CHEMICAL CONTROL OF RING ROT BACTERIA CONTAMINATING WOODEN, METAL AND POTATO SEED PIECE SURFACES [1/]

by

G. D. Easton, M. E. Nagle and D. L. Bailey [2/]

SUMMARY

In this 3-year study, yields of potato variety "Norgold Russet" were reduced 19-36% grown from healthy seed pieces rubbed on ring rot contaminated wooden surfaces. Yields were reduced 52-56% when seed pieces were dipped directly into a ring rot slurry. Spraying contaminated wood and seed piece surfaces with experiemental disinfectants, C-22, Consan 20, Clor, Clorox, formaldehyde, Physan 20 and Roccal, controlled ring rot and increased yield. Sprays of Roccal II and water were not effective. Rubbing potato seed pieces on contaminated unpainted metal surfaces produced very few ring rot plants. Misting rather than spraying the chemical disinfectants on contaminated cut potato seed to reduce excess surface liquid (to prevent other bacterial rots) did not control ring rot.

INTRODUCTION

Every year there are reports of certified seed potatoes infected with ring rot bacteria, Corynebacterium sepedonicum (Spieck, and Kott) Skap. and Burk, which have contaminated railcars, trucks, storages, seed cutters, seed handling equipment and potato planters. Occasionally trucks previously contaminated by hauling infected commercial lots of potatoes are used to haul certified seed potatoes. Contaminated seed storage, handling and cutting equipment not disinfected the previous year can, likewise, contaminate certified lots of seed potatoes.

Occasionally, severe epidemics of ring rot have occurred in Washington. In 1965 about 4,000 acres of commercial potatoes were infected with ring rot. About 5,000 acres were infected in 1976 and many of these were rejected for shipment to foreign markets by State of Washington inspectors.

Yields may be reduced considerably by ring rot and expense and labor are required in cleaning and disinfecting contaminated equipment. Since there is a zero tolerance for ring rot in most certification programs, many thousands of dollars are spent in litigation as a result of losses from this disease.

The ring rot disease was first reported in 1913 in Germany (23). In 1937 it was found in Maine (1, 6) and it soon spread to all potato producing areas of the USA. Ring rot has been eliminated in most of Europe where whole rather than cut seed potatoes are planted, except for Northern Europe (15).

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2/ Plant Pathologist, Research Technologist III, and Experimental Aide I, Department of Plant Pathology, Irrigated Agriculture Research and Extension Center, Prosser, Washington 99350.

Certification programs have provided satisfactory control but have not eradicated ring rot (18). Cutting of potato seed spreads bacteria from diseased to healthy seed (8, 21). Bacteria remain infectious until the next season on contaminated potato handling equipment, but not in the soil (4, 8). Occasionally, ring rot occurs in a certified lot that has been ring-rot-free for many years. Ring rot can be spread from plant to plant and probably from field to field by grasshoppers, Melanoplus differentialis, Colorado potato beetles, Leptinotarsa decimlineata, and black blister beetles, Epicauta pennsylvanica (13). The bacteria can remain latent and symptomless in potato tubers in very low concentrations in cool growing areas (8, 12, 15). The optimum soil temperature for symptom expression of ring rot is 77 F (25°C) (15). Symptoms are delayed at 60.9 F (16°C) and 93.2 F (34°C).

Very low populations of ring rot bacteria in infected plant parts cannot be detected by present methods (12). The gram stain method (20) still remains more sensitive than serological diagnosis (19), and much more reliable than the serological detection of systemic glycopeptides produced by the organism (24).

Breeding programs have developed the ring rot resistant variety, Teton, and many other resistant seedlings, but none have gained commerical acceptance (2, 3).

Sanitation practices probably are incapable of eliminating ring rot from certification programs but have reduced yield loss from this disease in commerical potatoes. Electric heat, boiling water, antibiotics, various chemicals and fumigation have had varied success in decontaminating potato handling equipment and potato seed (5, 8, 12, 14, 15, 16, 17, 18, 21, 22). Mercuric compounds, such as mercuric chloride and Semesan Bel® have given most reliable to instantaneous protection (18), but recently were found toxic to humans and were removed from use by the Environmental Protection Agency (EPA). Some antibiotics were reported effective in controlling ring rot, but were either phytotoxic (5, 14, 18), delayed symptoms expression only (14), or were uneconomical (14). Antibiotics and other chemicals become quite phytotoxic as seed tubers sprout (18). A few formulations of quaternary ammonium compounds are being used for decontamination of potato handling equipment where instantaneous killing is not required (18). Formaldehyde and chlorine also have had some success as disinfectants (8, 18, 21).

