

release would be that the ampules continue to retain active ingredient for many years. This might become a concern were the pole to be involved in a vehicle accident, since the ampule could be ejected from the hole, or the chemical could be released if the pole were cut through with a chainsaw. However, prior tests by the manufacturers have shown that even cutting through an ampule in the wood results in little or no airborne exposure of workers to the chemical. In addition, there is only 2 to 4 g of chemical in the tubes stored under the cooler condition at this time. Thus, there are minimal risks posed by long term residual chemical in the tubes.

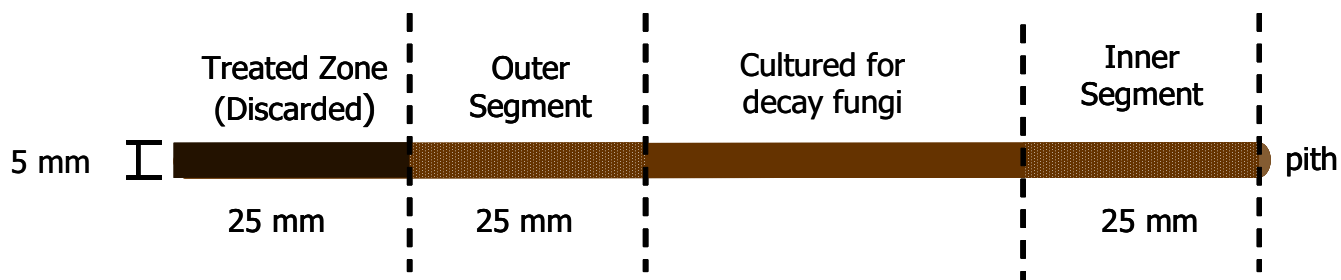
2. Performance of Copper Amended Dazomet in Douglas-fir Transmission Poles

Date Established:	June 1993
Location:	Corvallis, OR
Pole Species, Treatment, Size	Douglas-fir, penta, Class 1-75 to H2-85
Circumference @ GL (avg., max., min.)	144, 160, 132 cm

While chloropicrin, metam sodium, and MITC-FUME have all provided excellent protection, each has handling characteristics that are of concern to some users. In the late 1980’s we began work with dazomet, a solid, crystalline chemical that decomposes in the presence of water to produce MITC and a host of other compounds. Preliminary trials suggested that the rate of decomposition was too slow to be of use for controlling wood decay, but continuing trials suggested that this chemical might have promise, particularly because of its ease of handling. In a series of laboratory and small-scale field trials, we showed that dazomet could produce effective levels of MITC in wood over time and also continued to produce MITC for far longer periods than was found with metam sodium. We also found that the presence of some copper in the system markedly improved MITC production. Following these successful small scale trials, we established the following test on transmission-sized poles.

Three steeply angled holes were drilled beginning at groundline and moving upward at 150 mm increments and around 120 degrees in Douglas-fir transmission poles (420 to 510 mm diameter). Drill shavings from each drill hole were retained. These shavings were briefly flamed and then placed on the surface of malt extract agar in plastic petri dishes. These chips were observed for evidence of fungal growth, which was then examined under a microscope for characteristics typical of basidiomycetes, a class of fungi containing many important wood decayers.

The poles were treated with either 200 or 400 g of dazomet with or without 1 % copper sulfate (w/w). The dosages were premixed and evenly distributed among the three treatment holes. An additional set of poles was treated with 500 ml of metam sodium, also distributed among three holes at the same locations as those drilled in the dazomet treatments. The treatment holes were plugged with tight-fitting wood dowels. Chemical movement and efficacy were assessed annually for the first 5 years after treatment, then 7, 10, and 12 years after chemical application by removing increment cores from three equidistant points around each pole 0.3, 1.3, 2.3, and 3.3 m above groundline. The outer, heavily treated zone was discarded, and then the outer and inner 25 mm of each core was removed (see below) and placed into 5 ml of ethyl acetate. The cores were stored at room temperature for 48 hours to extract any MITC in the wood, then the increment core was removed, oven-dried, and weighed. The core weight was later used to calculate chemical content on a wood weight basis.



The ethyl acetate extracts were injected into a Shimadzu gas chromatograph equipped with a flame photometric detector with filters specific for sulfur (a component of MITC). MITC levels in the extracts were quantified by comparison

with prepared standards and results were expressed on an ug MITC/oven dried g of wood basis. The remainder of each core was cultured on malt extract agar for the presence of Basidiomycetes, a group of fungi containing many important wood decayers. Other fungi present were classified as non-decay fungi. Although these fungi do not cause wood decay, their roles in chemical performance remain unknown.

Evaluations of previously collected data suggest that the MITC threshold for fungal protection in Douglas-fir poles is approximately 20 ug/oven dried g of wood. This level was selected on the basis of comparisons between fungal isolations and residual chemical levels in various field tests. Using this level as our guide, protective MITC levels were present within one year in poles receiving metam sodium and with either dazomet dosage amended with copper sulfate (Table I-2, Figure I-2 to I-6). MITC levels tended to be highest within one meter of the groundline, reflecting the concentration of the original application holes near that zone. MITC levels in metam sodium treated poles remained above the threshold in this zone for the first 3 years after treatment, then declined sharply after the fourth year. These results are consistent with the finding that wood from metam treated poles remains inhibitory to decay fungi in bioassays for 3 to 5 years after treatment. It also shows the relatively minimal fungicidal effect of metam sodium in comparison with other fumigants.

