EFFECT OF 2-(THIOCYANOMETHYLTHIO) BENZOTHIAZOLE (TCMTB) ON EMERGENCE AND GERMINATION OF CEREALS, FLAX, AND RAPE[1]

J.T. Mills[2] and W.H. Silversides[3]

Abstract

Three formulations of 2-(thiocyanomethylthio) benzothiazole (TCMTB) liquid, including Busan (Buckman Laboratories) liquid, were tested for effects on germination and emergence at varying dosages on each of seven seed crops of differing bushel weights. Tests were made under laboratory and greenhouse conditions and in the field at Winnipeg, Morden, and Brandon, Manitoba. TCMTB used on wheat, oats, and barley at the recommended field rate of 0.75 oz/bu, resulted in increased abnormal germination on moist filter paper and reduced seedling emergence in sterile soil. Emergence of rye, rape, flax, and corn was variable in sterile soil. Use of TCMIB 30EC (Busan 30EC) and 301P at 0.75 and 1.00 oz/bu resulted in decreased emergence in the field of two lots of Manitou wheat and one lot each of Betzes and Conquest barley, Cougar rye, and Redwood 65 flax compared to the respective controls. A slight reduction in emergence may not seriously affect the amount of grain harvested as it is cornwensated for by increased tillering. However, further work does appear warranted on dosage rates and alternative formulations.

Introduction

In Canada seed- and soil-borne diseases can cause serious losses which may be reduced through the use of chemical seed treatments. Treatment chemicals containing mercury are presently being phased out in Canadian agriculture and are being replaced by treatments of lesser toxicity. Many of these compounds are formulated either as slurries or as liquids so that they can be used in seed treatment plants that formerly utilized liquid mercurial treatments. This is particularly true in Alberta. One of the replacement compounds is Busan 30EC liquid (P.C.P. No. 11,261), also known as TCMTB 30EC, manufactured by Interprovincial Cooperatives Ltd. of Winnipeg from technical material supplied by Buckman Laboratories, Memphis, Tennessee. TCMTB has been included in cereal seed treatment trials previously carried out in Canada (5,6,7), but no extensive laboratory or field trials with a variety of crops have been made. It was considered important to obtain data on this new product as it could be used extensivelv throughout the Prairie region. Busan 30EC is claimed to control bunt of wheat, false loose smut and covered smut of barley, loose and covered smuts of oats, and seed- and soil-borne seedling blights (seed-borne root rots) of wheat, barley, and oats. This paper describes the results of germination and emergence trials using several formulations of TCMTB at varying dosages on seed crops of differing bushel weights under greenhouse and field conditions. The effectiveness of TCMTB for control of disease is described elsewhere (3).

Materials and methods

Most of the greenhouse and laboratory tests were with TCMTB 30EC (Busan 30EC), an emulsifiable concentrate formulation containing 30% 2-(thiocyanomethylthio) benzothiazole, an emulsifier (X 193 Rohm & Haas), cyclohexanone, plus 0.2% rhodamine B concentrate dye. The field tests with all crops and the laboratory and greenhouse tests with winter wheat (Triticum aestivum L.) were with either TCMTB 30EC plus 1% rhodamine B dye or TCMTB 301P plus 1% rhodamine B dye, a formulation containinq 30% 2-(thiocyanomethylthio) benzothiazole with 10% isopropyl alcohol.

The bushel weight and source of cultivars used are given in Table 1. Barley (Hordeum vulgare L.), wheat, and oat (Avena sativa L.) seed was generally screened before use. Peeling was most severe in Conauest lot F,

---

[1] Contribution no. 547, Research Station, Agriculture Canada, Winnipeg, Manitoba.

[2] Plant Pathologist, Agriculture Canada, Research Station, Winnipeg.

[3] Agronomist, Interprovincial Cooperatives Ltd., Saskatoon, Saskatchewan.

