Management of RPW: Development and Implementation of Small to Large Scale Control Programs

Jose Romeno Faleiro

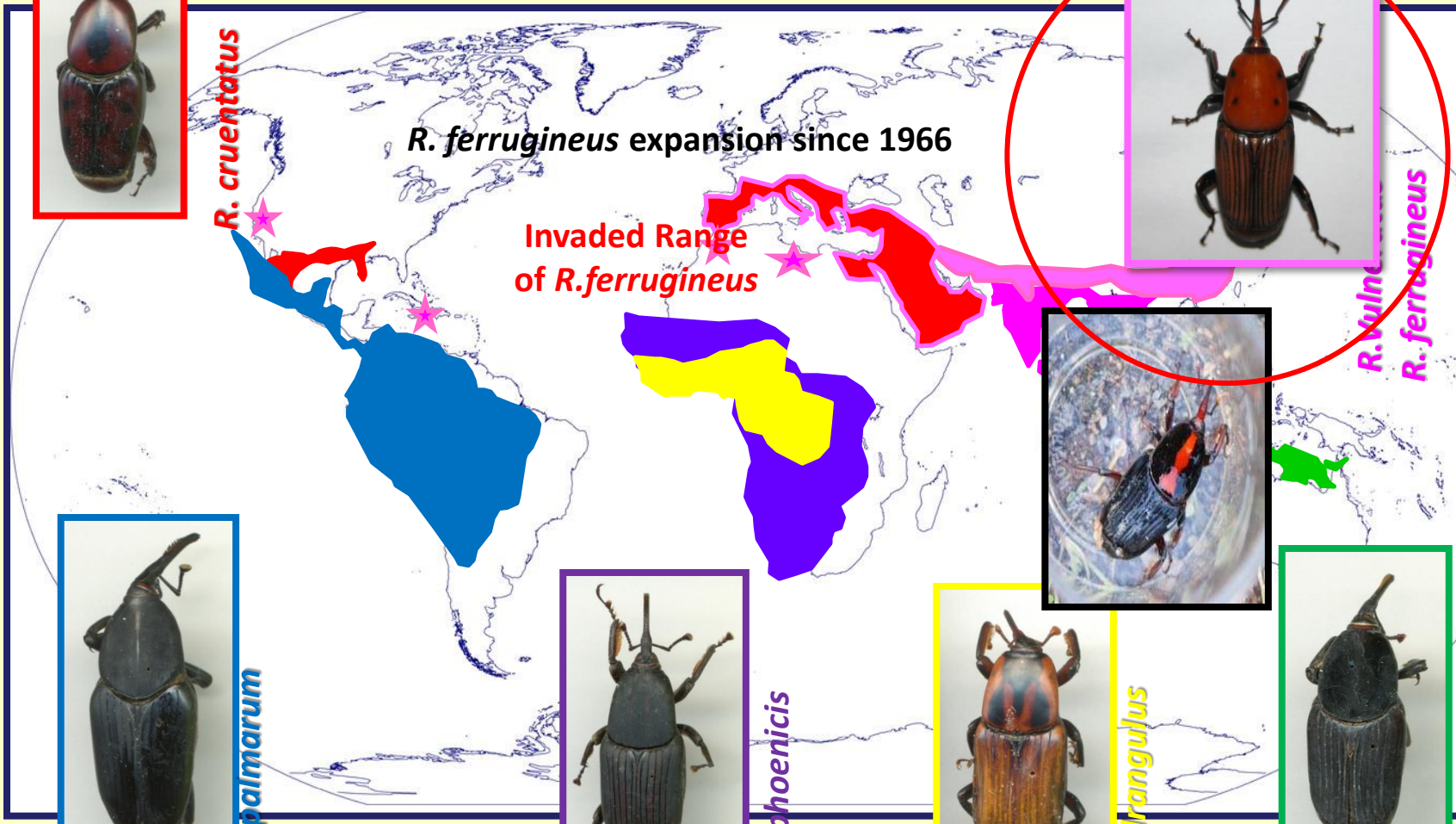
Goa, India

jrfaleiro@yahoo.co.in

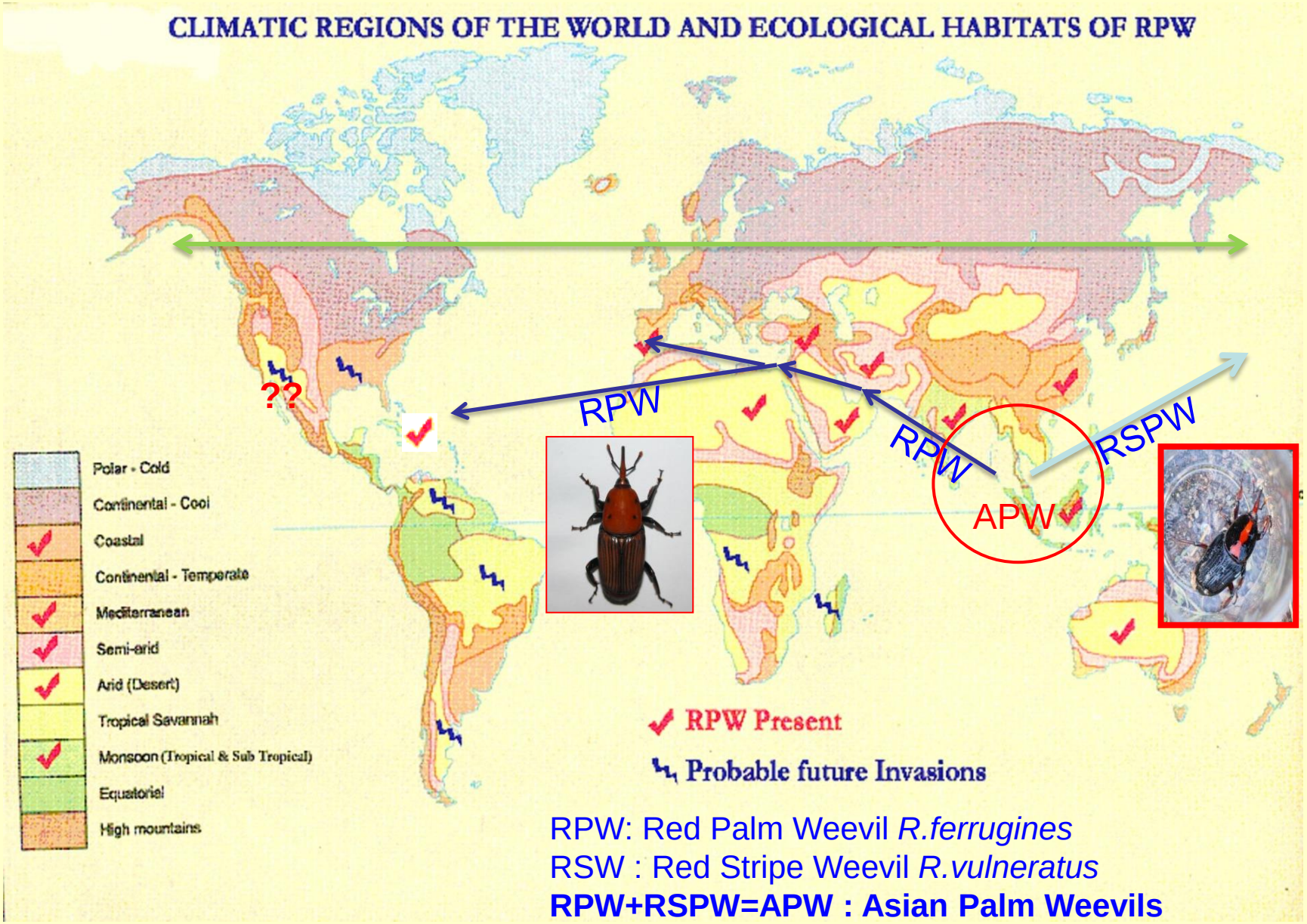
International Conference on the Red Palm Weevil inTunisia
3-5 May, 2017
[Organized by: Ministry of Agriculture, Water Resources & Fisheries of Tunisia, IRESA, US Embassy in Tunis, SOS BIAA]

Rhynchophorus Distribution

There are ~10 species in *Rhynchophorus*



This slide is modified from Robin Giblin-Davis, Univ. FL, Fort Lauderdale



The California Report of 2010 is RSPW (*R. vulneratus*) and not RPW

Geographical distribution of RPW