Table I-2. Residual MITC (ug/g ODW) levels at selected locations in Douglas-fir poles 1 to 12 years after treatment with metam sodium or dazomet. Numbers in bold are above the lethal threshold for MITC of 20 ug/g ODW.

Treatment	Height (m)	Position inner/outer		Year 1	Year 2	Year 3	Year 4	Year 5	Year 7	Year 10	Year 12
200g dazomet	0	inner	avg.	8	18	51	25	31	38	134	43
			SD	21	20	44	15	31	20	178	35
		outer	avg.	2	29	50	39	37	35	68	32
			SD	7	37	63	31	26	30	75	19
	1	inner	avg.	5	8	19	8	10	11	48	14
			SD	9	11	21	4	5	7	17	8
		outer	avg.	13	7	38	9	7	7	44	6
			SD	23	16	36	11	6	8	25	5
	2	inner	avg.	0	4	8	0	0	0	20	2
			SD	0	6	5	1	1	0	11	4
		outer	avg.	0	1	9	0	0	0	10	1
			SD	0	4	7	0	1	0	9	2
3	inner	avg.	1	4	2	0	0	0	7	0	
		SD	4	8	4	0	0	0	9	0	
	outer	avg.	1	4	2	0	0	0	6	0	
		SD	2	7	3	0	0	0	7	0	
200g dazomet+ Cu	0	inner	avg.	12	72	182	110	110	80	114	70
			SD	27	100	215	86	92	73	111	66
		outer	avg.	14	50	203	103	59	77	112	45
			SD	31	74	272	86	101	87	90	62
	1	inner	avg.	26	13	63	25	28	22	55	13
			SD	38	18	70	20	21	14	35	5
		outer	avg.	42	8	47	11	10	21	57	7
			SD	65	13	52	16	10	18	56	7
	2	inner	avg.	0	7	10	1	3	5	30	4
			SD	0	19	13	2	4	4	20	4
		outer	avg.	1	4	9	0	1	4	19	2
			SD	5	9	17	2	2	5	14	4
3	inner	avg.	2	6	1	0	0	0	15	0	
		SD	5	13	4	0	0	0	12	0	
	outer	avg.	0	10	0	0	0	0	11	0	
		SD	0	21	0	0	0	0	9	0	

Oregon State University Utility Pole Research Cooperative

Table I-2 (cont.). Residual MITC levels at selected locations in Douglas-fir poles 1 to 12 years after treatment with metam sodium or dazomet. Numbers in bold are above the lethal threshold for MITC of 20 ug/g ODW.

Treatment	Height (m)	Position inner/outer		Year 1	Year 2	Year 3	Year 4	Year 5	Year 7	Year 10	Year 12	
400g dazomet	0	inner	avg. SD	5 9	45 47	102 97	59 35	42 23	60 31	139 128	67 56	
		outer	avg. SD	22 49	110 108	137 207	84 54	38 31	59 27	103 80	76 106	
	1	inner	avg. SD	16 31	5 5	107 106	11 8	12 8	15 7	58 20	11 9	
		outer	avg. SD	56 86	1 3	69 105	7 6	7 6	12 6	51 36	6 6	
	2	inner	avg. SD	1 4	1 2	15 15	0 0	1 2	1 2	19 7	3 6	
		outer	avg. SD	0 0	1 3	6 8	0 0	0 0	0 2	13 8	1 3	
	3	inner	avg. SD	0 0	1 2	3 6	0 0	0 0	0 0	10 7	1 3	
		outer	avg. SD	1 3	4 10	3 6	0 0	0 0	0 0	2 4	0 0	
	400g Dazomet + Cu	0	inner inner	avg. SD	25 41	100 93	435 613	121 82	108 89	70 89	79 43	13 9
			outer outer	avg. SD	25 76	69 126	501 787	130 116	54 70	51 30	53 29	16 19
		1	inner inner	avg. SD	31 46	7 8	149 162	9 10	13 14	10 8	40 22	5 9
			outer outer	avg. SD	64 139	3 5	132 185	7 10	9 10	10 7	46 46	6 19
2		inner inner	avg. SD	0 0	2 5	11 11	1 2	14 48	1 2	11 10	4 14	
		outer outer	avg. SD	0 0	3 5	6 8	0 1	6 21	1 2	10 7	0 0	
3		inner inner	avg. SD	0 0	3 5	1 2	0 0	0 0	1 4	8 8	0 0	
		outer outer	avg. SD	0 0	4 6	1 2	0 0	0 0	0 0	3 7	0 0	
500ml metam sodium		0	inner	avg. SD	21 43	53 47	48 34	15 16	8 8	3 5	8 15	1 4
			outer	avg. SD	30 61	26 28	64 106	14 11	7 6	2 4	3 7	1 2
		1	inner	avg. SD	57 82	15 17	51 122	7 8	6 6	1 2	1 4	1 3
			outer	avg. SD	38 46	8 16	25 31	4 7	2 4	1 2	1 3	1 2
	2	inner	avg. SD	1 3	4 7	12 9	1 3	0 1	0 0	0 0	0 2	
		outer	avg. SD	0 0	3 5	5 5	1 2	0 1	0 0	0 0	0 0	
	3	inner	avg. SD	1 3	3 6	7 15	0 0	0 0	0 0	0 0	0 2	
		outer	avg. SD	0 0	3 5	2 6	0 0	0 0	0 0	0 0	0 1	

