Biotechnical methods in insect pest management: Research and Implementation Studies in Turkey

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Biotechnical Methods

The concept of «biotechnical methods»

Disrupting insect biology, physiology and behaviour,

- Attractants (sexual pheromones, feeding attractants, oviposition attractants, kairomones)
- Traps (bait, visual, pheromone, light and water traps)
- Trap systems (Mass trapping, Attract and kill, Mating disruption, Auto-confusion)
- Insect Growth Inhibitors/Regulators (JHA, Benzoylurea, Acylurea, Precocene)
- Oviposition deterrents/stimulants, antifeedants, repellents
- Chemosterilants
- Sterile Insect Release Technique (SIT)

Advantages

- Species-specific,
- Harmless to environment and non-target organisms,
- Flexible (easy adaptation to environmental conditions),
- Re-establish natural balance if the key pest is targeted,
- Make control of secondary pests possible by beneficial fauna,
- Decrease in need of chemical control,

Utilization

- ✓ Indirect utilization:
  -detecting,
  -monitoring
  -timing in Forecasting System, for example: *Lobesia botrana* and *Cydia pomonella*

- ✓ Direct utilization:
  -Attract and Kill/Male annihilation
  -Mass trapping
  -Mating disruption
  -Auto-confusion

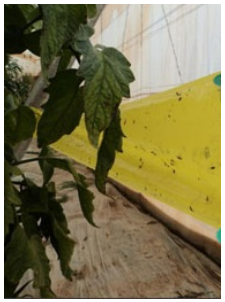
Mass Trapping

- decrease population by attracting and capturing target sex, change in sex ratio and decrease of encountering and oviposition
- Combination of two or more mechanisms-both sexes, if possible,

-Food attracts females,

-Pheromone attracts males,

-Color attracts both sexes,



- More successful in Medfly, Olive fruit fly, Cherry fruit fly

Attract and Kill/Lure and Kill

Bait spraying,

Food lure (hydrolyzed protein) mixed with malathion

by ULV or ground application/branch application

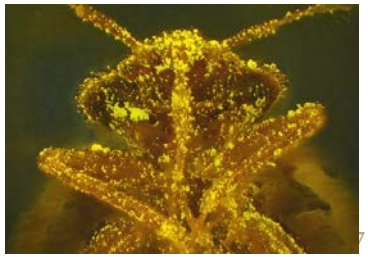
Olive fruit fly, Medfly…

Mating Disruption (MD) Technique

- aims at preventing males from finding unmated females by saturating the atmosphere to artificial pheromone, leaving females unfertilized and incapable of laying viable eggs.
- The most common method in the World (756 000 ha in 2012)

Auto-confusion

- Pheromone added electrostatic powder adheres to the males' body and antenna. So they cannot detect virgin females.
- Contaminated males transmit pheromone to other males in the population, also act as a false lure for other males when flying.
- Males visiting dispensers cannot encounter females.
- If they encounter by chance, females reject contaminated males.
- Newly emerged males also consider contaminated ones as female.

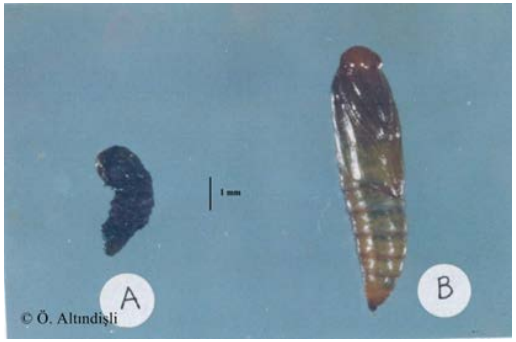


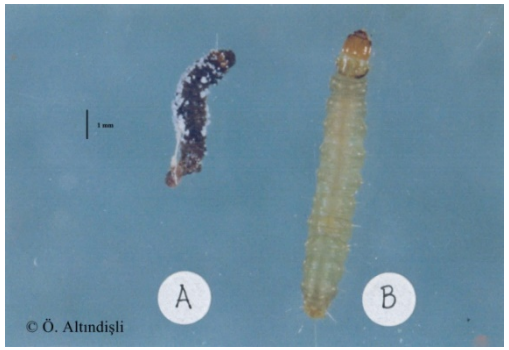
Insect Growth Inhibitors

- Accumulated in the insect's chitin layer at exoskeleton, inhibiting chitin synthesis,
- prevent an insect from reaching maturity by interfering with the molting process, causing the insect to die.
- can also kill eggs by disrupting normal embryonic development.

