# Section 17: Emerging concepts and practices

- By the 1960s it became apparent that dependence solely on insecticides for pest control could lead to severe problems. Examples include:
  - Cotton pests in Cañete Valley of Peru. This is an isolated valley with insecticide resistance problems. Problem solved by using only least-toxic insecticides, re-intro of beneficials, and refugia for beneficials.
  - Spotted alfalfa aphid in California. OP resistance. Reduced insecticide dosages to favor survival of beneficials, and intro. of new parasitoids and resistant varieties.

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- Green peach aphid in chrysanthemum greenhouses, UK. Continuous production of flowers throughout year led to continuous aphid breeding and dev't of OP resistance. Biocontrol difficult because there were other pests: whitefly, spider mites, thrips. Combination of selective insecticides and BC used.

Green peach aphid,
Myzus persicae

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# IPM or Integrated control

- Solution to this type of problem was not to abandon pesticides, but to integrate them with other control tactics and minimize their use.
  - This is called pest management (IPM) or integrated control.
  - IPM is a knowledge-based system that promotes intelligent use of pesticides only when needed. Often emphasizes economic justification, sampling, and environmental protection.
  - Often non-chemical control used to maximize environmental resistance; insecticides are back-up.

# Applicability of IPM

- Although IPM is often used in agriculture, it certainly is not limited to this arena. Examples include:
  - Mosquito management with reduction in breeding sites, use of predators (fish), bacterial insecticides, repellents.
  - Cockroach management with removal of food and harborages, exclusion, IGRs, baits, etc.
  - Chinch bug management with turf variety selection, fertilization, watering.

# Integration can occur at various levels

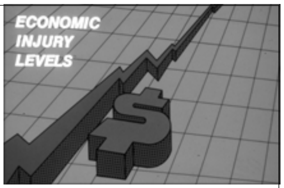
- Level 1 - Integration of several procedures against a single pest.
- Level 2 - Integration of many methods against a complex of pests attacking a single commodity.
- Level 3 - Integration of many methods against a complex of pests attacking a group of commodities.
- Level 4 - Integration of pest management systems into crop, livestock and forest production and marketing systems.

# The IPM Process

- Not simply application of various methods of pest prevention or suppression.
- Need to apply the entire process of:
  - Problem prevention, if possible
  - Inspection and monitoring for pests and beneficials
  - Correct identification of the pest or problem
  - Careful selection of management tools
  - Evaluation of effectiveness of the management approach

Followed by re-inspection, diagnosis, etc. until the problem is alleviated. Hopefully, means will be found to prevent the problem from re-occurring.

## Economic basis for pest suppression



- Economic injury level (EIL) and economic threshold (ET) concepts
  - EIL is point at which economic damage occurs, or point at which it costs more not to control pests than to kill them.
  - ET is level of pest abundance or damage that stimulates actions to avoid reaching the EIL; a threshold for action.

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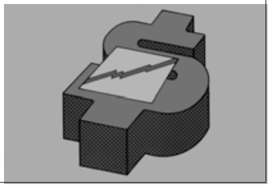
- EIL/ET concepts usually applied to "crop" pests, but the threshold concept also applies to nuisance pests (e.g., mosquitoes) and even for disease vectors (though not usually admitted)
- Plant compensation is an important aspect of determining EIL/ET, as are the variable costs of pest control, crop values, and aversion to risk



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## How are EILs established?

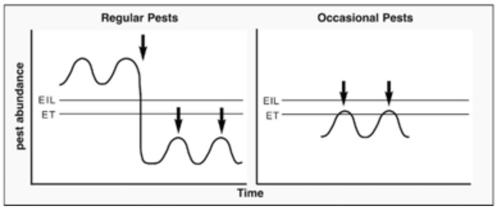
- The relationship of pest numbers or damage to yield must be determined.
- Natural variation in pest abundance, or induced variation with cages or pesticides, used to establish damage/yield relationships.
- Concept easy to appreciate, but interpretation difficult due to other variables: crop variety, crop health, weather, multiple pests, pesticide effects on plants, population density changes, predator abundance, etc.

Corn ear with caged insects

## How are EILs & ETs used?

- Scouting or monitoring is used to determine when population density/damage reaches ET.
- ET allows time for producer to take actions and prevent EIL from being exceeded.
- Simple scouting procedures are preferred, but less likely to be accurate.
- With disease vectors, presence/absence may be adequate threshold, and used to predict onset of epidemic (e.g., sentinel chickens and arboviruses).

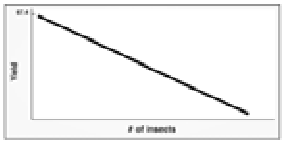
These graphs shows how the ET concept, accompanied by insecticide application (denoted by arrows), is applied to pest management. For routine pests (left) insecticide is applied to knock the population to a lower than normal level of abundance. It is then maintained at a lower level with regular treatments. With occasional pests (right), insecticides are only used when the population threatens to exceed the EIL. Typically, the interval between treatments is short with regular pests, long with occasional pests.



## Who uses EILs & ETs?

- EILs and ETs seem to be used most often when economics favor their use
  - Most often used with low-value, large-acreage crops with low frequency of treatment
  - Less likely used with high-value, small-acreage crops that are treated frequently
  - Less likely used when pesticide costs are a small proportion of total production costs
  - When high profits are possible, concern over pesticide costs diminish, and thresholds/scouting not often used (exception is with pesticide resistance)

# Calculating the economic injury level



- Consider a yield relationship described by the regression equation: Y = 67.45 – 1.43 x, where

- Y = yield
- a = the regression intercept, or yield with an insect density of 0 (in this case it is 67.45 boxes)
- b = the regression line slope, or reduction in yield per insect (in this case it is 1.43 boxes)
- x = number of insects

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The formula for calculating an EIL is
EIL = C / (V) (b)
or EIL = C / (V) (b) (K) where

C = the cost of pest management per unit area
(in this case $125 / ha)
V = value per unit of produce (in this case $5 / box)
b = yield loss per insect
K = decimal proportion in damage reduction (80% control would be computed as 0.8, but if virtually complete control is assured the value is 1.0 and can be ignored)

So the calculation is EIL = $125 per ha / ($5/box) (-1.43 boxes/insect/ha) assuming complete control

EIL = 17.4 insects per ha

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# Questions about the IPM concept

- What are the key elements of the IPM concept? (how is it defined?)
- The “integrated” portion of integrated pest management can mean different things, depending on the level of integration. What are the levels of integration? Which levels are most commonly implemented? Why?
- Who uses EILs and ETs. Why are they not always used?
- How is linear regression used in calculating EIL?

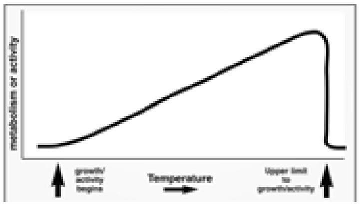
# Forecasting pest and vector outbreaks

- Monitoring and sampling provides an estimate of pest abundance and the stage of development, but the damaging stage may be other than that which is being monitored. It may be necessary to forecast the optimal time to initiate a management plan (e.g., adult emergence, egg hatch).
- Temperature and precipitation are the key elements in most forecasts, though habitat/food may be involved. Temperature is most often used for insect prediction, moisture for plant disease (fungi).

- Insect development is temperature driven, so temperature-based models are used for forecasts, particularly degree-day (day-degree) approaches.
- Basic premise is that a life stage requires a certain amount of heat in order to grow (a thermal constant). If it gets more heat it grows faster. There are upper and lower limits, but they are not often exceeded except in winter.
- Amount of heat required is expressed in degree-days. For example, assume the developmental threshold is 50°F, and egg development occurs in 10 days at 68 degrees.