Treatment of poles with 200 or 400 g of dazomet alone produced more variable MITC levels one year after treatment. Protective levels were present at the groundline within the second year for the 200 g dosage, but levels further above the groundline were more variable. Doubling the dosage improved MITC levels after the first year and also produced increased MITC levels 1 m above the groundline. In addition, both dosages resulted in protective levels at groundline 12 years after treatment. This long term release rate is a secondary benefit of the use of this fumigant. While initial

chemical levels were lower than those found with metam sodium, the longer release period from this treatment should produce more uniform protection against renewed fungal attack.

Over the longer term, we have seen a periodic increase in MITC levels near the groundline for both the 200 and 400 g dazomet treatments without any added copper (Figures I-2, I-4). The apparent fluctuations in MITC levels over time may reflect variations in moisture availability. Moisture is essential for dazomet decomposition to produce MITC and any increases in precipitation patterns should be accompanied by a later rise in MITC levels. This relationship is evidenced in the year 3 results, which followed a record setting rainfall year (1500 mm vs the normal 1000 mm); however, the sudden increase in MITC levels at year 10 followed a normal precipitation year.

The addition of copper to dazomet at the time of treatment produced marked increases in levels of MITC found one year after treatment. The copper enhancement of dazomet decomposition to MITC remained evident for 5 years after treatment, then the effect declined and MITC levels were similar in amended and non-amended treatments. In both cases, the residual MITC levels were well above those required for protection against renewed fungal attack. This copper effect appeared to occur for the first 10 years of the test. This past year, however, the MITC levels near groundline in the 400g dosage with amended copper were below the threshold for fungal protection, while MITC levels in the lower dosage were similar to those found in the non-copper amended treatment (Figures I-3, I-5). These results suggest that the enhancement effect of copper ultimately declines, although this decline occurs well beyond the traditional 10 year retreatment cycle.

Culturing increment cores from the poles revealed that decay fungi were periodically isolated from various locations over the course of the test, but there was no consistent increase in fungal frequency over the 12 year test. For example, decay fungi were isolated near the groundline in poles 5 years after treatment with 200 g of dazomet plus copper sulfate;

