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Studies on fungicide treatment of soil and seed tuber for control of potato black scurf (*Rhizoctonia solani* Khun) in Argentina

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Abstract

During 2008 to 2010 growing seasons, three trials were conducted on fungicide treatment of soil and seed tuber for control of potato black scurf at INTA Balcarce Experimental Station, Argentina in randomized complete block design. Before planting, fungicides Monceren 25SC (pencycuron 25%) at 1.25 L/t and Celest 25FS (fludioxinil 2.5%) at 0.5 L/t were sprayed on potato whole seeds. After planting, the same fungicides were sprayed on each row at 2.5 and 1.0 L ha^{-1}, respectively. Whole healthy (no symptons) and diseased (15-20% surface covered by sclerotia) seeds of Kennebec cultivar were used. Artificial inoculations to the soil were made with *Rhizoctonia solani* AG3 anastomosys group. Disease incidence was registered every year. Yields were recorded and each tuber was goruped according to health. Fungicides showed better results than both checks and reduced plant disease incidence in the field. Inoculated check showed 50% of unhealthy plants while the fungicides reduced it to 10%. Yield increase of marketable tubers was 42% better in fungicide treatments than in the inoculated check. Both fungicides produced more healthy tubers than the inoculated check or uninoculated check. Yield increase of healthy tubers was 45% higher when compared with the inoculated check. Fungicide seed treatment was better when disease seeds were used and fungicide soil treatment was better than healthy seeds.

Key words: *Rhizoctonia,* scurf, soil inoculum, Kennebec, sclerotia, fludioxinil, pencycuron

Introduction

Potato black scurf is caused by fungus *Rhizoctonia solani* Kühn during its asexual stage. *Thanatephorus cucumeris* (Frank) Donk, at its sexual stage, has increased its incidence and effect in potato areas in Argentina mainly in early crops planted in September and November in South East Buenos Aires province. Potato black scurf causes severe losses due to poor tuber quality and yields reduction (Andrade *et al.,* 2008). The plants produce small, cracked or malformed tubers since the pathogen develops the mycelium on the surface or sclerotes. The usage of disease-free seed is a recommended practice to avoid the pathogen as infection source for the crop (Carmona *et al*., 2003; Tsror, 2010). As the disease is caused by a soil-borne pathogen, knowing how to determine the levels in the seed tubers and in soil is extremely important for an efficient control of the disease (Farah *et al.,* 2008). The disease causes severe damages before emergence when planted at low temperature and wet soils. It is therefore a common disease for early crops in the southeast of the Bonaerense geographical area in Argentina. Integrated control practices are necessary to decrease potato black scurf severity. Chemical control is a recommended practice that significantly reduces disease effects. Planting of diseased seed in soils with high levels of inoculum severely reduces the efficacy of chemical control under cold and wet environment. Fungicides can be applied on the tuber and/or to the soil before seeding (Mantecon, 2007). There are certain differences between cultivars as regards behaviour towards the pathogen (Mantecón, 2008). Chemical treatment reduced disease symptoms to 70 % in plants and a 55 % in tubers (Mantecón and Manetti, 2000). The objective of this study was to analyse the severity of potato black scurf and its effects on plants and yields when seeded healthy or disease seeds on natural or inoculated soil with or without fungicide treatment to seed or soil sprays in Argentine conditions.

Materials and methods

The field trial was undertaken during 2008-2010 growing seasons, at the INTA Balcarce Experimental Station, Province of Buenos Aires, Argentina. The trials were fertilised and irrigated by aspersion system. Whole seed tubers of Kennebec cultivar, susceptible to the disease and widely used in the industry was used. The seed potato used for the trials were of high health status (no symptons) and a disease status of 15-20% surface covered by sclerotia according to Falloon *et al.* (1995) and James (1971) diagrammatic scales. A randomized complete block design with four replications was used. Each plot contained four rows, each 4 meters long, spaced 0.8 meters apart. Each plot was spaced 0.2 meters apart in all directions.