  18 X 10 = 180 degree-days

  In this case, the total heat requirement (thermal constant) is always 180d-d, whether obtained as 18 degrees for 10 days or 9 degrees for 20 days, or another combination.



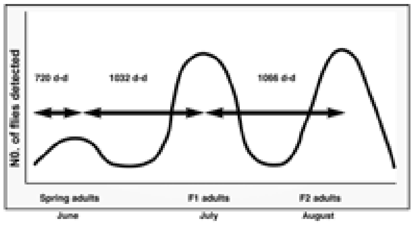
This is a typical temperature response curve for insects. Metabolism or activity of the insect is initiated at some low temperature (often about 7°C in temperate climates), increases in a linear manner up to some higher temperature (often 35-40°C), and then the insect goes into heat stress. The linearity of the temperature response over most of the temperature range makes prediction of temperature-limited growth and activity fairly easy.

# How are degree-day data used?

- By summing the temperature data daily, it is possible to estimate the amount of heat to which an insect has been exposed, thereby forecasting its development. In it’s simplest form

$$\frac{\text{Daily high + daily low}}{2} - \text{dev't threshold} = \text{d-d /day}$$

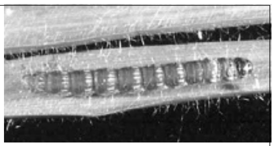
By summing the degree days over time, it is possible to estimate how far along insect development may be, and to predict developmental and behavioral events. Must know thermal constant, developmental threshold, and temperatures.



This graph show the flight activity of seedcorn maggot flies during the summer months. Note that the d-d interval between flight peaks is about the same (about 1050 d-d). The first peak (June) occurs 720 d-d after January 1 because the flies overwinter as pupae; i.e., they underwent part of their growth(the larval stage) the preceding year. Thus, for the first flight, fewer d-d are required for adult emergence.

- More complex models, including sophisticated weather monitoring technologies, increase reliability of predictions.
- Temperature is not the only variable. Flooding, rainfall, hurricanes, and water from snow-melt precede outbreaks of mosquitoes.
- Rainfall and other weather events also precedes outbreaks of grasshoppers, locusts and many cutworms/armyworms.

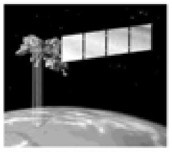
# Lesser cornstalk borer, and borer-days

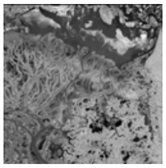

lesser cornstalk borer larva

- Lesser cornstalk borer is adapted for hot, dry conditions, and such weather favors occurrence of this pest.
- Sum of "borer days" is days when temperature exceeds 35°C ***and*** precipitation is less than 2.5 mm, less the number of days with temperature less than 35°C ***and*** precipitation equals or more than 2.5 mm. This sum of hot, dry days less cooler, dry days is indicative of borer numbers. If borer days exceed 10, borer problems are likely.

# Remote sensing: satellite imagery, GIS technology

- Remote sensing (particularly Landsat satellites) provides high resolution images that can be used to map habitat, flooding rainfall, soil types and condition, etc. GIS increases analytical abilities.
- Useful not so much in absolute prediction as in focusing monitoring by identifying possible loci of pest outbreak (bark beetles, locusts). Can elimination of foci prevent outbreaks?
- Remote sensing, GIS still mostly promise.


*Landsat 7 will gather remotely sensed images of the land surface and surrounding coastal regions.*


*A view of an estuary as seen from space.*

# Augmenting ecosystem resistance

- It is highly desirable to make landscape-level modifications to enhance the resistance of ecosystems to pest outbreak
  - Less monoculture, more diverse cropping
  - Inclusion of resistant host plant in cropping schemes
  - Crop rotation
  - Refugia for beneficial insects
  - Inclusion of beneficial nectar sources
  - Destruction of crop residues and weeds
  - Timely planting and harvesting


Weeds can be good nectar sources

# Organic farming

- Organic gardening, sustainable agriculture
- Defined as ecological production system that promotes biodiversity, biological cycles and biological activity. Uses minimal off-farm inputs, and restores ecological harmony.
- Minimizes use of synthetic chemicals, promoting natural plant nutrition,  natural pest management, and biorational pesticides.
- Promotes soil enhancement & plant health by green and animal manures, cover crops, composting, and mulching.

# Organic farming: allowed practices

- Companion planting
- Intercropping
- Crop rotation
- Cover crops
- Beneficial insects
- IPM monitoring
- Composting
- Mulching
- Altered planting schedules
- Sanitation
- Resistant varieties (not GMOs)
- Trap crops
- Physical barriers
- Solarization
- Trapping
- Tillage
- Burning
- Flooding
- “Natural” pesticides

# Natural pesticides for organic

- Beneficial insects and other organisms
- Biological pesticides (Bt, spinosad; not GMOs)
- Botanical pesticides (pyrethrum, rotenone, sabadilla, neem, ryania, garlic; not piperonyl butoxide)
- Dormant and summer oils (vegetable or animal-derived, some petroleum oils)
- Insecticidal soaps
- Mineral-based pesticides (sulfur, some copper, diatomaceous earth, kaolin)
- Pheromones

## Prohibited pest control materials in organic production

- Synthetic pesticides
- Heavy metal-based pesticides (arsenic, lead, sodium fluoaluminate)
- Synthetic wetting agents
- Nicotine sulfate and other tobacco products
- Strychnine

## Certification of organic producers

- Governmental (USDA in USA)
- Required if food labeled “organic”
- Applicant must provide history of land for previous 3 yrs, monitoring practices to be used, record-keeping, practices to prevent mingling with non-organic
- On-site inspections

## Are there data to support organic practices?

**Distribution of eggs (eggs per plant) deposited on collards bordered by companion plants in autumn crop**
**(after Latheef and Ortiz, Virginia State Univ.)**

| Companion plant | Imported cabbageworm | Cabbage looper |
|---|---|---|
| hyssop | 3.24 ab | 3.35 c |
| southernwood | 3.82 ab | 2.71 bc |
| tansy | 1.82 b | 0.71 d |
| wormwood | 5.49 a | 5.15 a |
| catnip | 4.47 ab | 5.51 abc |
| santolina | 2.69 b | 3.07 ab |
| control (none) | 0.80 c | 2.98 bc |

Means within a column followed by the same number are not significantly different.

# Are there data to support organic practices?

**Control of alfalfa weevil larvae 8 days after treatment with 3 conventional insecticides (pyrethroids) and several "organic" insecticides (after Galen Dively, Univ. MD)**

| Treatment | Rate/acre | No. larvae/5 sweeps |
|---|---|---|
| pyrethroid no. 1 | 6 oz | 39.8 b |
| pyrethroid no. 2 | 3.8 oz | 1.8 c |
| pyrethroid no. 3 | 1.9 oz | 1.8 c |
| spinosad | 36 g | 45.0 b |
| pyrethrum | 1.5 pt | 325.0 a |
| silicon dioxide + pyrethrin | 3.0 lb | 427.0 a |
| rosemary oil | 1 qt | 493.0 a |
| neem | 8 oz | 392.0 a |
| Beauveria bassiana | 0.75 qt | 504.8 a |
| Check (untreated) | | 450.8 a |

Means within a column followed by the same number are not significantly different.

# Are there data to support organic practices?

**Control of imported cabbageworm larvae with several "organic" insecticides (after Galen Dively, Univ. MD)**

| Treatment | Rate/acre | No. worms/10 heads | % marketable heads |
|---|---|---|---|
| pyrethrum | 32 oz | 3.5 b | 95.2 a |
| synergized pyrethrin | 7.5 oz | 1.1 bc | 90.7 ab |
| neem | 8 oz | 2.6 bc | 97.7 a |
| pyrethrum + neem | 32+8 oz | 0.6 c | 100 a |
| syner. pyrethrin + neem | 7.5+8 oz | 0.0 c | 97.7 a |
| Bacillus thuringiensis | 1.25 lb | 0.6 c | 100.0 a |
| spinosad | 36 g | 0.1 c | 97.5 a |
| check (untreated) | | 22.5 a | 63.2 b |

Means within a column followed by the same number are not significantly different.

