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# Sustainable crop production technologies for ethnic vegetables


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# List of Asian vegetable crops

- **Legumes**
  - Long bean, Hyacinth bean
- **Brassicas**
  - A choy, cauliflower, Daikon radish, Lobok radish, Napa, mustard leaves, Shanghai bok choy, etc.
- **Cucurbits**
  - Bitter melon, Kabocha, Kalabosa, Long squash, luffa, winter melon, etc.

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# Yard-long bean in Southeast Asia

- **Yard-long bean (*Vigna unguiculata sesquipedalis*) is the most popular vegetable**
- **Occupies 7% of the total vegetable production area in Southeast Asia (Ali et al., 2002)**
- **Cultivated on more than 130,000 ha in Indonesia, Thailand and Vietnam (Benchasri & Bairaman, 2010; Kuswanto & Waluyo, 2011)**
- **The average value of its sales is US$ 4400/ha per cropping cycle**

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# Hyacinth bean in South Asia

- **Hyacinth bean (*Lablab purpureus* (L.) Sweet) is an adaptable, multi-purpose legume**
- **Popular as a vegetable and pulse, grown in both commercial fields and home gardens**
- **Requires a temperature of 18–30°C. Low frost tolerance; prefers rainfall at 200–2500 mm/year. Once established, it is drought-tolerant.**

# Yard-long bean nutrition

- **Beans are rich in protein, calcium, iron, riboflavin, phosphorus, potassium, and vitamin A, and are a very good source of vitamin C, folate, magnesium, and manganese.**
- **The pods are harvested and cooked when young and tender.**

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# How to grow long- and hyacinth beans?

- Use raised beds 120 cm wide and 15 cm high, with a 40 cm wide drain between beds
- Incorporate organic matter such as compost or dried manure into the beds
- Soak seeds in water overnight to soften the seed coat.
- The next morning, draw two rows on a bed, 20 cm in from each bed edge. Sow the seed in the rows 2-3 cm deep and about 20-25 cm apart

# Crop management for long- and hyacinth beans

- These beans are climbing plants, which require support for best production
- Use bamboo poles for staking
- **Irrigation:** Supply water during critical growth stages, especially when flowering starts
- **Fertilizer application:** Optimum fertilizer rate is 169-208-309 kg N-$P_2O_5$-$K_2O$/ha (varies according to the soil type)

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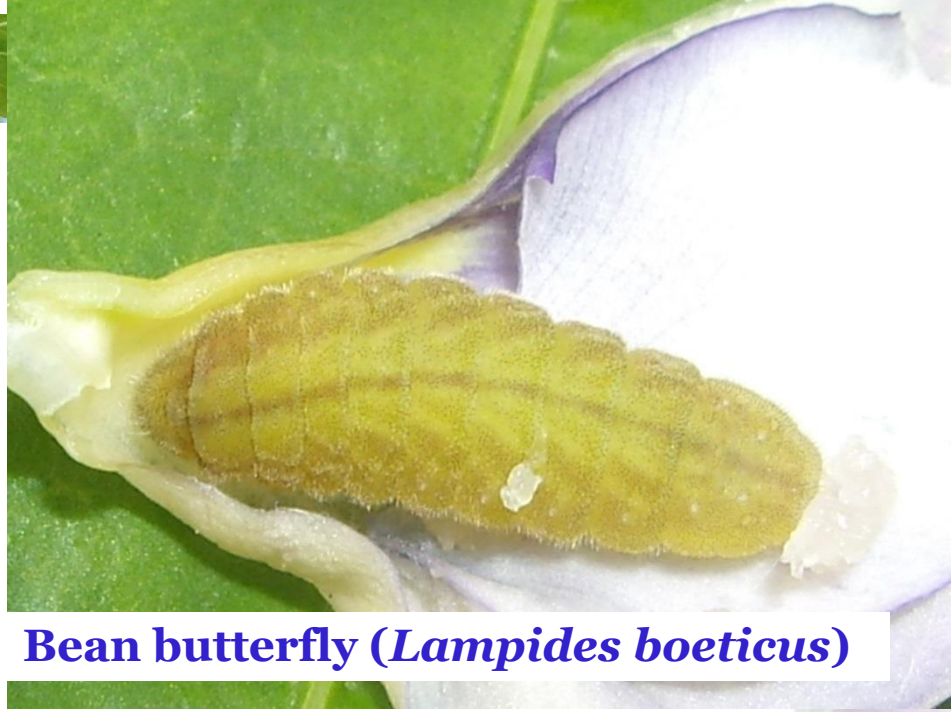
# Major pests and their management

Pod borer (*Maruca vitrata*)



Bean butterfly (*Lampides boeticus*)

American bollworm (*Helicoverpa armigera*)

Armyworm (*Spodoptera spp.*)


Thrips


Aphids


Stink bug


Pod bug

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# Damage potential of *M. vitrata*

- In green beans, the pod damage could reach as high as 80% in Southeast Asia
- In grain legumes, the loss in grain yield has been reported up to 60% in sub-Saharan Africa

# *Maruca vitrata* sex pheromone

- (E,E)-10,12-hexadecadienal, identified as the major component of *Maruca vitrata* sex pheromone (Adati and Tatsuki, 1999)
- (E,E)-10,12-hexadecadienol, and (E)-10-hexadecenal identified as minor components (Downham et al., 2003)
- Major & minor components – 100:5:5 attracted higher male *M. vitrata* moths in Benin and Ghana; however, (E,E)-10,12-hexadecadienal alone was most effective in Burkina Faso (Downham et al., 2004)

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# *M. vitrata* Pheromones – intraspecific variations

J Chem Ecol
DOI 10.1007/s10886-015-0653-z

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## Pheromone Blend Analysis and Cross-Attraction among Populations of *Maruca vitrata* from Asia and West Africa

Stefanie Schläger[1,2] · Franziska Beran[3] · Astrid T. Groot[3,4] · Christian Ulrichs[1] · Daniel Veit[3] · Christian Paetz[3] · Bhanu R. M. Karumuru[5] · Ramasamy Srinivasan[6] · Monika Schreiner[2] · Inga Mewis[7]

