Spongospora subterranea f.sp. *subterranea*: Its Association with Imported Seed Potato Tubers and Its Probable Economic Impact

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ABSTRACT

Presence of the pathogen causing powdery scab of potato, *Spongospora subterranea* f.sp. *subterranea* J.A.Toml. in Sri Lanka was suspected and the soil from contaminated field was tested to determine its occurrence. Pots with potato plants were inoculated with such soil to find the presence of the pathogen. Main pathway of the introduction of pathogen is the infected seed potato tubers. Samples obtained from consignments of seed potato imported in 2005/06 season were inspected under the microscope to find spore balls and motile zoospores. Some seed tubers were grown in pots with sterile sand. Tomato plants grown in sterile sand were used as bait plants for the pathogen. All tested samples and soil did not show any evidence for the occurrence of powdery scab.

Next, hypothetical economic impacts of the disease, if introduced to the potato growing regions were evaluated. It became evident that powdery scab of potato could have both direct and indirect effects on the economy of the potato growers and the country.

KEYWORDS: Economic impact, Potato, *Spongospora subterranea*,

INTRODUCTION

Difficulties encountered in detecting *Spongospora subterranea* f.sp. *subterranea* J.A.Toml. (Merz *et al.*, 2004), pathogen causing powdery scab of potato (PSP) may allow it to pass unnoticed during inspection of seed potato tubers. Until now, authorities in Sri Lanka paid little attention to this disease confusing it with common scab. Little information is available on its occurrence in Sri Lanka (CABI, 2005) where no detailed studies have been reported. Suspected incidences were from potato cultivations of government farms where imported seed potatoes had been planted (de Silva *et al.*, 2006) and not from other fields. Hence, a study was undertaken to find whether the imported seed potatoes were helping the introduction of the pathogen as suggested by Braithwaite *et al.*, (1994) and Falloon *et al.*, (2005). Although PSP can infect some other hosts (CABI, 2005), they are not economically important except tomato (Kunkel, 1915) seeds of which may not help the introduction of the pathogen (Richardson, 1979).

Annually, Sri Lanka imports about 6000 t of seed potato (Kelaniyangoda *et al.*, 2004) from countries where PSP is present. This accounts for about 40% of the annual seed potato requirement. Thus, there is a potential for the disease to enter into potato growing regions of the country.

The symptoms of PSP can easily be confused with that of common or deep pitted scab because of their similarities (Cullen and Bell, 2004). PSP is now getting importance and more significance than common scab (*Streptomyces scabies* (Thaxter) Lambert and Loria) or netted Scab (*Streptomyces reticuliscabies* Boucheck-Mechiche *et al.*) because of their comparative economic impacts (Braithwaite *et al.*, 1994). In addition to considerable reduction of crop yield (Falloon *et al.*, 2005), the disease can cause severe tuber distortion affecting the marketability of potato (Iftikhar *et al.*, 2002). Spore balls of *Spongospora subterranea* survive possibly for more than ten years (Secor and Rivera-Varas, 2004) in a quiescent form as uninucleate or some binucleate thick walled resting spores (Harrison *et al.*, 1997). They survive passage through the alimentary canal of farm animals (Harrison *et al.*, 1997). Those spore balls are both a vector and a carrier of potato mop top virus (Asschman *et al.*, 1996, Harrison *et al.*, 1997, Kirk and Grethe., 2004), which is not naturally transmitted by insects or other vectors except by mechanical injuries (Turkensteen, 1996). The virus also could cause problems in potato cultivation. Thus, establishment of PSP in potato fields of the country could result in considerable loss to farmers. Hence probable economic impact of the disease in Sri Lanka is evaluated in addition to testing the presence of PSP in seed potato imported during 2005/06 season.

MATERIALS AND METHODS

This study was carried out at the National Plant Quarantine Service (NPQS), Katunayake.

(1) Inspection of Imported Seed Potato

During 2005/2006 season, 228 lots of seed potato have been imported into Sri Lanka. After inspecting the consignments by plant quarantine officers at the entry point, 100 tubers selected randomly from each lot were brought to the Plant Pathology Laboratory at NPQS. These samples were inspected for scab lesions, and 20 lots (Table 01) were selected for this study, because they showed deep pitted scab lesions suspected as infections of PSP. Cross sections taken from scab pustules were observed under the light microscope.

