

EVALUATION OF TERRACLOR AND TERRACLOR SUPER-X FOR THE CONTROL OF RHIZOCTONIA ON POTATO IN BRITISH COLUMBIA¹

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Abstract

Broadcast applications of Terraclor or Terraclor Super-X containing a minimum of 20 lb quintozone/acre, when applied to the soil prior to planting and incorporated by disking or rototilling, controlled *Rhizoctonia solani* on 'Netted Gem' potatoes grown in a clay soil. However in muck soil rates as high as 90 lb/acre did not control the disease. Rates of up to 90 lb/acre did not affect yield adversely. Control of stem cankers gave increased marketable yield in 1966, when soil moisture was deficient for about 3 weeks in mid-season. In 1965 and 1967, when soil moisture was supplemented by irrigation or when no shortage occurred, control of stem cankers failed to influence yield. Quintozone residues in tubers were found only in the peels. Tubers from plots that received 90 lb quintozone/acre contained a maximum residue of 0.512 ppm in the peel or a calculated residue of 0.101 ppm in whole tubers.

Introduction

Terraclor³ and Terraclor Super-X³ are products which contain quintozone, the common name for pentachloronitrobenzene. Terraclor Super-X also contains Terrazole³, a trade name for 5-ethoxy-3-trichloromethyl 1,2,4-thiadiazole. Quintozone is known to suppress *Rhizoctonia solani* Kühn (*Thanatephorus cucumeris* (Frank) Donk) by making the soil solution toxic (4). However, in the Columbia River Basin in Washington, where potatoes are grown under irrigation, quintozone failed to consistently reduce rhizoctonia stem canker and tuber black scurf or to increase the yield of marketable tubers (1, 2, 3).

The tests reported here were conducted on alluvial clay and on muck soils in the Fraser River delta of British Columbia. In the low-lying soils of this area, moisture is normally adequate until mid-season or later and often, due to subirrigation or summer rain, there is no need to apply water. Experiments were conducted during the growing seasons of 1965, 1966, and 1967.

Materials and methods

The experiments were located on well-managed farms on which there was a history of moderate to severe *Rhizoctonia* infection on potato (*Solanum tuberosum* L.). The variety 'Netted Gem' was used each year and 'Warba' was included in the 1967 test.

In 1965 soil moisture was not measured, but irrigation water was applied as required in the opinion of experienced farm operators. In 1966 and 1967, the soil moisture in the 'Netted Gem' plots was determined by a bouyoucos bridge with conductivity blocks placed at the 6-, 12-, and 18-inch levels. No supplementary water was added in either year.

Terraclor and Terraclor Super-X were used as emulsifiable concentrates each year. In addition both products were used as wettable powders in 1965 and as granules in 1967. Rates applied were in lb/acre actual quintozone.

In 1965 both clay and muck soils were given broadcast treatments at rates of up to 90 lb/acre. In 1966 rates up to 60 lb/acre were applied as broadcast treatments to clay soil. In 1967 similar clay soils were treated at rates of up to 60 lb/acre as broadcast and up to 20 lb/acre as row treatments.

Broadcast treatments were incorporated by double disking or rototilling within 4 hours of application. Planting was completed within a week after treatment. Row treatments were applied in a 12-inch band on the bottom and sides of open furrows just before planting. The experiments were set up in a randomized block design containing four replications. The standard plot for broadcast treatments contained eight rows 34 inches apart and 25 feet long. Row treatments were applied to two rows 34 inches apart and 25 feet long.

All stems in 50 feet of row in each broadcast-treated plot and all stems in 10 feet of row in each row-treated plot were dug 30-40 days after planting. Each stem was rated as follows: 0 = no cankers, 1 = few superficial cankers, 2 = many superficial and 2 deep cankers, 3 = 3 or more deep cankers, 4 = stem completely girdled. A canker index was

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³ Trade names of Olin Mathieson Chemical Corporation, Little Rock, Arkansas.

calculated for each plot by multiplying the number of stems in each class by the class value, adding the products and dividing the sum by the number of stems examined. In 1967 a second canker index was calculated on another sample taken from each treatment of 'Netted Gem' 77 days after planting.