# Are there data to support organic practices?

**Survival (% mortality) of Colorado potato beetles raised on plants receiving animal manure or synthetic fertilizer (Alyokhin and Atlihan, Univ. Maine)**

| | **Instar 1** | **Instar 2** | **Instar 3** | **Instar 4** | **Pupa** |
|---|---|---|---|---|---|
| **manure** | 12* | 2 | 0 | 32 | 18 |
| **no manure** | 3 | 0 | 0 | 29 | 20 |

*significantly different

# How effective are organic practices?

- Good for creating environment hostile to pests (small plots, biodiversity, fostering beneficials)
- Some practices (e.g., companion plants) seem ineffective
- Some practices (e.g., botanicals, oils) seem effective for certain situations
- Organic fertilizer as basis for environmental resistance uncertain

# Relevance of organic practices to IPM

- Considerable overlap
- Use of synthetic chemicals (fertilizer, pesticides) is major difference
- Organic producers are smaller, and seem to be more flexible, but usually not scientifically oriented

# Pesticide selectivity

- Although it is highly desirable to use insecticides/bioinsecticides that kill only pests, this is not often an option. Not much economic incentive to develop these.
- Better approach is to find ways to use broad-spectrum materials more selectively through selective placement and timing, or through reduced dosages.
- Often it is possible to use such selective placement or timing to shift the ratio of pests to beneficial insects to a more favorable ratio.

## Control versus eradication

- The IPM approach usually emphasizes lowering pest numbers to a tolerable level, rather than attempting to eliminate the pests. IPMers usually avoid the term “eradicate” (or Total Pest Management, TPM) to avoid creating unrealistic expectations.
- So is there a place for eradication in IPM?

## When is eradication logical?

- Eradication is usually not appropriate when confronted by extensive acreage, well established pests about which we know little, and solely insecticide-based elimination is involved.
- Eradication is worth considering when small acreage is infested by pests, we know much about them, and various options to monitor and control them are available.
- When the economic impact is extremely great, eradication becomes more feasible.

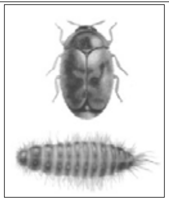
## Classic examples of eradication


The boll weevil,
Anthonomusgrandis Boheman

- Screwworm: The cost in the southern USA was so great that eradication was justifiable.
- Cotton boll weevil (not yet complete): In addition to direct economic impact, eradication may provide greater opportunity for level 3 or 4 IPM by removing a key pest.
- Mediterranean fruit fly eradicated several times from California and Florida because of potential cost.
- In all cases, biology well known and various technologies were available and used in an integrated manner.

# Less well-known eradications

- Khapra beetle from USA
- Egyptian armyworm from USA
- Tree termite from USA



Khapra beetle

- In these cases (and many others around the world), only insecticides were used because the infestations were small.
- If eradication is successful, the economic cost may be low in the long run, and environmental effects of eradication minimal. With elimination of a key pest, IPM may be more feasible for other pests.

# Implementing IPM

- Several issues limit adoption of IPM approaches in insect control. Two major types: technical and human.
- Technical limitations - e.g., lack of effective sampling techniques, economic thresholds, alternatives to insecticides
  - Mostly simply a matter of emphasis; these constraints are researchable and solvable; may already exist.
- Human limitations - e.g., risk aversion, independence, lack of motivation, lack of knowledge
  - These are personal and organizational issues that are more difficult (for scientists) to deal with effectively.

# Lack of motivation and risk aversion

- Pest management is, in most cases, a relatively small component of overall operational concern for crop and livestock producers, landscape management personnel, homeowners, and business people.
- There are many elements about which they are concerned, and over which they have little control (e.g., weather, commodity prices). Use of reliable pest management techniques such as insecticides reduces the risk of an unknown problem occurring. This is analogous to purchasing auto or home insurance. They avoid risk by purchasing "insurance" in the form of insecticide.

This is an example of tomato production costs in Florida. It is a situation with unusually high investment in insect control (insecticide), but represents no more than 13.8% of operating costs.

| | **Average cost ($ per acre/$ per hectare) during spring and autumn cropping seasons** | | | |
|---|---|---|---|---|
| | **Spring $/acre** | **$/hectare** | **Autumn $/acre** | **$/hectare** |
| OPERATING COSTS | | | | |
| transplants | 224 | 560 | 224 | 560 |
| fertilizer and lime | 326 | 815 | 326 | 815 |
| scouting | 35 | 87 | 35 | 87 |
| fumigant | 562 | 1,405 | 562 | 1,405 |
| fungicide | 175 | 437 | 267 | 667 |
| herbicide | 37 | 92 | 37 | 92 |
| insecticide | 381 | 952 | 488 | 1,220 |
| labor | 347 | 867 | 387 | 967 |
| machinery | 306 | 765 | 360 | 900 |
| interest | 121 | 302 | 696 | 1,740 |
| **Total operating cost** | $3,187 | $7,967 | $3,530 | $8,825 |

There are other costs to consider (see below). When other factors are considered, the cost of insecticide falls to 8.4% of preharvest costs, and 4.7% of total costs.

| | **Spring $/acre** | **$/hectare** | **Autumn $/acre** | **$/hectare** |
|---|---|---|---|---|
| FIXED COSTS | | | | |
| land rent | 300 | 750 | 300 | 750 |
| machinery | 212 | 530 | 255 | 637 |
| management | 715 | 1,787 | 787 | 1,967 |
| overhead | 894 | 2,235 | 984 | 2,460 |
| Total fixed cost | $2,122 | $5,305 | $2,328 | $5,820 |
| TOTAL PREHARVEST COST | $5,309 | $13,272 | $5,858 | $14,645 |
| HARVEST AND MARKETING COSTS | | | | |
| harvest and haul | 980 | 2,450 | 962 | 2,405 |
| packing | 2,590 | 6,475 | 2,312 | 5,780 |
| containers | 1,050 | 2,625 | 937 | 2,342 |
| marketing | 280 | 700 | 250 | 625 |
| Total harvest & marketing costs | $4,900 | $12,250 | $4,462 | $11,155 |
| TOTAL COSTS PER ACRE/HECTARE | $10,209 | $25,522 | $10,320 | $25,800 |

# Independence and lack of knowledge

- People often take pride in being independent of others, including crop consultants, and other private or public advisors.
- IPM is a knowledge-based system, requiring considerable knowledge or access to knowledge-based services.
- It often is easier to follow a schedule of prescribed (insecticide) treatments than to make the many decisions necessary to implement IPM.
- Chemical companies and applicator services often provide”free” advice on when and where insecticides need to be applied, freeing producers of intensive involvement in the decision-making. In most cases, independent crop consultants can provide more objective advice.

