Food safety: Degradation of two pesticides in vegetable

Pesticides used on vegetable

Pesticides are chemicals used to control and/or destroy pests or diseases or weeds. They are further classified into different categories based on their usage such as insecticides, fungicides or weedicides. Chlorpyrifos and cypermethrin are two insecticides commonly used to control insects on vegetable. Chlorpyrifos degrades to TCP (3,5,6–trichloropyridinol) which has low human toxicity but is more easily leached in soils compared to the parent compound. Cypermethrin is highly toxic to fish and aquatic invertebrates. The two insecticides have different water solubility and vapour pressure. Both chlorpyrifos and cypermethrin have low water solubility of 0.4 and 0.004 mg/L, respectively. The vapour pressures of the two insecticides differ widely, chlorpyrifos at 2.5 mPa, and cypermethrin at 8.7×10^{-4} mPa. Chlorpyrifos is more toxic than cypermethin. The acceptable daily intake is 0.05 mg/kg body weight for the former while 0.01 mg/kg body weight for the later.

Pesticide deposition and residue dissipation

Many factors affect the pesticide deposition and residue dissipation on vegetable. Among them are the morphology of the crop, cuticle characteristics, stage of growth at treatment, growth rate, pesticide application method (formulation, rate, nozzle type), and climate (sunshine, rainfall, temperature). Pesticide exhibits its own dissipation rate on each crop after application. Hence its residues must be examined individually according to the prevalent climatic conditions of a country. Data on dissipation of pesticides in tropical vegetables are relatively few. Higher and frequent rainfall, high temperatures and higher solar radiation can increase the rate of pesticide dissipation in the tropics.

Permitted pesticide levels in food

The World Health Organisation/Food Agriculture Organisation Codex Alimentarious Commission (Codex) provides the permissive levels or Maximum Residue Limit (MRL) for pesticide residues in food. The Codex MRL for cypermethrin in green mustard (chai sim) is 1 mg kg^{-1} (1 mg of cypermethrin in 1 kg of vegetable) while the limits for chlorpyrifos has not been established. However, the MRL for chlorpyrifos for other leafy vegetables such as kale (kai lan) is 1 mg kg^{-1}. TCP is considered as non-toxic and thus exempted from the Codex MRL.

The Food Regulation 1985 Schedule 16 under the Food Act 1983 provides the MRL for pesticides residue in Food. The national MRLs for chlorpyrifos and cypermethrin in green mustard are 0.01 and 1.0 mg/kg, respectively.

Green mustard

Green mustard/chai sim (*Brassica juncea*) is a vegetable crop widely grown and consumed in Malaysia. It is grown throughout the year with very short crop rotation cycles of about one month. Different types of insecticides are used on green mustard. Their choice depends on the time interval between insect attack and crop harvest, and the pre-harvest interval (PHI) or waiting time between the last pesticide spray and harvesting of the vegetable. Frequency of spray mainly depends on size and nature of insect populations, climatic and other site characteristics.

Field dissipation studies

These studies were conducted according to the common vegetable growers' practice at three sites, Semongok, Tarat and Balai Ringin. Young seedlings of green mustard (20 days old) were transplanted from nursery into the field. The commercial pesticide solutions diluted according to the pesticide label were sprayed onto the green mustard immediately after transplanting. Pesticides were applied again on green mustard for additional three times at weekly intervals on day 7, 14 and 21 after transplanting. 1 kg of green mustard was harvested at day 21, 23, 25, 27, 34 and 41 for pesticide residue analysis.

Instruments with high precision and capable of detecting trace pesticide levels were used to detect pesticides in vegetables

Plots of newly transplanted vegetables

Matured vegetables of 21 days old which are ready for harvest and analysis of pesticides

Chlorpyrifos degradation

Chlorpyrifos dissipated exponentially with time; 57–70 % degraded within the first two days (Figure 1). The concentrations of chlorpyrifos was below 1.0 mg/kg at day 4 for Semongok and Tarat, while, additional two days were required for Balai Ringin to comply with the Codex MRL. A period of 21 days is needed for complete chlorpyrifos dissipation in

compliance with the national MRL of 0.01 mg/kg. Initial chlorpyrifos concentrations after last spraying were in the range of 5.91–12.7 mg/kg. The differences in initial chlorpyrifos concentrations among sites at day 0 were due to different plant sizes as bigger plants with larger leave surface areas trap higher amounts of pesticide compared to smaller plants. The half-lives or time needed for 50% of a chemical compound to degrade from its parent compound for chlorpyrifos were between 1.2 and 1.5 days for three sites.

