

The Current Global Situation and Challenges of RPW Management Programs

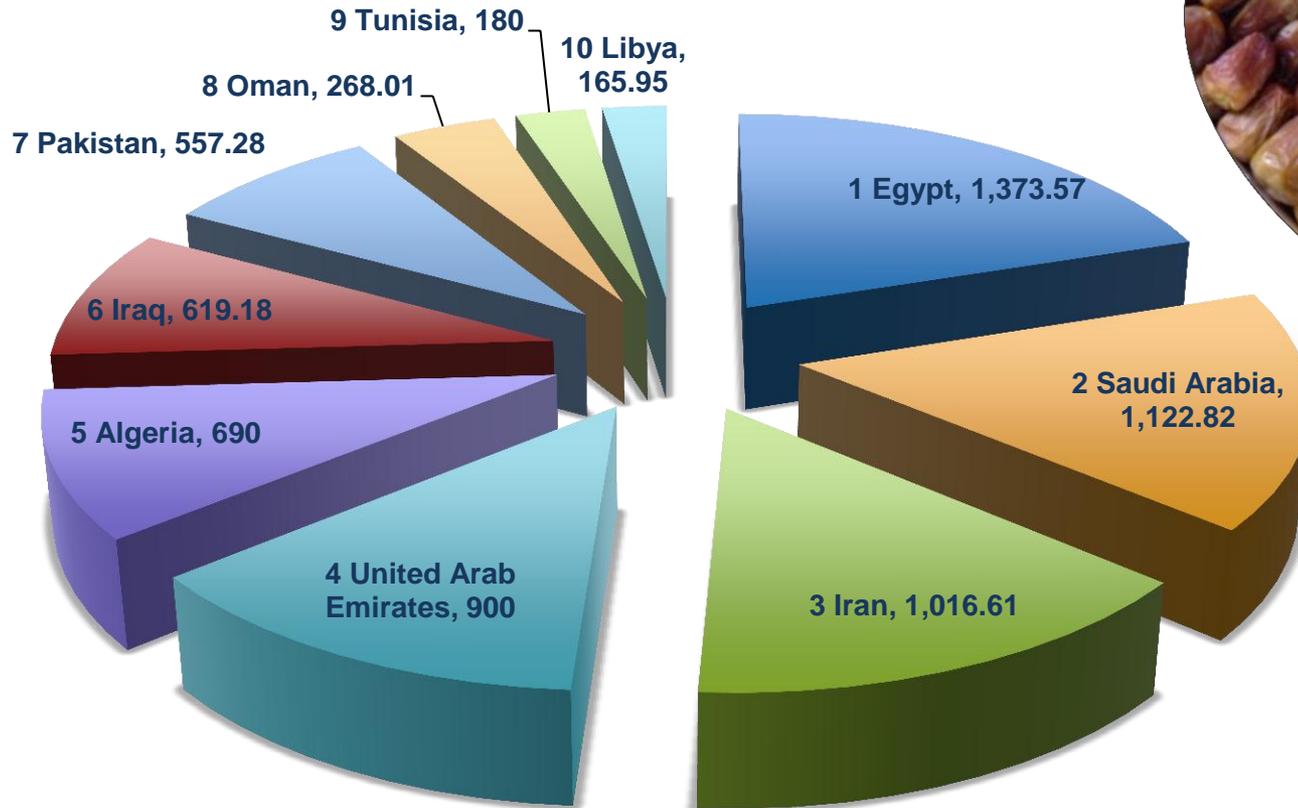
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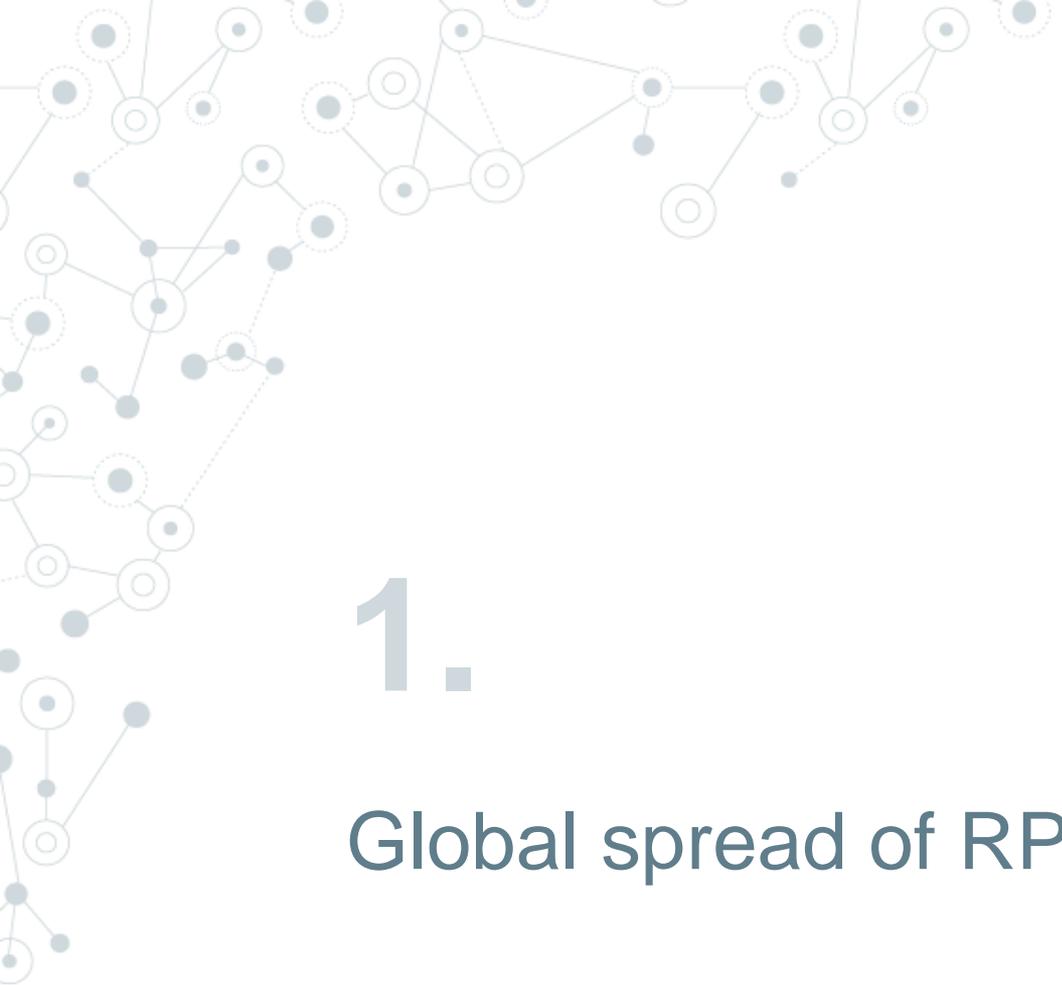
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Scientific Consultation and High-Level Meeting on Red Palm
Weevil Management, FAO-UN, Rome, Italy, 29-31 March 2017

World Top 10 Date Fruit Producing Countries 2011 (Production in 1000 MT)



(Source: UN FAO updated on Feb 9, 2016)