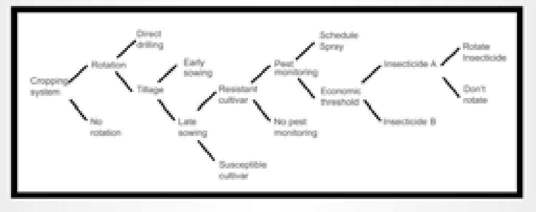
# Why IPM is not always used

| **Preventative (prophylactic) versus responsive (IPM) approaches** | |
|---|---|
| More risk aversion | Less risk aversion |
| Poor access to advice | Good access to advice |
| High managerial cost | Low managerial cost |
| Limited choice of controls | Wide choice of controls |
| High damage cost | Low damage cost |
| Poor natural control | Good natural control |
| Frequent pest attack | Infrequent pest attack |
| Multiple pest species | Few pest species |
| Monitoring difficult | Monitoring easy |

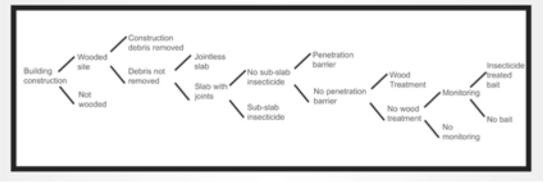
# Decision support

- IPM decision-making is not always an easy, one-step process, so decision-support systems, menus, and models have been developed to aid the process. Most information is
  - System (crop) specific.
  - Target (insect) specific.
  - Several actions (control techniques) are applied both in advance (preventatively) and in response (curatively), and sequentially or simultaneously.
  - Dependent on extensive research and financial investment.

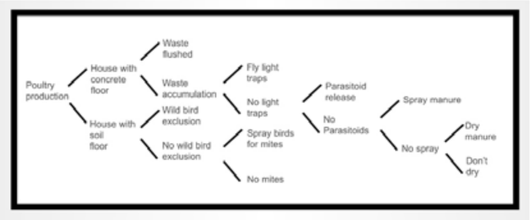
Some examples follow.



The sequence of pest management decisions that might be made by a farmer of a hypothetical grain crop, including some that the farmer might not perceive as influencing crop pest abundance and damage (adapted from Dent, 2000). The farmer has many opportunities to influence pest damage (including some not shown above), though once a problem develops, insecticides tend to be the principal curative action.



The sequence of pest management decisions that might be made in protecting a new house from attack by termites. Note that some of the construction practices have to be considered from the earliest stages of construction. Often consumers have no opportunity to be involved in anything but the post-construction decisions.



The sequence of pest management decisions that might be made in protecting a poultry production facility from mites and nuisance flies. What does wild bird exclusion have to do with mite control on hens?

# What speeds adoption of IPM?

- Peer (early-adopter) acceptance.
- Economic incentive not to use pesticides.
- IPM approaches adopted of necessity, due to
  - Pesticide resistance
  - Pesticides become too expensive
  - Regulatory constraints on pesticide use
    - worker protection
    - wildlife
    - cancellation of registrations

# Future of IPM

Over time, various approaches to pest management have been popular. Experience has shown that single-factor approaches rarely are adequate.

A better approach is to maximize environmental resistance by integrating various resistance factors, hopefully eliminating the need for curative actions.

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IPM is often misrepresented as being an environmentally-based approach. This is only part of the story, and it is as much about profits as ecology.

It is also a knowledge-intensive approach to pest management, and very much depends on education.

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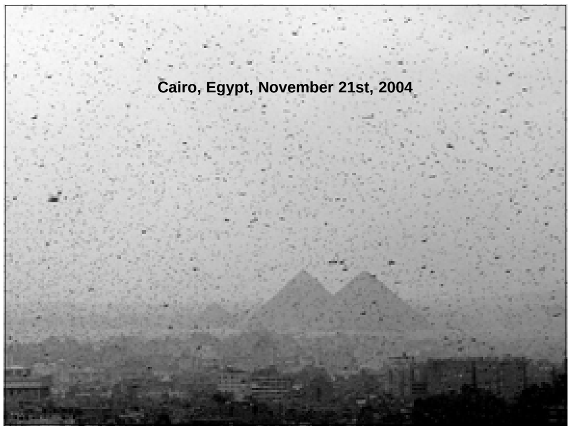
## Desert Locust:

## A Major Threat to Agriculture in Africa, and Current Methods of Management

Adapted From a Presentation by Dr. Abderrahmane Hilali,
National Center for Desert Locust Control,
Agadir, Morocco

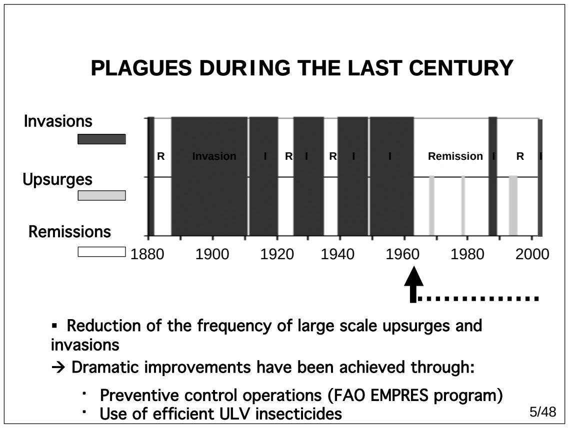


Cairo, Egypt, November 21st, 2004

*"They shall cover the surface of the land, so that no one will be able to see the land. They shall devour the last remnant left you after the hail, and they shall devour every tree of yours that grows in the field."*

*Exodus 10:5*

***Schistocerca gregaria*** ***Locusta migratoria***



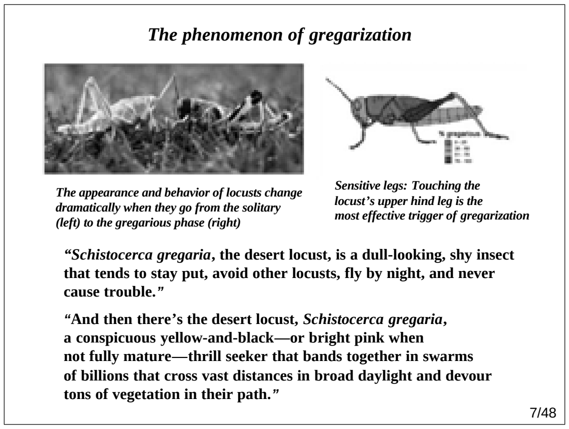
## PLAGUES DURING THE LAST CENTURY

- Reduction of the frequency of large scale upsurges and invasions

→ Dramatic improvements have been achieved through:

  - Preventive control operations (FAO EMPRES program)
  - Use of efficient ULV insecticides

- What is a Desert Locust?
- Life cycle
- Areas of breeding and invasion
- Organization of control operations
- View of the 2004/2005 invasion



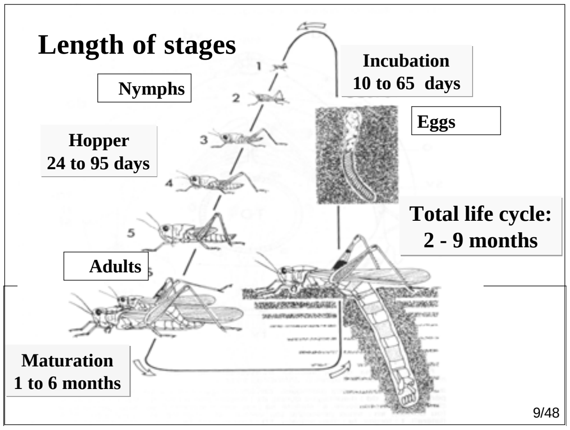
### *The phenomenon of gregarization*

*The appearance and behavior of locusts change dramatically when they go from the solitary (left) to the gregarious phase (right)*

*Sensitive legs: Touching the locust's upper hind leg is the most effective trigger of gregarization*

**"*Schistocerca gregaria*, the desert locust, is a dull-looking, shy insect that tends to stay put, avoid other locusts, fly by night, and never cause trouble."**

**"And then there's the desert locust, *Schistocerca gregaria*, a conspicuous yellow-and-black—or bright pink when not fully mature—thrill seeker that bands together in swarms of billions that cross vast distances in broad daylight and devour tons of vegetation in their path."**