Table 1. Source and bushel weights of seed lots used to test the effects of TCMTB on emergence and germination

Seed lot code*	Crop	Cultivar	Source	weight (lb/bu)
A	Barley	Betzes	Saskatoon, Sask.	44.0
B	Barley	Betzes	Saskatoon, Sask.	48.0
C**	Barley	Betzes	Saskatoon, Sask.	54.0
D	Barley	Conquest	Saskatoon, Sask.	46.5
E	Barley	Conquest	Saskatoon, Sask.	48.0
F**	Barley	Conquest	Saskatoon, Sask.	54.0
G**	Spring wheat	Manitou	Saskatoon, Sask.	61.0
H	Spring wheat	Manitou	Saskatoon, Sask.	63.0
I**	Spring wheat	Manitou	Saskatoon, Sask.	65.5
J	Spring wheat	Neepawa	Saskatoon, Sask.	65.0
K**	Oats	Harmon	Winnipeg, Man.	42.5
L	Oats	Harmon	Saskatoon, Sask.	42.0
M	Oats	Harmon	Saskatoon, Sask.	43.5
N**	Oats	Kelsey	Winnipeg, Man.	40.5
O	Rape	Target	Strathclair, Man.	54.0
P**	Rape	Arlo	Strathclair, Man.	54.0
Q**	Rape	Span	Strathclair, Man.	55.0
R	Corn	Unknown	Toronto, Ont.	64.0
S	Corn	Unknown	Toronto, Ont.	63.0
T	Corn	Unknown	Toronto, Ont.	63.5
U	Corn	Unknown	Toronto, Ont.	63.0
V**	Rye	Frontier	Winnipeg, Man.	58.0
W**	Rye	cougar	Winnipeg, Man.	59.0
X**	Flax	Noralta	Winnipeg, Man.	54.0
Y	Flax	Raja	Winnipeg, Man.	52.0
Z**	Flax	Redwood 65	Winnipeg, Man.	53.0
AA	Winter wheat	Winalta	Lethbridge, Alta.	67.5
BB***	Corn	Morden CM7	Morden, Man.	63.0
CC***	Corn	Morden W219	Morden, Man.	63.5

* A to Z and AA used in laboratory and greenhouse tests.

** Also used in field tests.

*** Used in field tests only.

Table 2. Dosages of TCMTB in fluid ounces per bushel used in laboratory, greenhouse, and field tests

*Laboratory & greenhouse tests**	
Spring wheat, barley:	0.50, 0.75, 1.00, 1.25, 1.50, 3.00, 6.00
Winter wheat :	0.50, 0.75, 1.00, 1.25, 1.50, 3.00
Oats :	0.50, 0.75, 1.00, 1.25, 1.50
Rye :	0.50, 0.75, 1.00, 1.25, 1.50, 3.00
:	0.50, 0.75, 1.00, 1.50, 2.00, 2.50
Flax :	0.42, 0.56, 0.84, 1.12, 1.68
Corn :	1.12, 1.40, 1.68, 2.24, 2.80
*Field tests***	
Spring wheat, barley, oats, flax:	0.75, 1.00
Rye :	0.50, 0.75
:	1.50, 2.50
Corn :	1.12, 1.40

* In laboratory and greenhouse tests, the formulation used for all crops except winter wheat was TCMTB 30EC containing 0.2% rhodamine B dye; forwinter wheat the formulations were TCMTB 30EC containing 1.0%rhodamine B dye, and TCMTB 301P containing 1.0% rhodamine B dye and 10%isopropyl alcohol.

** In the field tests the formulations were TCMTB 30EC containing 1.0% rhodamine B dye, and TCMTB 301P containing 1.0% rhodamine B dye and 10%isopropyl alcohol.

less severe in Betzes lot C and only slight in the other barley lots. For treatment, the appropriate quantity of TCHTB was pipetted onto the inside wall of a 1-liter qlass jar, which was then rotated to spread the fungicide as evenly as possible. Two hundred grams of seed were added, and after sealing the jar was thoroughly shaken to ensure even coverage of the seed. The dosages used for all tests are given in Table 2. The treated seeds were left in the jars for at least 24 hours at 15C before removal.