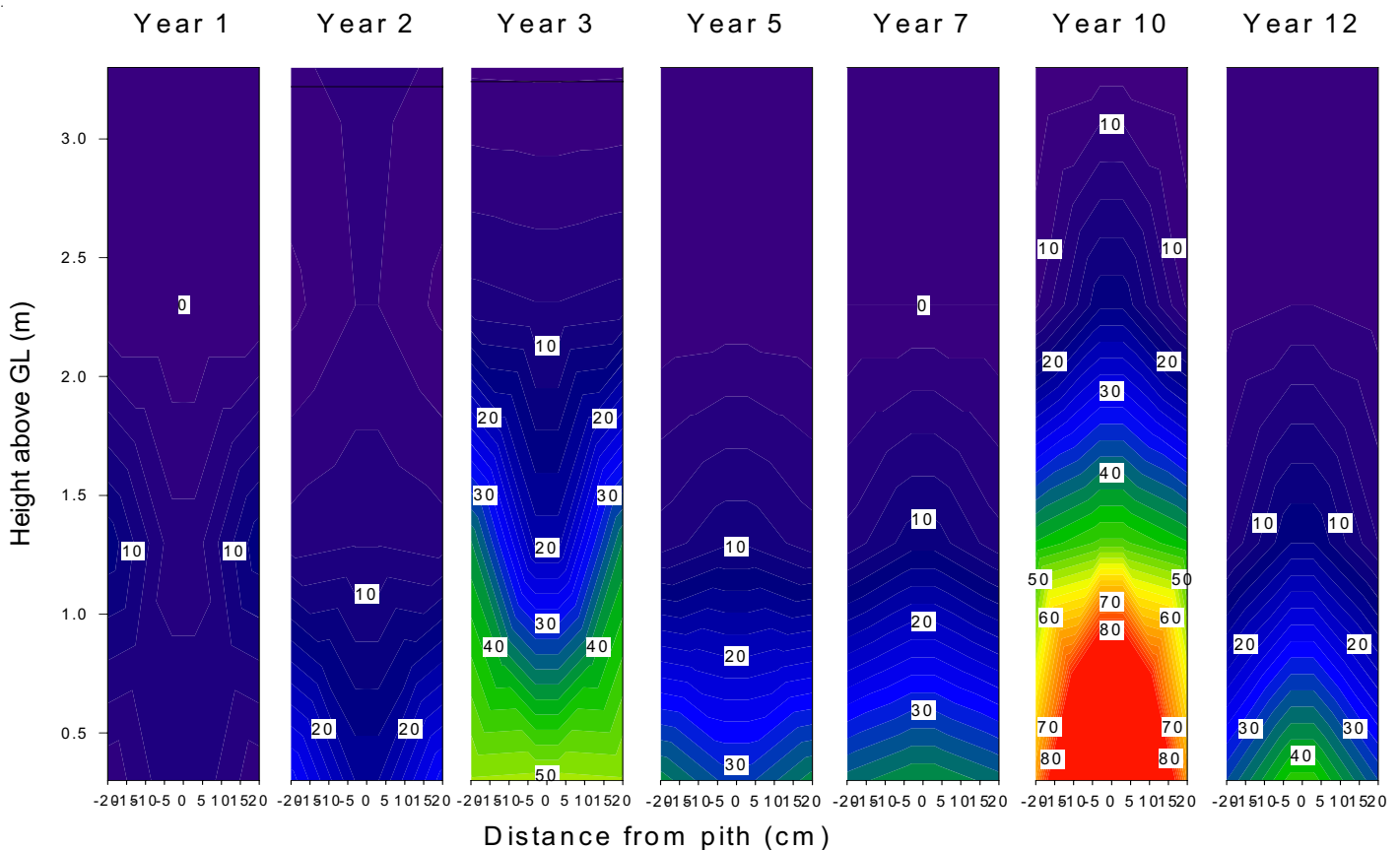


Figure I-2 Residual MITC (ug/g ODW) levels in Douglas-fir poles 1 to 12 years after treatment with 200 g of dazomet. Dark blue indicates MITC levels below threshold. Light blue and all other colors indicate MITC levels above the lethal threshold.

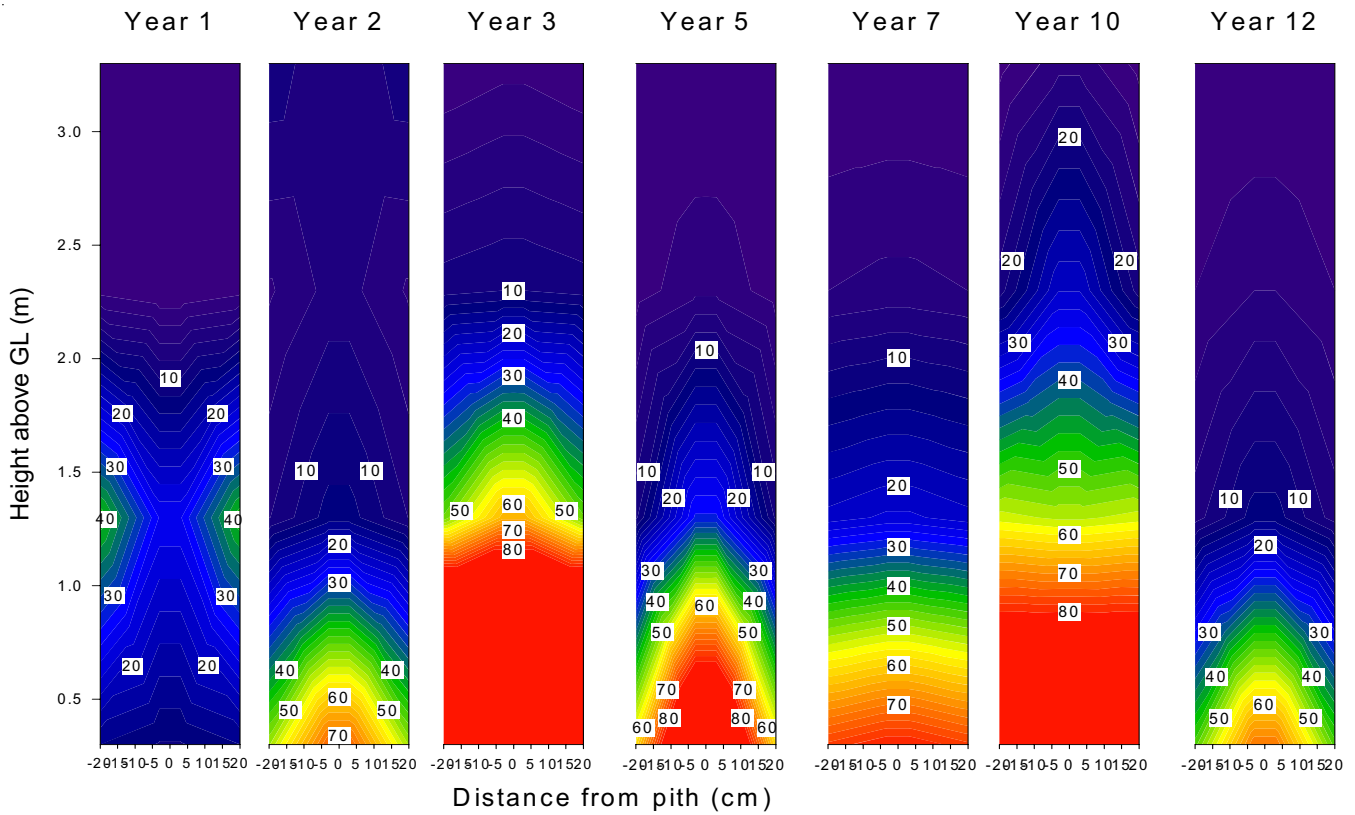


Figure I-3. Residual MITC (ug/g ODW) levels in Douglas-fir poles 1 to 12 years after treatment with 200 g of dazomet amended with 1 % copper sulfate. Dark blue indicates MITC levels below threshold. Light blue and all other colors indicate MITC levels above the lethal threshold.