## Length of stages

**Incubation**
**10 to 65 days**

**Nymphs**

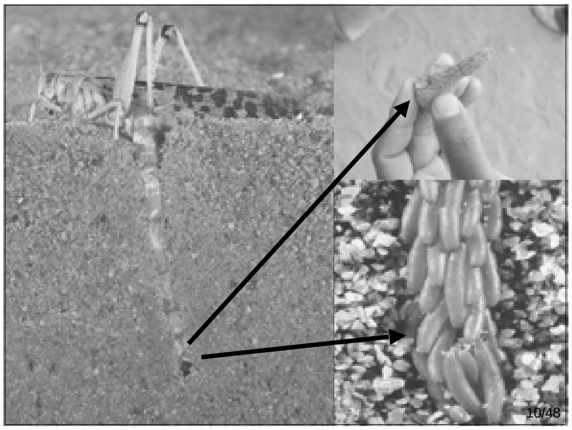
**Eggs**

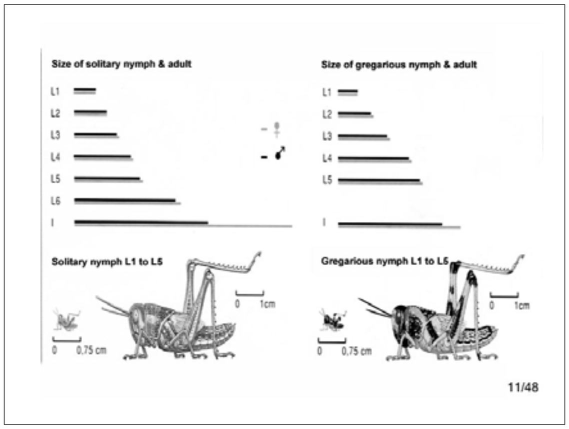
**Hopper**
**24 to 95 days**

**Total life cycle:**
**2 - 9 months**

**Adults**

**Maturation**
**1 to 6 months**



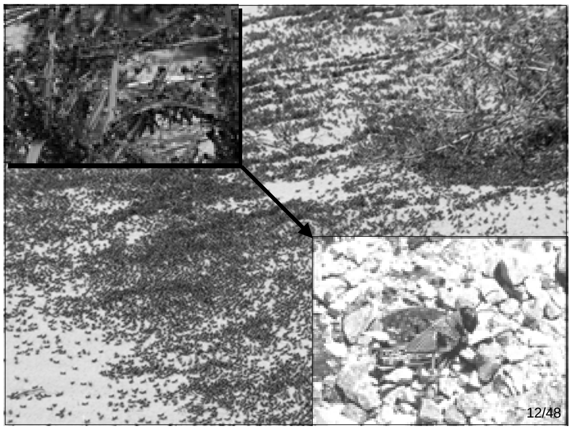


Size of solitary nymph & adult

Size of gregarious nymph & adult

Solitary nymph L1 to L5

Gregarious nymph L1 to L5

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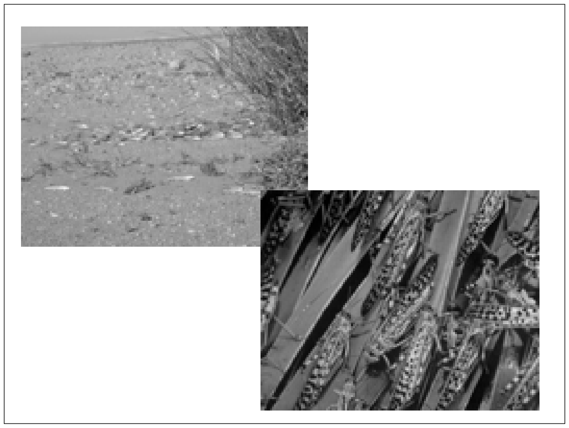
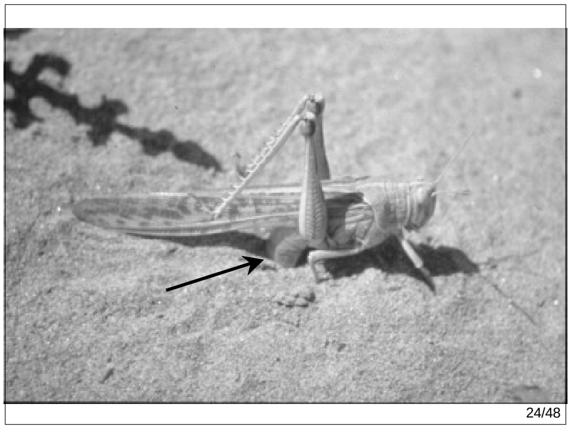
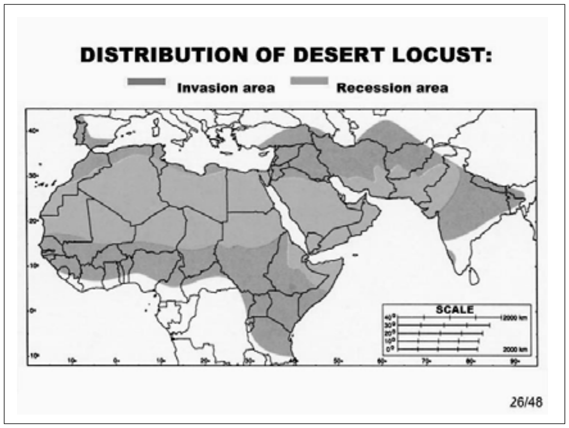
Young adult of *Schistocerca gregaria,* gregarious form

Mature adult of *Schistocerca gregaria*, gregarious form

1 sq. km may contain 5 million insects

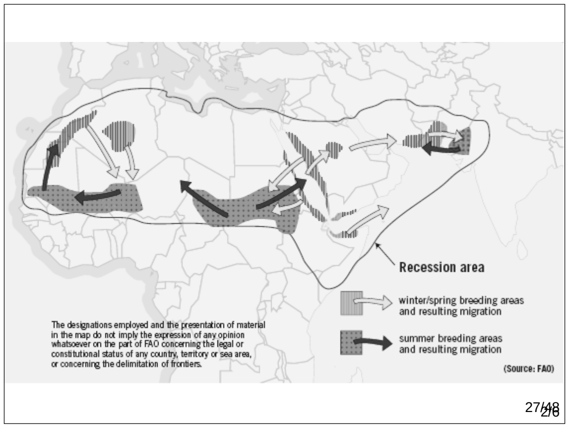






DISTRIBUTION OF DESERT LOCUST:

Invasion area Recession area



The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

(Source: FAO)

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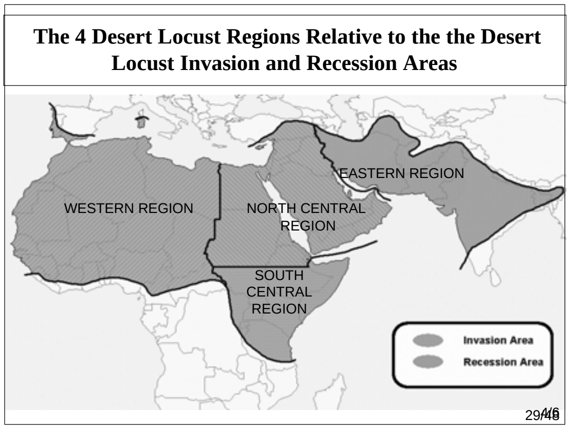

