural practices such as the use of good crop rotation and by practicing hygienic protocols (Struik et al., 1997; Brooklyn Botanic Garden, 2000; Henderson and De Boer, 2001; CIP, 2008; FAO, 2008). For example, clean irrigation water must be used when irrigating the potato fields, as the bacterium can spread through contaminated irrigation water (Brooklyn Botanic Garden, 2000; Henderson and De Boer, 2001; FAO, 2008). As for the crop rotation technique, the potato crops can be rotated with cereals and pastures (Brooklyn Botanic Garden, 2000; Henderson and De Boer, 2001; FAO, 2008). However, it is also very important to note that the potatoes must not be replanted for at least 2-5 years after a bacterial wilt outbreak, and the growth of self-sowns and solanaceous weed hosts such as nightshades, Narrawa burr and thornapple must be controlled after potato cropping.
because the bacteria can persist in closely related plants (such as the ones mentioned previously) (Henderson and De Boer, 2001).

Besides that, similar to the control methods against the late blight disease, good crop management is also very important to protect potatoes from the bacterial wilt disease (Struik et al., 1997; Platt et al., 2000; Henderson and De Boer, 2001; CIP, 2008; FAO, 2008). The crops must be regularly inspected and checked for any presence of the disease symptoms and immediate actions must be taken once the symptoms has been identified (Brooklyn Botanic Garden, 2000; Platt et al., 2000; Henderson and De Boer, 2001; FAO, 2008).

In addition, there is also another control method, which now is probably the most important option to consider in potato crops protection; namely the Integrated Pest Management (IPM) (Struik et al., 1997; Platt et al., 2000; Henderson and De Boer, 2001; CIP, 2008; FAO, 2008). Both the International Potato Center (CIP) and the FAO (Food and Agriculture Organization of the United Nations) have been promoting IPM as the most preferred pest control strategy during potato production (CIP, 2008; FAO, 2008). This method aims to maintain pest populations at acceptable levels and keep pesticides and other interventions to levels that are justified economically and yet is safe for the environment and human health (Brooklyn Botanic Garden, 2000; Platt et al., 2000; Virgen-Calleros et al., 2000; CIP, 2008; FAO, 2008). For example, the FAO has promoted IPM in many developing countries by using Farmer Field Schools; where the farmers are trained to identify insects and diseases and attempt to improve crop yield and productivity by using other means available while decreasing pesticide use at the same time (CIP, 2008; FAO, 2008).

**CONCLUSION**

There are indeed a lot of pests and diseases that can adversely affect potato production, and this calls for an effective control method to be carried out. However, farmers must not necessarily opt to use chemical controls to fight against the pests and diseases, but may also consider other options such as to employ good crop management practices, using cultural methods and also by implementing disease forecasting programs so that the farmers can estimate the degree of disease severity if it occurs and hence only use the minimal and appropriate amount of chemical controls to fight against the pests and diseases. This is especially important as the abuse of chemicals such as pesticides and fungicides can cause harmful damage to the environment. This indirectly implies that a good
IPM (integrated pest management) has to be employed to make full use of other control methods against pests and diseases while cutting down on chemical uses.

REFERENCES