- (E,E)-10,12-hexadecadienal
- (E,E)-10,12-hexadecadienol
- (E)-10-hexadecenal
- Ratio of pheromone components
  - Taiwan: 52% : 45.5% : 2.5%
  - Thailand: 37.2% : 55% : 7.8%

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# Diversity of natural enemies against *M. vitrata*

*Apanteles taragamae*

*Phanerotoma syleptae*

*Therophilus marucae*

*Therophilus javanus*

**(Huang et al., 2003; Srinivasan et al., 2009; Srinivasan et al., 2012)**

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# Screening and selection of bio-pesticides

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# Efficacy of δ-endotoxins against *M. vitrata*

| Bt δ-endotoxin | $LC_{50}$ (ppm) |
|---|---|
| Cry1Aa | 0.812 |
| Cry1Ab | 0.207 |
| Cry1Ac | 1.666 |
| Cry1Ca | 0.477 |
| Cry2Aa | 1.058 |

(Srinivasan, 2008)

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# Toxicity of different *B. thuringiensis* formulations to *M. vitrata* larvae in Taiwan

| Bio-pesticide | $LC_{50}$ (ppm) | $LC_{90}$ (ppm) |
|---|---|---|
| Xentari® (*B. thuringiensis* subsp. *aizawai*) | 102.64 a | 492.09 a |
| Crymax® (*B. thuringiensis* subsp. *kurstaki*) | 371.62 b | 2309.57 b |
| Strain E-911® (*B. thuringiensis* subsp. *kurstaki*) | 1432.51 c | 10677.65 c |

(Srinivasan et al., 2014a)

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# Toxicity of different *B. thuringiensis* formulations to *M. vitrata* larvae in Thailand

| Bio-pesticide | $LC_{50}$ (ppm) | $LC_{90}$ (ppm) |
|---|---|---|
| Zitarback F.C.® (*B. thuringiensis* subsp. *aizawai*) | 1150.58 b | 24870.99 ab |
| Redcat® (*B. thuringiensis* subsp. *kurstaki*) | 442.47 a | 12704.26 a |

(Yule and Srinivasan, 2013)

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# Toxicity of different entomopathogenic fungal strains to *M. vitrata* larvae in India

| Pathogen | Isolate | $LC_{50}$ (conidia/larva) | $LC_{90}$ (conidia/larva) |
|---|---|---|---|
| *Metarhizium anisopliae* | BCRLMa-3 | 20.96 a | $1.90X10^4$ a |
| | BCRLMa-6 | 140.70 b | $3.76 X10^4$ ab |
| *Beauveria bassiana* | BCRLBb-4 | 120.18 ab | $3.85 X10^5$ ab |
| | BCRLBb-16 | 3390.58 c | $8.65 X10^6$ b |
| | BCRLBb-18 | 1268 bc | $2.35 X10^5$ b |

(Srinivasan et al., 2014a)

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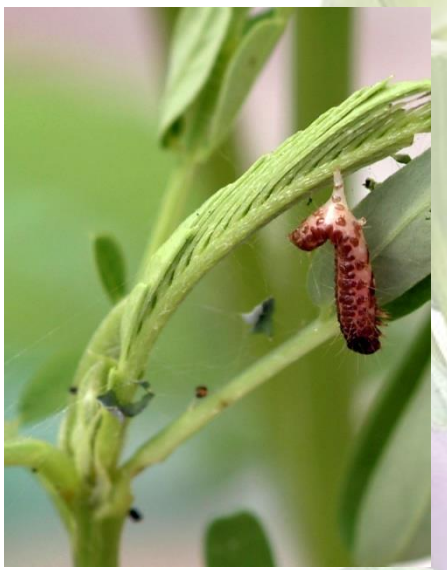
# Toxicity of different entomopathogenic fungal formulations to *M. vitrata* larvae in Vietnam

| Bio-pesticide | $LC_{50}$ (ppm) | $LC_{90}$ (ppm) |
|---|---|---|
| Luc cuong (*Metarhizium anisopliae*) | 56.48 A | 178.37 A |
| Bach cuong (*Beauveria bassiana*) | 272.90 BC | 414230 C |

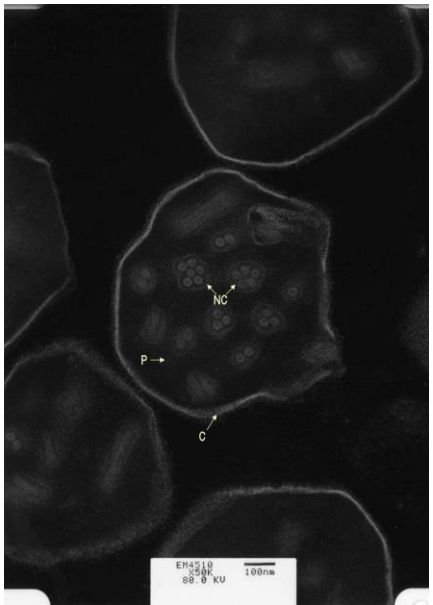
(Srinivasan et al., 2014a)

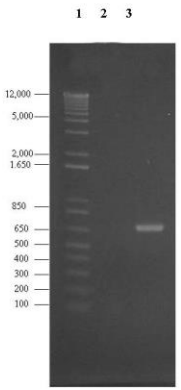
# *Maruca vitrata* multiple nucleopolyhedrovirus (MaviMNPV)

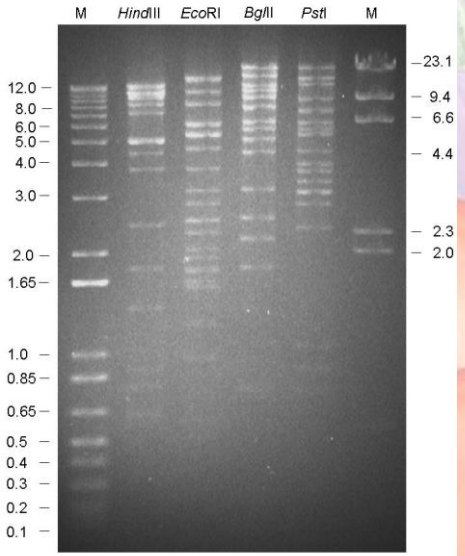
- First report of a NPV from dead larvae of *M. vitrata* in Taiwan during 2004
- Characterized based on ultra-structural morphology, restriction endonuclease cleavage patterns, and sequences of the coding region of the polyhedrin gene, and named as **MaviMNPV**



