Potato Rhizoctonia Disease in the Bolivian High Andes

Coca Morante M*

Plant Pathology Laboratory, Departamento de Fitotecnia, Facultad de Ciencias Agrícolas y Pecuarias, Universidad Mayor de San Simón, Cochabamba, Bolivia

*Corresponding Author: Coca Morante M, Plant Pathology Laboratory, Departamento de Fitotecnia, Facultad de Ciencias Agrícolas y Pecuarias, Universidad Mayor de San Simón, Cochabamba, Bolivia.

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Abstract

Rhizoctoniasis of potato, caused by *Rhizoctonia solani* Khun, is among the most important of soil-borne disease to affect this crop. Symptoms include stem canker and reductions in tuber yield and quality. In the Bolivian Andes the pathogen is considered of moderate importance; the true impact on yield is, however, not well known. Different native varieties of potato are cultivated in this region, although the Bolivian seed potato certification system records Desiree (*S. tuberosum*) and Waych’a (*S. tuberosum spp. andigena*) to be the most common. The present work describes the incidence and yield losses caused by *R. solani* in different parts of the Bolivian High Andes, where it would appear to have a widespread distribution but to affect crops with different incidence and intensity. In those infected, yield reductions may commonly reach 30 - 40%.

Keywords: Soil Pathogen; Soil-Borne Diseases; Yield Losses; Native Potato Varieties

Introduction

Rhizoctoniasis, caused by *Rhizoctonia solani* Khun, is among the most common soil-borne diseases affecting potato. Caused by the cosmopolitan fungal pathogen *Rhizoctonia solani* Kuhn (teleomorph= *Thanatephorus cucumeris* Frank Donk) [1], problems commonly appear when the soil is cool and damp [2,3]. Quantitative losses result from infection of the stems, stolons and roots, with a reduction in the number of tubers formed; some authors have reported yield reductions of around 30% [4] and on occasion over 50% [5]. Qualitative losses result from the growth of deformed tubers and the appearance of tuber sclerosis [1].

Little information is available on how the disease affects potato crops in Bolivia’s Andean region. Over 30 years ago, Hoopes and Sage [6] indicated it to be of moderate importance, although the full capacity of the pathogen to cause harm was then unknown. Coca Morante and Moreira [5] reported that *R. solani* brought in on potatoes from the Netherlands can now be found in nearly all soils at altitudes of 2900 - 3050m in the Carrasco Province of Cochabamba. Coca Morante [7] later reported native potatoes (*Solanum andigena*) in the High Andes region of the Department of La Paz (4100 - 4300m) to be affected, with yield reductions of 31-34%.

Local Andean growers know the disease by different names. In the Aymara region of the Department of La Paz (especially to the north of La Paz) it is known as *K’arakata* (an Aymaran word meaning “produced on the surface over the furrow”, while in the Quechua region (Cochabamba) it is known as *Sak’o papa* (meaning “it will no longer produce”), or *pata blanca*, meaning white leg in reference to the whitish woolly layer that forms at the base of the stem.

The disease is now generally believed to have become a limiting factor in the production of both introduced (*Solanum tuberosum* L.) and native varieties (*Solanum andigena*, *S. phureja*, *S. stenotonum*, *S. juzepzukii*, *S. ajahuiri*). It is also generally thought that disease inci-
dence and severity are increasing, especially in the more cold and wet high-altitude areas. *R. solani* may thus be considered an emerging pathogen in the Bolivian High Andes.

**Climate and season of potato cultivation in the Bolivian High Andes**

*S. tuberosum* L. is a traditional crop grown across the Bolivian Andes, from the High Andes (3000 - 4500 m) down to the Interandean Valleys (1000 - 3000 m). Native potatoes are grown at 3700 - 4500 m. The climate of the High Andes is largely dry and cold/wet and cold, depending on the time of year (rain usually falls from the end of October to March) and on proximity to the Western Cordillera (where the climate is influenced by clouds rising from the Amazonian region and the Yungas Transition Area). In the Interandean Valleys the climate is temperate-warm and generally dry-arid. Irrigation with surface and subterranean water is required for winter crops; summer crops are rainfed.