Liquid potato seed treatments have never been widely used because excess liquid combined with poor suberization conditions predisposes seed to other bacterial decays. However, other bacterial decays were not increased if seed was planted soon after treatment or was stored under proper suberization conditions prior to planting (9).

Presently no chemical treatment effective for control of ring rot on contaminated seed is cleared by the EPA. Clorox (1 part to 9 parts water) was cleared by the EPA in 1976 to spray on seed potatoes for control of the Verticillium wilt organism, but thus far it is not cleared for use in controlling ring rot (7, 10). Only formaldehyde and quaternary ammonium compounds such as Roccal and Hyamine 2389® are cleared by the EPA for use on some seed handling equipment (11).

The purpose of our study was to determine the effectiveness of new chemical disinfectants in controlling ring rot bacteria on seed handling equipment and seed surfaces.

METHODS AND MATERIALS

The experiment was designed to simulate methods that might be used to control ring rot bacteria on wood, metal, and cut seed piece surfaces. Unpainted, planed, 6-inch lengths of wooden laths and unpainted, 6-inch lengths of 1-inch unpainted metal flat bars were dipped into a slurry prepared by grinding 4-5 ring rot infected tubers in a food blender and adding 4000 ml of water as described by Bonde (3). Infested wooden laths and metal bars were allowed to drain 3 to 5 minutes, sprayed with various chemicals by a hand sprayer at about 20 psi, and allowed to drain for another 3 to 5 minutes. Twenty healthy, cut seed pieces of "Norgold

Russet" were rubbed vigorously on the laths or metal bars and placed in double paper bags for later planting. Control treatments of laths or metal bars contaminated but not sprayed with chemicals and not contaminated but sprayed with chemicals and not contaminated but sprayed with chemicals were also rubbed with seed pieces which were then bagged.

In 1974 and 1975 healthy, sprouted seed pieces of "Norgold Russet" were dipped into the ring rot bacterial slurry, allowed to drain 3-5 minutes and hand sprayed with various chemicals. In 1976 the chemicals were misted on by use of a Micro-gen Model HCSI-2A gasoline powered, hand carried, mist applicator (Micro-gen Equipment Corporation, San Antonio, TX), allowed to drain for 3-5 minutes, and bagged. Control treatments of seed pieces not contaminated but misted with chemicals and seed pieces contaminated but not misted were also bagged.

Within one hour after treatment, 20 potato seed pieces of each treatment were planted by hand one foot apart in an open furrow and covered by discs. In 1974 and 1975 our hands were disinfected with Clorox® (1 part to 9 parts water) between planting, rubbing and bagging of each treatment. In 1976 disposable plastic gloves were used and discarded after treatment and planting of each treatment.

Chemicals applied were C-22, Chapman Chemical Company, chemical composition not disclosed; Consan 20®, Consan Pacific, Inc., Whittier, CA, N-alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethyl benzyl ammonium chlorides-10%, n-alkyl (50% C_{12}, 30% C_{14}, 17% C_{16}, 3% C_{18}) dimethyl ethyl-benzyl ammonium chlorides - 9% and n-alkyl (50% C_{12}, 30% C_{14}, 17% C_{16}, 3% C_{18}) dimethyl benzyl ammonium chlorides - 2%; Clor®, Pennwalt Corporation, Tacoma, WA 12.5% sodium hypochlorite; formaldehyde 37%, Great Western Chemical Company, Seattle, WA; Kem San, Kem-San Limited, Montreal, Quebec, Canada, Hydroxydiphenyl 8.9% and chlorophenyl .48%. Physan 20® same manufacturer as for Consan 20, n-alkyl (60% C_{14}, 30% C_{16}, 5% C_{12}, 5% C_{18}) dimethyl benzyl ammonium chlorides - 10% and n-alkyl (68% C_{12}, 32% C_{14}) dimethyl ethylbenzyl ammonium chlorides - 10%; Clorox®, Clorox Company, Oakland, CA, 5.25% sodium hypochlorite; Roccal®, National Laboratories, Lehn and Fink Industrial Products Division of Sterling Drug, Inc., Montvale, NJ, alkyl (C_{12}, C_{14}, C_{16} and related alkyl groups from C_8 to C_{18}) dimethyl benzyl ammonium chloride - 10%, and Roccal II®, same manufacturer as Roccal, alkyl (C_{14} - 50%, C_{12} - 40%, C_{16} - 10%) dimethyl benzyl ammonium chlorides - 10%, ethyl alcohol 1.25%.