Before planting, fungicides, Monceren 25SC (pencycuron 25%) at 1.25 L/t and Celest 25FS (fludioxinil 2.5%) at 0.5 L/t were sprayed over the tuber seeds in fungicide treatments. Following seed tuber seeding, the same fungicides at a 2.5 L/ha^{-1} dose and at a 1.0 L/ha^{-1} dose, respectively were sprayed to the open rows in the treatments with fungicides applied to the soil. In the treatments with soil artificial inoculations, each seed was covered with soil inoculated with the pathogen and then the row was reconstructed with an earthling-up tool. Artificial inoculation was carried out by means of superficially distributing the ground oat grains, which were previously sterilised and colonised with *R. solani* (AG3), of known pathogenicity, causing stem canker and black scurf in potato. Inoculated soil was made by mixing inoculum with natural soil in 1:4 ratio and then each tuber seed was covered with 0.25 kg the inoculated soil. Fungicides were applied in water using a backpack pressure sprayer, with constant pressure and CO_2 pressure source, equipped with ceramic disc-type cone nozzles at a rate of 40 lb/pulg2, and a volume of 150 L/ha. There were four checks, two with and without artificial inoculation, and another two with and without diseased seed, in order to analyse effects of the disease at natural and high inoculum level conditions and the use of healthy and diseased seed. Due to extreme dry weather conditions during 2010, an additional 30 mm post-seeding watering was carried out to favour regular emergence of the crop and disease effect.

The trials were weekly sprayed with Folicur 25EC (tebuconazole 25%) at 0.25 L ha^{-1} and Previcur 72.2SL (propamocarb 72%) at 1.0 L ha^{-1} in order to control early (*A. solani*) and late (*Phytophthora infestans*) blight. Each year, visual evaluations were carried out 70 days after seeding to register the percentage of plants showing symptoms of stem canker produced by *R. solani*. Central rows in each plot were machine harvested in order to determine tuber yields. Following harvest, each tuber was washed and weighed, registering commercial yield (+ 60g) and seed yield (- 60g). Tubers were sorted depending on health (with no pathological symptoms) and unhealthy (with disease symptoms or cracked deformed). The outside rows of each plot were not taken into account. Data was subjected to analysis of variance and the average results were compared by LSD´s with a significance at P=0.05.

Results and discussion

Climatic conditions were favourable for the crop and disease development in 2008 and 2009 season but not favourable during 2010 due to severe drought conditions. However, additional irrigation compensated the water deficit and crop developed normally. Artificial inoculations by infested soil, deseased seeds and frequent irrigation allowed significant development of the disease during experimentation. During 2008 and 2009 (Table 1 and 2), all tested fungicides reduced unhealthy field plants in comparison to the healthy seed in infested soil or unhealthy seed in natural soil or infested. However, during 2010 (Table 3), all tested fungicides on healthy seed on natural or infested soil reduced number of unhealthy plants. During 2008 and 2009, significant differences were seen between checks. Healthy and unhealthy "seeds" on natural soil showed lower levels of unhealthy plants than the same "seed" on infested soil. This shows the importance of artificial inoculation on the soil. The highest disease severity on the field could be seen on tests using unhealthy "seed" on infested soil. These results are consistent with those found by Farah (2009). The highest disease severity on the field could be seen on tests using unhealthy seed on infested soil. These treatments showed average levels of 47 % of unhealthy plants during evaluation years; while the lowest levels on healthy seed with fungicide was 2%. Yields with commercial tubers showed better results with fungicide applications on healthy "seed" on natural or infested soil, whereas the poor results were found with

Table 1. Plant diseases, marketable, diseased and healthy tubers registered in 2008 season