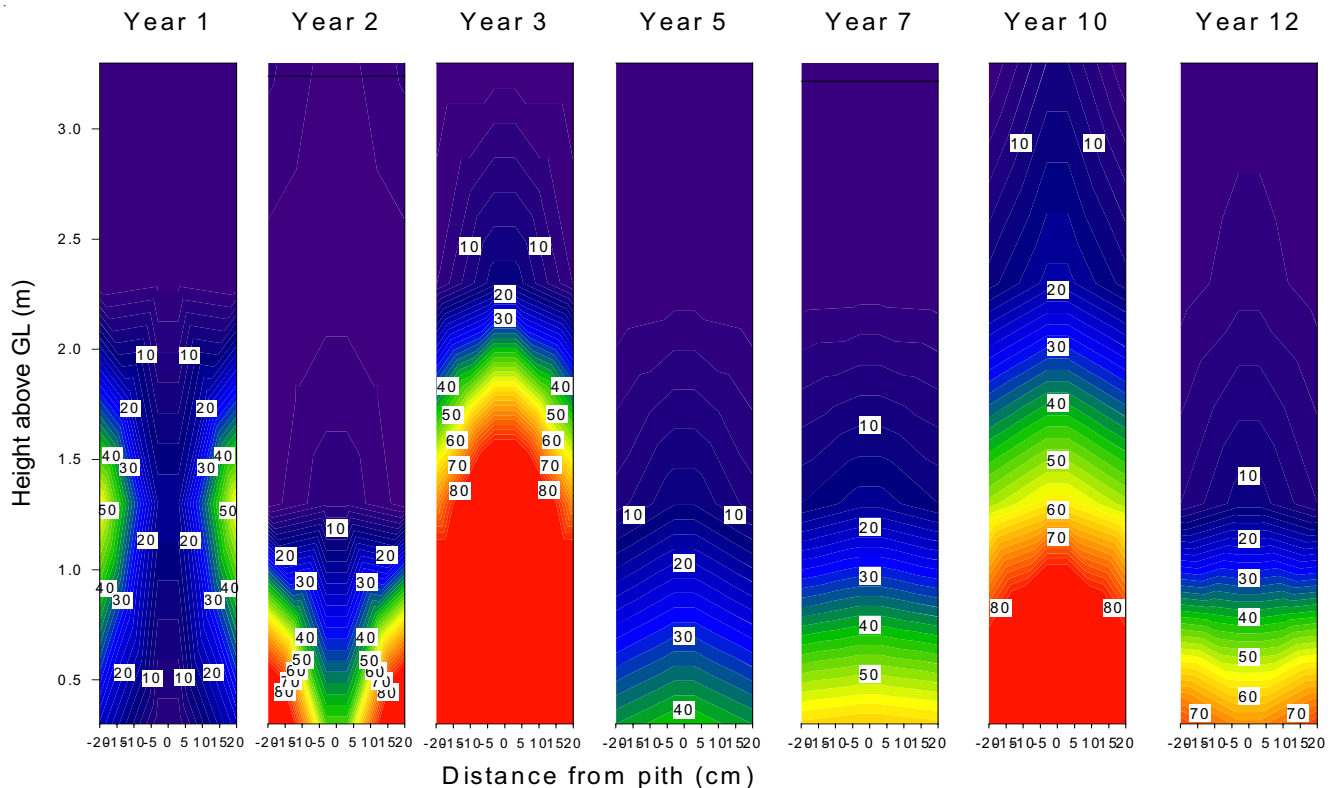


Figure I-4. Residual MITC (ug/g ODW) levels in Douglas-fir poles 1 to 12 years after treatment with 400 g of dazomet. Dark blue indicates MITC levels below threshold. Light blue and all other colors indicate MITC levels above the lethal threshold.