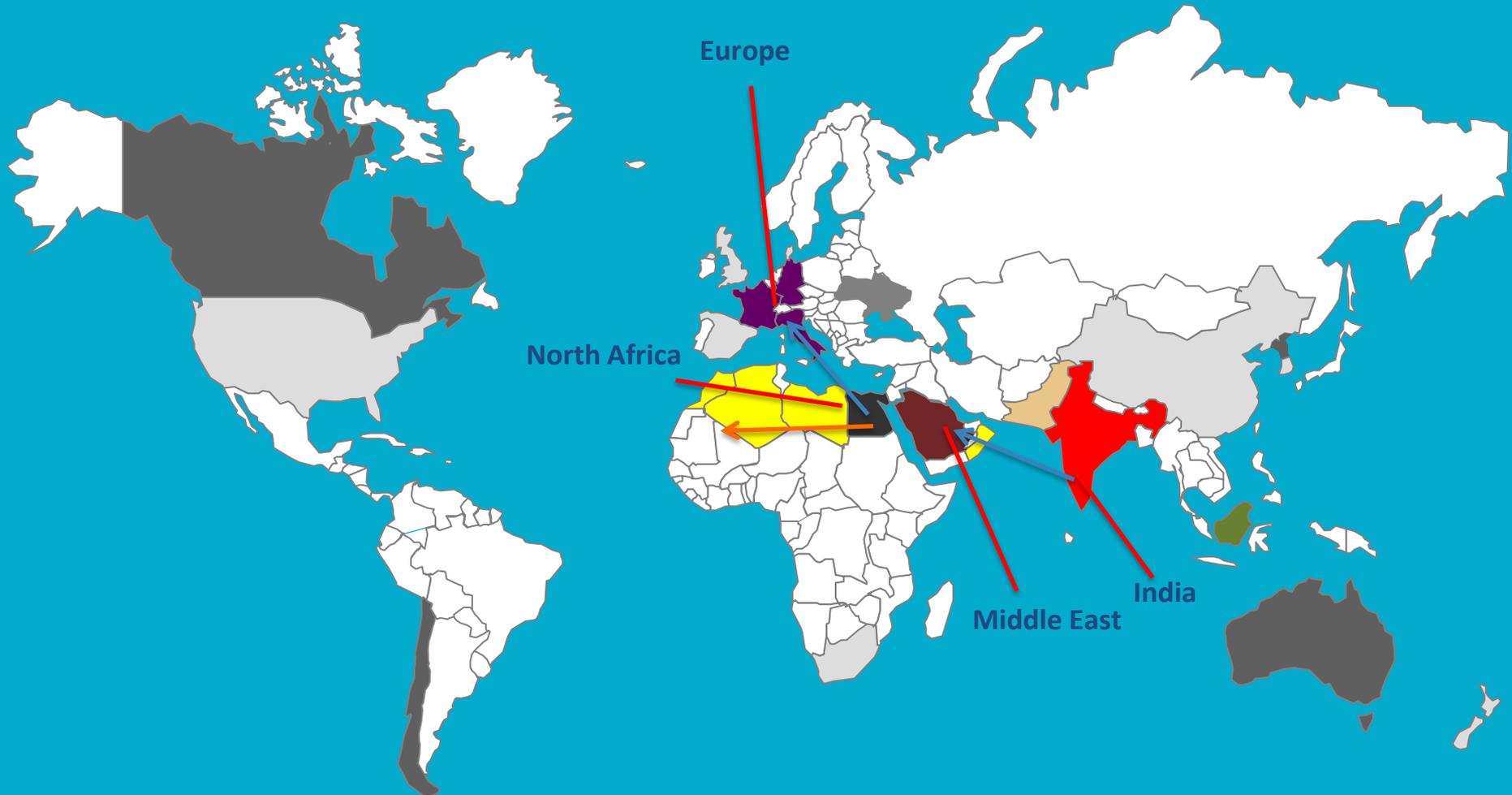
A decorative network diagram in the top-left corner, consisting of various sized circles (nodes) connected by thin lines (edges). Some nodes are solid grey, while others are hollow with a grey outline. The connections form a complex, branching structure.

1.

Global spread of RPW

A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It features a collection of nodes of different sizes and styles (solid grey, hollow grey) interconnected by a web of thin lines, creating a complex, organic-looking structure.

RPW Distribution World Wide





2.

Host range, biology, ecology,
symptoms and damage



Adult and Larval stages of RPW



Adult



Eggs



Pupal Cocoons from infested palm



Larvae in boxes

Damage symptoms in date palms



Toppled crown of date palm



Early infestation



infestation

Medium



Medium infestation



An adult weevil trying to hide in the leaf bases



Medium damaged palm



Damage below the crown.



Quotes of Norman Borlaug

“Food is the moral right of all who are born into this world”.

“There are no miracles in agricultural production.”

“If people want to believe that the organic food has better nutritive value, it's up to them to make that foolish decision. But there's absolutely no research that shows that organic foods provide better nutrition.”

A decorative network diagram in the top-left corner, consisting of various sized circles (nodes) connected by thin lines (edges). Some nodes are solid grey, while others are hollow with a grey outline. The network is dense and irregular, extending from the top-left towards the center of the page.

3.

Socio-economic and environmental impact

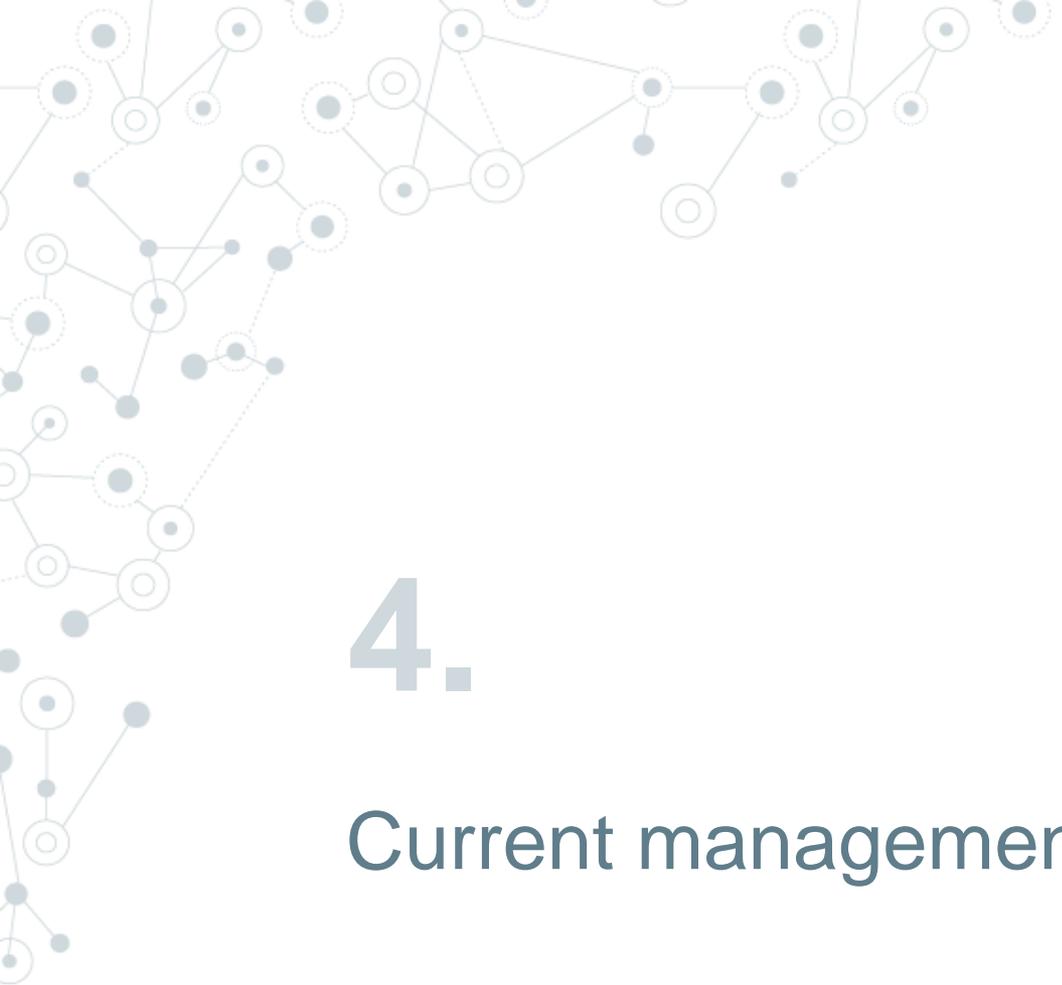
A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It features a cluster of nodes and connecting lines, with some nodes being solid grey and others hollow. The diagram is positioned in the lower right quadrant of the page.

Estimated Economic losses

- Cost of treatment for 115,000 palms (@200) SR 23,000,000
- Cost of removal for 115,000 palms (@200) SR 23,000,000
- Cost of new offshoots (115,000 @SR400) SR 46,000,000
- Estimated yield loss for 5yr SR 129,375,000

Grand total SR 221,375,000 or **\$59,033,333**

*Assumption is that about 1% of total palms are affected out of total 23 million palms and of that 50% is treated and remaining 50% removed

A decorative network diagram in the top-left corner, consisting of various sized nodes (some solid, some hollow) connected by thin lines, forming a complex web structure.

4.