Few tubers selected were kept in a tray with little water to allow formation of zoospores as suggested

by Merz (1997). After 5-8 hours both the tubers and the water were observed under the microscope.

Some tubers were allowed to sprout and grown in trays with sterile sand. After four weeks, roots were inspected under the light microscope for scab infection.

Table 1 - Varieties of seed potato tubers inspected for PSP:

Variety	Country of origin	Number of samples
Granola	Germany	03
	Netherlands	04
Desiree	Netherlands	04
Cicero	Netherlands	02
Rodero	Netherlands	01
Kondor	Netherlands	01
YP-97-064	Netherlands	01
Sabonete	Netherlands	01
Dornata	Netherlands	01
YP01-078	Netherlands	01
PW02-012	Netherlands	01
Total		20

(2) Present status of Spongospora subterranea in Sri Lanka

i. Host plant inoculation

Department of Agriculture, Sri Lanka sources indicate the appearance of disease symptoms similar to PSP in experimental plots of the Seed Certification Service in Sita Eliya. Soil samples were collected from the particular field. Ten tubers each of five seed potato varieties, viz, Desiree, Granola, Raja, Santana and Provento, were planted on plastic pots (12 cm diameter) filled with sterilized river sand. The pots were kept in a growth room at 15 hr light (12,000 lux cool white fluorescent tubes) at 18°C and 9 hr dark period at 16°C as described by Iftikhar *et al.*, (2002), which provides favorable conditions for PSP infection. Plants were supplied with 0.1 %(w/v) Albert's solution twice a week, and organic liquid fertilizer (Maxi crop©) once a week.

Four weeks after planting, soil collected from Sita Eliya was inoculated on to five pots from each variety. The remaining pots (five each) were kept as controls. Twelve weeks after planting, potato plants were uprooted and both root portions and daughter tubers were washed and observed under light microscope for the presence of spore balls and scab pustules.

ii. Bioassay test

Tomato cultivar 'Rajitha' was used as bait plants. Its seeds were sown on sterilized sand in a tray. After germination, seedlings were sprayed with liquid organic fertilizer and kept in growth room providing similar conditions mentioned above. Three weeks old tomato seedlings were transferred to a plastic tray containing soil suspected to be infected with the pathogen. After one week, the plants were uprooted and washed with sterilized distilled water. Epidermal cells of the roots and the root hairs were observed under stereomicroscope for the presence of root galls.

(3) Assessment of potential economic impact of powdery scab

Hypothetical economic consequence was calculated referring to the agriculture statistics published by Department of Agriculture of Sri Lanka (DOASL) (Anonymous, 2005). The effects were extrapolated to a hypothetical situation where the disease was thought wide spread in the country, thus losing its status as a quarantine pest.

RESULTS AND DISCUSSION

(1) Inspection of Imported Seed Potato

Spore balls of PSP appear as honey comb like structures under light microscopy (Kunkel, 1915 and Iftikhar *et al.*, 2002). However, all the samples observed under light microscope have not shown the spore balls. It is possible that the samples did not have PSP because the consignments have already been inspected and certified to be free from the disease by the Plant Quarantine Authorities of the countries of origin. Perhaps, our sample size might have been small, which was not indicative of the consignment. Also, the identification of PSP only with Light microscopy was difficult. Scientists now use Polymerase Chain Reaction (PCR), Enzyme Linked Immuno-sorbant Assay (ELISA), Epi-Fluorescent Microscopy (EFM), *etc.* for the detection of PSP (Cullen and Bell, 2004, Merz 1997), which was not accessible for this study.

(2) Presence of PSP in Sri Lanka.

i and ii Host Plant Infection and bioassay test

Both the host plant infection and the bioassay test have not indicated the presence of PSP incidences either in plants or in soil. Perhaps the duration of the experiment was insufficient to break the dormancy of spore balls and hence, the infection did not happen. Secor and Rivera-Varas, (2004) reports that individual spores of PSP exhibit different dormancy periods. Fallowing of infected field for several years decreases the infection potential even though potato varieties used in this study were reported to be susceptible to PSP (Falloon *et al.*, 1996, Secor and Rivera-Varas, 2004).

