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Insecticide Resistance Management for Diamondback Moth in Organic Farms: Integration of Trap Cropping, Intermittent Sprinkler Irrigation, and Biological Control

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Diamondback moth (*Plutella xylostella*)

Window screen damage by DBM

Diamondback moth (DBM), *Plutella xylostella*, is a recurring pest on cruciferous crops with a well-documented propensity to develop insecticide resistance, threatening cole crop producers around the world. In Hawaii, DBM inflicts substantial pest pressure, breeding year-round with around 15-17 generations per year. Farmers in Hawaii have reported 20-40% (and sometimes up to 100%) yield loss in crucifer crops despite intensive DBM management efforts (Shimabuku et al., 1997). While conventional growers can mitigate resistance development by rotating the use of several effective synthetic insecticides (Mau and Gusukuma-Minuto, 2001), organic growers have fewer options that are organic compliant, and primarily consist of *Bacillus thuringiensis* (Bt) and spinosad. *Bt*- and spinosad-resistant DBM populations are widespread in Hawaii (Mau and Gusukuma-Minuto, 2001). Thus, it is imperative to identify other biocontrol agents and cultural practices to assist organic farmers in managing DBM infestations. Presently, various integrated pest management (IPM) tactics are being investigated against different life stages of DBM (Fig. 1) to determine if combinations of multiple tactics would provide effective control of DBM.

Biocontrol using Entomopathogenic nematodes (EPNs): EPNs are naturally occurring parasites of insects. Under certain conditions, EPNs can be used as effective biological control agents, killing their insect hosts within 24-48 hours. EPN species in two families (Heterorhabditidae and Steinernematidae) have been tested as biological insecticides for DBM management. In a 2020 field trial, *Steinernema feltiae* was used as a foliar spray at 1.25 million nematodes per hectare (506,000/acre). This treatment suppressed 87% of DBM on kale when DBM population density was below 0.2 larva/plant. However, EPN treatment was not effective at higher DBM densities.

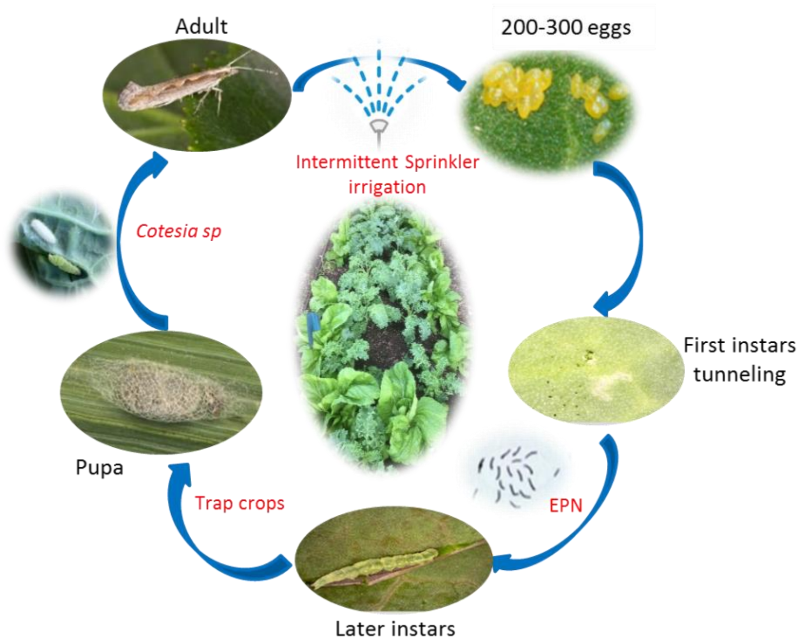

Fig. 1 Life stages of diamondback moth interfered by IPM strategies.

Trap cropping: Trap cropping is a form of companion planting which uses plants that are highly attractive to the target pests and divert the pests away from the cash crop. By attracting, retaining, or intercepting the pests, trap crops can reduce or eliminate damage to the cash crop. A recommended trap crop for DBM in head cabbage or kale fields is green mustard (*Brassica juncea*) 'Hirayama' (Fig. 2). 'Hirayama' reduced the numbers of DBM larvae and pupae on kale and head cabbage by 46% in two field trials conducted on Oahu in 2020. This corresponded to 22% and 44% less DBM feeding damage on kale and head cabbage, respectively (Budhathoki et al., 2020). Thus, trap cropping can reduce DBM pressure on cruciferous cash crops and complement other control measures.

Fig. 2. Green mustard as a trap crop intercropped with kale.

"Dead-End" Trap Cropping: This form of trap cropping leverages naturally occurring plant biochemicals for pest control. "Dead-end" trap crops are more attractive to adult female moths for oviposition than the cash crop, causing the females to lay their eggs on the trap crop over the cash crop. While these plants are also more attractive for larval feeding, they are detrimental to the development of the insect, keeping the pest from completing its lifecycle (Newman et al., 2016). In studies conducted in Europe and Continental North America, multiple plants including *Lepidium sativum* and *Barbarea verna* have shown success as dead-end trap crops for use against DBM. These plants, along with two other candidate crops did not show dead-end trapping capabilities on DBM populations in Hawaii, and even caused the moths to grow larger than they did on the cash crop (Pugh et al., 2020).