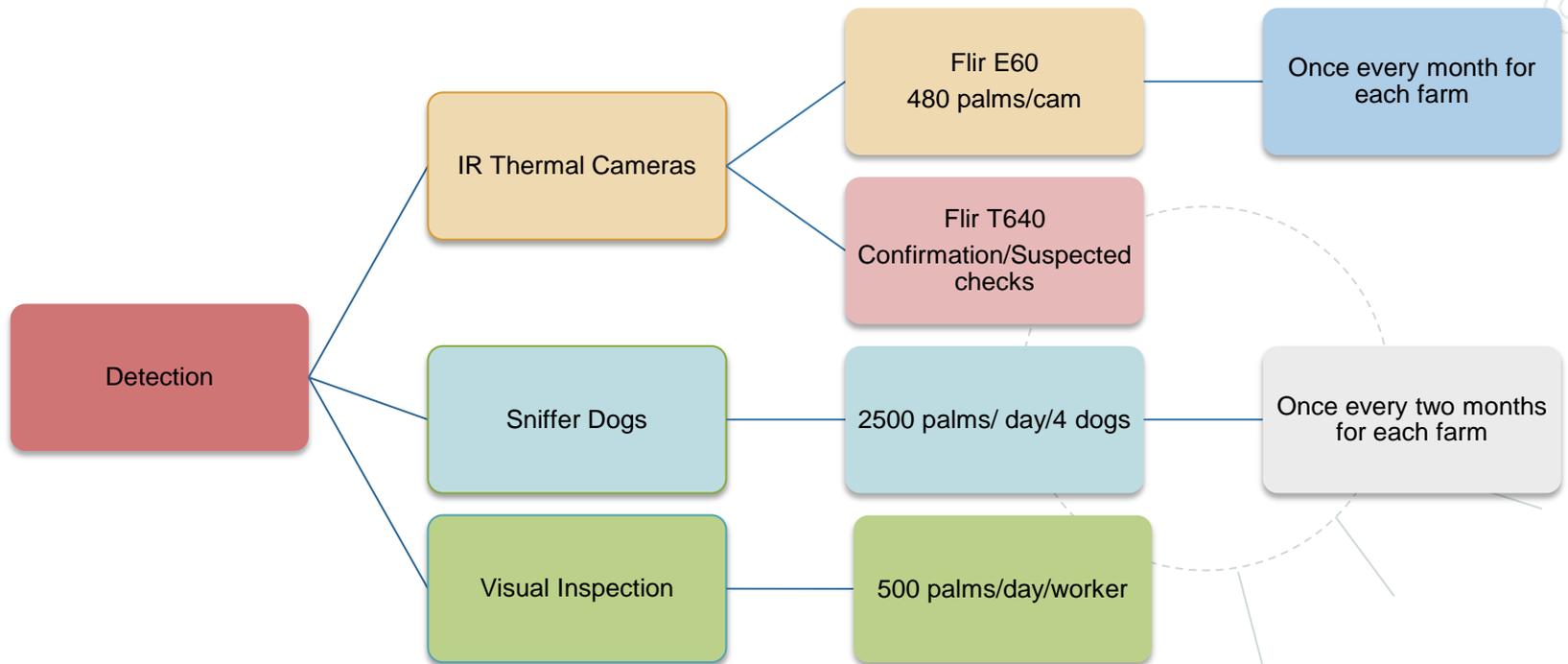
Current management practices

A decorative network diagram in the bottom-right corner, similar to the one in the top-left, with nodes and connecting lines.

IPM Method for RPW in Practice

- ◎ Prophylactic methods
- ◎ Mechanical methods
- ◎ Chemical treatment methods
- ◎ Stem injections
- ◎ Pheromone mass trapping methods
- ◎ Biological methods
- ◎ Microwave technique
- ◎ Any other method

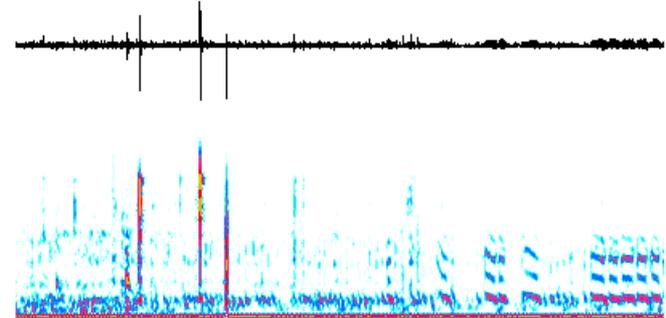
RPW – IPM – Detection Methods - Projected



Acoustic Detection methods

A

Laar WD 60 : High end amplifying system with special probe sensor sound activities from 50 Hz up to 250 kHz. Laar TCE 1 detector. Contact microphone, airsound ultrasound microphone, contact acceleration sensor and a combined contact airsound probe sensor. (Laar Tech Inc, Germany, 2004)



B

- ✓ The SP-1 sensor is magnetically attached to a nail inserted into the soft palm wood.
- ✓ The nail acts as a “waveguide” to conduct the sounds from RPW larvae feeding inside stem.

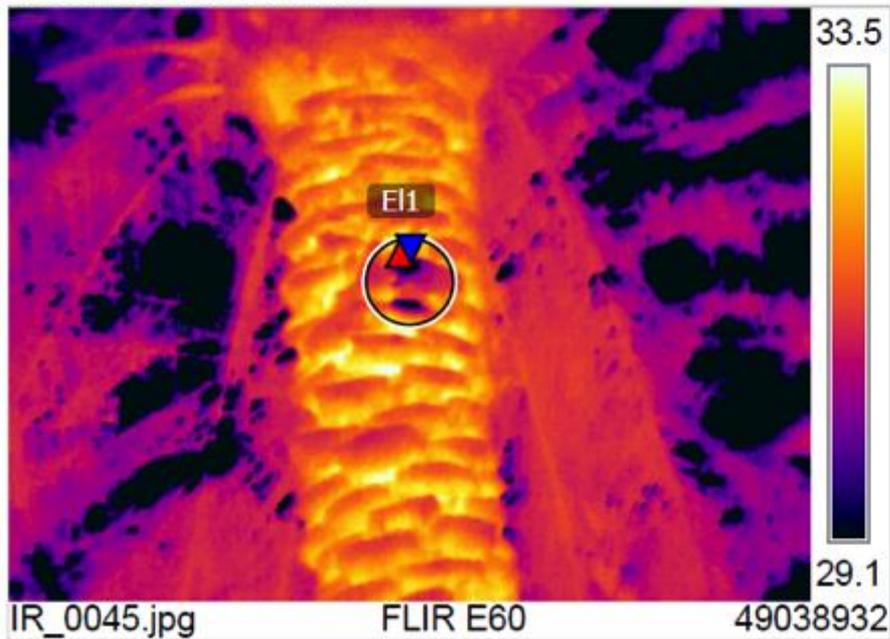
C

- ❑ Acoustic signals of boring RPW larvae recorded using off-the-shelf recording devices.
- ❑ Discrimination of RPW signals from those emitted by healthy palms is still difficult.
- ❑ The methodology applied was similar to speech recognition techniques, utilizing Vector Quantization or Gaussian Mixture Modeling.



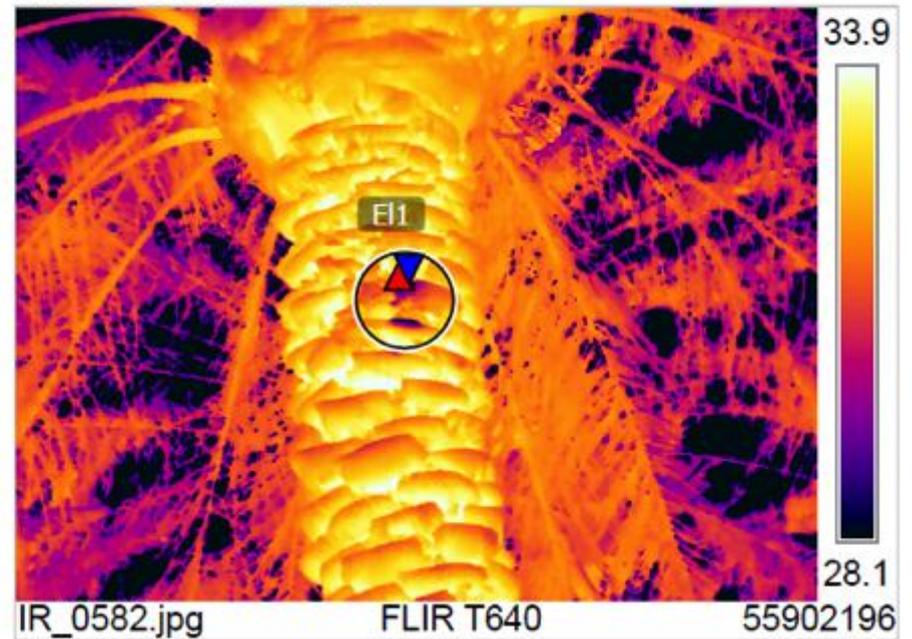
IR Camera Thermal Images of RPW damage

8/19/2013 12:31:11 AM



Measurements			°C
E1	Max	33.5	
	Min	25.5	
	Average	31.3	

8/19/2013 12:20:33 AM



Measurements			°C
E1	Max	34.6	
	Min	22.9	
	Average	32.1	

X-ray technology for detection of RPW inside the stem

- ⦿ A Private Company based in UAE has developed X-ray type machine with international collaboration for detection of early stages of red palm weevil.
- ⦿ This innovation received international Khalifa Award in 2010.
- ⦿ Due to lack of funds the validation and field studies were stopped.
- ⦿ An Italian Company involved in timber scanned with x-ray devices is also interested in developing new technology



Dogs sniffing offshoots



sniffer dog checking in field



sniffer dog inspecting offshoots

Case study in the inspection of palms in Al Qassim, KSA by trained workers & Sniffer dogs