Germination tests were carried out in the laboratory on filter paper and in greenhouse and field soil. On filter paper 100 treated or untreated seeds were used, 25 seeds in each of four petri dishes; for corn (Zea mays L.) there were 10 seeds per dish. Each 100-mm diameter dish contained a 90-mm no. 3 Whatman filter paper disc moistened with 5 ml distilled water for wheat, 6 ml for oats, 5 or 6 ml for barley, 5 ml for corn, and 4 or 5 ml for rye (Secale cereale L.), flax (Linum usitatissimum L.), and rape (Brassica campestris L.). Germination was assessed after 7 days at 25 C and was considered abnormal if the seedling did not have a shoot and three roots.

In greenhouse soil, 100 seeds of each treatment were used, 10 seeds per 7.6 cm (3 inch) diameter peat pot. The soil was a 3:1 mix of soil and sand sterilized moist at 116 C (240 F) for 48 hr and left to cool for 24 hr before use. Seeds were sown 3.75 cm (1.5 inches) deep. Pots were randomized in a growth cabinet at 16 C or on a greenhouse bench at 18-25 C. Fluorescent lights on a 15-hr photoperiod were placed 50 cm (20 inches) above the tallest leaves. Emergence and germination were assessed 21 days after seeding.

In the field tests, there were four treatments and a control for each of two seed lots of svring wheat, barley, oats, rye, rape, flax and corn. The four treatments for each seed lot were two formulations at each of two dosages. Treatments were sown in 12-ft randomized rows in four replicates at Brandon, Morden, and Winnipeg on May 1, 11, and 16, 1972, respectively. Emergence was rated 3 weeks after sowing.

Table 3. Total and abnormal germination of different seed lots of screened, untreated and TCMTB–treated spring wheat, barley, and oats after 7 days on filter paper in the laboratory

Dosage**	Barley						Wheat				Oats			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Total germination*													
Control	100	99	91	98	100	88	96	98	99	91	100	99	95	98
0.50	98	95	87	92	97	88	95	98	98	93	98	96	96	95
0.75	98	90	86	97	97	79	97	97	99	93	95	98	89	91
1.00							98	73	96	90	94	95	82	91
1.25							100	98	91	88	93	93	89	83
1.50	59	66	71	83	89	56	91	94	91	90	93	77	67	71
	Abnormal germination*													
Control	3	3	6	2	1	6	1	1	0	0	0	0	2	3
0.50	7	10	13	3	2	10	0	1	0	2	1	5	1	7
0.75	8	7	14	7	8	9	2	0	0	2	3	9	7	14
1.00							1	0	0	0	5	6	7	12
1.25							0	0	2	1	4	9	6	13
1.50	17	29	28	19	11	17	5	0	2	1	10	10	16	12

* Total and abnormal germination based on four replicates each of 25 seeds.

** Note: Tables 3–7, dosages in fluid oz/bu; see Table 2.

Results and discussion

Wheat, oats, barley, and rye

On filter paper, germination of seed treated with TCMTB 30EC + 0.2% dye at dosages of up to 0.75 oz/bu for barley, 1.50 oz/bu for spring wheat, and 1.25 oz/bu for oats and rye was generally similar to the untreated controls (Tables 3,4). However the percent abnormal germination at the recommended dosage rate of 0.75 oz/bu was hiqher than in the control in 12 out of 14 tests (Table 3). At and above 1.50 oz/bu there was evidence for reduced germination and increased abnormal germination in barley and oat samples. Germination of winter wheat seed treated with up to and including 1.25 oz/bu of the TCMTB 30EC + 1%of dye or 301P + 1% dye was generally similar to that of the untreated controls; at 3.00 oz/bu, germination was sharply reduced (data on winter wheat are not qiven in the tables).

