Application, packaging, formulation, monitoring & evaluation

Approaches

1. Importation or Introduction
   - Done with introduced exotic pest species.
   - Pest species with no known NE locally.
   - Need to import NE from native land of pest.
   - Classical... specific in nature, self-perpetuating, growers not involved... unless Co.
   - Government input necessary.
   - If successful gain large profit.

- Eg. Against insect pests - 
  - Trichogrammatoidea bacterae fumata wasp brought into Sabah to control CPB Conopomorpha cramerella; Diadagma semiclausum wasp against DBM Plutella xylostella in Cameron Highlands.
  - Microorganism such as Bacillus thuringiensis against caterpillars with alkaline gut pH... fungi & viruses

- Eg. Against weeds – 
  - Schematiza cordiae beetle brought into Semenanjung to control the weed Cordia curassavica in coconut; Weevils Neochetina eichhorniae & N. bruchi and moth
  - Naphograma albijugalis against water hyacinth Eichhornia crassipes; Weevil Cyrtobagous salminae against kelaya Sylvania molesta; Moth Pareuchetes pseudosinulata and gall fly Procecidochares connexa against Siam weed Chromobenna odonata

- Failure ? Liothrips mikaniae against Mikania micrantha
- What about Btcorn, Btcotton ??
- Biologically-Based Technologies (BBT)

2. Conservation & habitat manipulation
   - Conducted using indigenous species.
   - Has local NE... not really effective OR established.
   - Find out why not performing...
     - If no. NE low... esp. at any critical time... make effort to mass rear NE so that can do inoculative (intermittent) then inundative, on periodic basis.
   - Eg. Ladybird beetle Menochilus sexmaculatus against aphids field crops.
   - Wasp Cortesia plutellae against DBM on crucifers in the lowland
   - Mass-culture indigenous microbial isolate
     - Virus against nettle caterpillars in oil palms
     - NPV against armyworm Spodoptera, Heliothis, bagworms
     - Fungi Paecilomyces, Beauveria and Metarhizium against aphids, mites, microlepidopterans

- *If pesticides render NEs ineffective...
  - Stop applying pesticides... OR limit their use... selectively... timing, borders, blocking... allow NEs recovery/survival
  - Eg. case of DBM in C. Highlands...
- *If not due to pesticide...
  - manipulate/modify habitat/environment to favour the development of NEs... such as providing sanctuaries, shelters... soft grasses under control, specific spots.
  - Establish beneficial nectariferous weed plants as in oil palms (Casia cubanensis, Antigonon leptopus, Turnera subulata, Euphorbia heterophylla, Ayystasia ganghical) to support NEs like parasitoids Dolichogenidea meteae, Goryphus bunoh, Pedobius detrimentus, Brachymetra carinata, B. lassus, P. anomalus, and the predators Sycanus spp., Calicemus spp., and aspargin bugs like Platynopus malaconthos).
- A minimum of inoculating charge is needed for establishment.

3. Augmentation
   - Raise large number of NE & do inundative release where & when needed.
   - Establish a permanent insectary unit with good delivery strategies... control during limited time.
   - Eg.
     - Trichogrammatoidea nana against the cane borer Chilo sacchariphagous (commercial success)
     - Trichogramma minutum against rice stem borer in Tg. Karang (failed miserably, why??)
     - Trichogrammatoidea bacterae fumata against CPB in Sabah (will succeed once culture technique becomes efficient; strong culture)
Packaging & Formulation

- Products includes predators, parasitoids, pathogens such as virus, bacteria, fungi.
- What form?
  - Bioinsecticides
  - Biofungicides
  - Bioherbicides
  - microbial seed treatment
  - rhizobial seed inoculant
  - soil ameliorant & conditioners.

Commercial bioinsecticides

- * Biosys Inc. (Palo Alto, CA)
  - BioFlea (for flea); BioSafe (for garden insect)
- * Crop Genetics Inter. Corp. (Columbia, MD)
  - InCide (used inoculants for insects & diseases)
  - Spod-X (virus for beet armyworm)
- * Ecogen Inc. (Langhorne, PA)
  - CellCap (encapsulated Bt toxin)
- * Evans Biocontrol Inc. (Broomfield, CO)
  - NOLO BAIT (Nosema locustae on g-hoppers)
- * Mycogen Inc. (San Diego, CA)
  - MVP (genetically engineered bioinsecticide for caterpillars on fruits, grapes, cotton, vegetables)
- * Mycotech Corp. (Butte, MT)
  - Mycontrol GY (B. bassiana for g-hoppers, whiteflies, aphids, thrips)
- * Novo Nordisk Bioindustrials Inc. (CT) BioBit (Bt for lepidop.)
- * Uniroyal Chemicals Co. Inc. BIOCOT XL (Bt for lepidop.)

Monitoring the impact

- To look into cause-effect relationship...demonstrates applicability.
  - Comparison done before & after intro....
- Look for evidence of prey population
  - Suppression & NE establishment.
- If carry out repeated introduction...
  - Do subsequent sampling of population estimates such as relative, absolute, sequential, etc.
- Do male-female bating... attractants, methyl eugenol, protein hydrolysate, pheromones, coloured trays & sticky traps, trap crops, etc.

Evaluating the impact - 2 approaches

1. Experimental
   - NE addition method.
     - Compare before & after intro. imported NE.
     - eg. imported NE colonised in 10plots, its population measured... increased while host population reduced.
     - Then measure another 10 plots but without NE... compare!!!
   - This can be tricky... spoilt by indigenous generalist predators.
   - Greenhouse set-up will be beautiful.

2. Experimental
   - NE exclusion methods.
     - Mechanically... screen, barriers, tent net, or cage VS unprotected control
     - Physically... hand removal of NE (good for sessile like scales) VS control
     - Biologically... black cocoa ants is a case in point VS without ants as control
     - Interference... selective insecticidal spray VS untreated control
2. Analytical -
\(\wedge\) Regression
  - correlates population change of host with NE such that to show quantitatively the suppressive effect of NE on pest through time (season) synchrony with fluctuation cycle
  - sampling of the pest and the NE is done periodically from same sites through years.
\(\wedge\) Life-table & key-factor analysis
  - involves measuring pest population before & after intro of NEs associating pest no. to GEP & EIL a bit complicated observed over generations
  - Key-factors that cause major mortality for each stage of pest is then identified also tell types of mortality would prefer direct DD relationship between pest-NE.

Advantages of BC
\(\wedge\) Does not affect environment environment-friendly
\(\wedge\) Continued effect in the long term... when successful... self-perpetuate
\(\wedge\) Economical in the long run... when successful
\(\wedge\) Specificity... not affecting non-target species
\(\wedge\) Control follows pest’s population trend
\(\wedge\) Conserve biological diversity & environment
\(\wedge\) Pesticide free yield... when successful

Disadvantages of BC
\(\wedge\) Effect not immediate... takes time to establish
\(\wedge\) Pest is not/never eliminated completely... esp. if the NE is an obligate with narrow host range
\(\wedge\) Research demand... high level of knowledge
\(\wedge\) Management is complex... knowledge based
\(\wedge\) Success is difficult to access in monitory term
\(\wedge\) In cases of zero-pesticide... cascading effects of many other BBTs... the minor insect pest species have been effectively suppressed by the broad-spectrum insecticides all these yrs.