Date Palms Infested by RPW Near New Project 1,2,3 in Qassim, Saudi Arabia

S.No.	Area (5KM) around the New project 1	Total Palms	Daily Achieved Detection	Cumulative inspection	Remaining palm trees	Daily Infested Palms	Total Infested Palms	The actual percentage of infested palms after examination
1	F1 - F60	1,24,346		1,24,346	5,000		22,205	17.9
2	F1 - F60	1,24,346	4,787	29,477	86,630	7	90	0.3
Grand Total							22,295	18.2

Date Palms Infested by RPW Near New Project 2,3

S.No.	area(5)KM around the New project 2,3	Total Palms	Daily Achieved Detection	Cumulative inspection	Remaining palm trees	Daily Infested Palms	Total Infested Palms	The actual percentage of infested palms after examination
1	F1 - F47	1,64,474	2,400	62,359	1,02,115	0	729	1.2
Grand Total							729	1.2

Stem Injection to Save Tree

- ⦿ The holes are made to a depth of 10" depending on the injury. The diameter of each hole will be about 2cm. Appropriate drill bits will be used to make holes.
- ⦿ The battery charged drill may be used for making holes.
- ⦿ The pesticides recommended for injection are 1. Fipronil 2. Deltamethrin 3. Dozer etc.
- ⦿ The pesticide solution with these pesticides should be made of about 2% concentration of a.i.
- ⦿ After injection by this conventional method the wound area as well as the entire palm and will be sprayed with pesticide at a dose of 2ml/1L of water with the above pesticides, to kill any hiding adults in side the crown and crevices of the palm.
- ⦿ All adjoining healthy palms will be sprayed from the crown downwards up to the base of the stem to kill any insects.
- ⦿ After injection the palms will be watched at weekly intervals to take any further follow up action. If any fresh infestation is noticed in the same palm another round injection is given in the same way as described above.
- ⦿ In future when high pressure injection machines are purchased we will calibrate them provide a special manual for the sake of our supervisors.

Types of Injectors (pictures)



Drilling of holes



Administering Insecticide with bottle



Unit of high pressure Stem Injection

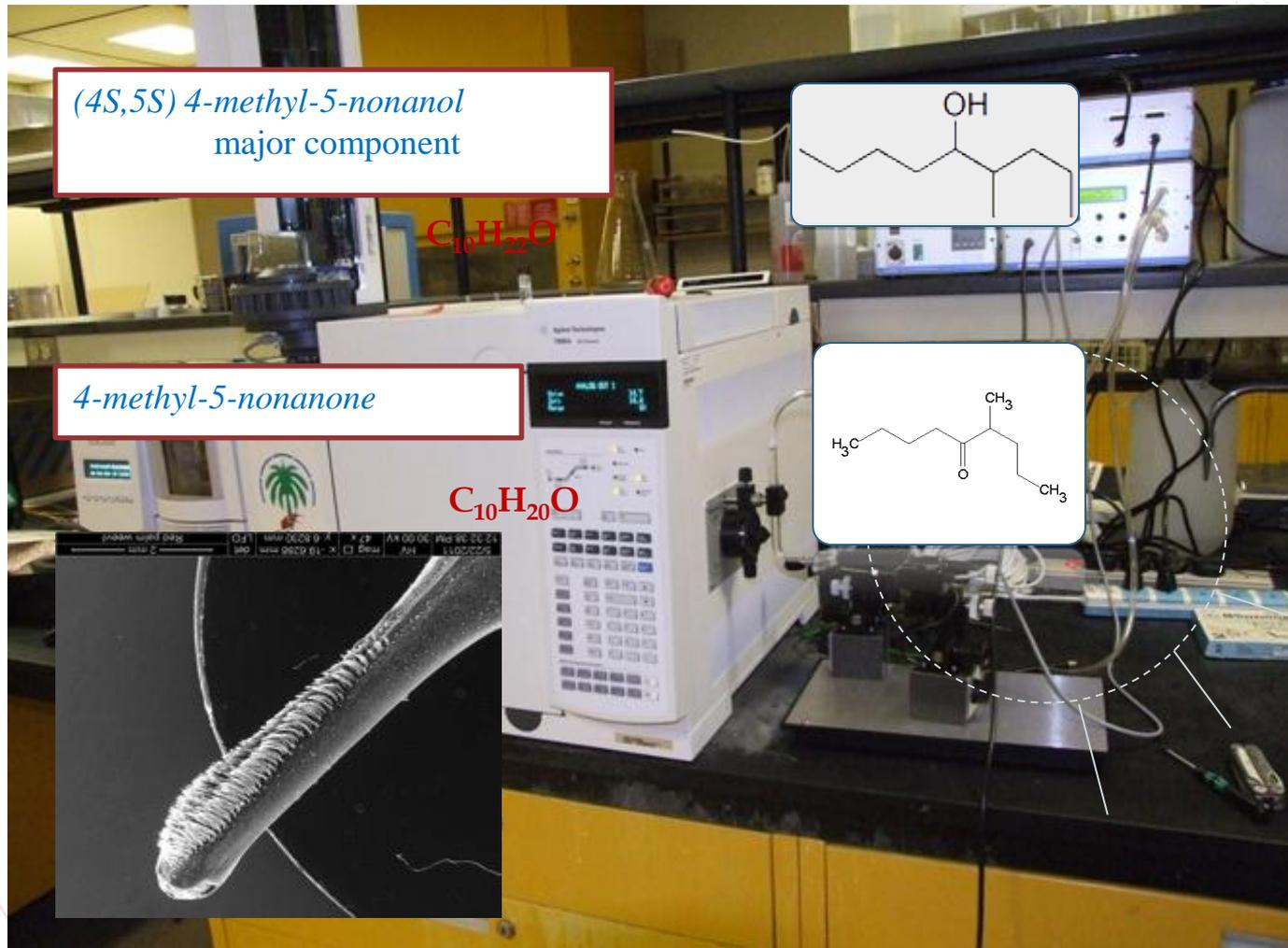
Electrical and Electronic Methods for RPW

- High radio-frequency jamming hit the tree.
- Reaches very high temperatures of up to 60 degrees Celsius.
- These high-frequency waves will produce heat inside the tree to kill to all organisms.



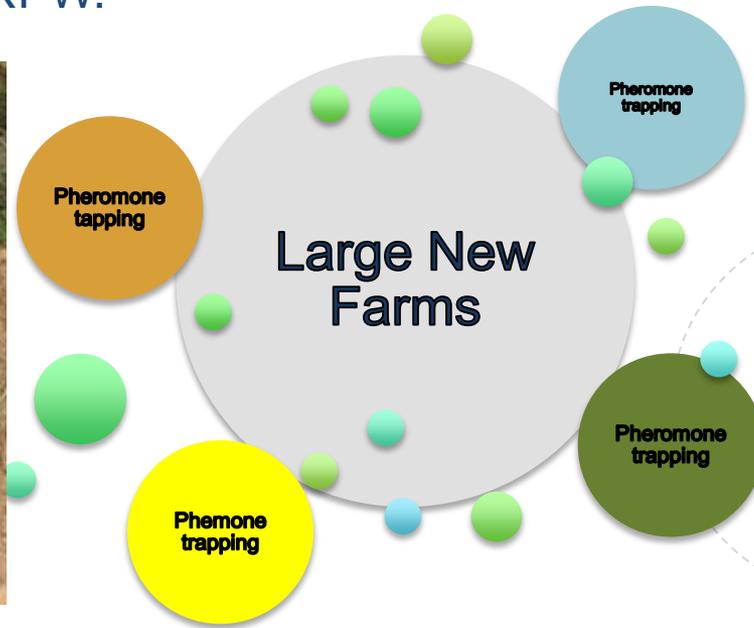
EcoPalm Ring, BioElle Microwave co.,
Modena, Italy

Male aggregation pheromone



Pheromone Baited Trapping

Mass trapping with pheromone and kairomone baited traps was successful in reducing the weevils and the infestations in the field. Need based mass and/or monitor pheromone trapping is recommended as a part of the IPM program against RPW.



About 250 Pheromone Traps were to be placed in farms with RPW infestations in cooperation with Agriculture Ministry by YALJ.