In sterilized soil in the greenhouse, there was slightly reduced emerqence in spring wheat, barley, and oats treated with TCMTB 30EC + 0.2% dye at 0.75 oz/bu. Compared to the control, emerqence was lower in 11 out of 23 tests, higher in 7 out of 23, and the same in 5 tests at this dosage. At the 3.00 and 6.00 oz/bu rates there was a large decrease in emergence of barley and spring wheat in a qrowth cabinet (Table 5). Rye treated above 0.50 oz/bu showed evidence of reduced emergence (Table 6). Data on emergence of treated winter wheat seed in sterilized soil were generally similar to those of the controls up to and including

Table 4. Total and abnormal germination of different seed lots of untreated and TCMTB–treated rape, flax, corn, and rye seed after 7 days on filter paper in the laboratory

Total germination*

Rape				Flax			
Dosage	O	P	Q	Dosage	X	Y	Z
Control	99	88	100	Control	100	98	98
0.50	96	78	100	0.42	100	99	95
0.75	97	85	100	0.56	98	94	98
1.00	94	85	100	0.84	99	97	98
1.50	96	83	98	1.12	98	97	98
2.00	98	78	98	1.68	98	98	91
2.50	97	68	99				

Total gfmination*

Corn					Rye		
Dosage	R	S	T	U	Dosage	V	W
Control	93	99	93	99	Control	34	95
1.12	94	82	91	100	0.50	34	94
1.40	80	96	93	97	0.75	51	94
1.68	92	93	94	98	1.00	30	91
2.24	94	94	91	97	1.25	31	92
2.80	87	84	83	88	1.50	24	87
					3.00	18	86

Abnormal germination"

corn					Rye		
Dosage	R	S	T	U	Dosage	V	W
Control	33	31	11	18	Control	1	3
1.12	35	33	14	16	0.50	3	2
1.40	22	44	10	11	0.75	10	1
1.68	24	30	16	13	1.00	6	6
2.24	30	34	16	20	1.25	3	4
2.80	38	39	15	26	1.50	8	3
					3.00	1	2

* Total and abnormal germination based on four replicates each of 25 seeds (corn 10 replicates each of 10 seeds).

Table 5. Emergence of different seed lots of untreated and TCMTB-treated wheat, barley, and oats after 21 days in soil in greenhouse or growth cabinet

Unscreened seed (growth cabinet)

	Barley						Wheat		
Dosage	A	B	C	D	E	F	G	H	I
	Total emergence*								
Control	95	100	88	98	99	98	94	99	93
0.50	99	96	91	99	98	98	94	99	92
0.75	98	95	94	98	99	96	93	96	92
1.50	96	97	91	93	93	95	92	86	89
3.00	74	75	76	75	62	82	72	69	31
6.00	29	29	29	42	33	54	44	30	5

Screened seed (greenhouse)

	Barley							Wheat			Oats			
Dosage	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	Total emergence*													
Control	98	99	84	99	99	99	96	98	95	85	99	100	100	100
0.50	100	97	92	96	97	96	95	98	97	90	100	100	96	99
0.75	97	100	91	99	95	97	93	100	98	87	99	100	98	99
1.00	95	97	92	95	95	93	91	96	98	87	100	99	99	99
1.25	91	97	89	94	96	92	98	96	92	91	100	100	98	100
1.50	97	93	92	97	95	94	97	97	85	86	99	97	99	100

* Total of 10 replicates each of 10 seeds.

dosages of 1.00 oz/bu TCMIB 30EC + 1% dye or 301P + 1% dye: at 3.00 oz/bu emergence was sharply reduced.

In field soil (Table 7) emergence of spring wheat, barley, and rye (seed lot V) was significantly reduced at all stations after treatment with TCMIB 30EC or 301P + 1% dye at 0.75 (the recommended dosage) and 1.00 oz/bu. There were no sigificant differences between treatments and respective controls in rye (seed lot W) and oats. The poor emergence of both rye samples in field soil was probably due to badly shrivelled seed. In particular, seed of Frontier rye (seed lot V, Table 1) had considerable embryo exposure due to cracks in the pericarp that could have allowed invasion By soil microorganisms and thus reduced germination. A reduction in emergence of wheat treated with TCMTB was also noted by Hansing et al. (1), who found reduced emergence in field soils from bunt-infested wheat seed treated with 2.00 oz/bu TCMTB 30EC + 0.2% dye, when compared to untreated infested seed. Recent work at Lacombe (2) and at Swift Current (4) with barley and wheat respectively have shown that highest yields were obtained with low seeding rates. At Swift Current (4) it was found that the plant population differences resulting from variations in seeding rate were largely eliminated by plant survival and tillerinq.