Insect Growth Regulators

- Hormonal IGRs typically work by mimicking or inhibiting the JH and ecdysone involved in insect molting.
- Mechanism of IGRs that mimic JH on larvae, eggs and adults,
- Mechanism of IGRs that inhibit ecdysone on pupae.





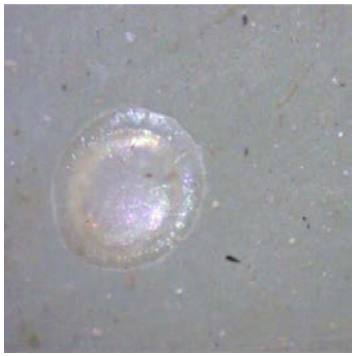
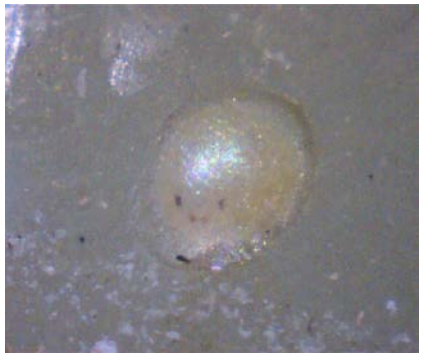
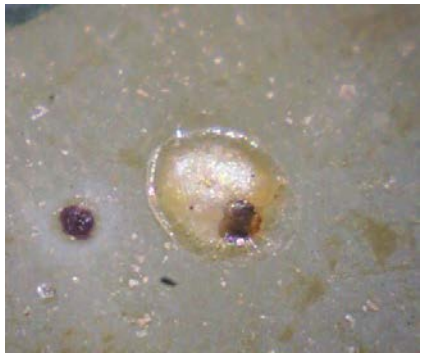
Insect Growth Inhibitors

Larvicides should be applied at the earliest larval instars,

Ovicides should be applied before egg laying,

tebufenozide, methoxyfenozide…

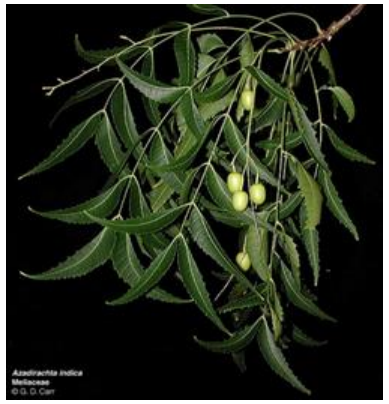
registered against *Cydia pomonella*, *Lobesia botrana and Spodoptera littoralis*.


Oviposition Deterrents and Attractants, Antifeedants, Repellents

- Chemicals or volatiles
- They are applied onto plants before or later than the pest can damage or

  They can be applied onto bait plant.
- Chemicals preventing oviposition, feeding or sheltering,
- Some signal pheromones released by females of fruit flies,
- Azadirachtin known as antifeedant, growth disruptor, sterilizing agent, reproduction deterrent, lethal and oviposition deterrent (Kısmalı and Madanlar, 1988).
- Zeolite 300 OD known as oviposition deterrent for *L. botrana* (Keçeci et al., 2016)



Sterile Insect Release Technique-SIT

Aim is preventing reproduction by means of mass released males after sterilization by gamma radiation or gene transfer.

Target area should be isolated, such as island,

- Target pest should be easily mass reared,
- Mating behaviour should not be affected by sterilization.
- Females should copulate once, whereas males mate several times in their lifetime, preferably.

History in the World

- **1920-1930's:** Improvement of attractant and trap against fruit pests-First study: Molasses against OFM (*Cydia molesta*)
- **1950-1960's:** Food attractants, baits, synthetic pheromones, sterile insect release (SIT) technique: first conceived by E. F. Knipling (1955)

-Practical feasibility by the eradication of the screwworm, *Cochliomyia hominivorax*, from the Caribbean island of Curaçao and peninsular Florida, 20 millions $ income/year

-Elimination of isolated infestations of the Medfly, *Ceratitis capitata*, other fruit flies, and the gypsy moth, *Lymantria dispar*.

Regional suppression programs against the cotton boll weevil, *Antonomus grandis*, mosquitoes and the codling moth, *Cydia pomonella*.