Mechanical - Removal of Palms and Shredding



Shredder of Date palm



Damaged palm removal in farms

Offshoot visual inspection & Dipping in Pesticide



Date Palm Offshoots in a Nursery



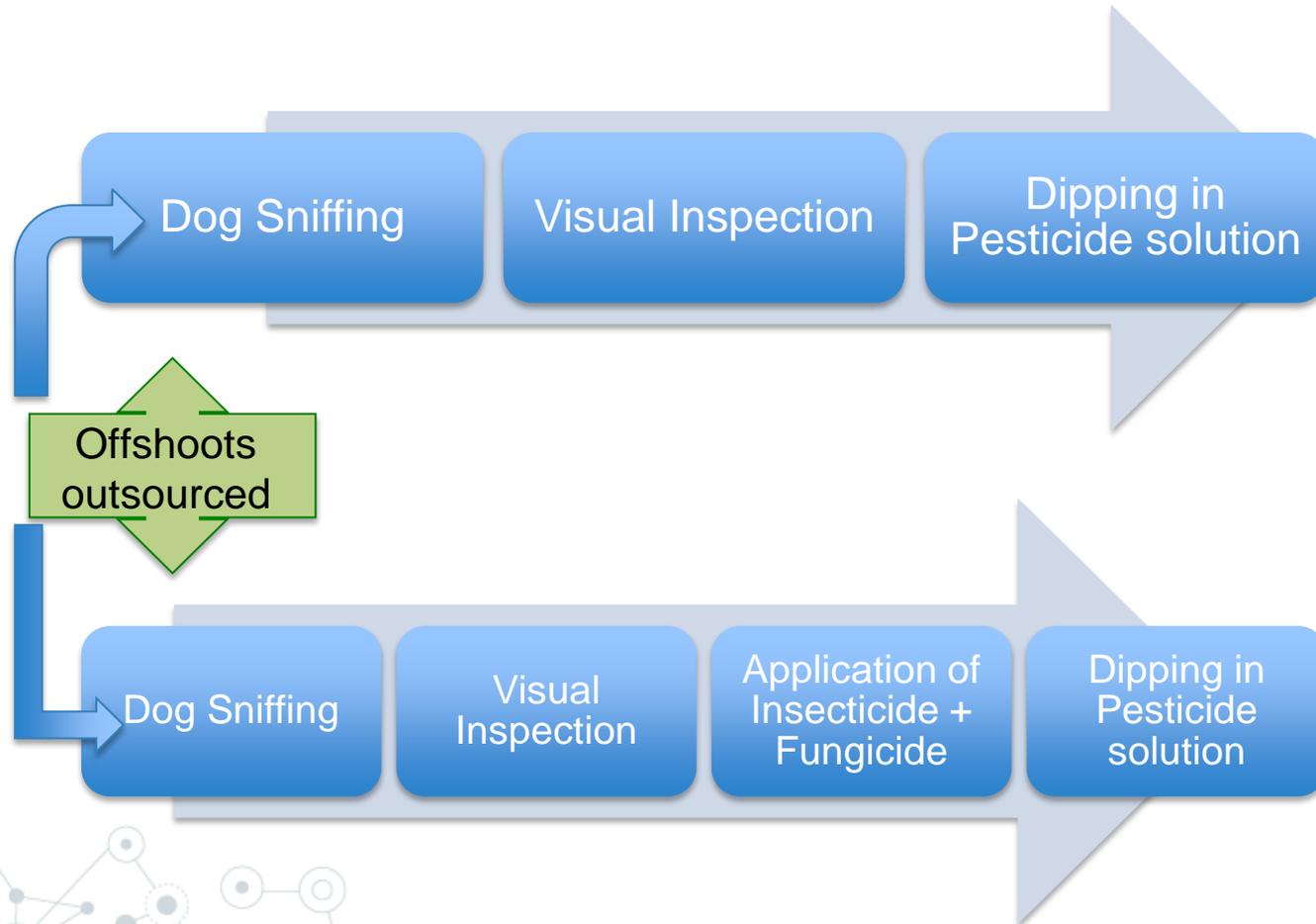
Offshoots are kept in nursery for 3-6 months depending on the variety and season. As an assurance of quality, Government's metal tags are attached to the elite material before lifting from source farm after thorough inspection of engineers.

Spraying newly transplanted offshoots

15 days after transplanting, offshoots to be treated with Fipronil (2ml/L)



Offshoot Planting in Nursery and Field



Before planting in pots



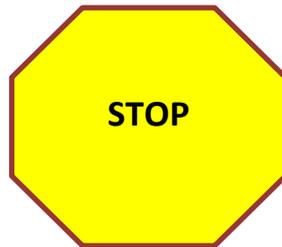
Transplanting in field

RPW Risk Analysis

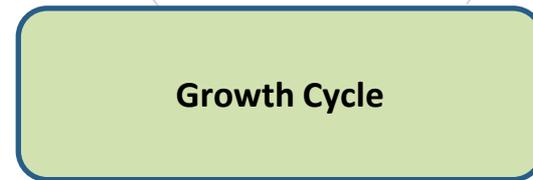
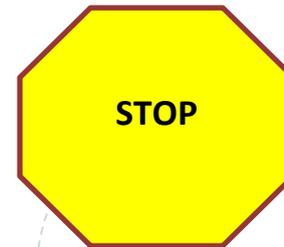
Offshoots



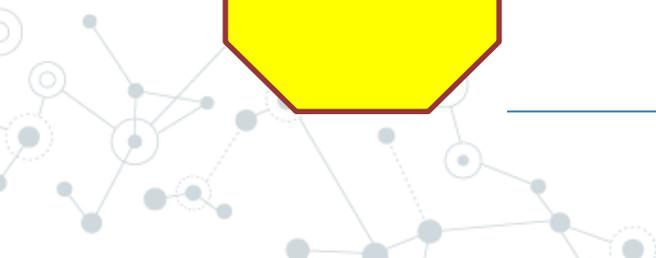
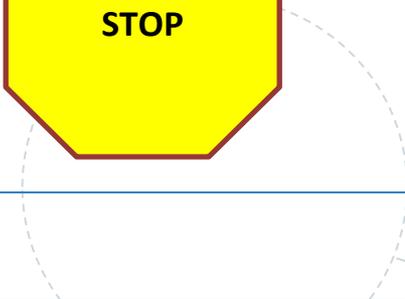
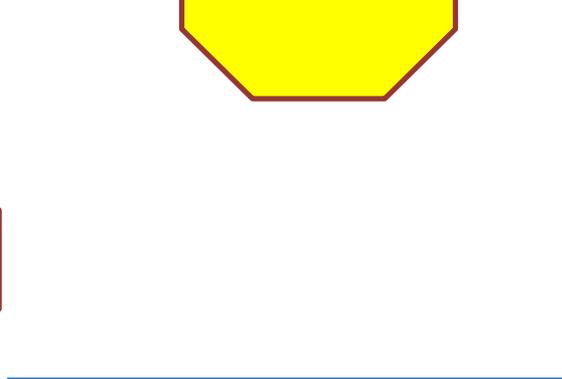
After Transplantation



Regular Scouting & preventive sprays



Growth Cycle



Adult palms and Offshoots transportation in open trucks



What is Required to improve Quarantine Measures worldwide

- ⊙ Countries affected by the pest should take suitable measures to ensure pest-free planting material at the time of export.
- ⊙ There should be an international body/committee of experts to make recommendations to help countries in organizing their national programs.
- ⊙ Every two years there should be an international conference exclusively devoted for the formulation of future plans.
- ⊙ Sharing of information on the status of the pest in various zones/regions of the affected countries has to be considered.
- ⊙ Quality methods of control or management have to be popularized with out any prejudice to any party.
- ⊙ Any plant protection protocol should be more focused on the offshoots as they are at a susceptible stage and hence responsible for spreading of the pest.

Success Story – Saudi Arabia

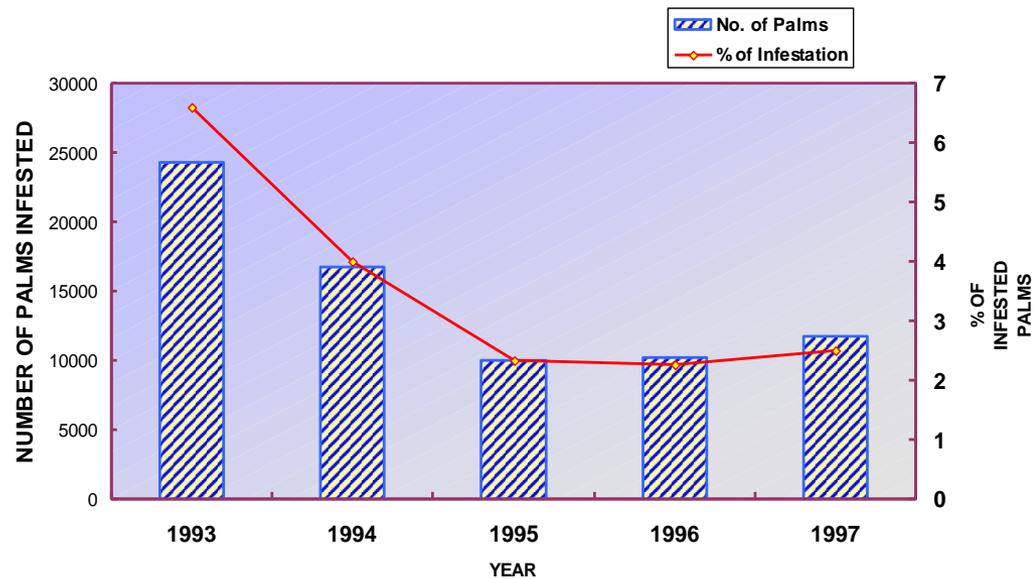
Very high infestation of 6.7% was brought down to 1.1% in the Eastern Province 1993 to 1998. IPM strategy was applied very rationally and this area is still good with less infestations.