At harvest, after grading and weighing, a random sample of approximately 80 tubers from each plot was stored in a dry room for 2 weeks. The tubers were then washed and examined for sclerotia. Each sample was assigned a sclerotial index calculated (as described) from tuber ratings, based on surface covered by sclerotia, as follows: 0 = no sclerotia, 1 = 0.5% or less, 2 = 1%, 3 = 3%, 4 = 5%, 5 = 7% or more.

In 1965 tubers grown in clay soil were analyzed for residues of quintozene by the Agricultural Experiment Station, Washington State University, Pullman; in 1966 analyses were made by the Agricultural Pesticide Laboratory, British Columbia Department of Agriculture, Vancouver. Tubers that had been in storage for about 4 months were scrubbed with a brush under running water before extractions were made from the peels and from peeled tubers. Quintozene residues were identified by gas chromatography.

Results

Soil moisture

In 1965 sufficient irrigation water was applied to both the clay and muck soils to provide excellent growing conditions. In 1966 the moisture content in the top 12 inches of soil was lowest from mid-July until August 10. Some temporary wilting of plants occurred. During this period the Bouyoucos bridge indicated resistance of $10-15 \times 10^3$ ohms at the 6-inch level, $7-10 \times 10^3$ ohms at the 12-inch level, and $3-5 \times 10^3$ ohms at the 18-inch level. Before and after this dry period the same blocks indicated resistance of $4-8 \times 10^3$ ohms at the 6- and 12-inch levels and $3-4 \times 10^3$ ohms at the 18-inch level. In 1967 resistance at all levels was 6×10^3 ohms or lower throughout the season and there was no evidence that moisture was deficient at any time.

The control of stem cankers and tuber-borne sclerotia and the effect on yield of Terraclor and Terraclor Super-X were independent of formulation. Consequently, the results of multiple tests with either product in the same experiment were consolidated.

Control of stem cankers

Both Terraclor and Terraclor Super-X reduced the numbers of rhizoctonia stem cankers on potato plants grown in clay soil (Figure 1). The minimum effective rate was approximately 20 lb quintozene/acre in broadcast applications. Results from the

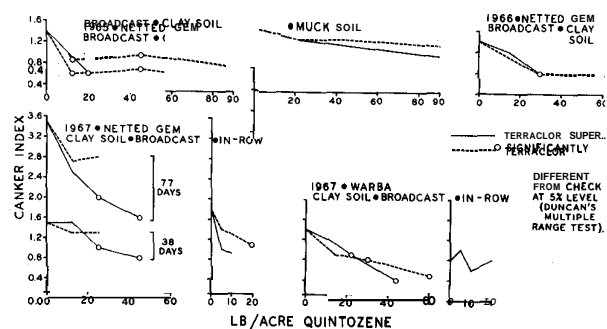


Figure 1. Effect of Terraclor and Terraclor Super-X on rhizoctonia stem canker of 'Netted Gem' and 'Warbo' potatoes grown in muck or clay soils in 1965, 1966, and 1967. A canker index of 0 indicates absence of cankers and 4 indicates complete girdling of the stem. Except where indicated, plants were examined 30-40 days after planting.

row treatments were inconsistent. In most experiments the fungicidal effectiveness of Terraclor and Terraclor Super-X were similar, but the 1967 data indicate somewhat better control by Terraclor Super-X than by Terraclor.