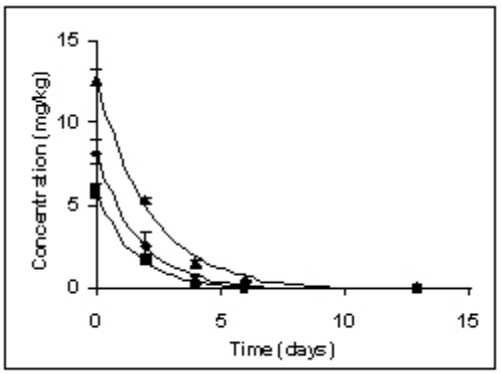

Figure 1. Concentration of chlorpyrifos versus time after its last (4th) application in green mustard at day 21 at Semongok (♦), Tarat (■) and Balai Ringin (▲).

Cypermethrin degradation

Cypermethrin dissipated slower compared to chlorpyrifos with 29–43 % degradation occurred within the first two days after the last pesticide application (Figure 2). Cypermethrin dissipated below 1 mg/kg for green mustard at day 3 and hence complied with the national MRL of 1 mg/kg. However, complete dissipation only occurred in 21 days. The initial concentrations of cypermethrin in green mustard after the last spraying were quite similar at the three sites (1.56–2.86 mg/kg). The half-lives for cypermethrin ranged between 1.6 to 3.1 days at three sites.

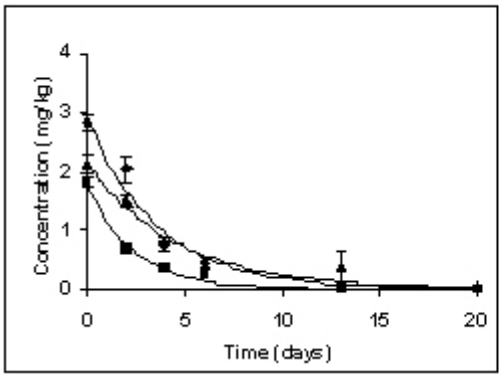

Figure 2. Concentration of cypermethrin versus time after its last (4th) application on green mustard at day 21 at Semongok (♦), Tarat (■) and Balai Ringin (▲).

Comparison of behavior of two pesticides

Similar degradation trends were seen for chlorpyrifos and for cypermethrin. For chlorpyrifos a PHI of 21 days is needed to comply with the national MRL of 0.01 mg/kg, while for cypermethrin only 3 days are needed to comply with the Codex MRL of 1 mg/kg. Among the two pesticides cypermethrin was the most persistent and could be detected up to 21 days after the last pesticide treatment. The number of pesticide applications, and type of vegetables (leafy/fruit or leaf size) may contributed to the persistency.

Rainfall and hence pesticide wash-off from leaves can cause rapid dissipation of pesticides. The cypermethrin dissipation from day 0 to 4 after the last application followed the order of Tarat > Balai Ringin > Semongok (Figure 2). This is in agreement with rainfall data: Tarat (27 mm, day 0), Balai Ringin (10.5 mm, day 0; 33.5 mm, day 1) and Semongok (12 mm, day 2). Rainfall has lesser effect on chlorpyrifos dissipation.

The vapour pressures for the two pesticides were chlorpyrifos (2.5 mPa) > cypermethrin (0.00019 mPa). This is the reverse sequence of the average half-lives with cypermethrin (2.4 days) > chlorpyrifos (1.3 days) indicating that solar radiation and hence volatilization and photo-degradation may also contribute to dissipation in green mustard.

Conclusions

The persistence and dissipation of the two pesticides varied in green mustard. The half-lives for chlorpyrifos and cypermethrin in green mustard were 1.2-1.5 and 1.6-3.1 days, respectively. Rainfall stimulated cypermethrin dissipation in green mustard but had no clear effect on chlorpyrifos. Solar radiation and hence volatilization and photo-degradation appeared to increase pesticide dissipation in the vegetable. A PHI of 21 and 3 days were required for chlorpyrifos and cypermethrin to degrade below the national tolerance levels in green mustard.

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