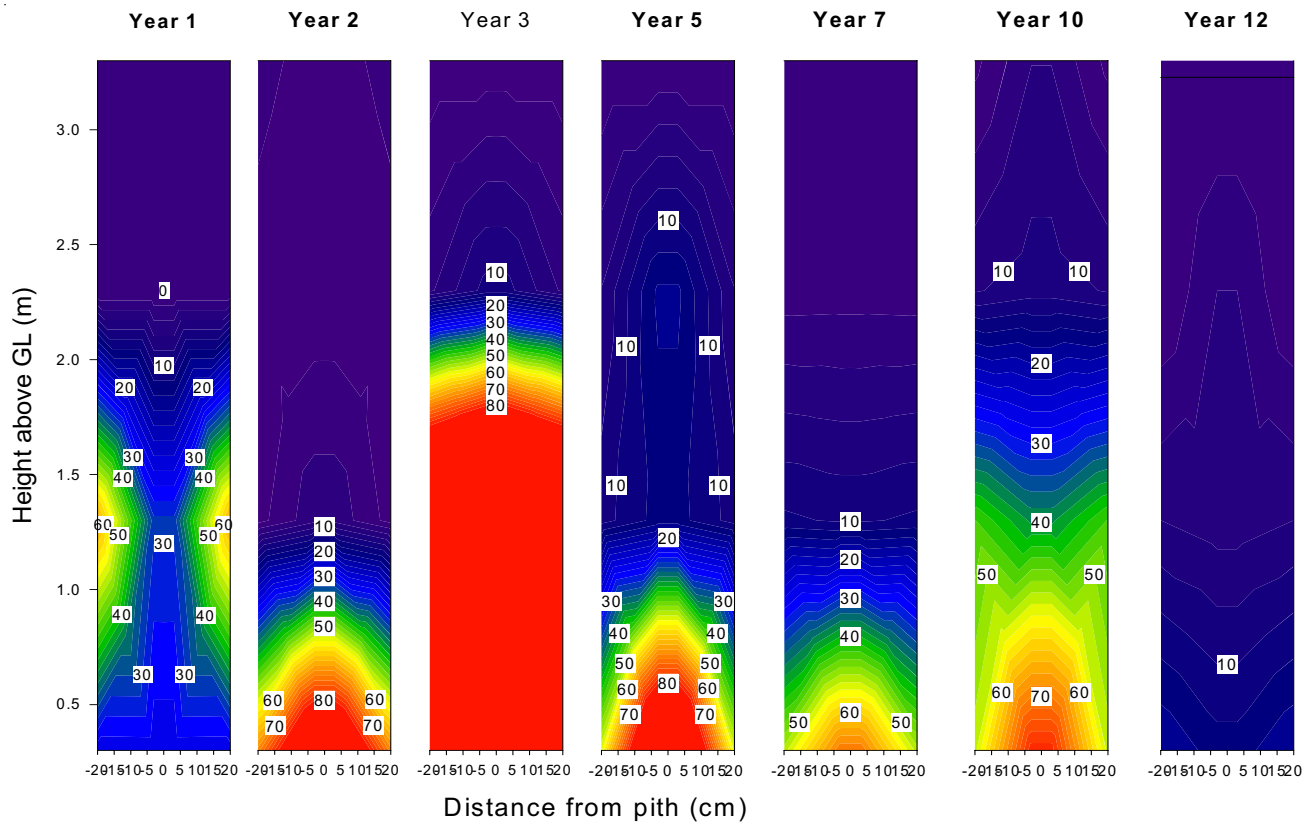


Figure I-5. Residual MITC (ug/g ODW) levels in Douglas-fir poles 1 to 12 years after treatment with 400 g of dazomet amended with 1% copper sulfate. Dark blue indicates MITC levels below threshold. Light blue and all other colors indicate MITC levels above the lethal threshold.

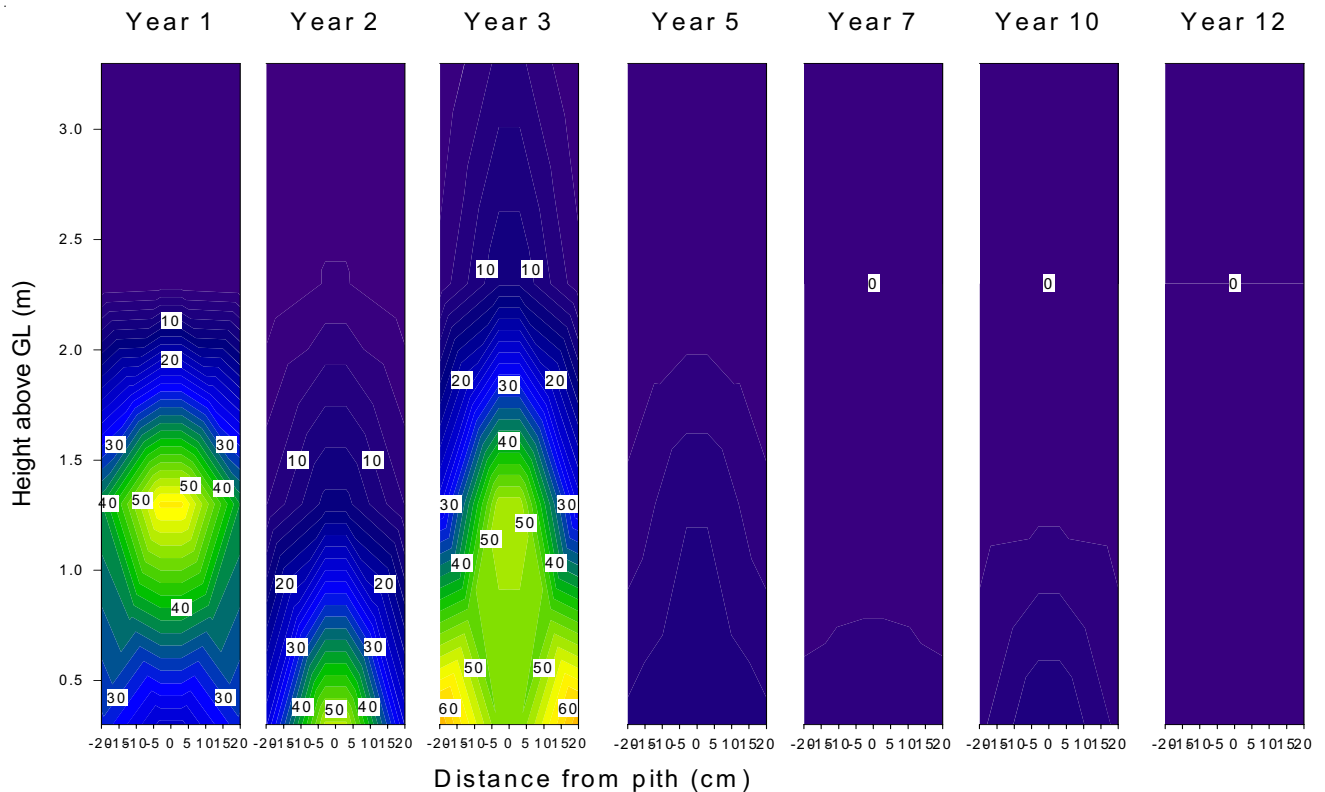


Figure I-6. Residual MITC (ug/g ODW) levels in Douglas-fir poles 1 to 12 years after treatment with 500 ml of metam sodium. Dark blue indicates MITC levels below threshold. Light blue and all other colors indicate MITC levels above the lethal threshold.