- **1970's:** Research studies on sticky traps
- **1980-1990's:** Mass trapping and Mating disruption, IGR's, semiochemicals

History in Turkey

1970-1980's: In general, against fruit pests;

- Bio-efficacy tests of traps,
- <Interaction between trap catches and damage rate,
- Basic studies for SIT,

1990-2000's: Research studies on the effectiveness of

- Mass trapping
- IGR's
- SIT + biological control
- Mating disruption
- Traps and combinations

Starting in Turkey

First study: 1973-1977

Basic research in Bornova Plant Protection Research Institute required for SIT application against Medfly

-Economical and mass rearing of Medfly,

-The most suitable biological stage and radiation dose,

-Bio-ecology and population dynamic of Medfly,

-The most efficient release method,

Research and Improvement

- **Research on quality parameters of lab reared Medfly population, Bornova PPRI, (1973-1980)**

Determination of

-flight distance marking individuals by radioactive phosphor,

-radiation dose causing the highest sterilization of Medfly pupae,

As a result

80% suppression of Medfly in Çeşme peninsula by releasing 3,2 million sterilized pupae

- **Mass rearing of Medfly, Bornova PPRI, (1978-1984)**

Determination of the most feasible mass-rearing of Medfly

Indirect Utilization of Trap and Trap Systems

Ankara PPCRI and Bornova PPRI, (1984-1988)

- Codling moth (*C. pomonella*) and Grapevine Moth (*L. botrana*)
- Bio-efficacy studies of pheromone traps in Forecasting System (Ataç et al., 1987; Altınçağ, 1987; Zümreoğlu et al., 1995; Zeki, 1996).

Indirect Utilization of Trap and Trap Systems

(1994-97)

- Development of Trap Systems against Medfly
- Supported by International Atomic Energy Agency
- Different Institutions coordinated by Bornova PPRI
- Determining mating ratio of wild females with released sterile males
- Developing trap-attractant combination for mass trapping
- Visual-Food-Pheromone trap combination

Research and Improvement

- **Improving domestic food lure for Attract and Kill Method**

- Ziray (120 g/l hydrolysed protein) has been improved by Ankara PPCRI (Büyükurvay et al., 1998) .
- Field tests were conducted together with other PPRIs.
- Good efficiency + cheap cost against Medfly and Olive fruit fly
- Still in use
- Molasses based MKI and MKT formulations (1000 ml/10 l water) has been improved by Ankara PPCRI (Kahyaoğlu and Gürkan, 2010).
- As effective as Ziray in partial branch application against Medfly.

- **Improving domestic pheromone for monitoring traps**

Sex pheromone of Pistachio Twig Borer, *Kermania pistaciella*, synthesized in Turkey for the first time, has attracted more males than commercial pheromone (Yanık et al., 2016).

Bio-Efficacy Tests

Technique	Target Organism	Result
Mass trapping	*Ceratitis capitata*, mandarin	Pheromone-food-visual trap (Zümreoğlu et al., 1987; Zümreoğlu and Çakıcı, 1996)
Mass trapping	*Bactrocera oleae*, olive	Pheromone-food-visual trap or Pheromone + Food (lure) + deltamethrin comb. 1 trap/2 trees in homogenous orchards (Zümreoğlu, 1992)
Mass trapping	*Prays oleae*, olive	1 pheromone trap/3 tree (Pala et al., 1995)
Mass trapping	*Rhagoletis cerasi*, cherry	Visual (Yellow) + Food Lure (ammonium) comb.; (4 Rebell traps/tree) (Zümreoğlu, 1992; Tezcan and Gülperçin, 2000; Özdem and Kılınçer, 2002)
Mass trapping	*Archips* spp., cherry	Food trap (900 ml water + 100 ml wine + 25 g sugar + 25 ml vinegar/l), 1 trap/tree (Ulu, 1992) in Aegean Region Food trap (grape molasses) in Central Anatolia
Mass trapping	*Synanthedon myopaeformis*, apple	Food trap (830 ml water + 170 ml molasses + 2-3 g yeast/l) in Central Anatolia, 1 trap /5 trees (Zeki et al., 1996) Pheromone trap, 1 Delta trap/tree in Aegean Region (Önuçar and Ulu, 1999)

