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Effect of a combination of chlorine dioxide and thiophanate-methyl pre-planting seed tuber treatment on the control of black scurf of potatoes☆

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Abstract

The pre-planting seed tuber treatments of chlorine dioxide (ClO_2), thiophanate-methyl (TPM), and a combination treatment of ClO_2, followed by TPM, were evaluated for control of stem canker and black scurf (*Rhizoctonia solani*), and storage rots; black scurf, common scab (*Streptomyces scabies*), dry rot (*Fusarium* spp.) and silver scurf (*Helminthosporium solani*) on potato (*Solanum tuberosum* L.) cv. Kennebec. Field experiments were conducted in two consecutive years, 1999 and 2000, at the Agriculture and Agri-Food Canada Research Farm in Harrington, Prince Edward Island (PEI), Canada. The combination treatment of ClO_2 (200 μg g^{-1}) and TPM (50 g active ingredient100 kg^{-1} of tubers) significantly ($P = 0.05$) reduced stem canker and black scurf on progeny tubers at harvest and after storage. The low incidence of scab and dry rot in untreated controls hindered the evaluation of the efficacy of the combination treatment and also showed that conditions were not favourable for disease development during this period at Harrington. The combination treatment was not effective on silver scurf in storage. A comparison among control, ClO_2, TPM, and the combination treatment indicates that pre-planting ClO_2 treatment may have killed the majority of the black scurf sclerotia on the tuber surface and that the combination of TPM fungicide treatment following ClO_2 treatment gave protection to progeny tuber by suppressing the growth of the *R. solani*. A higher marketable yield was observed in the combination treatment as compared with the untreated control. Phytotoxicity was not observed in tubers treated with the combination treatment.

Keywords: Black scurf; Common scab; *Rhizoctonia solani*; Storage diseases; *Streptomyces scabies*; Thiophanate-methyl

1. Introduction

Rhizoctonia solani Kühn is an important fungal pathogen that causes both stem canker and black scurf on potato (*Solanum tuberosum* L.) world-wide. Disease symptoms include pruning of emerging sprouts, canker of roots, stolons and stems, and 'black scurf' on tubers (Banville and Carling, 2001). Above-ground symptoms of disease such as plant stunting, chlorosis, purpling of leaves and the formation of aerial tubers may also be apparent (Banville and Carling, 2001). Early season infection of sprouts can result in delayed emergence and stand reduction (Carling et al., 1989; Frank and Leach, 1980; Hide et al., 1985). Stem and stolon canker have been linked to reductions in yield of marketable tubers (Banville, 1989; Scholte, 1989; Weinhold et al., 1982). Black scurf results in tubers that are

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misshapen, cracked and discoloured by the presence of sclerotia on the tuber surface. The presence of black scurf (*R. solani*) on seed and table potato tubers reduces tuber quality, and therefore marketability of tubers. Black scurf causes significant economic losses in potatoes annually (Banville, 1989).

Although both soil-borne and seed-borne inoculum of *R. solani* can contribute to infection of underground plant parts of potato (Frank and Leach, 1980; Weinhold et al., 1982), seed-borne inoculum plays an important role in Rhizoctonia disease development in the majority of fields (Carling et al., 1989; James and McKenzie, 1972; Papavizas et al., 1975). Seed-borne inoculum of *R. solani* can be a significant factor in the development of disease, particularly in the early part of the growing season (Banville, 1989; Carling et al., 1989; Gudmestad et al., 1979; Weinhold et al., 1982). Various seed tuber treatments are effective in reducing the disease levels in the crop. Seed treatment with thiabendazole and pentachloronitrobenzene (Leach and Murdoch, 1985), tolclofos-methyl dusting or spraying seed with fenpiclonil or pencycuron (Wicks et al., 1995), dipping tubers in solutions of formaldehyde (Carling et al., 1989; Weinhold et al., 1982; Wicks et al., 1995), or seed treatment with fludioxonil (Errampalli et al., 1999) are effective in reducing the viability of tuber-borne sclerotia and/or reducing the severity of disease in the subsequent crop. In some seasons, the storage rots, black scurf, common scab (*Streptomyces scabies* (Thaxter) Lambert & Loria), dry rot (Fusarium spp.) and silver scurf (*Helminthosporium solani* Durieu & Mont) have caused yield losses in potato under favourable conditions (Rowe and Secor, 1993; Errampalli et al., 2001).