### The 4 Desert Locust Regions Relative to the the Desert Locust Invasion and Recession Areas

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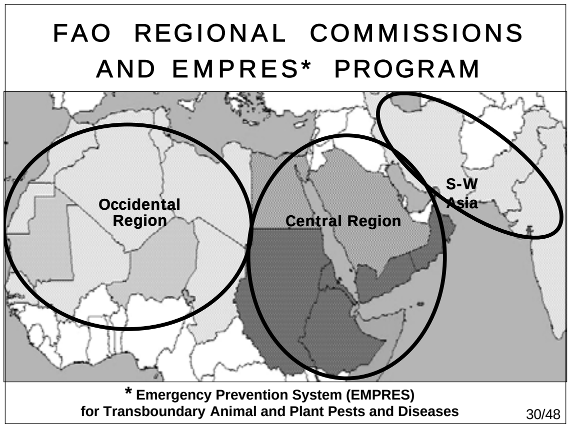

### FAO REGIONAL COMMISSIONS AND EMPRES* PROGRAM

* Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases

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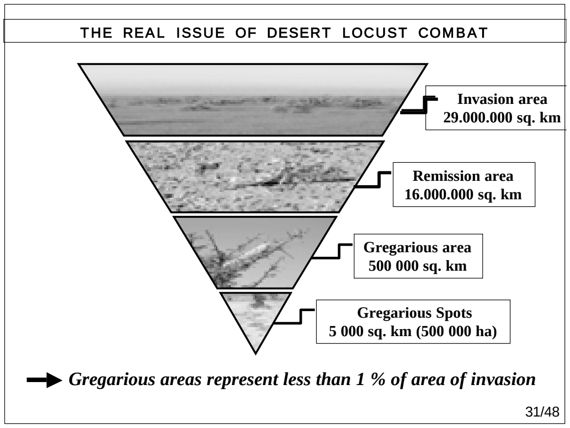


THE REAL ISSUE OF DESERT LOCUST COMBAT

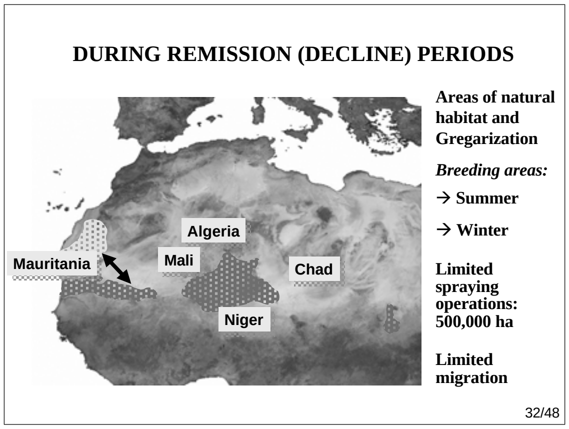
**Invasion area**
**29.000.000 sq. km**

**Remission area**
**16.000.000 sq. km**

**Gregarious area**
**500 000 sq. km**

**Gregarious Spots**
**5 000 sq. km (500 000 ha)**

→ ***Gregarious areas represent less than 1 % of area of invasion***



## DURING REMISSION (DECLINE) PERIODS

**Areas of natural habitat and Gregarization**

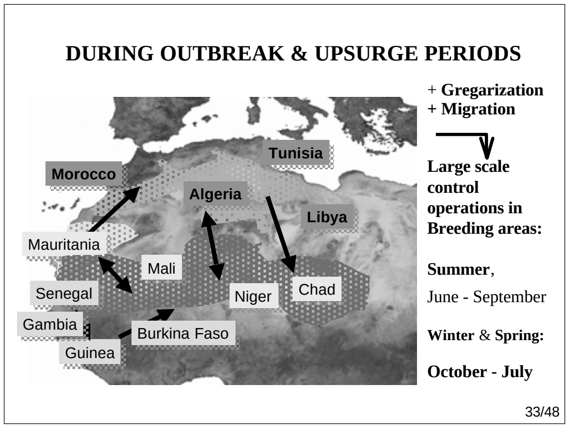
***Breeding areas:***

→ **Summer**

→ **Winter**

**Limited spraying operations: 500,000 ha**

**Limited migration**



## DURING OUTBREAK & UPSURGE PERIODS

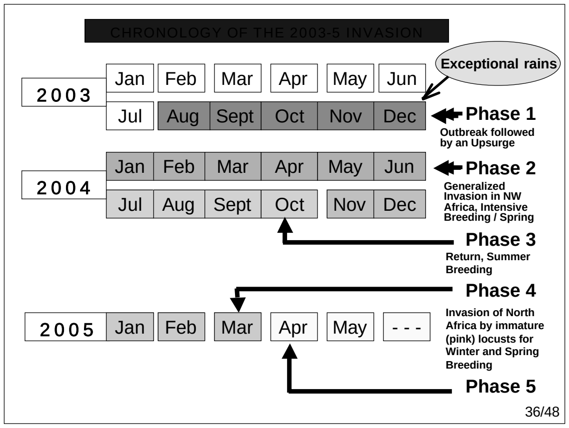
**+ Gregarization**
**+ Migration**

**Large scale control operations in Breeding areas:**

**Summer**,
June - September

**Winter** & **Spring:**

**October - July**



## CHRONOLOGY OF THE 2003-5 INVASION

| | | | | | | |
|---|---|---|---|---|---|---|
| 2003 | Jan | Feb | Mar | Apr | May | Jun |
| | Jul | Aug | Sept | Oct | Nov | Dec |
| 2004 | Jan | Feb | Mar | Apr | May | Jun |
| | Jul | Aug | Sept | Oct | Nov | Dec |
| 2005 | Jan | Feb | Mar | Apr | May | - - - |

Exceptional rains

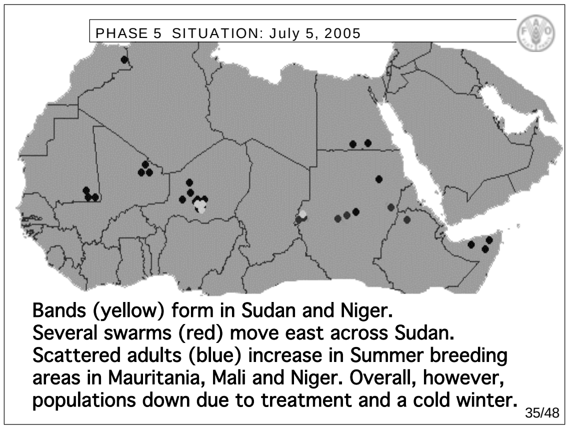
**Phase 1**
Outbreak followed by an Upsurge

**Phase 2**
Generalized Invasion in NW Africa, Intensive Breeding / Spring

**Phase 3**
Return, Summer Breeding

**Phase 4**
Invasion of North Africa by immature (pink) locusts for Winter and Spring Breeding

**Phase 5**

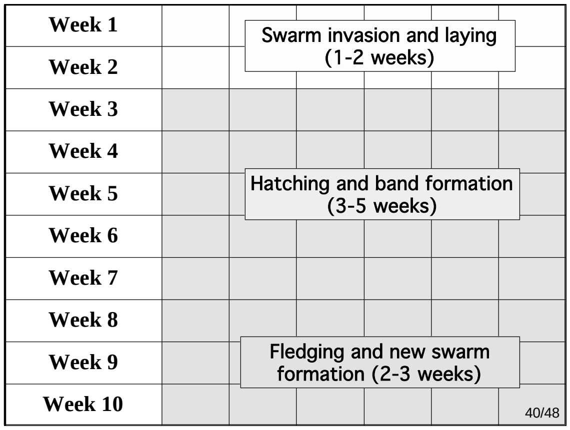


## PHASE 5 SITUATION: July 5, 2005

Bands (yellow) form in Sudan and Niger.
Several swarms (red) move east across Sudan.
Scattered adults (blue) increase in Summer breeding areas in Mauritania, Mali and Niger. Overall, however, populations down due to treatment and a cold winter.