Treatments and dose (L ha^{-1})	Plant/plot		Yields (kg/plot)				
	Number	Diseases (%)	Healthy tubers	Healthy tubers (%)	Diseased tubers	Marketable tubers	Seed tubers
Seed healthy / natural soil	48a	10d	16.6b	66.0	8.6cd	20.6bc	25.2cd
Seed healthy / infected soil	40b	28c	11.6c	51.4	11.1ab	14.8de	22.7cde
Monceren 25SC 2.5 seed healthy sprayed /natural soil	49a	0f	23.7a	77.2	7.2d	27.2a	30.9ab
Celest 25FS 1.0 seed healthy sprayed /natural soil	50a	2ef	24.0a	73.9	8.5cd	27.8a	32.5a
Monceren 25SC 2.5 seed healthy / infected and sprayed soil	43ab	4ef	17.9b	65.5	9.4bcd	22.6b	27.3bc
Celest 25FS 1.0 seed healthy / infected and sprayed soil	45ab	10de	18.4b	67.8	8.7cd	22.0b	27.1bc
Seed disease / natural soil	30c	40b	10.2c	50.0	10.2abc	16.4cde	20.2e
Seed disease / infected soil	25c	65a	8.5c	41.0	12.2a	12.3e	20.7de
Monceren 25SC 2.5 seed disease sprayed/natural soil	48a	10d	17.5b	70.3	7.4d	19.5bc	24.9cd
Celest 25FS 1.0 seed disease sprayed/natural soil	46ab	12d	17.0b	69.3	7.5d	20.1bc	24.5cd
Monceren 25SC 2.5 seed disease / infected and sprayed soil	39b	15d	12.5c	50.5	12.3a	17.1cd	24.8cd
Celest 25FS 1.0 seed disease / infected and sprayed soil	39b	15d	11.8c	51.7	11.0ab	17.4cd	22.8cde
LSD (P=0.05)	8.0	8.5	3.4	----	2.2	4.2	4.4

Table 2. Plant diseases, marketable, diseased and healthy tubers registered in 2009 season

Treatments and dose (L ha^{-1})	Plant/plot		Yields (kg/plot)				
	Number	Diseases (%)	Healthy tubers	Healthy tubers (%)	Diseased tubers	Marketable tubers	Seed tubers
Seed healthy / natural soil	49a	10d	15.1cd	60.0	10.1ab	20.4cd	25.2bcd
Seed healthy / infected soil	32c	20c	11.0de	48.3	11.7a	17.9de	22.7cde
Monceren 25SC 2.5 seed healthy sprayed /natural soil	50a	4e	28.8a	82.5	6.1d	28.9a	34.9a
Celest 25FS 1.0 seed healthy sprayed /natural soil	50a	6e	27.2a	79.8	6.9cd	27.3a	34.1a
Monceren 25SC 2.5 seed healthy / infected and sprayed soil	45ab	4e	21.9b	72.4	8.4bc	25.4ab	30.3ab
Celest 25FS 1.0 seed healthy / infected and sprayed soil	45ab	8de	20.9b	70.7	8.7bc	23.7bc	29.6ab
Seed disease / natural soil	22d	32b	9.1e	48.6	9.6b	14.8e	18.7e
Seed disease / infected soil	20d	44a	8.0e	40.2	11.9a	16.3e	19.9de
Monceren 25SC 2.5 seed disease sprayed/natural soil	46ab	6e	19.8bc	75.3	6.5d	21.3cd	26.3bc
Celest 25FS 1.0 seed disease sprayed/natural soil	46ab	8de	18.7b	74.4	6.4d	20.8cd	25.1bcd
Monceren 25SC 2.5 seed disease / infected and sprayed soil	38bc	12cde	14.5d	55.6	11.6a	20.8cd	26.1bc
Celest 25FS 1.0 seed disease / infected and sprayed soil	36c	15cd	11.9de	50.1	11.8a	18.3d	23.7cde
LSD (P=0.05)	8.5	8.0	4.9	----	1.8	3.75	5.6

* Within a column, means followed by the same letter are not significantly different (P=0.05).

Table 3. Plant diseases, marketable, diseased and healthy tubers registered in 2010 season