Table 6. Emergence of different seed lots of untreated and TCMTB-treated rape, flax, corn, and rye after 21 days in greenhouse soil

	Rape				Rye	
Dosage	O	P	Q	Dosage*	V	W
	Total emergence					
Control	82	65	77	Control	37	94
0.50	88	58	84	0.50	27	92
0.75	85	40	85	0.75	28	79
1.00	93	38	67	1.00	18	75
1.50	70	63	79	1.25	23	70
2.00	92	38	64	1.50	17	72
2.50	76	41	59	3.00	8	46

	corn				Flax		
Dosage	R	S	T	U	Dosage*	X	Y	Z
	Total emergence							
Control	94	100	89	92	Control	88	69	68
1.12	91	98	83	96	0.42	68	78	57
1.40	95	99	86	95	0.56	58	75	71
1.68	89	97	87	93	0.84	64	69	49
2.24	84	97	77	94	1.12	52	78	64
2.80	88	97	71	75	1.68	64	64	54

* Total of 10 replicates each of 10 seeds.

Table 7. Mean percentage emergence at three locations* of different seed lots of untreated and TCMTB-treated cereals and flax, rape, and corn after 21 days in field soil

CROP:		WHEAT		BARLEY		OATS					
variety:		(G) Manitou (I)		Betzes(C)	Conquest(F)	Harmon(K)			Kelsey(N)		
Location:		WMB	WMB	WMB	WMB	W	M	B	W	M	B
LSD:		1.4	1.8	1.6	2.0	all NS			all NS		
Treatment and percentage emergence	A	90.2	83.5	84.5	89.0	90.5	92.3	98.0	96.3	95.0	94.3
	B	86.8	76.6	79.8	83.7	94.0	91.0	93.3	92.5	95.5	89.5
	C	85.0	72.9	78.4	80.8	91.8	88.8	91.0	86.0	92.3	95.5
	D	84.7	77.2	81.7	81.7	92.3	90.3	92.8	94.5	96.0	95.8
	E	87.5	72.8	78.3	80.7	90.8	91.3	86.8	92.5	92.3	95.8

CROP:		RYE				FLAX			
Variety:		Frontier(V)			Cougar(W)	Noralta(X)			Redwood 65(Z)
Location:		W	M	B	WMB	W	M	B	WMB
LSD:		all NS			4.1	all NS			2.2
Treatment and percentage emergence	A	7.8	2.0	17.8	50.1	69.0	55.3	68.3	58.7
	B	12.8	3.0	11.3	37.8	55.8	55.0	73.8	53.3
	C	12.5	4.0	18.5	42.3	62.8	56.5	59.0	54.3
	D	10.5	2.5	18.8	48.0	61.0	53.8	64.8	51.4
	E	11.3	3.0	13.8	39.2	63.0	58.8	70.0	50.3

CROP:		RAPE						CORN					
Variety:		Arlo(P)			Span(Q)			CM 7(BB)			W 219(CC)		
Location:		W	M	B	W	M	B	W	M	B	W	M	B
LSD:		all NS			all NS			all NS			all NS		
Treatment and percentage emergence	A	3.8	3.8	6.5	35.5	54.3	31.8	50.5	14.0	12.8	44.5	13.8	9.8
	B	4.3	4.3	5.0	32.5	49.3	32.5	52.0	14.8	17.8	44.0	20.8	15.5
	C	6.8	1.3	9.0	47.3	44.0	32.3	48.8	9.0	11.5	42.3	18.5	11.3
	D	6.3	4.8	4.0	33.8	52.5	32.5	57.3	14.3	13.5	48.3	17.8	15.5
	E	10.8	1.5	7.3	32.0	47.3	25.0	53.8	15.8	9.5	43.8	12.0	8.8

*
Location: W = Winnipeg, M = Morden, B = Brandon, WMB = Winnipeg & Morden & Brandon combined.
Treatment: A = control, B = 0.75 oz/bu TCMTB 30EC, C = 1.0 oz/bu TCMTB 30EC, D = 0.75 oz/bu TCMTB 30IP, E = 1.0 oz/bu TCMTB 30IP.
LSD = least significant difference 5.0% level.
NS = not significant.

