EXTENSIVE APPLICATION OF ETHYL FORMATE WITH NITROGEN ON NUSERY PLANTS AND CUT FLOWERS IN QUARANTINE USE

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Introductions

Ethyl formate (EF) has gained its popularity as a safe methyl bromide (MB) alternative for fumigating fresh fruit commodities. Cylinderized EF formulation has been most widely adopted for this purpose. However, high operation costs, worker safety related to handling heavy cylinders, and CO_2 emissions has raised concerns. Therefore, we recently developed a liquid EF application technology and commercialized the liquid EF formulation (Fumate^{TM}). Liquid EF application with nitrogen has been shown more cost-effectiveness and safer in workplace than MB (Yang el al. 2016, 2017). To expand liquid EF application to other perishable commodities, here we report 1) the efficacy of liquid EF treatment on five main pests of ornamental crops and 2) the phytotoxicity of EF on eight nursery plant and four cut flower species.

Materials and methods

- Nursery plants tested: *Sansevieria trifasciata, Peperomia obtusifolia, Peperomia puteolata, Hoya carnosa, Rhapis excalsa, Hedera helix, Fatsia japonica, Sansevieria stuckyi*

- Cut flowers tested: *Alpinia purpurata, Heliconia caribae, Heliconia wagneriana, Heliconia spp*

- Insect pest tested: Two spotted spider mite (TSSM, *Tertranychus urticae*), Cotton aphid (CA, *Aphis gossypii*), Western flower thrips (WFT, *Frankliniella occidentalis*), Sweetpotato whitefly (SWF, *Bemisia tabaci*), Citrus mealybug (CMB, *Planococcus citri*)

- Fumigant and application**:** Fumate^{TM} (Ethyl formate, 99%, Safefume Inc., Korea) was used to treat all nursery plants and mites, aphids, and whiteflies. Fumate^{TM} was vaporized with heated nitrogen gas, to eliminate explosive risk through the all vaporizer system to gas-out, and discharged into a middle-scale fumigation chamber (0.275 m^{-3}). Ethyl formate (97%, Sigma-Aldrich, St. Louis, MO, USA) was used to treat cut flowers and thrips and mealybugs in small scale fumigation chambers (30 cm x 30 cm x 30cm).

Results and discussions

The efficacy of EF, based on *Ct* products, to main pests in nursery plants and cut flowers was shown in Fig.1. The degree of phytotoxic damages with EF-fumigation varied with species, age and physical conditions of nursery plants and cut flowers. For nursery plants, although the high dose treatment (*Ct* products >100 gh m^{-3}, n=2) caused withering and color changes on leaves, the treated plants could fully recover within 2 weeks post-fumigation, suggesting that EF-fumigation is still a viable option for export market. For cut *Alpinia* (red ginger) flowers that were treated to target two accumulated *Ct* products (35 and 70 gh m^{-3}) over two different exposure time (4 and 12 h), we found less phytotoxic damage on flowers treated with 12h-EF-fumigation (31.5 and 55.9 gh m^{-3}) than 4 h-

EF-fumigation (31.6 and 51.2 gh m^{-3}) despite similar Ct products. This suggests that exposure time may be an important factor to consider in reducing EF phytotoxicity on cut flowers. Although not directly compared in this study, it has been reported that MB treatment could cause unrecoverable damage on nursery plants and cut flowers and be hazardous in workplace post fumigation (Kim et al., 2016). Thus, EF fumigation may be a viable MB alternative for the phytosanitary treatment of nursery plants and cut flowers.

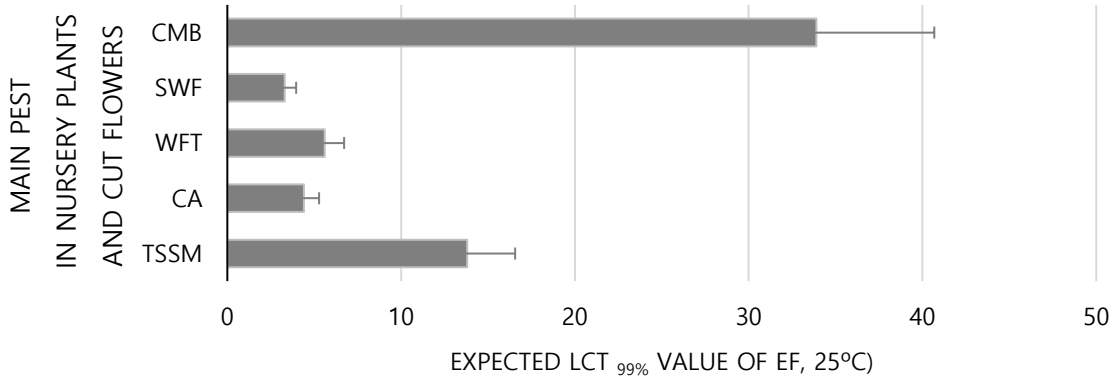

Fig. 1. Expected $LCt_{99\%}$ values (gh m^{-3}) of EF at 25 ºC to main pest hosted in nursery plants and cut flowers