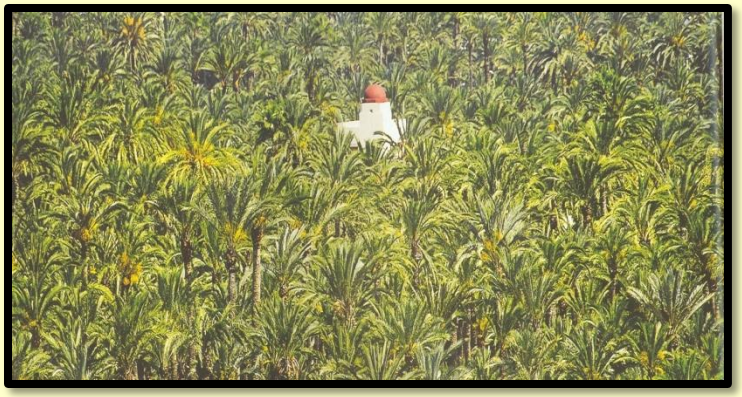
Asia			*Africa*	*Europe*	*Americas*
India*	Thailand	**UAE (1985)**	**Egypt** (1992)**	Spain** (1995)	Curacao Islands (Caribbean-2009)
Pakistan*	Cambodia	Qatar	Morocco**	Turkey**	**USA , 2010 ???**
Sri Lanka	Vietnam	Saudi Arabia	Libya** (2009)	Italy**	
Myanmar	China*	Kuwait	Tunisia 2011	Greece**	
	Taiwan	Oman	Mauritania 2015	France**	
	Philippines	Bahrain		Portugal**	
	Malaysia	Israel		Cyprus**	
	Indonesia	Palestine		Malta**	
	Timor	Jordan		Georgia(2009)	
	Papua New Guinea	Iran		Croatia (2011)	
	Solomon Is./Australia	Iraq ? (1918) **Iraq 2015**		UK (2016)	
		Lebanon (2010)			
		Yemen 2013			