The growing season for native potatoes (*S. andigena*, *S. juzepzukii*, *S. phureja*, *S. ajahuiri* and *S. stenotonum*) is known as the siembra de año (the year’s sowing) or Jatun tarpuy in Quechua, or *Ch'oghe Sataña Calltagihua* in Aymara. Sowing begins with the first rain (September-October). In November and December the crops generally suffer water stress, while in January-March rain can be abundant. April to June/July is the cold period, when the crops are harvested. This late sowing time is the consequence of the late cycle of native potatoes, although phurejas potatoes (*S. phureja*) and some stenotonum crops (*S. stenotonum*) are quite early and can be sown at several moments during the year. In the High Andes, especially around La Paz and Cochabamba (the centre of diversity for native potatoes), *S. andigena*, *S. phureja*, *S. stenotonum*, *S. ajahuiri* and *S. juzepzukii* are all grown. *S. andigena* is the most important; especially the varieties of the *papas imillas* group (Figure 1); other important groups include the *palas*, *runas* and *luk’ys* groups.

![Figure 1](image-url)  
*Figure 1: Historical record of Imillas group native potatoes (S. andigena), and varieties currently cultivated in different microcentres of diversity for native potatoes around La Paz and Cochabamba. Numbers above the bars represent the number of varieties.*

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Rhizoctoniasis: distribution and symptoms

Rhizoctoniasis is now found all over the High Andes region, as well as in the Interandean Valleys and even Bolivia’s tropical east. However, little more-detailed information exists. In a study on the pathogenicity, aggressiveness and chemical control of R. solani [8], isolates from patches of tuber sclerosis on the variety Waych’a (S. tuberosum spp andigena) were identified as belonging to anastomosis group AG-3. In a commercial pilot study performed in the High Andes region of Murumamani locality (4290m) - an area of seed potato production to the Omasuyos Province, north of the Department of La Paz - R. solani was reported to be distributed with a “clustered to uniform” pattern, while in an area not devoted to seed potato production (Chojchoni locality, 4186 m, Larecaja Province, Department of La Paz) the distribution pattern was described as “clustered or aggregated” according the dispersion index’s (Figure 2 and Table 1) [7]. The difference seems to have something to do with the conditions associated with seed potato-producing areas - perhaps the reduced number of varieties grown in such areas. Waych’a (S. andigena) and Desiree (S. tuberosum) were the only ones grown in the latter seed potato area (certified seed potato production in Bolivia generally focuses on these varieties) (Figure 3).

**Figure 2**: Distribution of R. solani in a plot with two varieties of native potato (Murumamani, Omasuyos Province, Department of La Paz, 1999/2000).
**Figure 3:** Production of certified seed potatoes in Bolivia, both of introduced (Desiree) and native varieties (S. andigena) such as Huaych’a, and of improved varieties such as Revolución (INIAF, 2017).

**Table 1:** Dispersion indices for R. solani in plots at high altitude in the Department of La Paz.

$X^2; P = 0.05 = 7.82; P = 0.01 = 11.35$

$VM^* = Relationship$ $between$ $variance$ $and$ $mean$

$C^* = Aggregation$ $test$

$LIP^* = Lloyd’s$ $index$
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Rhizoctoniasis in the High Andes occurs from flowering until crop ripening. This coincides with the wettest time of year (January to March); the wet, cold conditions that then reign are favourable to fungal growth. Symptoms appear both on native and introduced varieties, both on the aerial part of the plant and on the tubers. At the time of flowering the apical leaves begin to curl and develop a red-purple coloration at their edges (Figure 4A). As the plant grows the leaves may die and the stem become deformed. Small aerial tubers may also appear at the base of the stem and in the axillae (Figure 4B). A whitish, woolly powder then appears at the base of the stem; these are the sexual state of the fungus (*Thanatephorus cucumeris*) (Figure 4C). Notable stem canker follows as the plant matures, and the secondary roots begin to rot (Figure 4D). The tubers of plants so affected generally form on the surface of the furrow (Figure 4B). Underground, small, deformed tubers proliferate; others (also small) may show deformations and gashes, a reticulated scaliness of the skin, and eyeless or blind tuber (Figure 4E). Even otherwise healthy-looking tubers may show Black scurf.

![Images of potato plants and tubers showing symptoms of rhizoctoniasis.](image)

**Figure 4:** Symptoms of rhizoctoniasis in potato (var. Waych’a, *S. andigena*) in the High Andes region of Bolivia. A: Curling and purple pigmentation of the apical leaves; B: Formation of aerial tubers at the base of the stem, and of small underground tubers; C: Whitening stem, caused by the sexual organs of *R. solani* (*T. cucumeris*); D: Canker at the stem base; E: Surface tubers at harvest in the variety Qoyllu papa (*S. andigena*); F: Effect of *R. solani* on yield.