Treatments and dose (L ha[-1])	Plant/plot		Yields (kg/plot)				
	Number	Diseases (%)	Healthy tubers	Healthy tubers (%)	Diseased tubers	Marketable tubers	Seed tubers
Seed healthy / natural soil	49a	4cd	21.5bc	75.3	7.0b	22.5abc	28.5ab
Seed healthy / infected soil	42bc	12b	18.1c	66.4	9.2a	20.8cd	27.3bc
Monceren 25SC 2.5 seed healthy sprayed /natural soil	50a	2d	26.7a	81.7	6.0b	26.8a	32.7a
Celest 25FS 1.0 seed healthy sprayed /natural soil	48ab	0d	24.6ab	82.3	5.5b	23.2abc	30.1ab
Monceren 25SC 2.5 seed healthy / infected and sprayed soil	50a	0d	26.5a	82.4	5.6b	25.7ab	32.1ab
Celest 25FS 1.0 seed healthy / infected and sprayed soil	47ab	4cd	23.3ab	81.6	5.2b	23.6abc	28.5ab
Seed disease / natural soil	40c	26a	13.0d	57.3	9.7a	17.0d	22.7cd
Seed disease / infected soil	38c	32a	11.3d	55.3	9.0a	17.9d	20.3d
Monceren 25SC 2.5 seed disease sprayed/natural soil	48ab	10bc	22.3ab	77.2	6.6b	22.8abc	28.9ab
Celest 25FS 1.0 seed disease sprayed/natural soil	49a	6bcd	22.4ab	76.8	6.8b	23.8abc	29.2ab
Monceren 25SC 2.5 seed disease / infected and sprayed soil	46abc	10bc	20.4c	76.1	6.4b	22.5ab	26.8bc
Celest 25FS 1.0 seed disease / infected and sprayed soil	50a	12b	19.9c	74.4	6.8b	21.7bc	26.7bc
LSD (P=0.05)	6.0	6.0	4.5	-	1.75	4.4	5.2

* Within a column, means followed by the same letter are not significantly different (P=0.05).

healthy or unhealthy "seed" on infested soil. During the first two evaluation years, significant differences were seen on commercial tubers among treatments with healthy and unhealthy "seed", with healthy "seeds" showing the best results. These results confirm those found by Mantecon (2008). Fungicides applied on healthy seeds planted in natural soil increased commercial tuber yields (37.6% in comparison with the check) while the use of healthy seeds in infested soil treated with fungicides had 34.1% more yield in comparison with the check. Diseased seeds, sprayed with fungicides and planted on natural soil yielded an average of 35.5% more in comparison with the check while diseased seeds planted in a infested soil sprayed with fungicides yielded 30.7% more than the check.

When analysing health of harvested tubers, fungicides applied on healthy "seeds" planted on natural soil showed higher number of healthy tubers than the check, and reported earlier (Mantecon, 2000). During 2008 and 2009 season, diseased seeds sprayed with fungicides and planted in natural soil produced more healthy tuber than the checks but diseased seeds planted in infested soil sprayed with fungicide could not surpass the checks and showed low control levels of the disease. These results could be affected by the cultivar susceptibility as demonstrated by Mantecón (2007). Only in 2010 season, these treatments overcome the checks in this parameter but showed lower disease control when compared with fungicide sprays over diseased seeds. This demonstrates the effect of the soil-borne inoculum as a source of the disease. Fungicides applied on healthy seeds, planted in natural soil produced more healthy tubers with average levels of 21.3%, in comparison to the check while healthy seeds planted in infested soil sprayed with fungicides showed an increase in healthy tubers with average levels of 35.2%. Diseased seeds sprayed with fungicides and planted in natural soil produced an increase in healthy tubers levels (43.4%) and diseased seeds planted in infested soil sprayed with fungicides showed an increase of healthy tuber level of 34%. When analyzing yields of disease tubers in 2008 and 2009 season when the disease was severe, the lower disease tubers levels were observed in the treatments in natural soil and the high level was registered always in infested soil while in 2010 season when the disease was less severe all fungicides reduced the diseased tubers than the checks and no differences were detected between healthy or diseased seeds planted in infected soil. These results show the need to treat seeds with fungicides before seeding, mainly when the seeds show symptoms of the disease, since the inoculum in the soil produced a decrease in health of the harvested tubers. On the other hand, when the use of healthy seeds is a common practice between growers, the fungicide sprays to the soil can be a very good tool to reduce the incidence of soil inoculum and improve healthy plants in the field.

Fungicide sprays on diseased potato seeds before seeding and fungicide soil applications before seeding healthy potato seeds showed the best results and are a very good tool to potato black scurf control in Argentina conditions.

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