(Lee et al., 2007)



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# *Maruca vitrata* multiple nucleopolyhedrovirus (MaviMNPV)

- Effectiveness confirmed against LPB in Taiwan and Benin in laboratory conditions (Lee et al., 2007)

| Larval stage | $LC_{50}$ (OBs/ml) |
|---|---|
| First instar | $2.053X10^2$ |
| Second instar | $1.410X10^3$ |
| Third instar | $2.390X10^3$ |
| Fourth instar | $2.636X10^3$ |

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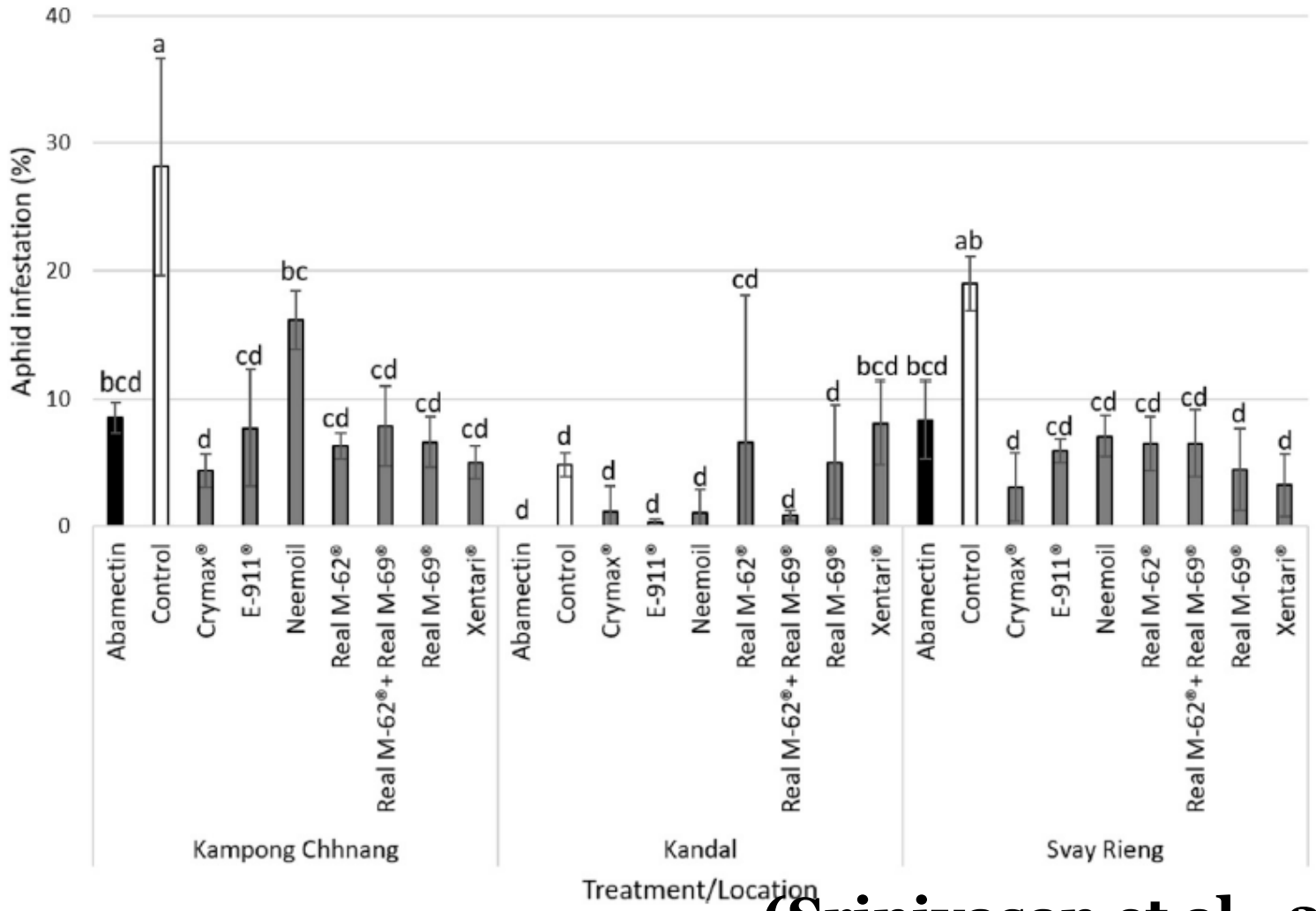
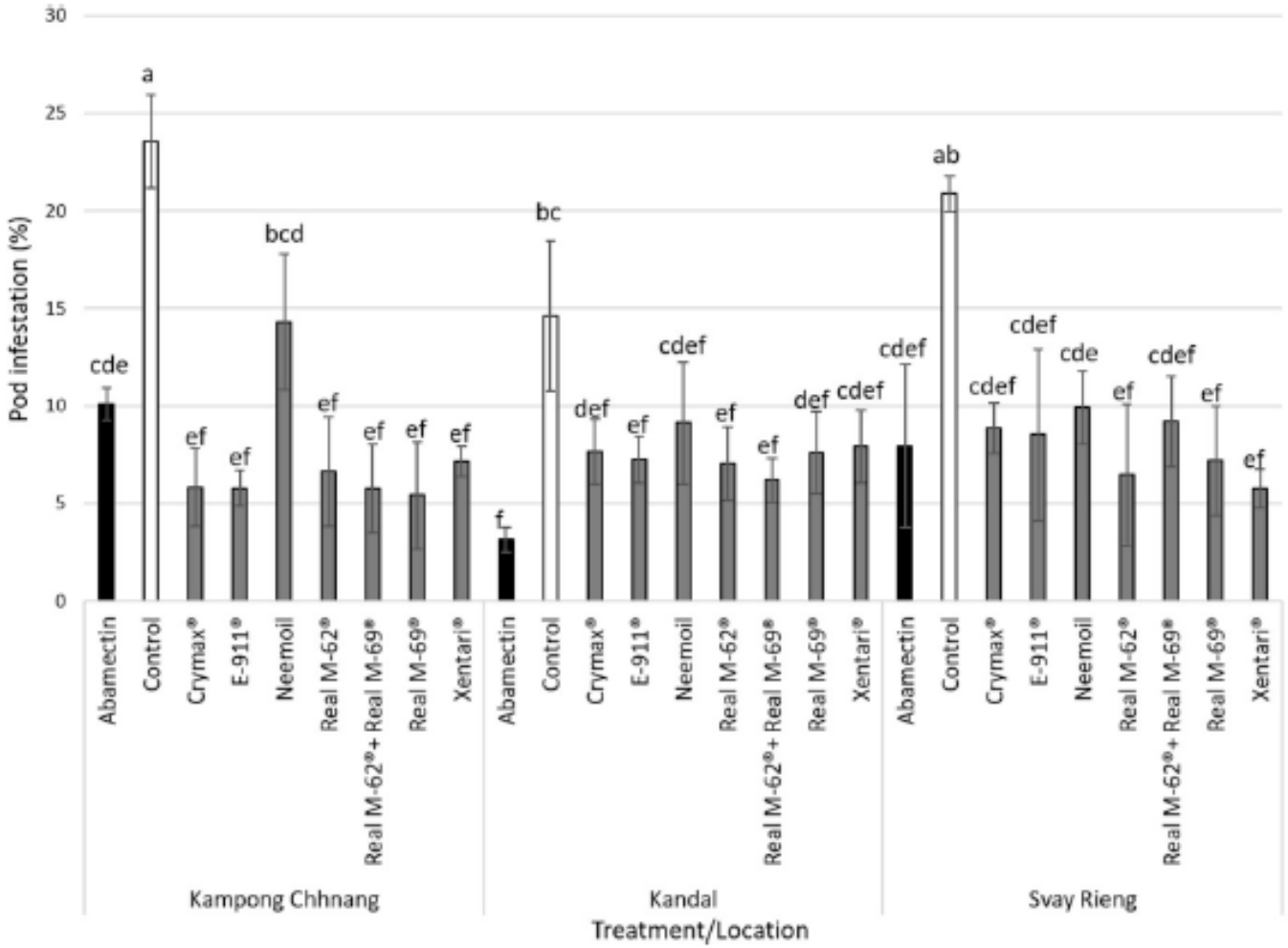
# Bio-pesticides against aphids on yard-long bean in Cambodia