## LOCUST CONTROL REQUIREMENTS:

1. Biology & behavior
2. Survey, monitoring
3. Information & forecasting
4. Control operations (pesticides)
5. Campaign organization & execution
6. Safety & environmental precautions



Week 1

Week 2

Week 3

Week 4

Week 5

Week 6

Week 7

Week 8

Week 9

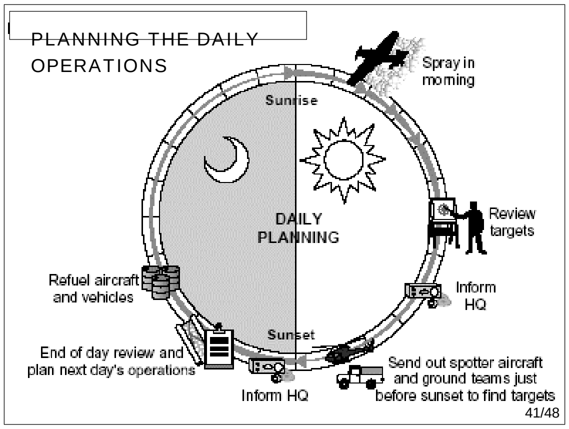
Week 10

Swarm invasion and laying (1-2 weeks)

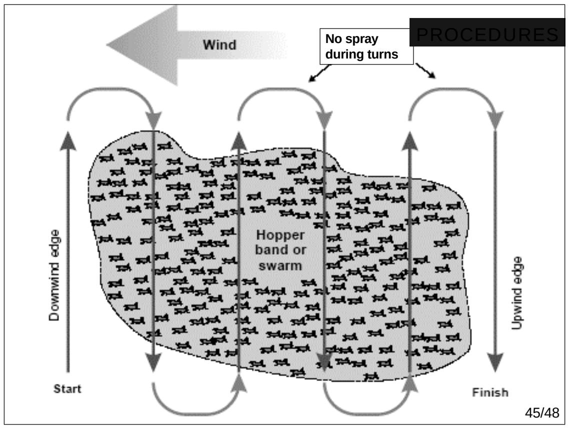
Hatching and band formation (3-5 weeks)

Fledging and new swarm formation (2-3 weeks)

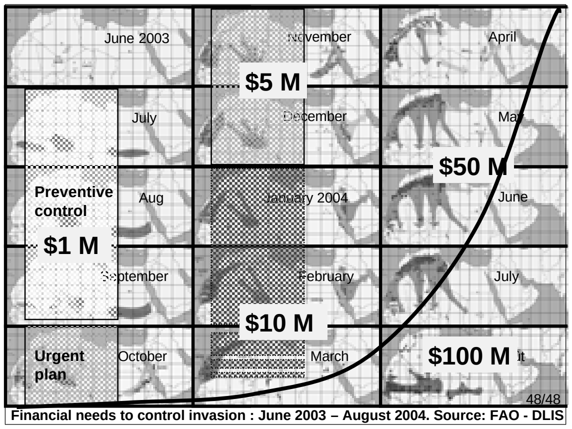
PLANNING THE DAILY OPERATIONS



ORGANIZATION OF CONTROL OPERATIONS



## PROCEDURES



Financial needs to control invasion : June 2003 – August 2004. Source: FAO - DLIS

Moroccan strategy in controlling Desert locust plagues is based on 5 principles:

1. An multi-institutional and multi-disciplinary organization bringing together the authority and capacity of several administrations in a perfect synergy;
2. Mobilizing all means and taking all necessary steps and measures to localize, monitor and destroy desert locust swarms as soon as they cross the borders;

## Moroccan strategy :

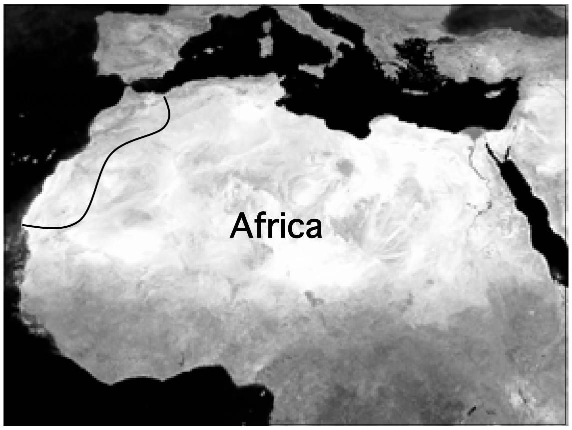
*(Continued)*

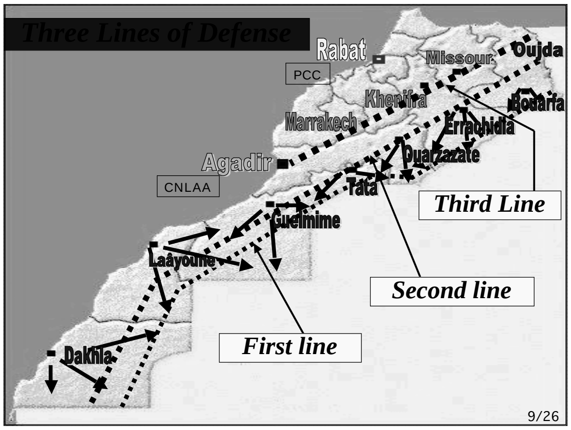
3. Ensure a continuous training program to DL control technical staff (whatever the administration to which they belong) and maintain active research activities;
4. Dedicate exclusive equipment (vehicles, sprayers, field tools, camping material, etc.) to the DL control system and ensure their permanent maintenance;
5. Keep up with international development of DL activities around the world, exchange information and promote regional cooperation (through FAO regional Commissions) especially with neighboring countries.

## History and Impact :

- During the 20th century, Morocco went through 5 major invasions, each lasting 2 to 7 years;
- The last one (1988-89) resulted in the treatment of over 5 million hectares (ha).
- In 1987-1989, Morocco spent more than $100 million in control operations, of which, $15 million was from international aid.

*1933 Act*
*1950 Creation and development of the AGADIR Desert Locust Control Center.*



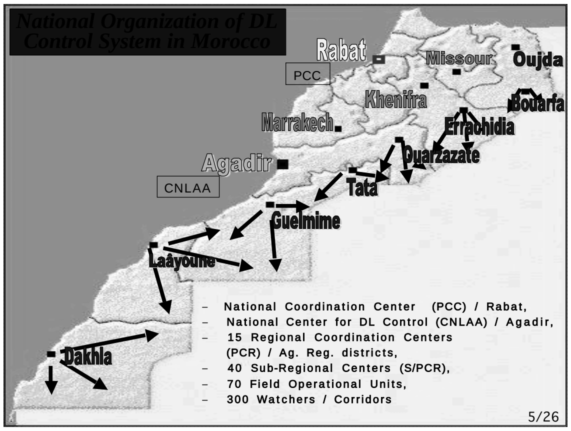


## Three Lines of Defense

*Third Line*

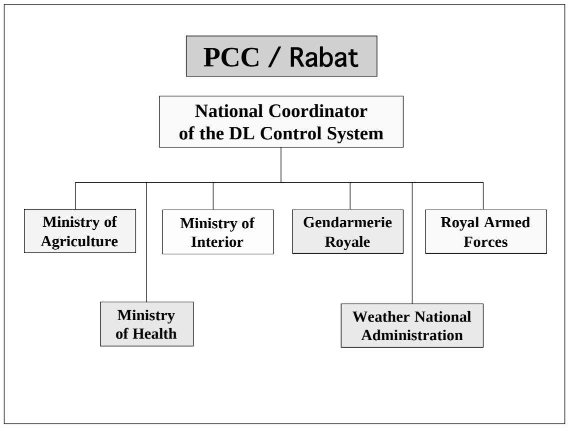
*Second line*

*First line*



## National Organization of DL Control System in Morocco

- National Coordination Center (PCC) / Rabat,
- National Center for DL Control (CNLAA) / Agadir,
- 15 Regional Coordination Centers (PCR) / Ag. Reg. districts,
- 40 Sub-Regional Centers (S/PCR),
- 70 Field Operational Units,
- 300 Watchers / Corridors