* Grow coconut & date palm ** *P. canariensis*

RPW a Major Threat to Heritage/Historic Palms World Wide

Al Hassa, Saudi Arabia

Tangier, Morocco

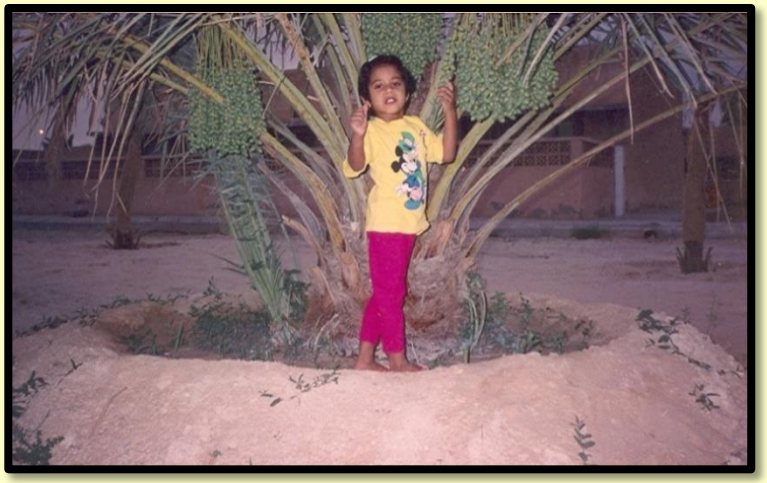


Elche, Spain

Host range of *R. ferrugineus* (1956 to 2013) : 4 to 40 palm species

Sr. No.	Host Palm Species	Reference
1	*Cocos nucifera*, *Phoenix dactylifera*, *Metroxylon sagu* and *Corypha umberaculifera*	Nirula, 1956
2	*Cocos nucifera*, *Areca catechu*, *Arenga pinnata*, *Caryota* sp. *Coelococcus* sp., *Corypha* sp., *Elaeis guineensis*, *Livistona* sp., *Metroxylon sagu*, *Nypa* sp., *Oncosperma* sp. and *Phoenix* sp.	Lever, 1969
3	*Areca catechu*, *Arenga pinnata*, *Borassus flabellifer*, *Caryota maxima*, *Caryota cumingii*, *Cocos nucifera*, *Corypha gebanga*, *Corypha umberaculifera*, *Corypha elata*, *Elaeis guineensis*, *Metroxylon sagu*, *Oreodoxa regia*, *Phoenix canariensis*, *Phoenix dactylifera*, *Phoenix sylvestris*, *Sabal umbraculifera*, and *Washingtonia* sp. *Chamaerops humilis and Howea forsteriana (syn. Kentia forsteriana)*	Esteban-Duran *et al.*, 1998 (OJEU, 2008; EPPO, 2009).
4.	40 palm species world wide (Report from Portugal) http://www.savealgarvepalms.com/en/weevil-facts/host-palm-trees	Anonymous, 2013

Most Preferred Hosts –*Phoenix canariensis*, *P.dactylifera* and *Cocus nucifera*



Large Stretches of Monocultures of Young Palms

Currently nearly 1.0 million ha are under date palm in the NENA region with an estimated 50 million palms in the susceptible age group of less than 20 years

Check Escape of RPW Through Planting Material

Lack of Quarantine Protocols

Unregulated Palm Nursery Industry

Weak Enforcement

EU Rules to Regulate the Palm Trade : Official Inspections of Immobilized Areas (2007/365/CE)