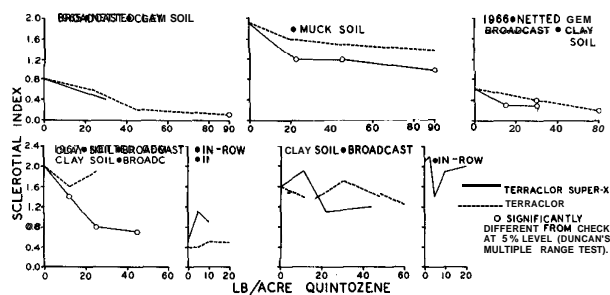


Figure 2. Effect of Terraclor and Terraclor Super-X on the formation of tuber-borne sclerotia of *Rhizoctonia solani* on tubers of 'Netted Gem' and 'Warbo' potatoes. A sclerotial index of 0 indicates no sclerotia and 5 indicates 7% or more of the tuber surface covered by sclerotia.

Control of sclerotia

Terraclor and Terraclor Super-X applied as broadcast treatments to either clay or muck soil reduced the incidence of tuber-borne sclerotia on 'Netted Gem' potatoes (Fig. 2). In 1966 both products controlled sclerotia on clay soil when broadcast at rates of 15 to 30 lb quintozene/acre. In 1965 on muck soil and in 1967 on clay soil, broadcast treatment with Terraclor Super-X gave good control in 'Netted Gem', but Terraclor did not. Neither product reduced sclerotia on the early variety 'Warbo' and neither gave control on 'Netted Gem' or 'Warbo' when applied as a row treatment.

Yield

Neither Terraclor nor Terraclor Super-X at as much as 90 lb quintozone/acre reduced marketable or total yield. In 1965, when 'Netted Gem' potatoes were grown on treated clay or muck soils that were irrigated to maintain good growing conditions, there was no increase in yield (Table 1), even though both

fungicides, when applied to the clay soil (Figure 1), controlled rhizoctonia stem canker. However, in 1966, when water was not applied to relieve a drought in late July, an increase in marketable yield followed the use of Terraclor and of Terraclor Super-X (Table 2). This increase was due to the prevention of second growth, which caused tubers in the control plots to become knobby.

Table 1. Yield of 'Netted Gem' potatoes from irrigated plots on clay and muck soils treated with broadcast applications of Terraclor or Terraclor Super-X in 1965

Soil	Fungicide	Quintozone (lb/acre)	Mean ¹ yield (cwt/acre)	
			Marketable	Total
Clay	Terraclor	22.5	308	342
	Terraclor	45	378	438
	Terraclor	90	312	360
	Terraclor Super-X	30	336	372
	Control		332	372
Muck	Terraclor	22.5	271	328
	Terraclor	45	247	316
	Terraclor	90	272	321
	Terraclor Super-X	22.5	264	332
	Terraclor Super-X	45	258	314
	Terraclor Super-X	90	258	326
	Control		272	344

¹Means are not significantly different at the 5% level (Duncan's Multiple Range Test).

Table 2. Yield of 'Netted Gem' potatoes from non-irrigated plots on clay soil treated with broadcast applications of Terraclor or Terraclor Super-X in 1966

Fungicide	Quintozone (lb/acre)	Mean* yield (cwt/acre)	
		Marketable	Total
Terraclor	30	366 a	438
Terraclor	60	384 a	440
Terraclor Super-X	15	342 ab	430
Terraclor Super-X	30	366 a	438
Control		308 b	418

*Means followed by the same letter or no letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

In 1967, soil moisture in the 'Netted Gem' plots was adequate throughout the growing season, and, although both products controlled stem cankers (Figure 1), yield was not affected (Table 3). In plots of 'Warba' in a location where soil moisture was not measured but where low yields (Table 3)

indicated adverse growing conditions, broadcast applications of both Terraclor and Terraclor Super-X controlled stem cankers (Figure 1). Small increases in yield of 'Warba' followed the application of both fungicides at rates providing more than 40 lb quintozone/acre (Table 3).