Flax, rape, and corn

Germination on filter paper of flax, rape lots O and Q, and corn seed treated with 1.68, 2.50, and 2.24 oz/bu TCMTB 30EC + 0.2% dye, respectively, was similar to the untreated controls (Table 4). Rape lot P, whether untreated or treated had lower germination than lots O and Q. All lots of corn, whether untreated or treated, had much abnormal germination, possibly a reflection of insufficient moisture.

In sterilized soil in the greenhouse, emergence of rape and flax was variable (Table 6), and emergence of corn was reduced with treatment rates above 1.68 oz/bu TCMTB 30EC + 0.21 dye.

In field soil (Table 7) emergence of flax lot Z was significantly reduced at all three stations after treatment with TCMTB 30EC + 1% dye or 30IP + 1% dye at 0.75 and 1.00 oz/bu. Emergence of flax lot X and of rape and corn did not differ significantly from the resnective controls. Flax lot Z had much more cracking and embryo exposure than lot X. Emergence of rape lot P was extremely low in field soil and in sterilized soil (Table 6). Some of the reduced emergence in rape lots P

and Q can be explained by infestations of flea beetles [Phyllotreta cruciferae (Goeze)], which often ate the plants to ground level. Corn lots BB and CC (Table 7) had much higher emergence at Winnipeq than at Morden and Brandon because the soil at Winnipeg was much warmer at and just after sowing. Despite the lack of response of corn to treatment in these tests, later sowinqs of corn seed lot BB treated with TCMTB 301P in warmer soils at Morden and Brandon showed significantly improved emerqence due to control of soil-borne fungi (3).

Conclusions

TCMTB used at the recommended dosage of 0.75 oz/bu was associated with increased abnormal germination of spring wheat, oats, and barley on moist filter paper and with reduced emergence in sterile soil. These effects were more pronounced at and above 1.50 oz/bu. Emergence of rye, rape, flax, and corn was variable in sterile soil. Use of TCMTB in the field at rates of 0.75 and 1.00 oz/bu resulted in decreased emergence in two lots of Manitou spring wheat and one lot each of Betzes and Conquest barley, Cougar rye, and Redwood 65 flax compared to the respective controls. Mercurial seed treatments were also often associated with slightly decreased seedling emergence. A slight reduction in emergence may not seriously affect the amount of grain harvested as there is often increased tillering. However, further work does appear warranted on dosage rates and alternative formulations.

Acknowledgments

The writers wish to thank Mr. Don Brown of Interprovincial Cooperatives Ltd., Winnipeg and Mr. Morley Barron and Mr. Harold Platt of Canada Agriculture, Research Station, Winnipeg, for technical assistance.

Literature cited

1. Hansing, E. D., J. C. Reyes, and A. Baig. 1971. Effect of seed treatment on control of wheat and oat diseases. Kansas Extension Chemical Task Force, Sept. 1971. Kansas State Univ., Manhattan.

2. McFadden, A. D. 1970. Influence of seeding dates, seeding rates, and fertilizers on two cultivars of barley. Can. J. Plant Sci. 50:693-699.

3. Mills, J. T. 1972. Cooperative seed treatment trials - 1972. Can. Plant Dis. Surv. 52:126-129.

4. Pelton, W. L. 1969. Influence of low seeding rates on wheat yield in southwestern Saskatchewan. Can. J. Plant Sci. 49:607-614.

5. Wallace, H. A. H. 1969. Cooperative seed treatment trials - 1969. Can. Plant Dis. Surv. 49:49-53.

6. Wallace, H. A. H. 1971. Cooperative seed treatment trials - 1970. Can. Plant Dis. Surv. 51:3-8.

7. Wallace, Ii. A. H. 1972. Cooperative seed treatment trials - 1971. Can. Plant Dis. Surv. 52:20-24.