(Srinivasan et al., 2019a)

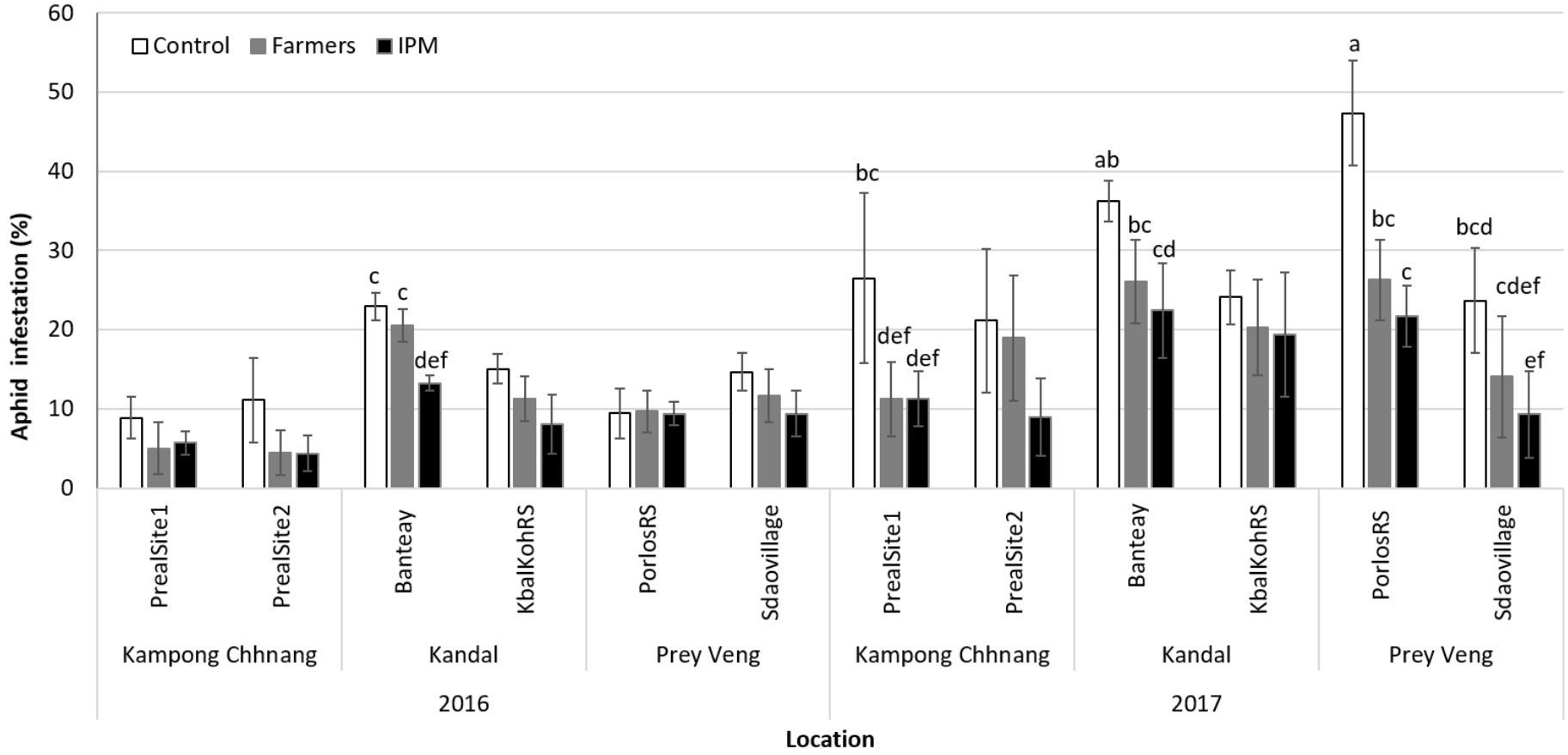
# Bio-pesticides against pod borer on yard-long bean in Cambodia