-Delimitation of survey and demarcated areas

-Three monthly official inspections

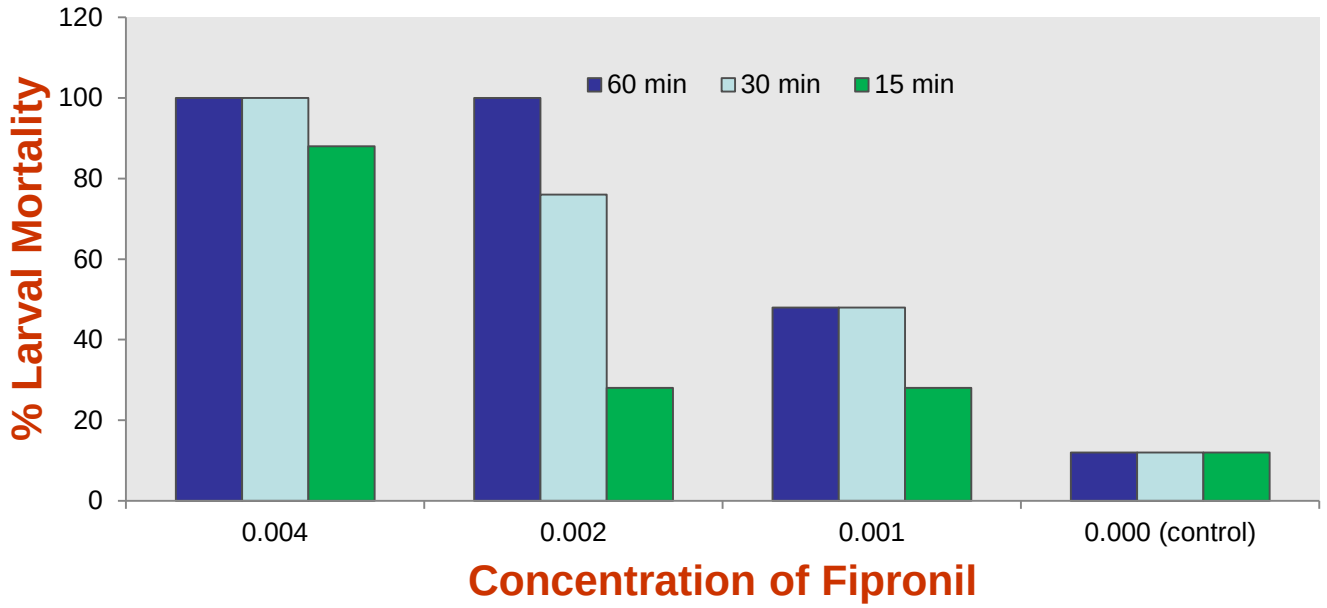
- Annual crop declaration

-Application of phytosanitary treatments

-Registration of planting material movement

-Use of plant passport to monitor trade of palms

A Quarantine Protocol for Treating Date Palm Offshoots against RPW



RPW larval mortality in date palm offshoots dipped in different conentrations of Fipronil at different durations

Al-Shawaf et. al. 2013. Journal of Plant Protection Research, Poland

Behavior & Bio-ecology of RPW

Behavior of RPW : Not Well Understood

Why is This Weevil Here?
-On Freshly Ploughed Barren Land
-From where did it come?

Life Cycle of RPW

(Adult)
Partially Hidden/Cryptic

Adult RPW lives for 2-3 months. Females lay 250-350 eggs

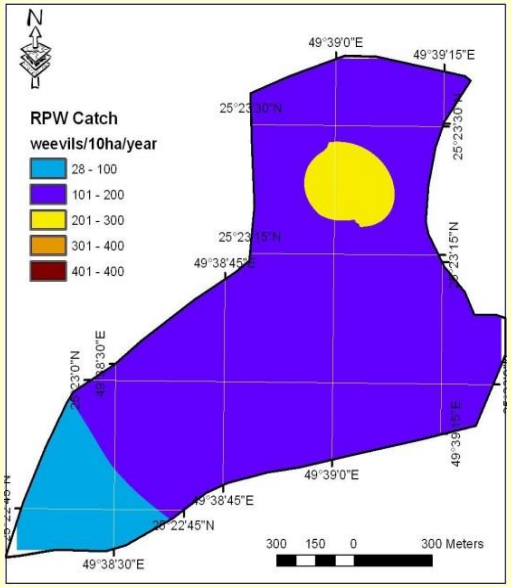
Eggs hatch in 3-6 days

Larvae live for 1to 2months and feed on the palm tissue causing extensive tissue damage

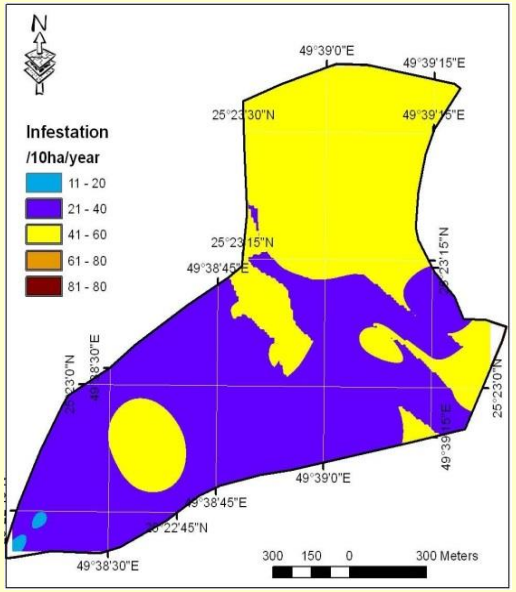
Pupal stage lasts for 15-30 days

(Egg-Larva-Pupa)
Hidden/Cryptic

GIS Based Spatial Spread of RPW [Al-Soodha (126ha) KSA- 2008]