Treatment plots were 3 rows wide (9 ft) by 20 ft long and treatments were randomly arranged and replicated 6 times. The plots were treated and planted on April 3-8, 1974, April 16-21, 1975 and April 2-8, 1976 and harvested September 5, 1974, September 11, 1975, and August 30, 1976.

RESULTS

Over the three year period, C-22, Consan 20, Clor, Clorox, formaldehyde, Kem San, Physan 20, and Roccal sprayed on ring rot contaminated wooden surface reduced the % of ring rot in plants and tubers and increased the % lb. of U.S. No. 1 tubers (except for 1974) and yield compared to the unsprayed, contaminated control (Table 1). Roccal II or the water spray check did not reduce ring rot.

Very few infected plants resulted from seed pieces rubbed on contaminated metal bars even when no chemical disinfectants were applied, therefore, this data is now shown.

Rubbing seed pieces on ring rot contaminated wooden surfaces reduced yields (385 - 276 = 109 cwt/a = 28%) in 1974, 646 - 414 = 232 cwt/a = 36%) in 1975, and (609 - 493 = 116 cwt/a = 19%) in 1976 (Table 1).

In 1975 Clorox, Clor, formaldehyde, Kem San, Physan 20 (1.5 and 3 oz/gal) but not Roccal II and water sprayed on contaminated seed reduced the % of ring rot in plant and tubers and increased the % of U.S. No. 1 tubers and yield compared to contaminated seed receiving no chemical sprays. Of the chemicals tested in 1976 only Clorox (1 part to 4 parts water) and Physan 20 (1.5 oz. per gal) misted on contaminated seed reduced the % ring rot in plants. None of the treatments increased yield.

Dipping seed pieces into a ring rot slurry reduced yields (646 - 283 = 363 cwt/a = 56%) in 1975 and (617 - 297 = 320 cwt/a = 52%) in 1976 (Table 1).

In 1976 chemical treatments misted or sprayed on wooden laths or sprayed on seed surfaces not contaminated with ring rot bacteria had no deleterious effects to plant growth (data not shown).

DISCUSSION

The use of chemical disinfectants on contaminated cut seed surfaces reduced tuber rot and yield losses but did not eradicate the organism (Table 1). Therefore, chemical disinfectants would not eliminate ring rot from infected certified seed, especially from healthy appearing tubers from infected hills of susceptible varieties that do not produce plant symptoms until the second season (8, 12).

The ring rot epidemic of 1965 in Washington was attributed to reuse of contaminated seed sacks. During the last three to four years a majority of the seed potatoes have been handled bulk. As predicted, this type of handling has caused loss of seed lot identity in some cases and carelessness in ring rot contamination from lot to lot during shipment, storage, cutting and planting. Most of the pallet box containers handling bulk seed are made of rough-planed wood which would absorb and retain ring rot bacterial smears for months. The painting of these pallet boxes to produce a smooth non-absorbitive surface similar to metal flat bars where we obtained very little ring rot infection (see text), coupled with regular chemical disinfectant sprays, would greatly reduce ring rot inoculation.

It doesn't appear that phytotoxicity will occur as a problem for EPA clearance of chemicals tested since none misted on sprouted seed and planted shortly after treatment appeared to be phytotoxic (see text).

Misting or fogging minute quantities of disinfectant chemical on contaminated potato seed to reduce surface moisture did not effectively control ring rot (Table 1). Therefore, it will be necessary to spray liquid disinfectants and plant within a few hours after treatment to reduce other bacterial seed rots.

The ideal chemical disinfectant of contaminated equipment and seed piece surfaces would kill the bacteria almost instantaneously, penetrate the cut potato surface 5-10 mm (12), be nontoxic to man and plant parts, resist degradation by other organisms, resist loss of chemical effectiveness in the presence of soil organic matter, be noncorrosive to metals and be relatively inexpensive. Hopefully, such a disinfectant will eventually be developed and cleared by EPA; however, for now we will have to continue to work for EPA clearance of the partially effective disinfectants presently available.