## PCC / Rabat

**National Coordinator of the DL Control System**

- Ministry of Agriculture
- Ministry of Interior
- Gendarmerie Royale
- Royal Armed Forces
- Ministry of Health
- Weather National Administration

## Human and material resources

### 1. Human resources:

The locust control mobilizes specialized personnel in many areas: plant protection, aviation, transmissions, health, meteorology, etc., assisted by administrative staff, in particular from the local authorities;

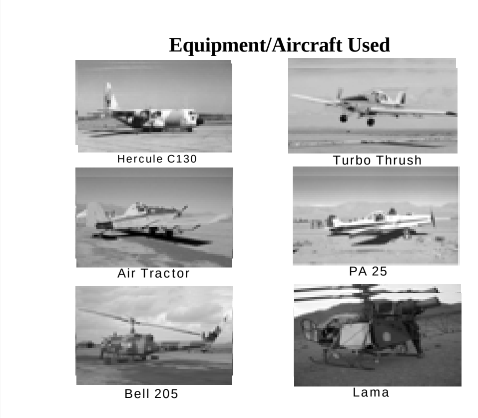
Currently, beside labor, about 2,000 people, more than 1,000 government employees are on duty:

| PCRs | Agriculture | Interior | Royal Gendarmerie | Health | R.A.F. | Total |
|---|---|---|---|---|---|---|
| Total | 580 | 200 | 150 | 55 | 90 | 1,075 |

## Survey operations

The swarms are reported by:

- Royal Armed Forces staff stationed at the control posts on the border;
- Local authorities and the inhabitants of the villages and oases of the border areas;
- Surveillance teams (plant protection staff) who position, monitor and decide - with the other PCR members and the PCC - the way swarms should be handled and/or sprayed;



## Equipment/Aircraft Used

Hercule C130

Turbo Thrush

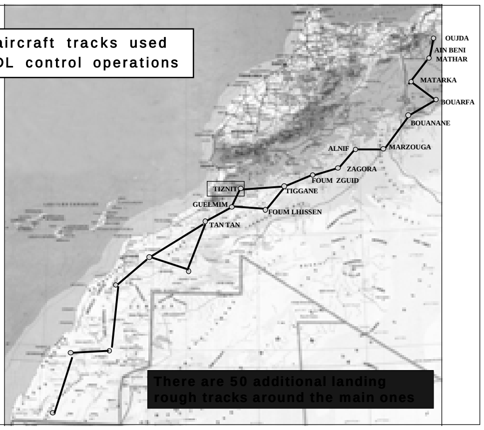
Air Tractor

PA 25

Bell 205

Lama

Main aircraft tracks used in the DL control operations

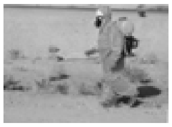


There are 50 additional landing rough tracks around the main ones

## LAND SPRAYING EQUIPEMENT

Ulvamast Sprayer

Sprayer Micronair AU 8115



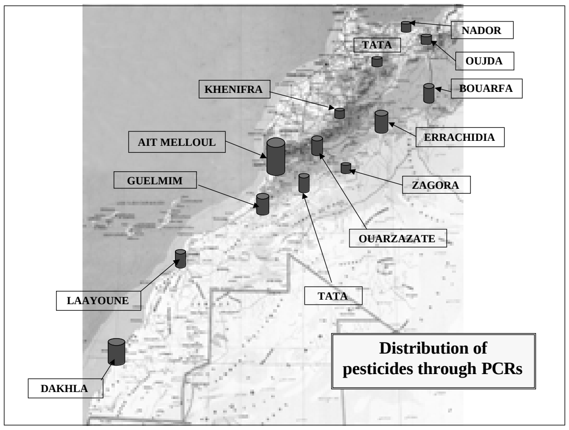
Back held motor – sprayer

Kits for blood analysis

## Pesticides :

Pesticides used are those recommended by FAO and WHO. They are the least toxic to human health and the environment, if used properly:

- *Malathion* (Malathion 96%);
- *Chlorpyriphos* (Dursban 240).
- *Deltamethrine* (Decis EC & ULV);



Distribution of pesticides through PCRs

## Spraying efficiency assessment

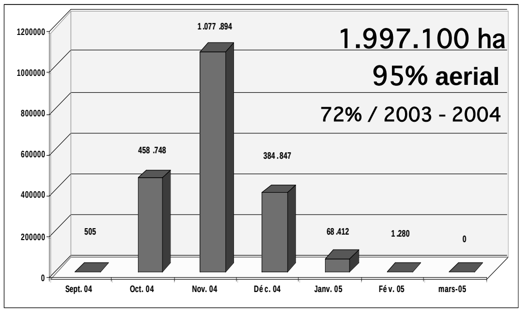
- After each spraying, locust efficiency is evaluated;
- The geographic position data of the sprayed area, where swarms of mature locusts have landed, are registered (GPS);
- A computer program allows forecast of egg hatching, and therefore survey and control operations against hoppers.

## Staff health care

Health preservation of workers in contact with pesticides is a major concern to the Moroccan DL control system:

- Wearing protective clothing is obligatory;
- Medical check-up and blood analyses are organized on a regular basis;
- Field teams are provided with medical first aid kits.

## Area sprayed between Sept. 04 and March 05



1.997.100 ha

95% aerial

72% / 2003 - 2004

## Financial contribution of international community

Bilateral contributions from donors were:

- Spain: $ 2.3 M, used to pay rented aircrafts;
- Korea: $1 M used to buy 4-WD vehicles;
- Netherlands: $1.5 M, used to acquire vehicles and spraying equipment;
- USAID: $3.2: used to buy vehicles, sprayers and field equipment;
- FAO ( its own resources): 776,000 $US

## More questions about IPM

- What are the key elements involved in forecasting pest occurrence?
- How are degree-days calculated and used in IPM?
- Why is remote sensing not employed more routinely?
- What can be done to foster resistance of the entire ecosystem to pests abundance/damage?
- How can pesticide selectivety be enhanced?
- Does eradication fit in with IPM? When?
- If IPM is so beneficial, why is it not used more?

## Questions from supplementary readings

- Reading 9, EIL and ET
  - Why are dynamic EILs not often used?
  - Are environmental costs routinely considered when establishing EILs?
  - What is a nominal threshold?
  - How does a fast-acting control agent affect the position of the ET to the EIL?

## Questions from supplementary readings

- Reading 16, thrips management
  - What are the vectors of tomato spotted wilt in Georgia?
  - What is the relationship between thrips abundance and wilt symptoms; between thrips numbers and yield?
  - What was more damaging, early or late infestation by thrips?
  - What are the benefits of host plant resistance, reflective mulch and insecticides? Do benefits vary with tomato spotted wilt incidence?

# Questions from supplementary readings

- Reading 26, entomopathogenic nematodes
  - Why is knowledge about the compatibility of nematodes with insecticides considered important? After all, these are insecticides, not nematicides.
  - Are insecticides compatible with nematodes? Does your answer vary with the method of evaluation?
  - Based on these studies, is it important to integrate application of insecticides and nematodes?

# Videos

Please watch the following videos found on the Video section of the CD:

- Reduced Spraying
- Foilage Plants and Biological Control
- Tomatoes and Cultural Control
- Locusts in Morocco