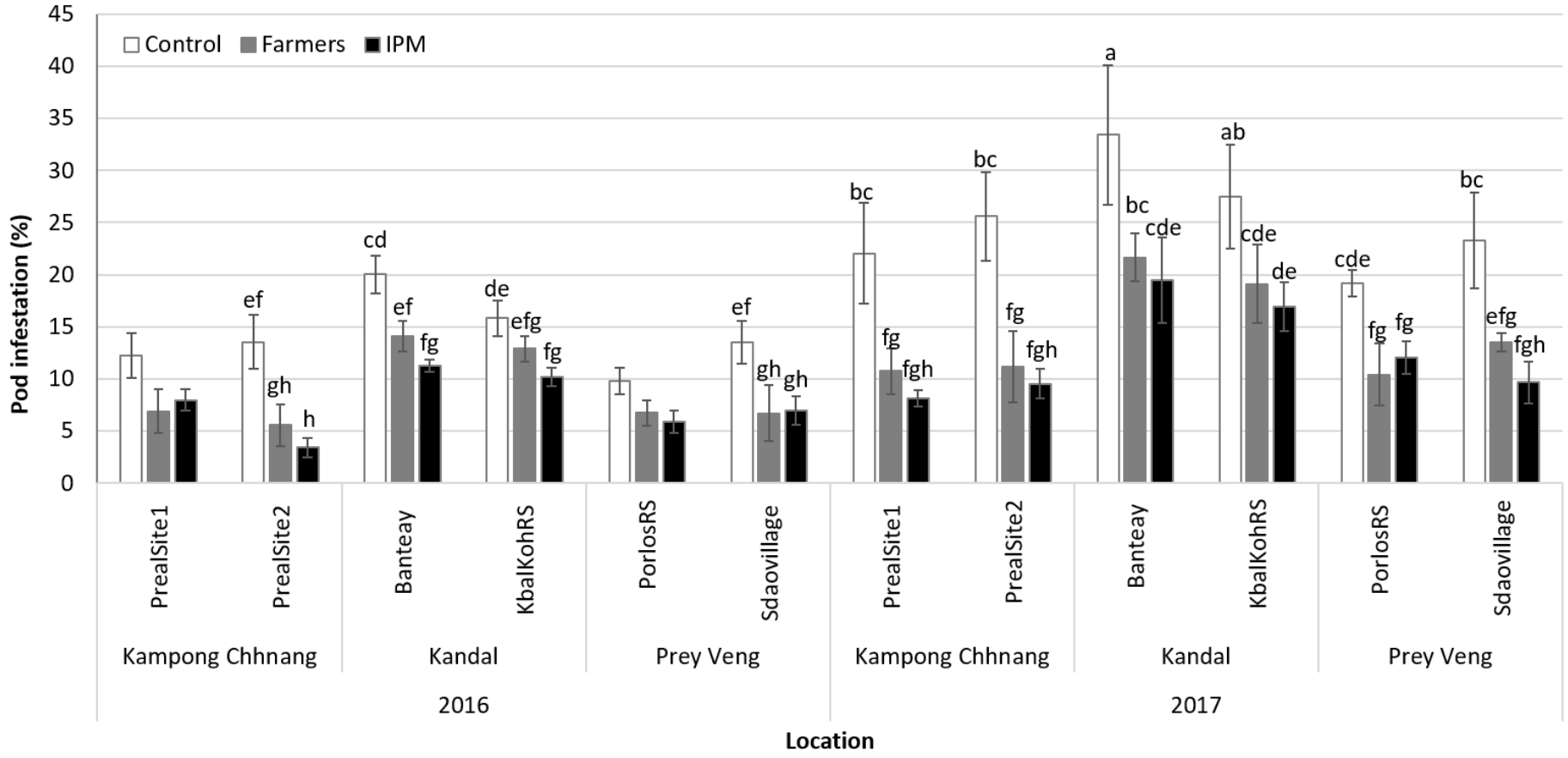

(Srinivasan et al., 2019a)

# Bio-pesticide based IPM for yard-long bean in Cambodia




(Srinivasan et al., 2019a)

# Bio-pesticide based IPM for yard-long bean in Cambodia






**(Srinivasan et al., 2019a)**

# Long- and hyacinth beans: when to harvest?

- **Long beans:** Flowering occurs 5-6 weeks after sowing. Open flowers develop into beans ready for harvest in about 10-12 days. Pick the pods at the tender stage at full length, before the seeds mature.
- **Hyacinth beans:** Growth period is 75 to 300 days. They start fruiting 60–65 days after sowing and continue for 90–100 days. Mature seeds are harvested 150–210 days after sowing, depending upon cultivar and time of sowing. Pods are harvested when tender & consumed as vegetable.


The average value of Chinese kale in Cambodia is US$ 6,900/ha per cropping cycle (Genova *et al.*, 2006 a&b; 2010)

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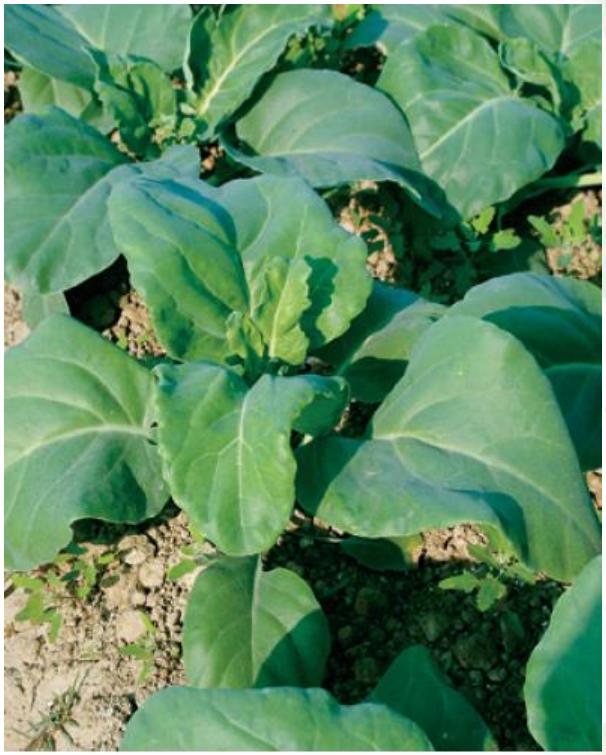
Peri-urban Hanoi