Table 1. Phytotoxic assessment of ethyl formate on nursery plants and cut flowers (7D-post-fumigation)

Nursery plants & Cut flowers	*Ct* products (gh m^{-3})[A]	Damage index[B] (Mean ± SE)		Hue value		Recovery after damaged[C]
		Control	Treatment	Control	Treatment	
Sansevieria trifasciata	127.1	0.0 ± 0.0	1.3 ± 0.3	7.5 ± 8.3	8.4 ± 0.1	-
Peperomia obtusifolia	127.1	0.0 ± 0.0	2.0 ± 0.0	12.8 ± 0.5	9.9 ± 0.7	Yes
Peperomia puteolata	127.1	0.0 ± 0.0	4.0± 0.0	18.3 ± 0.3	15.8 ± 0.3	No
Rhapis excalsa	100.3	0.0 ± 0.0	4.0 ± 0.0	13.2 ± 1.4	9.3 ± 0.3	Yes
Hoya carnosa	100.3	0.0 ± 0.0	1.0 ± 0.0	10.3 ± 0.3	7.8 ± 0.2	Yes
Hedera helix	100.3	0.0 ± 0.0	4.0 ± 0.0	17.6 ± 0.1	15.0 ± 0.2	Yes
Fatsia japonica	100.3	0.0 ± 0.0	4.0 ± 0.0	12.1 ± 0.2	9.0 ± 0.2	Yes
Sansevieria stuckyi	100.3	0.0 ± 0.0	0.0 ± 0.0	10.2 ± 1.7	14.5 ± 0.2	-
Alpinia purpurata (Red)	55.9[D]	0.0±0.0	0.0±0.0	12.5±1.5	14.1±1.8	-
Alpinia purpurata (Red)	51.2	0.0±0.0	0.3±0.5	12.5±1.5	13.0±0.6	-
Heliconia wagneriana	51.0	0.0±0.0	1	-	-	-
Heliconia spp (Jacaunli)	51.0	0.0±0.0	1	-	-	-
Heliconia spp (Claw II)	51.0	0.0±0.0	1	-	-	-
Heliconia caribae	51.0	0.0±0.0	0	-	-	-
Alpinia purpurata (Red)	31.7[D]	1.0±0.8	0.8±1.0	15.1±1.1	14.4±0.8	-
Alpinia purpurata (Red)	31.6	1.0±0.8	0.4±0.6	15.1±1.1	15.0±0.3	-

[A] Accumulated *Ct* products calculated based on 4h exposure. [B] Damage index were scored subjectively as 0(none),1 (<5% affected shoot), 2 (0-25% affected shoot), 3 (25-50% affected shoot), 4 (>50% affected shoot). In case of cut flowers (*Alpinia* and *Heliconia*), calculated browning index (%) of whole flower were scored subjectively as 0(none), 1 (slight, < 15% affected), 2 (moderate, 16-49% affected), or 3 (severe, >50% affected) [C] Recovery accessed 14 day post-fumigation. [D] Accumulated *Ct* products based on 12h exposure.

References

Kim, B.S., Park, C.G., Moon, Y.M. Sung, B.K., Ren, Y., Wylie, S.J., Lee, B.H., 2016. Quarantine treatments of imported nursery plants and exported cut flowers by phosphine gas (PH3) as methyl bromide alternative. Journal of economic entomology 109: 2334-2340.

Yang J.O., Park M.G., Jeong Y.C., Lee B.H., 2016. Application of ethyl formate with nitrogen for controlling fruit and vegetable insect pests in perishable commodities. Proceedings 10th Int. Conf. on CAF in Stored Products. 6-11. Nov. 2016. New Delhi, India. 4P-4. Pp. 241-243.

Yang J.O., Kim H.M., Park Y.J., Park M.G., Ren Y.L., Lee B.H. 2017. New quarantine trials for using liquid ethyl formate with nitrogen application on imported citrus fruits_Cost-effectiveness and worker safety. International symposium and annual meeting of the Korean Society of Pesticide Science (KSPS). Apr. 06-07, Yeosu. Korea. P-105.