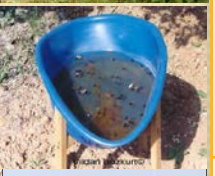






Bio-Efficacy Tests

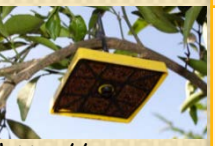



Technique	Target Organism	Result
Mass trapping	*Cydia pomonella*, apple	Pheromone (CM PHEROCON KIT) 1 trap /tree (Hepdurgun et al., 1996)
Mass trapping	Whiteflies, Leaf miners, thrips, protected vegetable	Visual trap (Yellow or blue sticky trap: 20 x 25 cm), 1 trap /10 m^2 (Yaşarakıncı and Hıncal, 1996; Ulubilir et al., 1996)
Mass trapping	*Xyloborus dispar* and *Lymantor coryli*, hazelnut	Visual (Red colour wing trap) + Food (ethyl alcohol, 96% and water, 1:1) 60-80 traps/ha if infestation rate is 70-80% 30-40 traps/ha if infestation rate is 40-50% (Ak et al., 2006)
Mass trapping	*Epicometis hirta*, fruits	Visual + Water trap combination, 1 trap/tree (Bozkurt et al., 2008)
Attract and Kill	*Cydia pomonella*, apple	Pheromone + half dose lambda cyhalothrin/acetamiprid (Kovancı et al., 2011)
Mass trapping	*Rhynchophorus ferrugineus*, palm	Pheromone + food combination (100 mg ethyl acetate + sugar + 1-2 l water), 50 traps/ha (Büyüköztürk et al., 2012)

Bio-Efficacy Tests

Source: Apak, 2013



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Technique	Target Organism	Result
Mass trapping	*Bactrocera oleae*, olive	1 trap/tree by 2% Diamonnium phosphate as effective as chemical control (Apak, 2013)
Mass trapping	*Zeuzera pyrina*, olive	Pheromone + light and visual traps are not effective (Kaptan et al., 2016)
Mass trapping	*C. capitata*, okitsu wase mandarin	5 Decis trap (pheromone+insecticide) /da 95% efficient (Satar and Tireng, 2016)
Mass trapping	*C. capitata*, mandarin	Ceranock food bait station (hydrolyzed protein + alphacypermethrin) (260/ha) (Zeki et al., 2016)
Mass trapping	*Tuta absoluta*, open and protected tomato	Pheromone + water + light or Pheromone + water trap comb., must be combined with cultural and biological methods (Kılıç et al., 2014; Topuz and Tekşam, 2015; Özkan et al., 2016).
Mass trapping	*Zeuzera pyrina*, pomegranate	*Beauveria bassiana* +pheromone traps (Delta) are 84% effective (Öztop et al., 2016).
Mass trapping	*Thrips* spp., nectarine	Attractants (Lurem-tr and Thripline-ams) increase efficiency of yellow sticky traps but costly (Hazır et al., 2016).

Bio-Efficacy Tests

Technique	Target Organism	Result
Mating disruption	*Cydia pomonella*, apple	1000 Isomate-C dispensers/ha (Hepdurgun et al., 1998; Kılıç et al., 1998)
Mating disruption	*Lobesia botrana*, grape	650 Isonet-L/ha (Altındişli et al., 2002) 600 Rak 2R/ha (Altındişli et al., 2012) 320 Isonet-LTT/ha (Altındişli et al., 2016)
Mating disruption	*Anarsia lineatella*, apricot	750-800 Isonet-A dispensers/ha (Öztürk, 2010)
Mating disruption	*Pectinophora gossypiella*, cotton	250 PB ROPE/ha (Anonymous, 2010)
Mating disruption	*Cydia molesta*, peach	Checkmate OFM-XL versus low (40 l water/ha) and high volume (635 l water/ha) sprayable Checkmate OFM-F, lower damage rate in pheromone-treated plots (Kovancı et al., 2011)
Mating disruption	*Cydia pomonella*, walnut	1000 Isomate-C dispensers/ha (Öztürk and Hazır, 2016)
Auto-confusion	*Lobesia botrana*, grape	180 Exo dispensers/ha decreased chemical requirement (Altındişli et al., 2009).

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Combined Application of SIT + Biological Control

- Bornova PPRS, 1999-2004, funded by FAO/IAEA
- Olive fruit fly control in olive orchard in Gökçeada Island (Çanakkale)
- Mass trapping (Ecotrap) + Releasing parasitized sterilized Medfly larvae
- Effective radiation dose blocking adult emergence without side effect on parasitoid, *Pysttalia concolor*.
- 90% efficacy without chemicals (Hepdurgun ve ark., 2002 ve 2005).

CONCLUSION

- **Importance of subsidy !**
  -Before subsidy, mating disruption in 500 hectares in 2003-2011
  ~15 000 hectares in 2016
- Extent and eligibility ?
- Vision and Mission of researchers
  -Domestic production

PHEROMONES

«There are many reasons for using pheromones. One is that they are elegant.»

(Arn, 1990)

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BORNOVA PLANT PROTECTION RESEARCH INSTITUTE

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