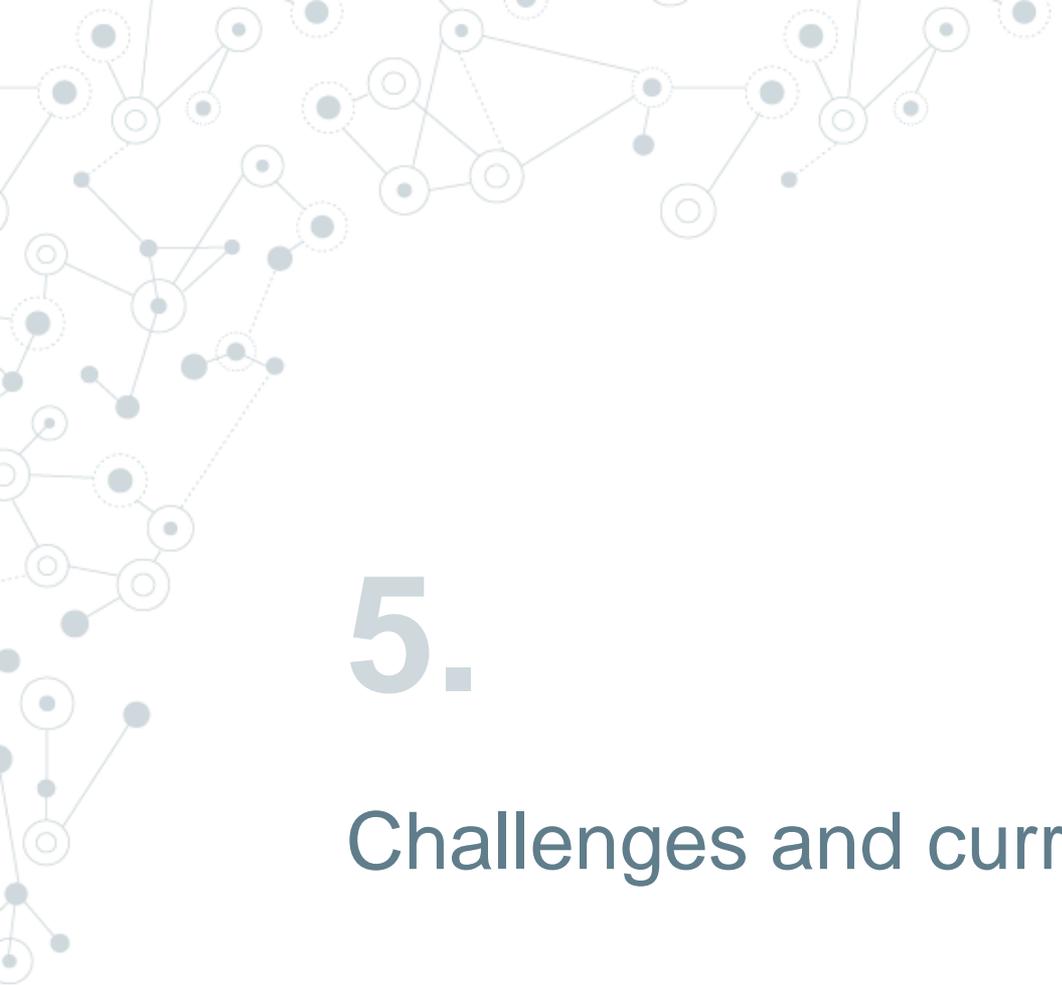
Two farms (year 2011) with infestations were applied with IPM technologies and in the past one year no infestation was reported.

Before IPM in one farm about 600 palms out of 5500 palms were removed due to infestation by RPW.

This clearly demonstrated that RPW can be kept under control if proper strategy is followed.

NUMBER AND PERCENTAGE OF INFESTED PALMS FROM 1993 TO 1997



A decorative network diagram in the top-left corner, consisting of various sized nodes (some solid, some hollow) connected by thin lines, forming a complex web structure.

5.

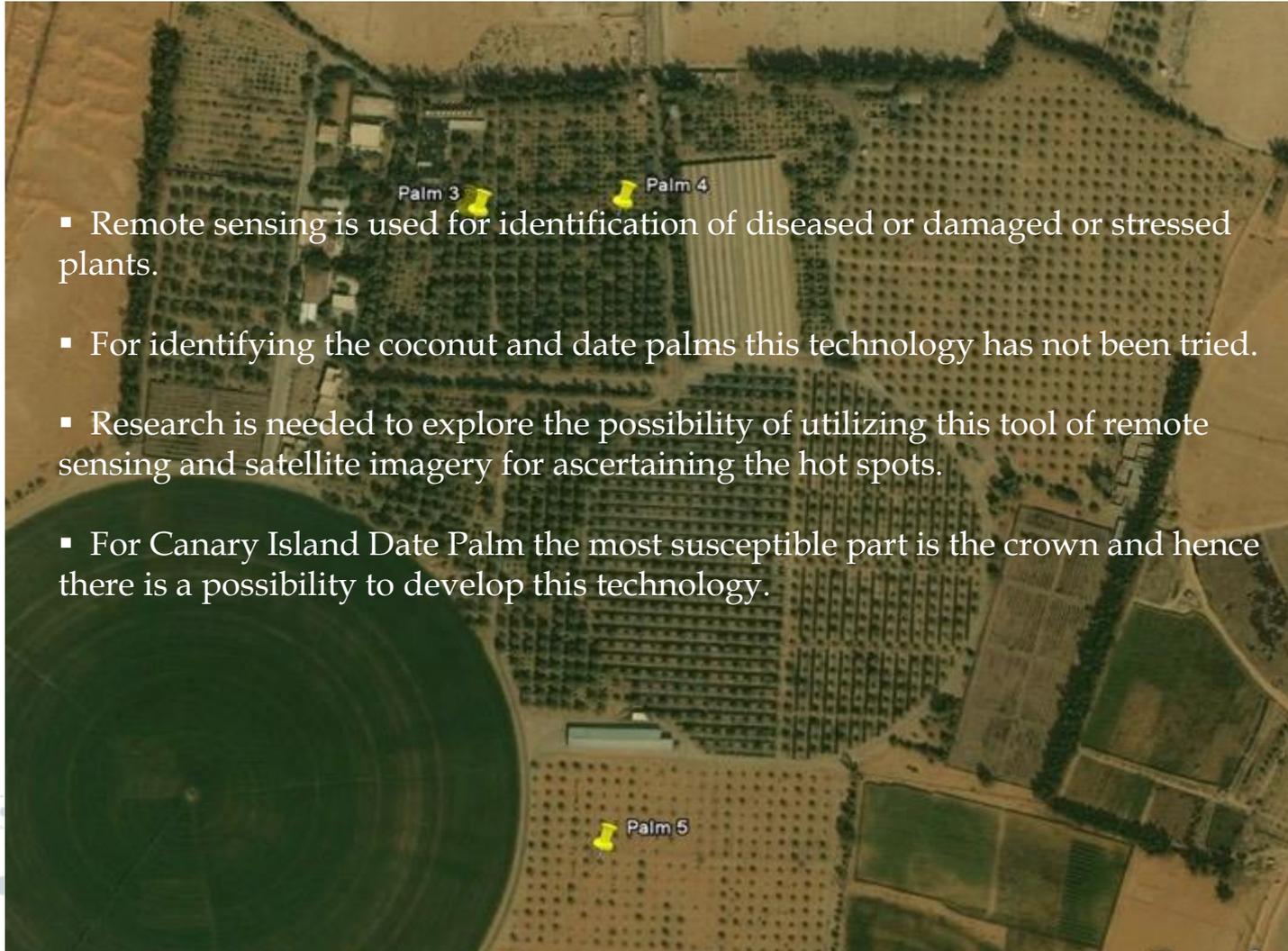
Challenges and current gaps

A decorative network diagram in the bottom-right corner, similar to the one in the top-left, with nodes and connecting lines.