(3) Economic impact of PSP

PSP can result in both direct and indirect economic consequences (Table 2), since almost all potato varieties including those popularly grown in Sri Lanka are susceptible to the pathogen to some degree (Harrison *et al.*, 1997, Secor and Rivera-Varas, 2004). For the presentation of the consequences (Table 2), impacts were categorized as:

1. If <5%, unlikely to be discernible or not significant,

2. If between 5-10%, minor significance,
3. If between 10-30%, significant, and
4. If >30%, highly significant.

The disease usually has a cosmetic effect on potato tubers making them appear unsightly so that marketing can be difficult (Cullen and Bell, 2004) and a considerable portion of the harvest has to be discarded (Harrison *et al.*, 1997). Sorting the tubers is labour intensive and further reduces the financial returns from the crop.

Severe infections of PSP may cause the plants to wilt and die thus destroying a considerable portion of the crop (Harrison *et al.*, 1997). Hypothetical condition used to estimate the destruction of potato cultivation was 10% (Table 2) and no solanaceous plants should be grown there for at least ten years to reduce the inoculum potential. PSP in endemic areas damage the potato crop in the field as well as during storage (Melhus *et al.*, 1916, Harrison *et al.*, 1997). The disease could lead to a dry rot or cankers during storage and the damage could be 30-70% (CABI, 2005), which can cause considerable income loss to farmer (table 2). Falloon *et al.* (1995) reports that, further to reduction in the plant growth, PSP could account for 19% yield loss (table 2). Crop failures lead to import of consumption potato spending a large amount of foreign exchange.

According to Merz (1997), PSP once established in a field is difficult to control. Use of chemicals for disease management is not very promising (Melhus *et al.*, 1916, Braithwaite *et al.*, 1994, Falloon *et al.*, 1996, Secor and Rivera-Varas, 2004). During potato cultivation, the DOASL recommends use of 0.9-1.3 kg of Mancozeb© per hectare for the control of late blight (Anonymous, 1997). However, according to Falloon *et al.*, (1996) this rate may enhance the PSP in the field and they recommend 7.5 kg of Mancozeb© per hectare for its control. The five fold increase in chemical application may result in more production cost and also environmental problems. PSP may not adversely change bio-diversity, ecological stability of the potato growing areas. Also, it may not affect employment or tourism.

Two decades ago, when the potato cyst nematode *Globodera rostochiensis* developed to epidemic proportions in upcountry areas, the banks refused to give credit to farmers who cultivate potato in infested fields.

Table 2 - Hypothetical economic impact of PSP:

Envisaged Effect	Damage/Loss per year	Monetary Value per year (Rs.)	Impact
Destruction of potato cultivation	10% or 32 t/ha yield loss	1,760,000.00	Significant
Yield loss due to			
• Reduction of plant growth	19% or 3.25 t/ha	178,750.00	Significant
• Reduction of marketability	50% or 8.57 t/ha	471,350.00	Highly Significant
• Loss during storage	30-70% or 5.14-11.9 t	282,700.00- 654,500.00	Highly Significant
Increase in production cost			
• Use of agrochemicals (7.5 kg/ha)	Excessive use	1,312.50	Significant
Cost for import of consumption potato	68	1,021,486.70	Uncertain
Increase in incidence of other pests	–	–	Significant
Cost in replanting alternate crops	–	–	Minor Significant
Finding markets for alternate crops	–	–	Significant
Loss in foreign income for Sri Lanka by export of potato	–	–	Not Significant
Meeting new phytosanitary measures	–	–	Not Significant
Cost of research	–	–	Significant
for PSP control	–	–	Significant
for alternate crops			
Reduction in standard of living	–	–	Not Significant
Social dislocation due to crop failure	–	–	Not significant
Inability to get credit for cultivation	–	–	Minor Significant
Increased cost of living	–	–	Not Significant
Environmental impact	–	–	Significant
• By excessive use of agrochemicals	–	–	Not Significant (positive effect)
• By fallowing			
Effect on biodiversity	–	–	Not Significant
Effect on tourism	–	–	Not Significant

Note: (–) Quantification was not possible

The farmers, when applied for bank loans, were asked to get the soils analyzed by the Department of Agriculture officials and get certification to the effect that the field was free of cyst nematodes. This attitude led to some socio-economic problems in the potato growing areas. Similar effect would be possible with PSP.

CONCLUSION

During this study, PSP was not detected in imported seed potato and in Sri Lanka. The perceived or extrapolated occurrence of PSP in the potato growing areas in the country will significantly affect potato cultivation, due to increase in the cost of production and decrease in the yield. The government will have to allocate more money for research and management of the disease.

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