however, no decay fungi were isolated from this location 7 or 10 years after treatment. The inconsistent isolations indicate that the treatment remains largely protective (Table I-3).

The 12 year results indicate that dazomet provides a slower initial protection, but that MITC remains in the poles at effective levels for far longer periods than would be found with metam sodium. The addition of copper to the dazomet markedly improves MITC release rates, producing a treatment that is initially comparable to metam sodium, but provides a far longer period of protection against renewed fungal attack.

Table I-3. Frequency of isolation of basidiomycetes and non-decay fungi from Douglas-fir poles 1 to 12 years after application of metam sodium or dazomet alone or amended with 1 % copper sulfate (w/w).

Treatment	Dose	CuSO ₄	Isolation Frequency % ^a															
			Distance above GL															
			0.3 m								1.3 m							
0 yr	2 yr	3 yr	4 yr	5 yr	7 yr	10 yr	12 yr	2 yr	3 yr	4 yr	5 yr	7 yr	10 yr	12 yr				
metam sodium	500 ml		0 ⁴⁷	0 ¹⁰	0 ⁵	0 ¹³	0 ²⁷	0 ⁴⁰	3 ²⁸	0 ¹⁷	0 ¹³	0 ³	0 ¹⁰	0 ³⁰	0 ²⁰	0 ²⁸	0 ³³	
dazomet	400 g		0 ¹⁴	0 ⁷	0 ⁰	0 ⁰	0 ²⁷	0 ⁰	0 ⁰	0 ²⁷	0 ²³	0 ⁰	0 ⁰	0 ¹³	0 ⁰	0 ⁰	0 ⁴⁷	
dazomet	400 g	+	0 ²⁷	0 ⁷	0 ²⁰	0 ⁰	0 ²⁷	0 ⁰	0 ⁷	0 ²⁰	0 ¹³	0 ⁷	0 ⁰	0 ²⁷	0 ⁰	0 ⁰	0 ²⁰	
dazomet	200 g		7 ²⁰	0 ²⁷	0 ⁰	0 ⁰	0 ³³	0 ⁷	0 ⁰	0 ²⁰	0 ³³	0 ⁰	0 ⁷	0 ⁴⁰	0 ⁰	0 ⁰	0 ³³	
dazomet	200 g	+	0 ⁰	0 ⁰	0 ⁰	0 ⁷	13 ¹³	0 ²⁰	0 ⁰	0 ⁶⁰	13 ⁰	0 ²⁰	0 ⁰	7 ⁴⁰	0 ²⁰	0 ⁰	7 ⁵⁰	
			2.3 m								3.3 m							
			2 yr	3 yr	4 yr	5 yr	7 yr	10 yr	12 yr	2 yr	3 yr	4 yr	5 yr	7 yr	10 yr	12 yr		
metam sodium	500 ml		-	0 ¹⁰	0 ⁷	0 ¹⁰	3 ⁴⁰	13 ²⁷	0 ²¹	0 ³³	0 ¹⁰	0 ³	0 ¹³	0 ⁵⁰	7 ⁷	0 ⁰	25 ⁶⁷	
dazomet	400 g		-	0 ⁷	0 ²⁵	0 ²⁰	0 ²⁷	0 ⁷	0 ⁷	0 ³⁶	0 ¹⁴	0 ²⁵	7 ⁷	7 ³³	0 ²⁷	0 ¹³	0 ⁴⁰	
dazomet	400 g	+	-	0 ¹³	0 ⁷	0 ⁷	0 ³³	0 ⁷	0 ⁷	0 ⁴⁷	0 ⁷	0 ¹³	0 ⁰	0 ³³	7 ⁰	0 ¹³	0 ³³	
dazomet	200 g		-	0 ²⁷	0 ¹⁴	7 ³³	0 ³³	0 ²⁷	0 ¹³	0 ⁷	0 ⁴⁰	0 ⁰	7 ²⁷	0 ³³	0 ⁴⁰	0 ⁷	0 ²⁰	
dazomet	200 g	+	-	0 ²⁷	0 ⁰	0 ⁷	0 ²⁷	0 ⁷	0 ⁰	27 ²⁷	0 ⁰	0 ¹³	0 ⁷	0 ²⁷	0 ⁰	0 ⁰	10 ²⁷	

a) Initial samples were shavings from the treatment hole. Values from other years represent 15 samples/treatment for dazomet and 30 for metam sodium. Superscripts represent percentage of nondecay fungi.