Red Palm Weevil IPM for Future

- ◎ Early detection methods.
- ◎ Efficacy of sniffer dogs in detection – experiments, trainings, validation.
- ◎ Pheromone trapping – lures improvement, food replacements with kairomones, dry traps with long service intervals.
- ◎ Biotechnology in RPW control through DSRNA methods and RPW antennal (DNA) Olfactory system studies and gene silencing through protein binding etc.
- ◎ Nano technology in the production of *Beauveria bassiana* fungus and its dispersal and new methods in biological control methods.
- ◎ IPM models suitable for palms in different eco zones and regions and agroclimatic zones.

Remote Sensing



- Remote sensing is used for identification of diseased or damaged or stressed plants.
- For identifying the coconut and date palms this technology has not been tried.
- Research is needed to explore the possibility of utilizing this tool of remote sensing and satellite imagery for ascertaining the hot spots.
- For Canary Island Date Palm the most susceptible part is the crown and hence there is a possibility to develop this technology.

Biological Control Methods for RPW

1. Efficacy of entomopathogenic nematodes namely *Heterorhabditis bacteriophora.*, *Steinernema* spp. and isolates already tested.
2. *Beauveria bassiana* and many isolates were tested against RPW.
3. Methods for the formulation of these biocontrol agents and application in field has been tested.
4. Integration of the most potent biocontrol agents in the management programs may be fully explored.
5. The delivery of the biocontrol agent to the target stage of the pest is crucial for getting effective control.
6. In recent years nanotechnology has made great advances and this technology can be used for making biocontrol agent/organisms effective.

Biological Control agents



Beauveria bassiana on RPW adults



Metarizhium spp. On RPW adult

- ⊙ *Beauveria bassiana* **GHA eShield** Formulation developed by Ecopesticides International, USA.
- ⊙ Stored in dry state (non-refrigerated temperatures).
- ⊙ Dried beads dispersed in water, suitable for spraying applications in aqueous or oil dispersions.
- ⊙ Insecticidal activity demonstrated with grasshopper bioassays.
- ⊙ Spore germination in eShield microbead is resistant to thermal stress and sunlight irradiation.

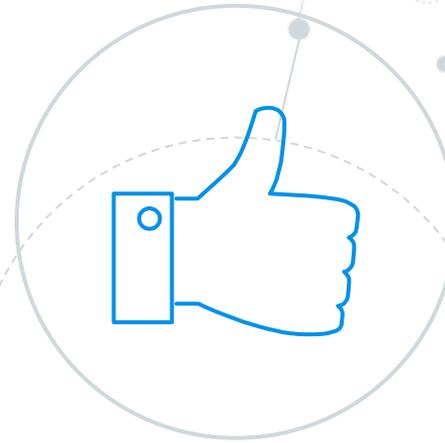
Drones in Agriculture



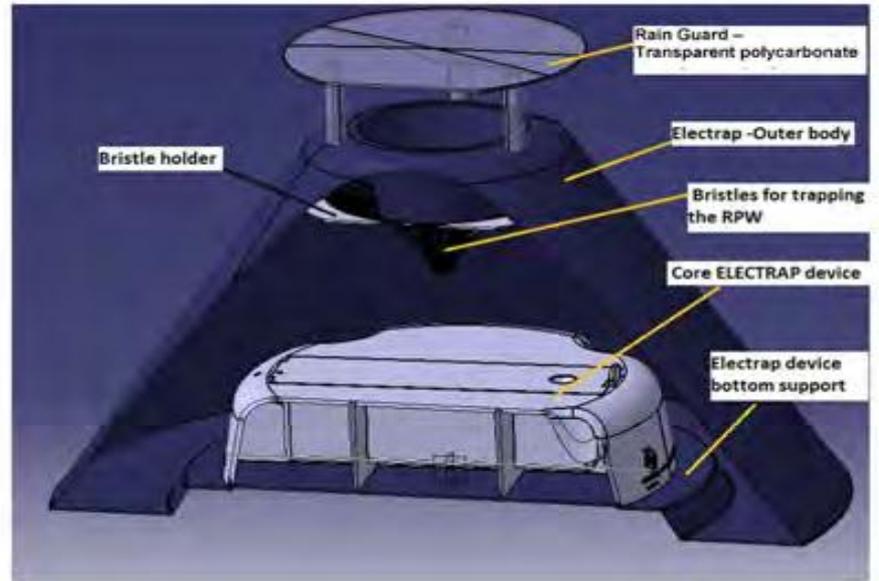
Ultra Low Volume spraying will be practical in tall palms to control Pests and Diseases



A new concept “Electrap” for RPW



ELECTRAP® GENERAL OVERVIEW



Use of natural products, repellents, attract & kill



Natural products

Identifying potential botanicals testing against various stages of insect.

Assessing the efficacy of any candidate natural product or a derivative with some degree of activity like toxicity, repellency, deterrence, prevention of oviposition, physiological alterations, etc.

Use of validated natural products in the prophylactic methods.

Neem, Pongamia, Turmeric and derivatives several others

Repellents, attractants etc

Use of repellents, attractants for killing the pest is a good idea which needs serious in depth research to make it viable and acceptable in view of initial pest loads.

Eco Light Traps against Rhinoceros beetles



Oryctes spp.



Solar light trap design

Solar light traps are good. Commercially available but can be easily fabricated.



Prototype ELT in field

Genomic & Bioinformatic Approaches for RPWs

Rhynchophorus

Genome Sequencing
eg. Comparative sequencing

Transcriptome Sequencing
eg. FL-cDNA

Mapping of Geographic Variation
e.g. tracking by mitogenomes

Endosymbionts

Pathogens

Endosymbiont Genomics
eg. Deep sequencing of accessory genomes

Pathogen Discovery
eg. Genomics of key pathogens of RPW

Mapping Pathogen and Endosymbiont Diversity
eg. Life cycle stage and geographic

Genomics Research on RPW

Relatively little is known about the RPW biology (including the role of **endosymbiotic bacteria**) and RPW's interaction with the **host-plant** (coconut/date palm) at the molecular level. Current status and gaps in our knowledge pertaining to the RPW biology, host-plant interactions, and other important studies should be undertaken.

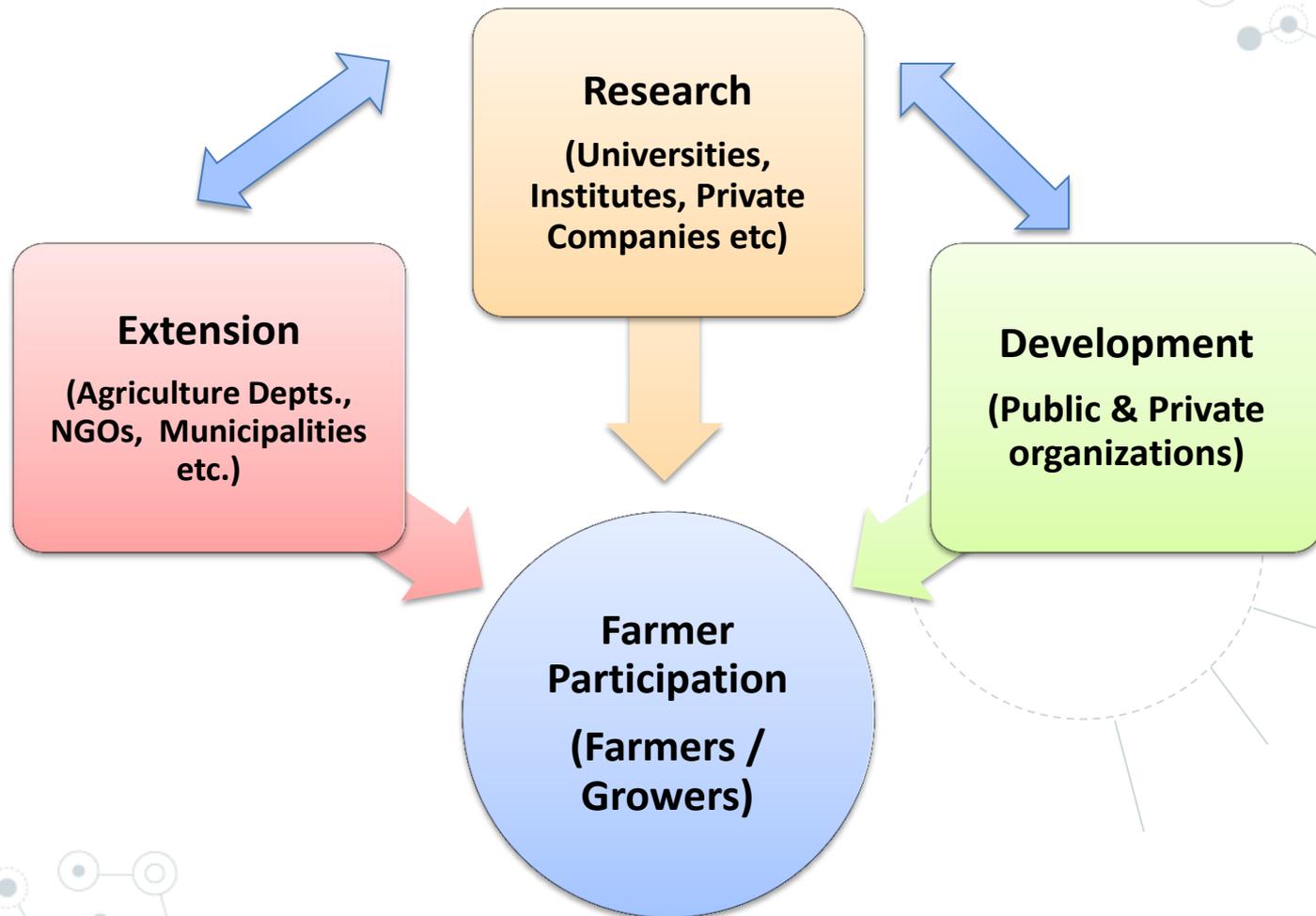
Elucidating the transcriptome of RPW will identify and validate expression of 10,000s of genes in different tissues and at various developmental stages of the life cycle of RPW. Subsequent detailed bioinformatics studies on the transcriptome data will enable us to identify genes involved in specific pathways and physiological processes including metamorphosis, digestion, and immunity related functions, as well as tissue specificity of gene expression.

