METHYL IODIDE AND MIXTURE GAS OF METHYL ISOTHIOCYANATE AND SULFURYL FLUORIDE FUMIGATION AS A QUARANTINE TREATMENT FOR SOLID WOOD PACKING MATERIAL

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On quarantine fumigation treatment of wood packing material infested with significant forest insect pests, methyl bromide (MB) fumigation standard is shown in the table of ISPM No.15. Furthermore, new MB fumigation standard for the pine wood nematode, *Bursaphelenchus xylophilus* proposed by Japan, the US and China has been discussed to add to the table of ISPM No.15 in the committee of the ICPM/IPPC. Here we report on fumigation standards for forest insect pests by methyl iodide (MI) alone and mixture gas of methyl isothiocyanate (MITC) and sulfuryl fluoride (SF) as alternatives to MB.

MI (MI 50%, carbon dioxide 50%)
MI is colorless liquid with characteristic odor and turns brown on exposure to light and moisture with a boiling point of 42.5C, a specific gravity in air of 4.9 and only slightly soluble in water. To vaporize MI in the air more quickly, it was dissolved in liquefied carbon dioxide in a pressurized cylinder. MI was registered as the agricultural chemical for logs infested with forest insect pests in Japan in 2005. Red pine lumber (10-15 cm thick×10-15 cm wide×50 cm long) with the pine wood nematode and red pine logs (10-20cm diameter, 100cm long) with the Japanese pine sawyer, *Monochamus alternatus* and the Far East rusty longicorn beetle, *Arhoalus rusticus* were fumigated at different doses of MI and temperatures for 24 hours with 51.2% loading under tarpaulin sheet of 1.95m3 with circulation fan. The difference of gas concentration between air space and the center of the load was ranges of 16-22% in the first 4 hours and the difference became small gradually as fumigation time passed owing to rapid evaporation and diffusion of particulate MI dissolved to liquefied carbon dioxide and use of circulation fan. Residual gas ratios of MI were ranges of 14.8-29.6% with low ratios at low temperatures. Complete mortality of the nematode and the longhorn beetle were attained at 84g/m3 at

10C, 60g/m3 at 15C, 64g/m3 at 20C, 48g/m3 at 25C, respectively, while some survivors of the pine wood nematode were confirmed at 36g/m3 at 25C in one replicate of 4 replicate tests owing to delaying gas uniformity at the beginning of fumigation caused by breakdown of circulation fan. The MI fumigation standard is proposed as shown in Table 1. Circulation fan should be operated during dosing, as MI is 5 times heavier than air.

Mixture gas of MITC and SF (MITC 30%, SF 30%, carbon dioxide 40%)

Mixture gas of MITC and SF was registered as the agricultural chemical for logs infested with forest insect pests in Japan in 2004. To vaporize MITC and SF in the air more quickly, it was dissolved in liquefied carbon dioxide in a pressurized cylinder. Red pine packing material (10-15 cm thick×10-15 cm wide×50 cm long) with the pine wood nematode was fumigated at different temperatures and doses of mixture gas of MITC and SF for 24 hours with 50% loading. The data from 100-liter fiberglass box showed that on SF fumigant, high residual ratios of 87.0-98.7% and extremely low absorption ratio were confirmed. The CT product of SF for complete mortality was 482mg h/l at of 21g/m3 of MITC/SF at 10C, 413mg h/l at 18g/m3 of MITC/SF at 15C and 346mg h/l at 15g/m3 of MITC/SF at 25C, respectively. A high correlation (R^2:0.996) was also observed between CT product and dose of SF. The CT product of SF could be possible to use as an indicator of mortality efficacy in a practical fumigation. On the contrary, on MITC fumigant, extremely low residual ratios of 1.5-3.9% and extremely high absorption ratio to wood material were confirmed, respectively. Low correlation (R^2:0.676) was also observed between CT product and MITC dose, because the CT product of MITC varied by absorption ratios even doses and temperatures and in the replicated test. The data from tarpaulin sheet fumigation showed that complete mortality of the pine wood nematode was attained at each of 27, 33, 42g/m3 of MITC/SF at 10C, 27g/m3 of MITC/SF at 15C and 15, 21g/m3 of MITC/SF at 25C, respectively. Some survivors, however, were confirmed at 27g/m3 of MITC/SF at 15C owing to low gas concentration of SF caused by gas leakage from the sheet. All stages of *Xyleborus perforance*, *X. pfeile*, *Callidiellum rufipenne* and *Cryphalus fulvus* were also killed completely at 21g/m3 of MITC/SF at 18.3-21.2C. The mixture gas of MITC and SF fumigation standard is proposed as shown in Table 2. Both procedures of operation of circulation fan for 30 minutes during dosing and prevention of gas leakage of SF from facilities, especially tarpaulin sheet should be taken during fumigation for obtaining enough CT products for complete mortality of the pest.

Table 1. Methyl iodide fumigation standards for wood packing material infested with the pine wood nematode and the long horned beetle.

Temperature (C)	Exposure time (hr)	Load factor (%)	Dose (g/m3)	Minimum gas concentration (mg/l)			Minimum CT product (mg□h/l)
				□	4	24 hs	
10-14.9	24	50 or below	84	42	20	14	450
15-19.9			60	36	18	12	400
20-24.9			48	30	16	10	350
25 or above			36	24	14	8	300

□Circulation fan is operated minimum 30 minutes at start of fumigation.

Table 2. Mixture gas of methyl isothiocyanate (MITC) and sulfuryl fluoride (SF) fumigation standards for wood packing material infested with the pine wood nematode and forest insect pests.

Temperature (C)	Exposure time (hr)	Load factor (%)	Dose (g/m3)		Minimum gas concentration of SF (mg/l)			Minimum CT product of SF (mg□h/l)
			MITC	SF	□	4	24hs	
10-14.9	24	50 below	33	33	29	25	12	490
15-24.9			27	27	24	21	11	420
25 or above			21	21	19	17	10	350

□Circulation fan is operated minimum 30 minutes at start of fumigation.