3. Performance of Dazomet in Powdered and Rod Forms in Douglas-fir Pole Sections

Date Established:	March 2000
Location:	Peavy Arboretum, Corvallis, OR
Pole Species, Treatment, Size	Douglas-fir, penta
Circumference @ GL (avg., max., min.)	84, 104, 65 cm

Dazomet was originally supplied in a powdered formulation which was intended for application to fields where it could be tilled into the soil. Once in contact with the soil, the dazomet would rapidly react to release MITC, killing potential pathogens prior to planting. The drawbacks to the use of powdered formulations for treatment of internal decay in wood poles include the risk of spillage during application, as well as the potential for the presence of chemical dusts that can be inhaled. In our early trials, we produced dazomet pellets by wetting the powder and compressing the mixture into pellets, but these were not commercially available. The desire for improved handling characteristics, however, encouraged the development of a rod form. These rods simplified application, but we wondered whether the decreased wood/chemical contact associated with the rods, might reduce dazomet decomposition, thereby slowing fungal control.

Pentachlorophenol treated Douglas-fir pole sections (206-332 mm in diameter by 3 m long) were set to a depth of 0.6 m at the Corvallis test site. Three steeply angled holes were drilled into each pole beginning at groundline and moving upward 150 mm and around 120 degrees. The holes received either 160 g of powdered dazomet, 107 g of dazomet

rod plus 100 g of copper naphthenate, 160 g of dazomet rod alone, 160 g of dazomet rod amended with 100 g of copper naphthenate, 160 g of dazomet rod amended with 100 g of water, or 490 g of metam sodium. Each treatment was replicated on five poles.

The poles were sampled one to five years after treatment by removing increment cores from equidistant points around each pole at 0.3, 0.8, and 1.3 m above the groundline. The inner and outer 25 mm of each core was extracted in ethyl acetate and the extract was analyzed for MITC by gas chromatography as previously described. The remainder of each core was then cultured for decay fungi as previously described.

MITC levels 0.3 m above groundline were all well over the 20 ug threshold one year after treatment regardless of chemical treatment (Table I-4; Figure I-7 to I-12). The addition of copper compounds to the dazomet treatments had little effect on MITC levels in the inner zones one year after treatment, but MITC levels appeared to be slightly

Table I-4. Residual MITC in Douglas-fir pole sections at selected distances above the groundline 1 to 5 years after treatment with metam sodium, dazomet powder, or dazomet rods with or without supplemental copper.

Treatment	Dosage	Additive	Year Sampled	Residual MITC (ug/g wood) ^a					
				0.3 m		0.8 m		1.3 m	
				inner	outer	inner	outer	inner	outer
Dazomet Rod	160 g	none	Year 1	50 (35)	24 (24)	6 (17)	4 (8)	0	0
			Year 2	52 (70)	16 (55)	42 (54)	1 (3)	25 (32)	27 (41)
			Year 3	38 (41)	28 (44)	28 (28)	39 (65)	54 (98)	34 (51)
			Year 5	145 (99)	97 (81)	32 (19)	22 (20)	8 (11)	4 (7)
Dazomet Powder	107 g	100g Cu naphthenate	Year 1	45 (57)	46 (44)	2 (4)	6 (8)	0	0
			Year 2	51 (70)	1 (2)	36 (51)	1 (3)	73 (101)	14 (28)
			Year 3	67 (81)	66 (102)	52 (98)	31 (46)	49 (67)	37 (71)
			Year 5	118 (53)	85 (52)	56 (38)	42 (73)	16 (11)	5 (11)
Dazomet Powder	160 g	none	Year 1	54 (95)	30 (30)	2 (4)	4 (7)	0	1 (3)
			Year 2	29 (37)	3 (6)	35 (53)	1 (3)	33 (46)	6 (12)
			Year 3	26 (36)	31 (43)	38 (51)	15 (20)	29 (34)	21 (49)
			Year 5	113 (56)	80 (66)	38 (29)	21 (11)	6 (11)	3 (7)
Dazomet Powder	160 g	100g Cu naphthenate	Year 1	49 (63)	85 (88)	9 (16)	9 (16)	1 (2)	1 (2)
			Year 2	80 (104)	17 (45)	49 (64)	4 (9)	62 (75)	5 (11)
			Year 3	76 (101)	39 (53)	47 (55)	73 (115)	47 (52)	28 (48)
			Year 5	175 (197)	159 (139)	62 (88)	46 (87)	18 (30)	11 (21)
Dazomet Powder	160 g	100 g water	Year 1	22 (22)	29 (35)	4 (6)	6 (10)	0	1 (2)
			Year 2	33 (47)	1 (2)	32 (34)	1 (5)	41 (41)	6 (11)
			Year 3	25 (23)	24 (28)	22 (31)	14 (26)	37 (45)	14 (27)
			Year 5	63 (28)	87 (104)	29 (14)	15 (18)	5 (7)	1 (3)
Metam Sodium	490 ml	none	Year 1	64 (44)	75 (74)	17 (18)	22 (27)	1 (3)	2 (4)
			Year 2	37 (49)	7 (11)	30 (27)	4 (7)	50 (78)	5 (10)
			Year 3	22 (19)	22 (22)	17 (18)	21 (20)	18 (15)	17 (19)
			Year 5	12 (11)	13 (10)	9 (9)	8 (10)	7 (8)	2 (5)

^aValues represent means of 15 analyses per treatment. Figures in parentheses represent one standard deviation. Figures in bold type represent levels above the lethal threshold for MITC.