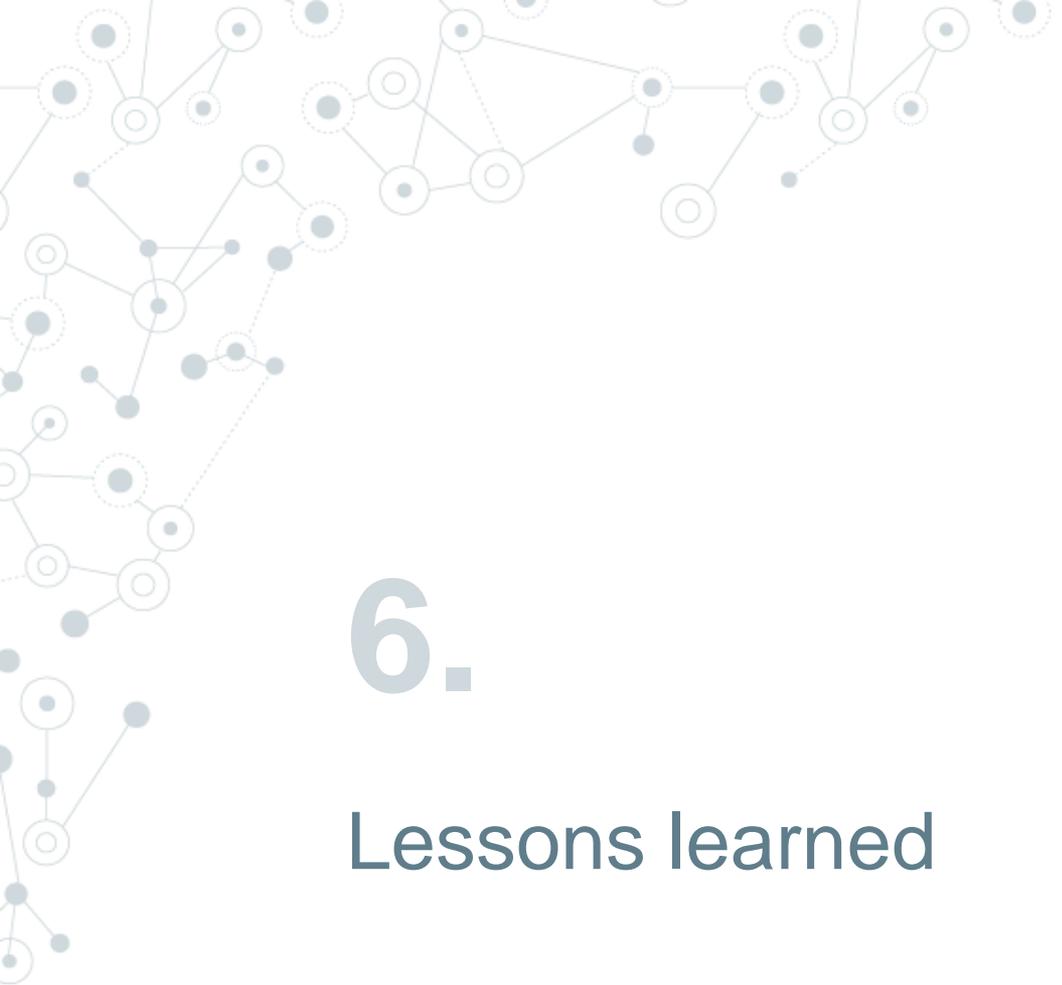
Understanding the **genome information** of the natural pathogens of RPWs (e.g. **entomopathogenic fungi, nematodes and viruses** infecting RPWs) may also help to identify gene products or metabolites that allow these organisms to successfully thrive in/on RPWs and often kill them.

Solutions Against Perceived Risk

- ⊙ Most of the advocated phytosanitary measures should be implemented.
- ⊙ The palm irrigation basins are made to avoid the splashing of water on the stem base.
- ⊙ Inspection of palms has to be done at regular intervals as a part of monitoring program against RPW infestations. Visual inspection is done to detect any early infestations by workers.
- ⊙ Sniffer Dogs with high degree of training will strengthen the process of early detection in farms/nurseries worldwide.
- ⊙ Though IR cameras were field tested for detection, the results were not good and hence some refinements are required before they are used in field in future.
- ⊙ The awareness programs/campaigns need to be organized more frequently in areas with poor infrastructure.
- ⊙ Knowledge based decisions should be taken in handling threats perceived due to RPW.
- ⊙ Training of farmers, workers and supervisors at regular intervals will go a long way in the management of the pest.
- ⊙ As a prophylactic measure, regular spraying/showering with pesticides is done. If preventive sprays are done at regular intervals, the risk of infestations is very much reduced. 3-4 rounds of sprays per year will act as a good preventive measure depending on the stage of the crop.
- ⊙ The awareness programs/campaigns need to be organized more frequently in areas with poor infrastructure with incentives for farmer participation.

Matrix of Activities for Date Palm Pest Management



A decorative network diagram in the top-left corner, consisting of various sized circles (nodes) connected by thin lines (edges). Some nodes are solid dark grey, while others are hollow with a light grey outline. The connections form a complex, branching structure.

6.

Lessons learned

A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It features a collection of nodes of different sizes and styles (solid dark grey and hollow light grey) interconnected by thin lines, forming a complex, branching network structure.

Conclusions

- National and international quarantine laws and rules must be implemented more vigorously. New rules may be framed keeping in mind the changing situations.
- Instead of banning infested farms from selling offshoots or adult palms, measures should be taken to allow pest free planting material. This is possible through certification of the plants.
- Certified nurseries should be established for supply of new planting materials.
- Adequate support should be provided for developing, testing and adoption of new methods of RPW management.
- Research should be focused on developing better scanning devices or early detection techniques with funding by international agencies.
- The present plant protection methods against the pest should be used optimally till new and more ecofriendly methods become available.

Thanks!

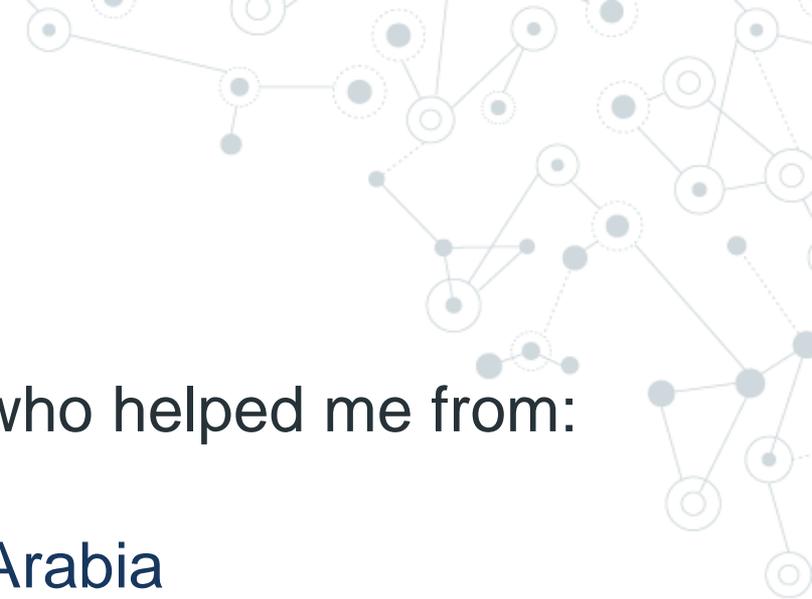
Any questions?

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