Products that contain active chlorine, such as common household bleach (sodium hypochlorite), can reduce levels of viable seed-borne inoculum and in conjunction with thiophanate methyl (TPM; fungicide seed treatment) have been shown to reduce black scurf severity in progeny tubers (Errampalli and Johnston, 2001). An oxidative compound, chlorine dioxide (ClO_2; marketed as Purogene, Bio-Cide International Inc., Norman, OK, USA), has shown some promise as a nonspecific biocidal agent when applied to potato tubers in storage via the humidification system (Olsen et al., 2000). Reduced levels of soft rot caused by *Erwinia carotovora* in simulated storage trials have been documented (Olsen et al., 2000; Tsai et al., 2001). However, the use of this product as a treatment to disinfest seed tubers has not been examined. Preliminary work indicated that there may be some benefit in applying ClO_2 as a pre-plant treatment in combination with TPM for control of black scurf in progeny tubers (Errampalli and Boswall, 2000; Errampalli et al., 2002). The purpose of this study was to further ascertain the efficacy of ClO_2 applied as a seed treatment alone or in combination with another fungicide seed treatment, TPM, for control of stem canker and black scurf caused by *R. solani*. The effect of these fungicides on the reduction of the storage diseases, black scurf, common scab, dry rot and silver scurf, was determined after 3–4 months of storage.

2. Materials and methods

2.1. Field plots

Field experiments were conducted in two consecutive years, 1999 and 2000, at the theAgriculture and Agri-Food Canada Research Farm in Harrington, Prince Edward Island (PEI), Canada. Since the objective of this study was to test the efficacy of ClO_2 on seed-tuber-borne pathogens, fields with low levels of *R. solani* and no detectable levels of *Streptomyces* spp. were selected. The colony forming units (CFU) of *R. solani* per 50.0 g of dry soil were determined by the method described by Johnston et al. (1994). The enumeration of CFU of *Streptomyces scabies* in field soils was conducted using the method of Davies and Williams (1970).

2.2. Seed tuber treatment chemicals and seed tubers

ClO_2 (Purogene) was supplied by Bio-Cide International Inc., Norman, OK, USA. TPM (Easout^{TM}, 10% a.i. dust, Syngenta Crop Protection Inc., Guelph, ON, Canada) is registered as a pre-planting potato seed tuber piece treatment to control storage diseases of potato including dry rot and silver scurf (Advisory Committee on Potatoes, 1995, 1996). Many potato growers use this product to protect the cut seed tuber pieces against storage pathogens. The seed piece treatment of TPM in combination with NaOCl was effective against black scurf at harvest and in storage (Errampalli and Johnston, 2001). Since TPM is used as a pre-planting treatment by many growers, we decided to test this chemical along with the ClO_2 treatment for the control of black scurf and storage diseases of potato.

2.3. Experimental design

Seed tuber pieces of potato cv. Kennebec with variable degrees of black scurf, (a) low (5%), and (b) moderate (10%), were treated with the following treatments: (1) untreated control, (2) $200\,\mu g\,g^{-1}$ of ClO_2 solution for 3 min, (3) $0.50\,g\,ai\,kg^{-1}$ of TPM and (4) ClO_2 ($200\,\mu g\,g^{-1}$) solution for 3 min and then treated with $0.50\,g\,ai\,kg^{-1}$ of TPM. Seed tuber pieces of potato were dip treated with ClO_2 for a minimum of 3 min, and air-dried. Seed tuber pieces, including the ones that were treated with ClO_2, were treated with TPM (powder) in a plastic bag for a minimum of 2 min. The controls did not receive any fungicides. The treatment of ClO_2 and TPM will subsequently be referred to as the combination treatment.

Fungicide-treated seed tuber pieces and the controls were planted within 2 h of treatment in rows 0.90 m apart with a seed spacing of 0.30 m. Plots were 3.6 m long and three rows wide for a total of 36 seed pieces per plot. The