Weevil Captures

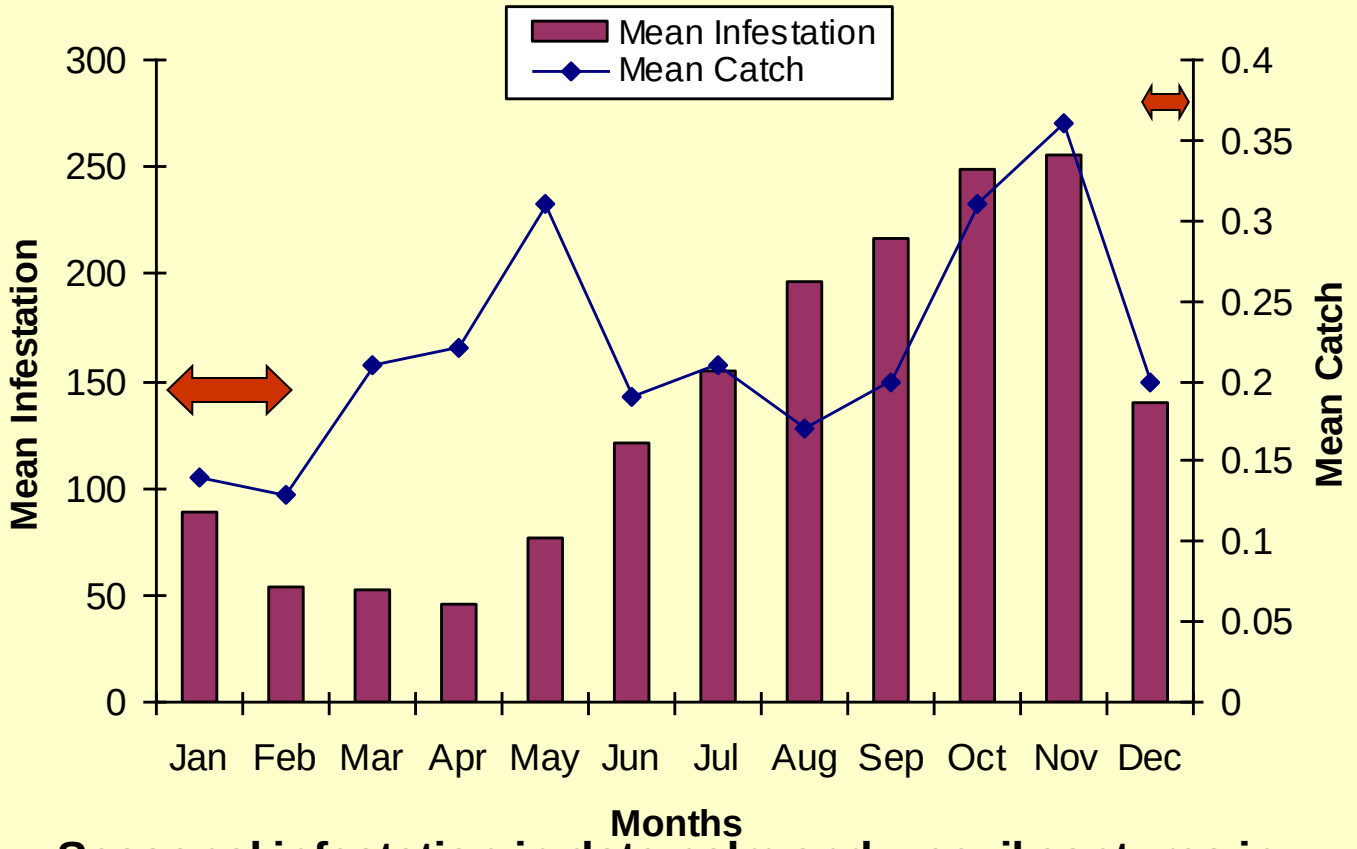


Infestation

Implications:

1.Infestations in clusters

2.Field trials(Trapping trials): Prone to error due to ‘spot effect’



Seasonal infestation in date palm and weevil captures in pheromone traps (Al-Hasa, Saudi Arabiaa, 1994 - 1997)

Anonymous, 1998. Final report of the Indian Technical Team (Part A), - Red palm weevil control project, Ministry of Agriculture and Water, Kingdom of Saudi Arabia, 65pp.

Predisposing Factors for RPW Attack

Neglected Gardens

- - - Wounds on the Palm - - -

Breeding site – Cut Palm

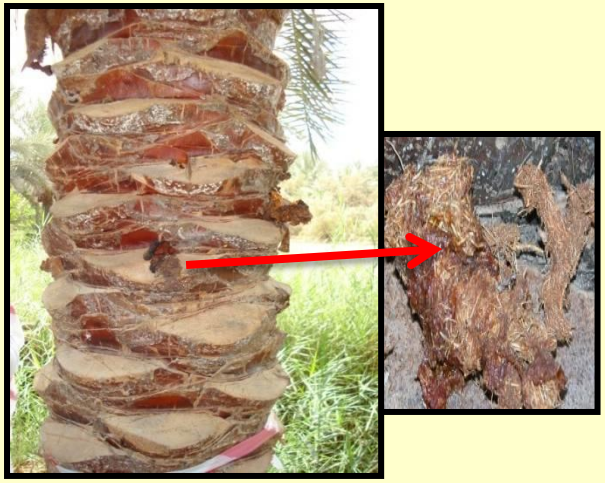
Closed Garden

In-groove Humidity*

Abraham et al., 1998 ; Aldryhim et al., 2003*

Damage-Detection-IPM

Symptoms of Damage Due to RPW



Extensive Damage to the Urban Landscape

Source: Agrinvest SRL, Italy

‘Rome Declaration’ To Control & Eradicate RPW Adopted After the Scientific Consultation and High Level Meeting, 29-31 March 2017