Table 3. Yield of potatoes from non-irrigated plots on clay soil treated with broadcast or row applications of Terraclor or Terraclor Super-X in 1976

Potato variety	Application method	Fungicide	Quintozone (lb/acre)	Mean yield (cwt/acre)		
				Marketable	Total	
Warba	Row	Terraclor Super-X	2.5	118	142	
		Terraclor Super-X	5	112	140	
		Terraclor Super-X	10	128	150	
		Terraclor Super-X	20	124	148	
		Control		106	132	
	Broadcast	Terraclor	15	106 a	134 a	
		Terraclor	30	136 ab	168 bc	
		Terraclor	60	154 b	184 b	
		Terraclor Super-X	11	124 a	154 ac	
		Terraclor Super-X	22	124 a	150 ac	
		Terraclor Super-X	44	130 ab	172 b	
		Control		110 a	157 ac	
	Netted Gem	Row	Terraclor	5	384	444
			Terraclor	10	386	448
Terraclor			20	392	442	
Terraclor Super-X			2.5	392	446	
Terraclor Super-X			5	378	430	
Terraclor Super-X			10	363	418	
Control				388	456	
Broadcast		Terraclor	12.5	462	537	
		Terraclor	25	414	514	
		Terraclor Super-X	12.5	405	458	
		Terraclor Super-X	25	427	499	
		Terraclor Super-X	45	423	491	
		Control		407	481	

*In each group, means followed by the same letter or no letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

Residue analyses

Analyses for quitozene (Table 4) showed that the amount of residue increased as the applied rate/acre increased. Virtually the entire residue, which varied considerably in the 2 years, occurred

in the peels. Tubers from plots that received twice the amount required for stem canker control in 1965 contained 0.257 ppm quitozene in the skin and 0.054 ppm in the whole tuber. In 1966, tubers from similar plots contained 0.015 ppm in the skin.

Table 4. Residues of quitozene in potato tubers from plots on clay soil treated for Rhizoctonia control by broadcast applications

Year	Quitozenc applied to soil (lb/acre)	Quitozene residue* (ppm)		
		Peel	Peeled potato	Whole potato**
1965	0	0.007	0.005	0.005
	22.5	0.079	0.005	0.019
	45	0.257	0.005	0.054
	90	0.512	0.005	0.101
1966	0	Trace	0.0	
	15	0.004	0.0	
	30	0.007	0.0	
	60	0.015	0.0	

* Average of duplicate samples.

** Calculated from the values obtained for the peel and peeled portions of the samples.

Discussion

This evaluation of Terraclor and Terraclor Super-X shows that quitozene suppresses growth of R. solani and thereby reduced the incidence of stem cankers and tuber-borne sclerotia. The fungicides were more effective on clay than on muck soils, and broadcast applications were superior to row treatments. Quitozene residues were confined almost totally to the peel of the tubers. The actual amount of residue, although small, varied considerably in 2 years. If an official tolerance is established, more work is needed before a safe application rate can be estimated.

The results show that the benefits that accrue from chemical control of R. solani stem cankers on 'Netted Gem' potato are obtainable in British Columbia by the provision of adequate soil moisture throughout the growing season. Further, since tuber-borne sclerotia do not constitute a serious grade defect in this area, it is unnecessary at this time to recommend chemical soil treatment for the control of this fungus.

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Literature cited

1. Easton, G. D. 1965. Will Terraclor (PCNB) control Rhizoctonia? 4th Annu. Wash. State Potato Conf., 1965, Proc.: 86-89.
2. Easton, G. D. 1966. Results of 1965 soil fungicide screening for control of Rhizoctonia and Verticillium. 5th Annu. Wash. State Potato Conf., 1966, Proc.: 45-48.
3. Easton, G. D., R. C. Maxwell, C. R. Oldenburg, and R. R. Legault. 1966. Two years experimentation with Terraclor (PCNB) for control of Rhizoctonia. PCNB residues in tubers. 5th Annu. Wash. State Potato Conf., 1966, Proc.: 49-53.
4. Smith, L. R., and L. J. Ashworth, Jr. 1965. A comparison of modes of action of soil amendments and PCNB against Rhizoctonia solani. Phytopathology 55: 1144-1146.