Final Report: Western Region IPM Project W0654

A. Grant Data

Title: Developing integrated management programs for soilborne potato diseases using mycofumigation, Trichoderma sp., pesticides and host resistance

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States Involved: Montana State University

First Year Funded: 2005 , Funded 2 years (8/31/05- 7/31/2007)

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B. Non-Technical Summary

This project addresses potential replacement of the fumigant pesticides metam sodium (Vapam), metam potassium (KPam) and 1,3 dichloropropene-1,3,3 trichloropropane (Telone) that are used to control potato early dying and nematodes. These fumigants are used on 30-55 % of the potato acreage in the western region. Alternative management strategies for Rhizoctonia black scurf and canker, the early dying complex that involves *Verticillium dahliae* or *V. albo-atrum*, *Colletotrichum coccodes* (Black dot) and root lesion nematodes (*Pratylenchus* sp.)(Rowe and Powelson, 2002; Sedegui et al, 2000; Stevenson, et al, 2001, Lees and Hilton, 2003) and control of other nematodes including *Meloidogyne chitwoodi* have been identified as high priorities by in the Pest Management Strategic Plan for Pacific Northwest Potato Production and in Potato Crop Profiles for Idaho, Washington and Colorado. This work focused on integrated approaches involving mycofumigation. Mycofumigation is the use of antimicrobial volatile chemicals produced by fungi such as *Muscodor albus* isolate 620 (MA 620) for the control of other microorganisms. Volatile organic compounds produced by this endophyte of cinnamon include the following chemical classes: alcohols, esters, ketones, acids and lipids, all of which are considered to be of low mammalian toxicity.

Field and greenhouse research has shown that use of the MA 620 barley formulation at 33-400kg/ha provides control of Rhizoctonia and scab equal to the best labeled fungicides (azoxystrobin (Quadris) and PCNB (Blocker)) and reduced black dot and *V. dahliae* stem infection by 50-80% in multi year field studies. Although disease incidence and severity was significantly reduced for all diseases studied, yield increases were not significant in four location years of work. In *in vitro* and greenhouse assays, we have demonstrated that the *M. albus* gases are highly toxic (95% + mortality) to the root knot nematode *Meloidogyne incognita* only 50% mortality was seen for the root lesion nematode, *Pratylenchus penetrans*. In *in vitro* agar plate assays and through greenhouse observation, we have demonstrated that *M. albus* does not inhibit or kill beneficial fungi in the genus *Trichoderma. Trichoderma harzianum* Rafai strain (T22) is lableled for control of potato root rots. Greenhouse studies showed a synergistic Rhizoctonia disease control and colonization effects when T-22 and MA 620 were used together but no improved disease control or *T.harzianum* colonization was seen in the field. Optimal control of Verticillium wilt and Black dot was seen with MA 620 seed treatment plus application of azoxystrobin (Quadris) when plants were 20 cm tall. Yield increases of 5.6% were noted for the cultivar Russet Burbank in naturally infected fields and early dying symptoms were dramatically reduced by infurrow application of azoxystrobin followed by application of either chlorothalonil or mancozeb when plants were 20 cm tall.

Mycofumigation with Muscodor albus isolate 620 is effective for controlling scab, Rhizoctonia, vertillium wilt and black dot when used as a seed treatment. Best control of black dot was achieved by use of the MA 620 seed treatment followed by a foliar application of azoxystrobin when plants were 20cm tall. Application at rates up to 400 kg/ha were not significantly different than seed treatment @33 kg/ha. Mycofumigation is highly effective for root knot control but only moderately effective for root lesion nematode control.

Thirty-five potato cultivars were screened in black dot inoculated greenhouse and field trials. The cultivars, Red Pontiac, Red Lasoda, Chipeta, Cal White, A-9045-7, A88388-

1, Gem Chip, Russet Burbank , Alpha and Sangre showed good resistance as measured by stunting in both greenhouse and field trails. Red Norland, Amisk, Umatilla, Altura, Bannock, Kennebec, Yukon Gold were amongst the most susceptible.

C. Introduction

Potatoes are grown in every Western Region state with more than 749,000 acres of production equaling 57.3% of the total U.S. acreage (USDA Ag Statistics 2002). The majority of the production is in ID (375,000 acres), WA (170,000 acres), CO (78,000 acres), OR (50,000 acres) and CA (44,400 acres). As evidenced in the The Pest Management Strategic Plan for Pacific Northwest Potato Production and in Potato Crop Profiles for Idaho, Washington and Colorado, management of the early dying complex, nematodes and Rhizoctonia are high priorities from a production basis. Montana seed producers provide approximately 50% of the seed potatoes planted in the Pacific Northwest and their concern is to produce high quality disease-free seed tubers. Alternative management strategies for Rhizoctonia black scurf and canker, the early dying complex that involves *Verticillium dahliae* or *V. albo-atrum*, *Colletotrichum coccodes* and root lesion nematodes (*Pratylenchus* sp.) and control of other nematodes including *Meloidogyne chitwoodi* have been identified as high priorities by in the Pest Management Strategic Plan for Pacific Northwest Potato Production and in Potato Crop Profiles for Idaho, Washington and Colorado. This proposal addresses potential replacement of the fumigant pesticides metam sodium (Vapam), metam potassium (KPam) and 1,3 dichloropropene-1,3,3 trichloropropane (Telone) that are used to control potato early dying and nematodes. These fumigants are used on 30-55 % of the potato acreage in the western region and these fumigants are both expensive and deleterious to the environment. Improved control strategies for Rhizoctonia and Black dot are needed.