Intermittent Sprinkler Irrigation: Sprinkler irrigation deters the DBM from the crop by disrupting the flying capability of the adults as well as interfering with their oviposition activities (Tabashnik et al., 1986). DBM mating occurs at dusk on the day of adult emergence from pupae and oviposition begins shortly after dusk. Sprinkler irrigation for as little as 1 minute at dusk can interfere with DBM mating behavior. Additionally, sprinkler irrigation can inhibit larval feeding as it can reduce feeding activity and drown or wash larvae off the plants. Previously, Nakahara et al. (1981) reported that intermittent overhead sprinkler irrigation for 5 minutes at 30-minute intervals from 8:00 am to 10:00 pm was effective in decreasing DBM populations on a watercress farm in Hawaii. A field trial conducted on Oahu in 2020 showed that intermittent sprinkler irrigation (Fig. 4) two times for 5 minutes during dusk (at 6:00 and 8:00 pm) reduced DBM damage on head cabbage by 19%, though there was no significant decrease in DBM larvae on the plants. Adding intermittent sprinkler irrigation throughout the day at 2-hour intervals did not lead to a further decrease in DBM damage. None-the-less, this daytime intermittent sprinkler irrigation did reduce the damage from another pest of the cole crop, imported cabbage worm (ICW), *Pieris rapae*.

Conservation Biological control: Natural enemies of the DBM include parasitoids as well as other predatory insects. The impact of natural enemies is higher at farms where non-chemical based IPM is implemented, as pesticides can render these biological control agents incapacitated (Furlong et al. 2004). Weeds and surrounding vegetation create habitats for predatory insects and flowers provide nectar to feed these beneficial insects. DBM are affected by both generalist and specialist parasitoids. One common DBM parasitoid in Hawaii is *Cotesia plutellae* (Fig. 3), a species that was introduced many times by the HDOA and finally established in 1982.

Fig. 3. *Cotesia plutellae*.

Fig. 4. Intermittent sprinkler irrigation at dawn to interfere oviposition and mating of diamondback moth, or in the daytime to interfere the activities of imported cabbage worm.

Conclusion: Further research is needed to examine the potential additive or synergistic effects of integrating multiple strategies discussed above (EPNs, trap crops, and intermittent sprinkler irrigation). For example, a likely benefit of intermittent sprinkler irrigation is that it creates a moist environment on the plants, which is optimal for the survival and movement of EPNs. Future research on testing synergistic effects of intermittent sprinkler irrigation with trap cropping could be tested by planting trap crops away from the sprinklers so that the trap crop could be more attractive to the DBM and ICW.

References:

Budhathoki, S., Wang, K. H., Waisen, P., Meada, M., Paudel, R., Silva, J., Manandhar, R., Uyeda, J., and Sipes, B. Using Trap crops and Entomopathogenic Nematodes to Manage Caterpillar Pests on Head Cabbage. Hanai'I Newsletter Jun-Aug 2020. https://gms.ctahr.hawaii.edu/gs/handler/getmedia.ashx?moid =67098&dt=3&g=12.

Furlong, M. J., Zu-Hua, S., Yin-Quan, L., Shi-Jian, G., Yao-Bin, L., Shu-Sheng, L., and Zalucki, M. P. 2004. Experimental analysis of the influence of pest management practice on the efficacy of an endemic arthropod natural enemy complex of the diamondback moth. Journal of Economic Entomology 97:1814-1827.

Mau, R.F.L., and Gusukuma-Minuto, L. 2001. Diamondback moth, Plutella xylostella (L.), resistance management in Hawaii. The management of diamondback moth and other crucifer pests: Proceedings of the 4th International Workshop.

Nakahara, L. M., McHugh Jr, J. J., Otsuka, C. K., Funasaki, G. Y., and Lai, P. Y. 1986. Integrated control of diamondback moth and other insect pests using an overhead sprinkler system, an insecticide, and biological control agents, on a watercress farm in Hawaii. *In* Diamondback Moth Management. Proceedings of the First International Workshop, Tainan, Taiwan 403-413. Asian vegetable research and development center.

Newman, K., You, M., and Vasseur, L. 2016. Diamondback moth (Lepidoptera: Plutellidae) exhibits oviposition and larval feeding preferences among crops, wild plants, and ornamentals as host plants. Journal of Economic Entomology 109:644-648.

Pugh, M., and Shikano, I. 2020. Assessing Dead End Trap Crops to Control Diamondback Moths (*Plutella xylostella*) in Hawai'i. Entomological Society of America Annual Meeting

Shimabuku, R. S., Mau, R. F. L., and Gusumuka-Minuto, L. 1997. Diamondback moth: feeding preference among commercial varieties of head cabbage. *In* The Management of Diamondback moth and other crucifer pests: Proceedings of the third International Workshop, Kuala Lumpur, Malaysia 29: 295-297.

Tabashnik, B. E., and Mau, R. F. 1986. Suppression of diamondback moth (Lepidoptera: Plutellidae) oviposition by overhead irrigation. Journal of economic entomology 79: 189-191.

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