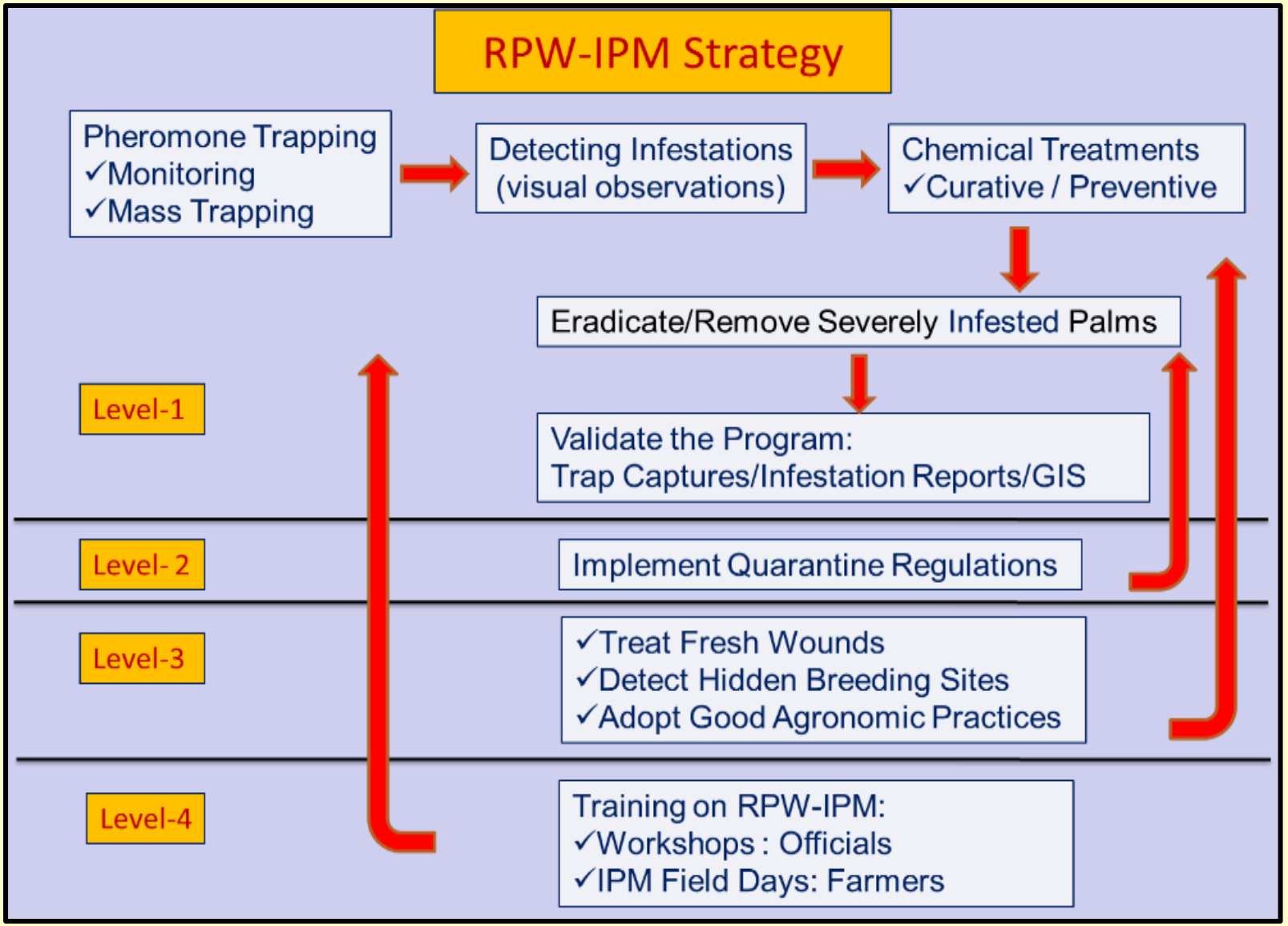
Recognize

- ✓ The devastating impacts of RPW
- ✓ RPW Remains a severe challenge
- ✓ A strategy supported by adequate human and financial resources with systematic planning, good coordination and involvement of all stakeholders, supplemented by the sensible use of new technologies, can lead to eradicating RPW;

Reaffirm the importance of collaborative efforts and commitments at the country, regional and global levels to stop the spread of this devastating pest;

Agree with the proposed Framework Strategy for Eradication of the Red Palm Weevil and seek the political will and necessary commitments to implement the Framework Strategy

http://www.fao.org/food-chain-crisis/high-level-meeting/en/
http://www.fao.org/news/story/en/item/854399/icode/