D. Objectives

1) Study the potential of mycofumigation for control of soil-borne plant pathogens of potato with emphasis on *Verticillium dahliae* (Verticillium wilt), *Colletotrichum coccodes* (black dot root rot) and *Rhizoctonia solani* (Rhizoctonia black scurf and canker). Field and greenhouse research has shown that use of the MA 620 barley formulation at 33-400kg/ha provides control of Rhizoctonia and scab equal to the best labeled fungicides (azoxystrobin (Quadris) and PCNB (Blocker)) and reduced black dot and *V. dahliae* stem infection by 50-80% in multi year field studies. The 33 kg/ha seed treatment was as effective as the 400 kg/ha infurrow treatment. Optimal control of black dot required the application of azoxystrobin when plants were 20 cm tall. Although

disease incidence and severity was significantly reduced for all diseases studied, yield increases were not significant in four location years of work.

2) Examine the potential to integrate fungicide controls and *Trichoderma harzianum* Rafai (T-22) for Rhizoctonia and black dot root rot with mycofumigation for control of *Verticillium dahliae* (Verticillium wilt), *Colletotrichum coccodes* (black dot root rot) and *Rhizoctonia solani* (Rhizoctonia black scurf and canker) in greenhouse studies.

Use of T-22 did not provide any measurable control of any disease studied and integration with MA 620 did not improve disease control over MA 620 alone. The use of MA 620 did not result in improved colonization of T-22.

3) Examine the efficacy of mycofumigation for control of *Pratylenchus penetrans* and *Meloidogyne chitwoodi* in in vitro and greenhouse studies .

Because cultures of *M.chitwoodi* did not provide high enough populations for all studies *M. incognita* was substituted for *in- vivo* studies. Both nematodes responded similarly in *in-vitro* studies with >95% mortality after 72 hours. In *in-vivo* studies 50-67% population reductions were noted for the root knot nematode. In *in-vitro* studies with *Pratylenchus penetrans* 50% mortality was noted after 72 hours and root populations were reduced by only 23% in *in-vivo* tests

4) Determine the resistance of cultivars commonly grown in the Pacific Northwest and other germplasm to black dot root rot.
Thirty-five potato cultivars were screened in black dot inoculated greenhouse and field trials. The cultivars, Red Pontiac, Red Lasoda, Chipeta, Cal White, A-9045-7, A88388-1, Gem Chip, Russet Burbank , Alpha and Sangre showed good resistance as measured by stunting in both greenhouse and field trails. Red Norland, Amisk, Umatilla, Altura, Bannock, Kennebec, Yukon Gold were amongst the most susceptible.

E. Approach

Experiments were set up as described in the methods and materials in the proposal. Randomized complete block designs and analysis if variance were used in all experiments. Greenhouse trials used MSU mix and were inoculated as described. Field trials were done at Creston and Bozeman, MT in naturally infested fields. Cultivar evaluation used tissue culture derived plantlets inoculated with 1 gram of 1 x 10^5 cfu of C. coccodes per plantlet into the transplant hole.

F. Results

Rhizoctonia Canker and Black Scurf

Disease severity indexes were significantly reduced in both 2005 and 2006 by fludioxanil seed treatment, azoxystrobin in furrow treatment and by fludioxanil seed treatment plus azoxystrobin in furrow treatment, *Muscodor albus* 620 seed treatment (33 kg/ha) and 200 and 400 kg/ha infurrow treatments over the untreated. The disease severity was reduced by 73-87% when compared to untreated potatoes. The chemical control and *Muscodor albus* 620 treatments were statistically equivalent.

Verticillium wilt

On the cultivars, Russet Norkotah and Russet Burbank, 25% of untreated potato stems were infected with *Verticilium dahliae* compared to 14.3 % for the *Muscodor albus* 620 seed treatment (33 kg/ha) and 7.3% for the 400 kg/ha *Muscodor albus* 620 in furrow treatments in field trials. The combination *Muscodor albus* 620 seed treatment (33 kg/ha) plus azoxystrobin 0.15 kg/ha applied at 20 cm growth had 10.3 % of stems infected. All treatments reduced Verticillium infection equivalently and significantly from the untreated or barley carrier only controls. Ground barley was used for a growth medium for *Muscodor albus* 620. In greenhouse trials, fresh weights were reduced by 71% in inoculated pots compared to non-inoculated pots after 60 days of growth. In pots where M. albus 620 was applied at the time of planting, growth was reduced by 25% at the 2.5 g/500 cc soil rate and 30% at the 5.0g/500 cc soil rate when compared to the non-inoculated pots. Research demonstrated that there was no need to provide gas proof covering or a 7 day mycofumigation period to achieve optimal results.