Table 1. Effect of disinfestants on the control of ring rot and production of potato 'Norgold Russet'

Disinfes- tants[5/]	Rate of chemical- water solution	Wooden Surfaces[1/] % Ring Rot Plants[3/] 1974	1975	1976	% Lb. Ring Rot Tubers[4/] 1975	1976	% Lb. U.S. No. 1 Tubers 1974	1975	1976	Yield (cwt/acre) 1974	1975	1976
Control[6/]		0a[8/]	7a	0a	1a	0a	78a	81a	89a	385a	646a	609a
No chemical		65b	27b	23c	17c	8bc	72a	66c	84b	276b	414d	493b
Water		[7/]	25b	23c	10b	8bc	–	67c	85a	–	443d	537ab
C-22	1:50	–	–	0a	–	2ab	–	–	86a	–	–	631a
Clorox	1 to 9	4a	9a	2a	2a	1a	84a	85a	90a	392a	610a	566ab
Clorox	1 to 4	–	–	3a	–	0a	–	–	87a	–	–	551ab
Consan 20	1200 ppm	35b	–	–	–	–	81a	–	–	378a	–	–
Clor	1 to 23.8	–	7a	–	1a	–	–	82a	–	–	588b	–
Formaldehyde	1 pt/15 gal	–	13a	20c	13bc	9bc	–	68b	81b	–	581b	500ab
Kem San	5 oz/gal	–	10a	–	7b	–	–	73b	–	–	566b	–
Physan 20	1.5 oz/gal	–	10a	13abc	9b	4ab	–	76b	89a	–	574b	559ab
Physan 20	3 oz/gal	–	10a	–	9b	–	–	77b	–	–	530b	–
Physan 20	6 oz/gal	–	–	8ab	–	3ab	–	–	88a	–	–	609a
Roccal	400 ppm	40b	–	–	–	–	75a	–	–	392a	–	–
Roccal II	800 ppm	–	20b	20c	13c	9bc	–	67c	85b	–	465cd	515ab

TABLE CONTINUED

Table 1. (Continued)

Disinfestants[5/]	Rate of chemical-water solution	Tuber Seed Piece Surfaces[2/] % Ring Rot Plants[3/] 1975	1976	% Lb. Ring Rot Tubers[4/] 1975	1976	% Lb. U.S. No. 1 Tubers 1975	1976	Yield (cwt/acre) 1975	1976
Control[6/]		7a	0a	1a	0a	81a	86a	646a	617a
No Chemical		37c	62e	38c	17d	47d	72c	283d	297c
Water		48c	48de	34c	22d	48d	82b	269d	312c
C-22	1:50	–	52de	–	19d	–	86a	–	319c
Clorox	1 to 9	28b	60e	11b	19d	72b	83b	486b	355cd
Clorox	1 to 4	–	45d	–	16d	–	84b	–	377cd
Consan 20	1200 ppm	–	–	–	–	–	–	–	–
Clor	1 to 23.8	27b	–	13b	–	72b	–	443b	–
Formaldehyde	1 pt/15 gal	17b	53de	12b	16d	65c	85b	450b	370cd
Kem San	5 oz/gal	25b	–	12b	–	65c	–	436b	–
Physan 20	1.5 oz/gal	28b	45d	12b	20d	68c	83b	479b	341cd
Physan 20	3 oz/gal	37c	–	14b	–	67c	–	421b	–
Physan 20	6 oz/gal	–	53de	–	16d	–	84b	–	355cd
Roccal	400 ppm	–	–	–	–	–	–	–	–
Roccal II	800 ppm	43c	57de	27c	19d	54d	82b	312d	312c

TABLE CONTINUED

Table 1. (Continued)

1/ Planed wooden laths 6 inches in length dipped into a ring rot slurry (4-5 infected tubers ground in a food blender and added to 4000 ml of water), dried 3-5 minutes, sprayed by hand sprayer with chemicals and dried for 3-5 minutes. Healthy cut seed pieces were rubbed on treated lath surfaces, bagged and hand planted within one hour.

2/ Healthy cut seed pieces were dipped into a slurry of ring rot, dried 3-5 minutes on a screen, sprayed by hand sprayer with chemicals in 1975 and misted with chemicals applied by a Micro-gen Model HCSI-2A gas powered mist sprayer in 1976. All treatments were bagged and hand planted within one hour.

3/ Readings taken from 20 plants in 1-20 ft row on July 15, 1974 and from 60 plants in 3-20 ft rows on July 18, 1975 and July 17, 1976.

4/ Readings from 1-20 ft row harvested Sept. 11, 1975 and Aug. 30, 1976.

5/ See text for chemical name and chemical formulation.

6/ Control treatments receive no ring rot slurry or chemical treatment. All other treatments were infected with ring rot slurry.

7/ - = no data taken.

8/ Vertical means with the same letter of the alphabet are not significantly different according to the F test and Duncan's Multiple Range Test at the 5% level.

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