**Disease incidence, severity and yield losses**

Depending on the temperature and humidity, rhizoctoniasis may appear on crops either in large patches or in a more isolated fashion. In one study performed at an altitude of 2900 - 3050m in the Department of Cochabamba, involving plots of seed potatoes belonging to
the varieties Cardinal and Alpha (*S. tuberosum*), disease incidence was recorded at 3 - 8.3% in 1985/86 and 4.57 - 8% in 1986/87 (Figure 5A) [5]. In 1999/2000, in a study performed in two high-altitude areas of the Department of La Paz, and involving native potatoes (*S. andigena*), disease incidence reached 8% (Figure 5B) [7].

Coca Morante and Moreira Ríos [5] reported an average *R. solani*-induced yield reduction of 52.74% in Dutch potatoes (varieties Cardinal and Alpha) (Figure 6A). The reduction in the number of first and second class tubers was significant (Figure 6B), these being replaced by tubers of third-fifth class; the latter were also deformed, had scales, and had developed no eyes (Figure 4F). In 1999/2000, 34 - 40% losses caused by *R. solani* were recorded in native Waych’a and Imilla negra (*S. andigena*) potatoes [7] (Figure 7A). Apparently, the foliar fungicide Tizoneb (Mancozeb) and Bravo (Clorotalonil) were effective (Figure 7A). In 2016/2017 in the High Andes areas of Cristobalo (4050m), Rodeo (3910m) and P’alta Loma (3700m) (all in the municipality of Colomi, Chapare Province, Department of Cochabamba), yields in infected plants were down by some 42% (Figure 7B) [9]. In these last locations, the differences in size of tubers (healthy plant and diseased plant) of effect of *R. solani* in yield are significant (Figure 8A and 8B).

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**Figure 5:** Incidence of *R. solani* in different parts of the High Andes of Bolivia. A: Communities in the Department of Cochabamba - varieties Cardinal and Alpha (*S. tuberosum*); B: Communities in the Department of La Paz - varieties Waych’a and Imilla Negra (*S. andigena*). 1999/2000.

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**Figure 6:** Effect of *R. solani* on yield in the variety Cardinal (*S. tuberosum*) in different places in Pocona Municipality (Carrasco Province, Department of La Paz) (Year, 1986/87).

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Figure 7: Effect of R. solani on the yield of Waych’a (S. andigena) in A: Murumamani Locality (Province of Omasuyos, Department of La Paz) (Year, 1999/2000); B: Different places in Colomi municipality, Department of Cochabamba, 2016/2017.

Figure 8: Effect of R. solani on the yield and tuber size of Waych’a (S. andigena) in different places in Colomi municipality, Department of Cochabamba, Year, 2016/2017. A: Healthy plant; B: Diseased plant. Numbers above the bars represent the tuber class or size.

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Management and control

Growers commonly try to control rhizoctoniasis with chemical agents. In a 1995 greenhouse study, Pencycuron (Monceren) was found to improve yields by 28% over no-fungicide controls [8]. This long-used fungicide is still employed, along with others such as benzimidazoles [8]. Coca Morante [7] reported that, in 1999/2000, foliar applications of different fungicides to control rhizoctoniasis at altitudes around 4100 m showed Mancozeb to be effective (Figure 7). However, most growers treat the seeds and the soil, not the leaves. One of the most often-used fungicides is Maxim XL (10 g/L Metalaxil-M25 g/L fludioxonil). This is commonly used in combination with the insecticide Actara (25% p/p Tiametoxam) - a mixture known as Curapapa. After 20 years of use, Curapapa is losing effectiveness in the high altitude areas of La Paz and Cochabamba, and growers have started to use Acronis (pyraclostrobin-methylthiophanate) as a tuber treatment [9].

Crop rotation is a common practice in the High Andes. However, its characteristics differ between regions. After harvesting potatoes, a cereal crop is commonly planted, such as oats (Avena sativa L.), but in other places another tuber; e.g. olluco (Ullucus tuberosus) or oca (Oxalis tuberosa) is cultivated. Fields are left fallow at different times too. In Murumamani (Omasuyos Province, Department of La Paz), the soil is left to rest every 5 -10 years in traditional rotation cycles known as Aynoghas. In other areas, however, where land is more scarce, the fallow period returns in under five years [10].

Conclusion

In conclusion, rhizoctoniasis of potato is widely distributed in the Bolivian High Andes. Disease is most severe in areas where soil use is more intense, such as in seed potato-producing areas, perhaps because of the reduced number of varieties grown. The aerial parts and tubers of affected plants have characteristic symptoms, and both crop yield and crop quality are reduced. Currently, the disease is usually controlled through the use of fungicides.

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