RPW-IPM Strategy
Pheromone Trapping
✓Monitoring
✓Mass Trapping
Detecting Infestations
(visual observations)
Chemical Treatments
✓Curative / Preventive
Eradicate/Remove Severely Infested Palms
Level-1
Validate the Program:
Trap Captures/Infestation Reports/GIS
Level- 2
Implement Quarantine Regulations
Level-3
✓Treat Fresh Wounds
✓Detect Hidden Breeding Sites
✓Adopt Good Agronomic Practices
Level-4
Training on RPW-IPM:
✓Workshops : Officials
✓IPM Field Days: Farmers

Success Stories of Control & Eradication

- ✓ Control of RPW in Mauritania
- ✓ Eradication of RPW in the Canary Islands, Spain (May 2016)

Mauritania

- Inspection of palms to detect infestation
- Pheromone trapping / Attract & Kill
- Eradication of Infested Palms
- Plant Quarantine measures
- Treatment of wounds
- Prohibited offshoot removal in the hot spot
- Training of all stakeholders
- Active participation of the farmers in the program
- Proactive Extension Campaign

Source – Mauritania : FAO

Canary Island : Coordinated Action Plan

- IPM : Zone Delemination (1km: intensive surveillance /3km: guided surveillance),Visual Inspection (intensive, guided, system alert),Eradication of Infested Palms, Chemical Treatments, Trapping, Cultural Practices
- Legislation (EU, Spain, Canary Island)
- Continuous Training
- Awareness & Extension
- Risk Evaluation
- Control Movement of Planting Material
- GIS : Database, Mobile Application, Web Application, Web Viewer

Source – Canary Island : Moisés Fajardo Bello , Coordinador GMR Canaria ;

HPR/ Agronomic Practices and RPW Attack

Host Plant Resistance Not Exploited
: Does RNAi Hold the Key?

Frond and Offshoot Management

Irrigation Method & Palm Density

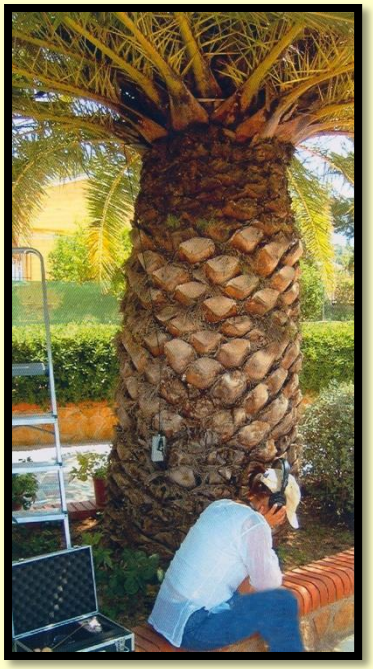
Poor Field Sanitation

Detecting RPW Infested Palms

Current Practice
- Visual
- Pest Collection (Trapping)

Experimental
- Detecting Chemical Signatures
- Acoustic Detection
- Infrared Cameras
- Thermal imaging