Vientiane province, Lao PDR

Kandal province, Cambodia

# How to grow brassicas?

- Cool season crops with some frost tolerance; some varieties can grow well under high temperatures (>30°C). The optimum temperature for germination is 18-24°C (seedlings emerge in 7-10 days) and 18-32°C for growth.
- Well-drained and fertile soils with ample moisture are desirable.
- Prepare the land with a mixture of compost (12-15 kg/$m^2$) and NPK fertilizers (60 N– 90 $P_2O_5$ –60 $K_2O$) one week before sowing / planting.



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# Brassicas: Preparing transplants

- Brassicas can be sown directly in the field. However, transplants are usually used to establish a uniform stand of plants. Transplants grown in cells or containers are ideal because they allow field planting without disturbing the root system.
- To minimize damping-off and other seed-borne diseases, soak the seeds in 50°C hot water for 25 minutes and then in 1% sodium hypochlorite (80% water, 20% household bleach) solution for 10 minutes (sometimes this treatment is already done by the seed supplier). Seeds may also be coated with fungicides to protect seedlings from fungi.
- Plug seedlings are raised under greenhouse or netting conditions.

# Crop management for Brassicas

- Seedlings are ready to be transplanted after 3 weeks. The ideal transplant is 5–6 leaved, well hardened, vigorous and free from diseases.
- **Irrigation:** While irrigating, supply an adequate amount of water to saturate all the cultivated soil. Frequent but insufficient irrigation should be avoided. Crops are vulnerable to even a brief period of flooding.
- **Fertilizer application:** Side-dressings at 10 and 20 days after sowing can increase yields. Side-dress with 30 N– 30 $P_2O_5$ –30 $K_2O$ in spring and winter, but use lighter applications of 30 N–7.5 $P_2O_5$ –15 $K_2O$ in summer and fall.

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# Major pests and their management

Diamondback moth (*Plutella xylostella*)

Cabbage web worm (*Hellula undalis*)

Cabbage cluster caterpillar (*Crocidolomia pavonana*)

Imported cabbage worm (*Pieris rapae*)

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Cabbage looper
(*Trichoplusia ni*)

Aphids

Flea beetles (*Phyllotreta* spp.)

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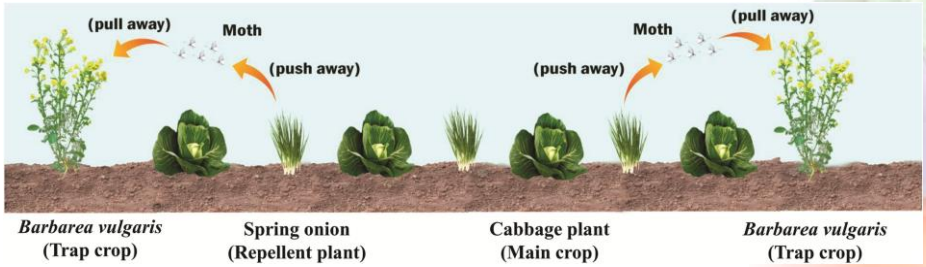
# Biological Control


***Pteromalus puparum*** **parasitizing** ***Pieris rapae*** **pupa**


- **Trap cropping**
- **Push-pull approach**
- **Pesticide window strategy for brassicas in Taiwan**
  - **Window 1 (spring): spinetoram, chlorfenapyr, indoxacarb and *B. thuringiensis* subsp. *kurstaki***
  - **Window 2 (autumn): emamectin, fipronil, chlorantraniliprole and *B. thuringiensis* subsp. *aizawai***




(Mayanglambam et al., 2021)