Black dot

On the cultivars, Russet Norkotah and Russet Burbank, 17.7% of untreated potato stems were infected with Colletotrichum coccodes compared to 15.7 % for the *Muscodor albus* 620 seed treatment (33 kg/ha) and 10.4% for the 400 kg/ha *Muscodor albus* 620 in furrow treatments in field trials. The combination *Muscodor albus* 620 seed treatment (33 kg/ha) plus azoxystrobin 0.15 kg/ha applied at 20 cm growth had 4.0 % of stems infected. All treatments reduced Black dot infection significantly from the untreated or barley carrier only controls. Ground barley was used for a growth medium for *Muscodor albus* 620. In greenhouse trials, fresh weights were reduced by 73% in inoculated pots compared to non-inoculated pots after 60 days of growth. In pots where M. albus 620 was applied at the time of planting, growth was reduced by 0% at the 2.5 g/500 cc soil rate and 0% at the 5.0g/500 cc soil rate when compared to the non-inoculated pots. Research demonstrated that gas proof covering and a 7 day mycofumigation period improved control at the 2.5 g rate but there were no effects of these treatments at the 5.0 g rate.

Nematodes

Because cultures of *M.chitwoodi* did not provide high enough populations for all studies *M. incognita* was substituted for *in- vivo* studies. Both *M.chitwoodi* and *M. incognita* responded similarly in *in-vitro* studies with >95% mortality after 72 hours. In *in-vivo* studies 50-67% population reductions were noted for the root knot nematode. In *in-vitro* studies with *Pratylenchus penetrans* only 50% mortality was noted after 72 hours and root populations were reduced by only 23% in *in-vivo* tests.

Black Dot

Several cultivars are highly resistant to this disease. Very susceptible cultivars have been identified.

Overall Conclusions

Mycofumigation with *M. albus* strain 620 has proven to be highly effective in controlling Rhizoctonia canker and black scurf, Verticillium wilt in field trials. In conjunction with azoxystrobin post emergence sprays it provides excellent control of black dot. While *in-vitro* control of root knot nematode is excellent, performance in soils is disappointing. Control of root lesion nematode is not acceptable in either in-vivo or in-vitro experiments. Growers with early dying problems due to black dot can select resistant cultivars. The use of mycofumigation with Trichoderma harzianum T-22 does not provide synergistic effects and T-22 does not provide meaningful control of any potato disease studied.

G. Impacts

1. This research has shown that mycofumigation is a potential alternative to the use of broad spectrum soil fumigants such as metam sodium (Vapam), metam potassium (KPam) and 1,3 dichloropropene-1,3,3 trichloropropane, chloropicrin (Telone C) that are used to control potato early dying and nematodes on 30-55 % of the potato acreage in the western region. In addition this research has demonstrated that the black dot disease causes yield losses equal to Verticillium wilt and that there are highly resistant adapted cultivars that growers can use where Black dot is a serious problem. Mycofumigation may provide organic and other growers with a proven technique to combat important soilborne potato diseases. The volatiles produced by *M. albus* 620 are considered to be GRAS by the USEPA and OMRI certification is pending. In the western region this could affect more than 749,000 acres of production equaling 57.3% of the total U.S. acreage (USDA Ag Statistics 2002). The majority of the production is in ID (375,000 acres), WA (170,000 acres), CO (78,000 acres), OR (50,000 acres) and CA (44,400 acres). Control of black dot is important for MT potato seed growers (10,000 acres) since this is an important seedborne disease.

2. Early dying caused by black dot is estimated to cause 10-20% yield loss on more than 200,000 acres in the western region. Control by use of resistant cultivars or by either chemical control or mycofumigation plus azoxystrobin will eliminate these yield losses if employed. Seed producers will be able to produce seed without or with low

amounts of black dot infection. Results of this research are being used on ~3000 acres in MT.

3. Results of this research have been seen by ~200 attendees at field days and 3 on farm demonstrations have been used to educate potato growers. This research has been presented to Montana seed potato growers (~120) each year since 2005 and they have provided a dollar for dollar match of this grant. Both extension and peer reviewed publications are being prepared. This research was presented at the 2006 meeting of the Potato Association of America (attendance 500) and the American Phytopathological Society 2007 meeting (attendance 1800).

4. Crop advisors have utilized this research in MT, ID, WA and OR for control of black dot