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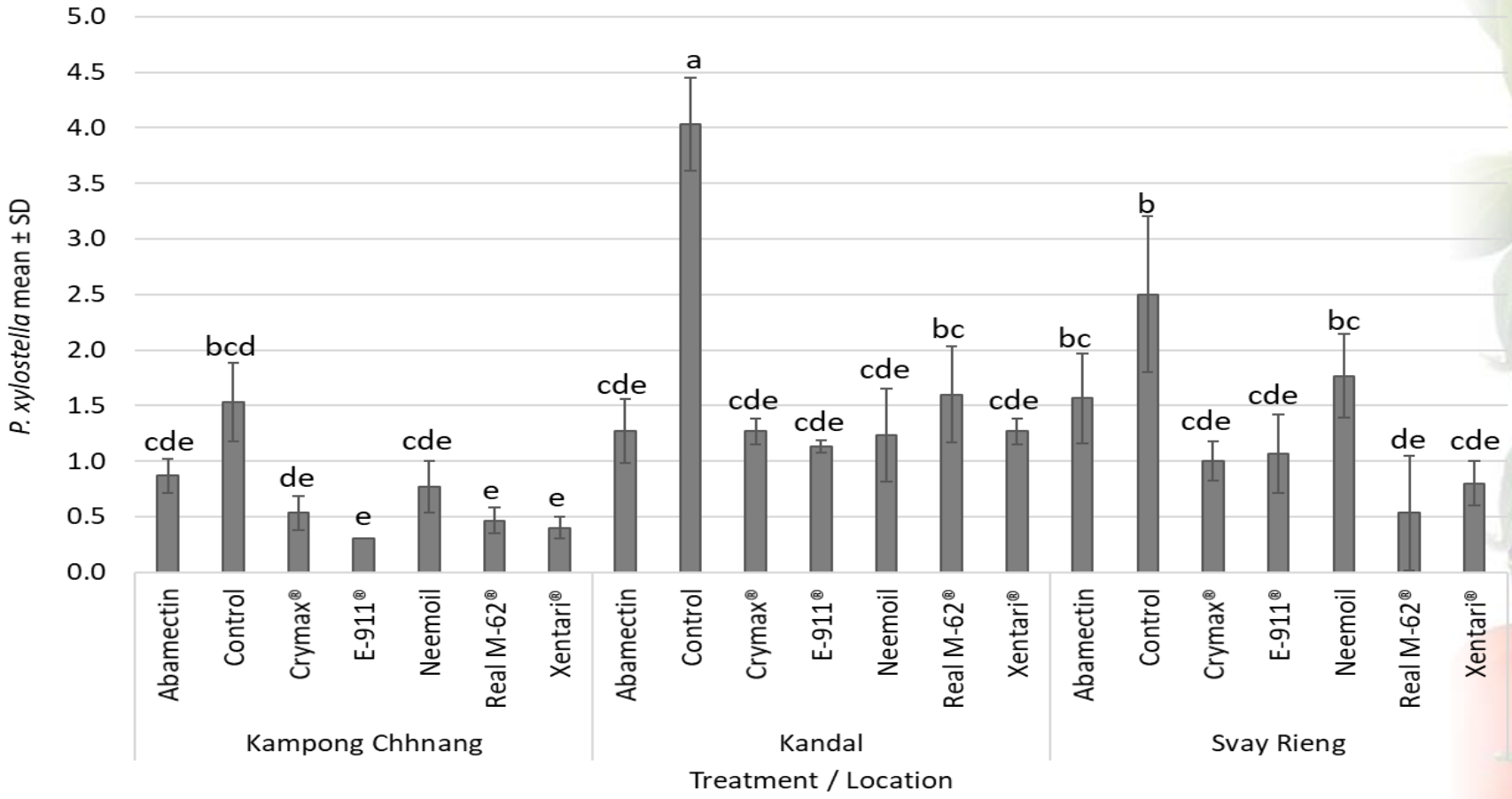
# Bio-pesticides against diamondback moth on Mustard in Cambodia




**(Srinivasan et al., 2019b)**

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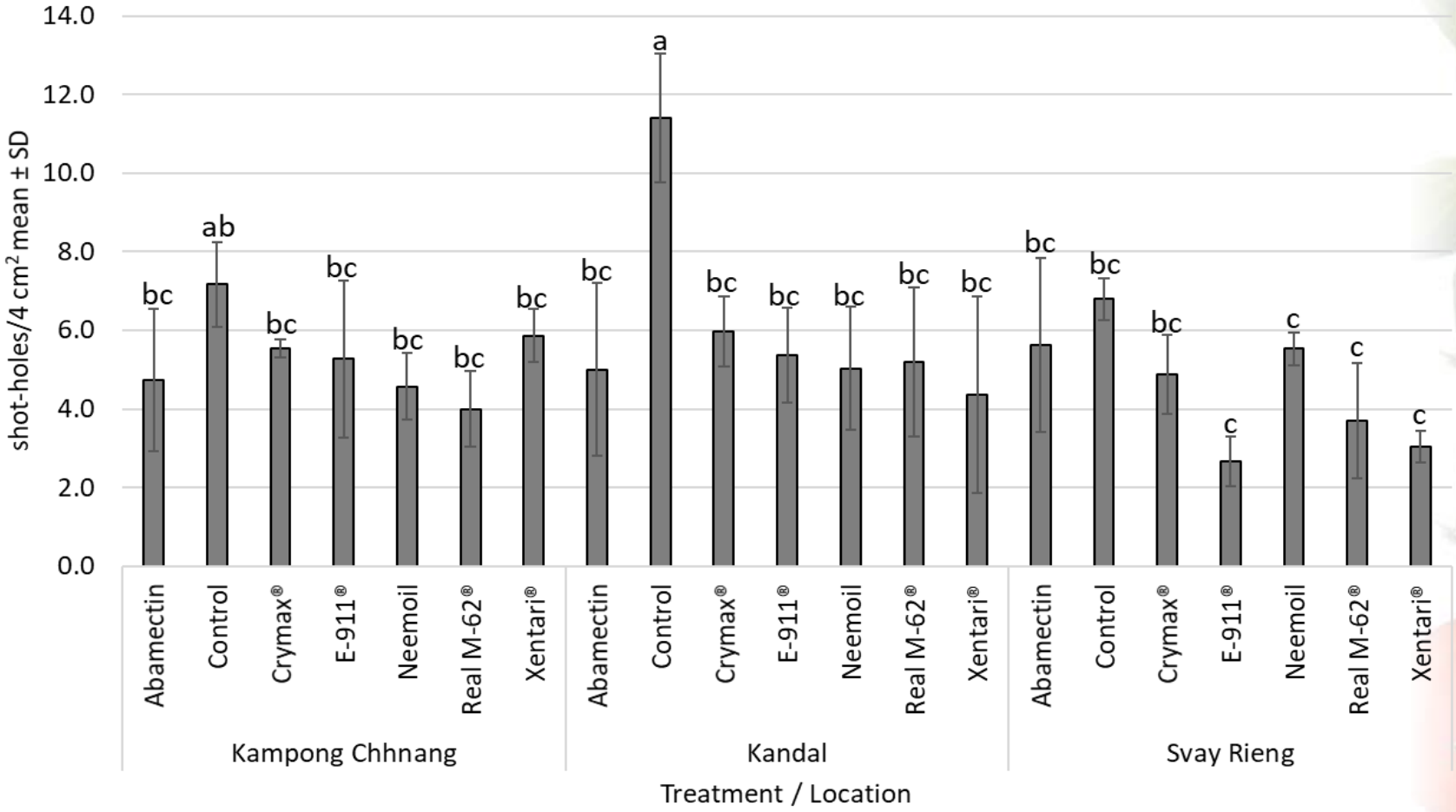
# Bio-pesticides against flea beetle on Mustard in Cambodia




(Srinivasan et al., 2019b)

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# Bio-pesticide based IPM for mustard in Cambodia

| Treatment | N | No. of *P. xylostella*/plant | No. of *S. litura*/plant | No. of *H. undalis*/plant | No. of shot holes/4 $cm^2$ | Marketable yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 36 | 3.84 (1.42) a | 1.27 (0.87) a | 0.69 (0.92) a | 7.53 (1.50) a | 21.49 (5.11) b |
| Farmers' practice | 36 | 1.48 (0.86) b | 0.49 (0.53) b | 0.31 (0.52) b | 6.13 (1.06) b | 23.47 (6.55) a |
| IPM | 36 | 1.32 (0.78) b | 0.48 (0.48) b | 0.29 (0.54) b | 5.29 (1.05) c | 24.11 (6.30) a |
| | | $F_{2,107} = 99.93$; $P < 0.0001$ | $F_{2,107} = 16.51$; $P < 0.0001$ | $F_{2,107} = 5.51$; $P = 0.0064$ | $F_{2,107} = 35.85$; $P = 0.0064$ | $F_{2,107} = 6.48$; $P = 0.0028$ |

**(Srinivasan et al., 2019b)**

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Validation of a bio-based integrated pest management package for the control of major insect pests on Chinese mustard in Cambodia

Srinivasan Ramasamy [a,*], Paola Sotelo [a], Mei-ying Lin [a], Chhun Hy Heng [b], Sareth Kang [b], Sor Sarika [b]

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# Cucurbits

- **Bitter melon (*Momordica charantia*)**
  - **Fruit contains folate, vitamin C, polypeptide-P, and vegetable insulin or charantin, which lowers blood sugar levels**
  - **Immature fruits, leaves, and young shoots are**
- **Pumpkin / squash (*Cucurbita* spp.)**
  - **Fruits are rich in starch, vitamins A, $B_1$, and C**
  - **Flowers, leaves, and young stems can be consumed**

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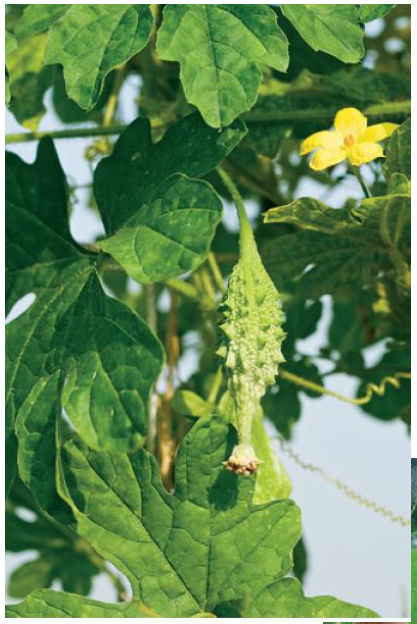
# How to grow cucurbits?

- **Bitter melon** requires a minimum temperature of 18°C during early growth, but optimal temperatures are in the range of 24-27°C.
- **Pumpkin** - annual warm season crop. Optimal temperatures range in 25-30°C. Plants require full sunlight. Pumpkin is tolerant to brief drought. However, it is sensitive to frost and not tolerant to wet conditions.
- They grow well in loam and sandy loam soils rich in organic matter, with good drainage.



# Cucurbits: Planting and Crop Management

- Prepare beds that are 20-cm-high during the dry season and 30 cm or higher during the wet season with a mixture of compost and NPK fertilizers
- The distance between centers of adjacent furrows should be about 150 cm with a 90-cm bed top.
- Soak seeds in water for 5-10 hours, wash clean, and cover with a wet towel or napkin in 25-30°C to hasten germination.
- For direct seeding, sow 2-3 seeds per hole at a depth of 2 cm. Space holes 40-60 cm apart in rows spaced 1.2- 1.5 m apart. Thin to one seedling per hole when plants have 4 true leaves.

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# Cucurbits: Planting and Crop Management

- **Prepare seedlings in plug trays. Plant one seed per container at a depth of 2 cm. Water the seedlings thoroughly every morning to maintain a moist but not wet soil.**
- **Use 50-60 mesh netting to enclose the nursery, to exclude insect pests. Transplant the disease-free and strong seedlings into raised beds when they are 10-15 cm tall.**
- **Form 20 cm-high beds during the dry season and 30 cm or higher during the wet season. The distance between centers of adjacent furrows is about 1.5 m with a 90 cm bed top.**

# Cucurbits: Planting and Crop Management

- **Pumpkin:** Irrigate plants moderately and let them creep on the ground. Apply NPK fertilizer during the growth (3 and 6 weeks after transplanting) and harvesting periods (every 2-3 weeks).
- **Bitter melon:** The plant grows very fast and vines elongate rapidly within 2 weeks after planting. Staking and trellising will increase fruit yield and size, reduce fruit rot, and make spraying and harvesting easier.

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# Cucurbits: Planting and Crop Management

- **Bitter melon:** **Fertilizer application rates depend on soil type, fertility level, and soil organic matter. In sandy soils, fertilizer application consists of a basal application followed by four side dressings, providing a total of 184 kg N, 112 kg $P_2O_5$ and 124 kg $K_2O$ per ha.**
- **Bitter melon will not tolerate drought. Maintain good soil moisture in the upper 50 cm of soil where the majority of roots are located.**
- **Bitter melon begins to flower at 45 to 55 days after sowing and vines will bloom for about 6 months. Flowers are cross-pollinated by insects, especially bees. Pollination can be a problem during the wet season since bees are less active during overcast conditions.**

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# Major pests and their management

**Pumpkin beetles (*Aulacophora* spp.)**

**Spotted beetles (*Epilachna* spp.)**

Leaf miner (*Liriomyza* spp.)

Whitefly *(Bemisia tabaci)*

Aphid (*Aphis gossypii*)

Spider mite (*Tetranychus* spp.)

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**Cucumber moth (*Diaphania indica*)**

**Melon fly (*Bactrocera cucurbitae*)**

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# Integrated Pest Management

- **Bagging of fruits**
- **Male annihilation and protein baits**
- **Bio-pesticides for soft-bodied pests & caterpillars – no disruption of pollinators**
- **Biological control**
- **Grafting with luffa (*Luffa* spp.), which is resistant to the *Fusarium* wilt and more tolerant to flooding**