Detecting RPW Infested Palms



Sound Detection Devices

Sniffer Dogs

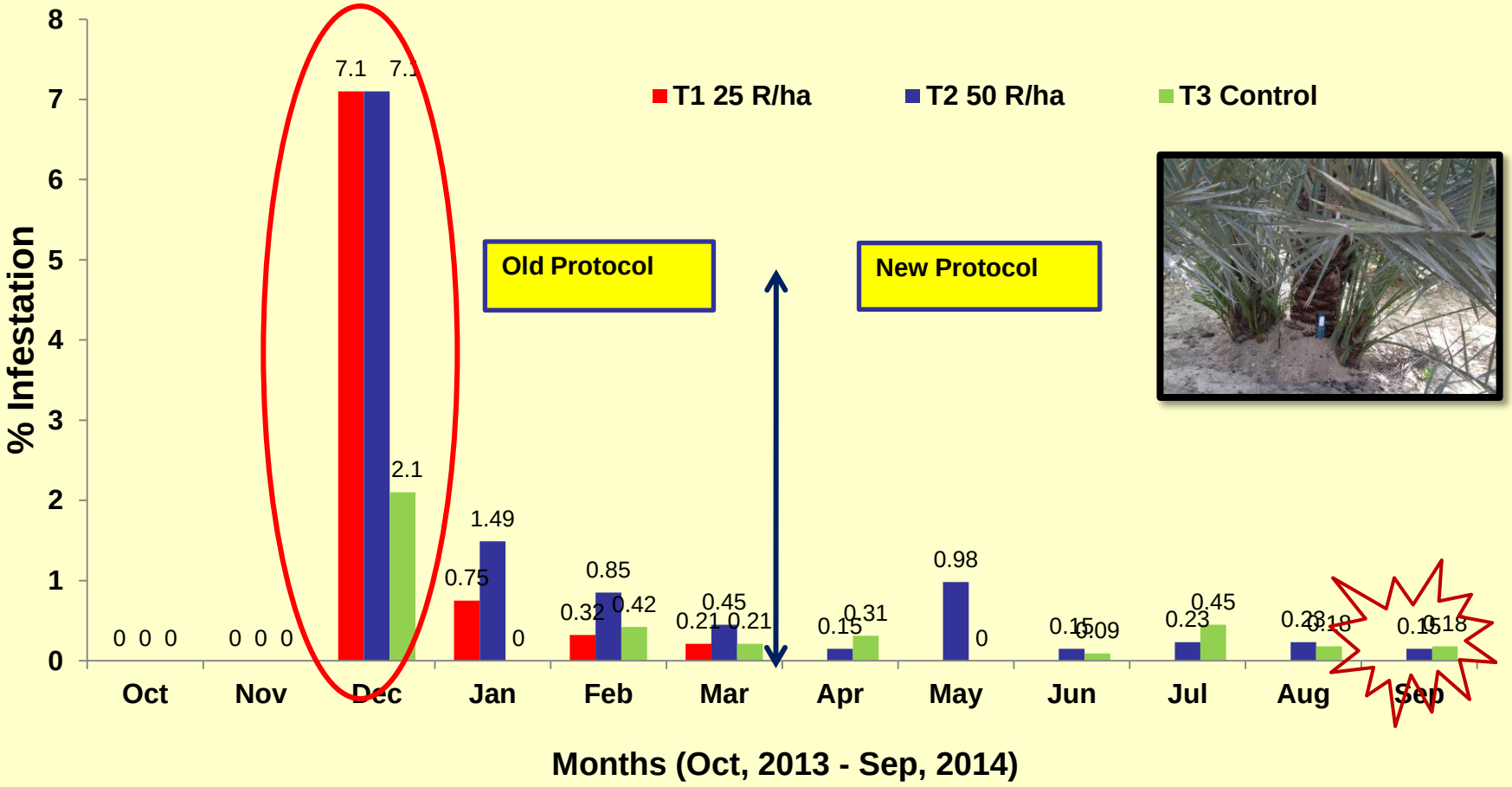
Sensor Based Detection

Visual Inspection of Palms to Detect RPW Infestation

Screw Driver Probe

Photos by : Moisés Fajardo Bello
Coordinador GMR Canarias

Impact of Periodic Visual Inspection of Palms [30 ha Date Plantation]



Regular Visual Inspections : Key to the Control of RPW

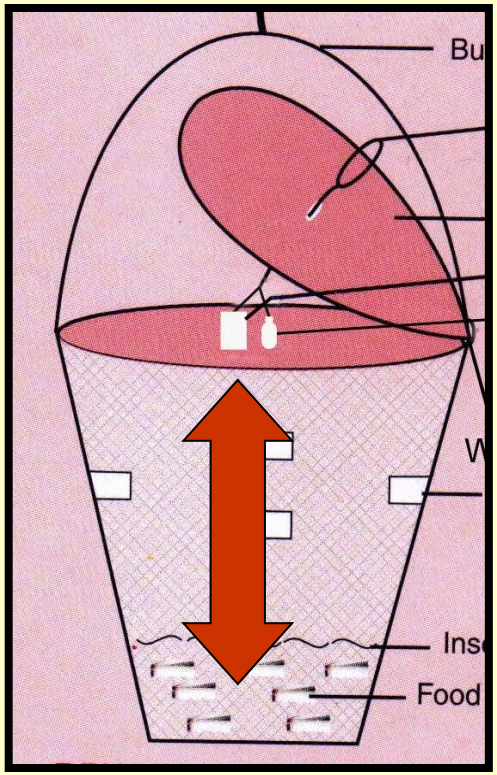
Semiochemicals

Semiochemicals are well-known management tools especially for cryptic species (Soroker et al., 2015)

- **RPW Pheromone** : 4S, 5S nonanol & 4S, 5S nonanone
- **Host Attractants** : ethyl acetate , ethyl alcohol, ethyl propionate, pentan-1-ol , 2-methoxy-4-vinylphenol & gamma-nonanoic lactone
- **RPW Repellents** : methyl salicilate , α-pinene, 1-octen-3-ol & geraniol

(Hallett et al., 1993;Soroker et al., 2015)

Adopt the Best Protocols to Enhance Trapping Efficiency



✓ **BAIT LURE SYNERGY**

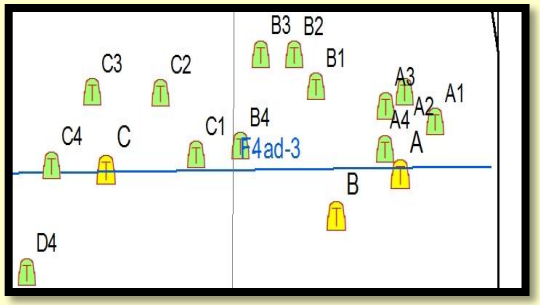
✗ **PALM LURE SYNERGY**

Pheromone Trapping : Overview

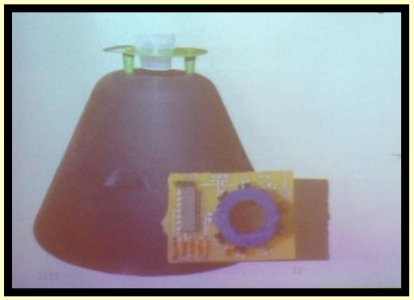
Trap Design and Lures

Food Baits and Kairomones

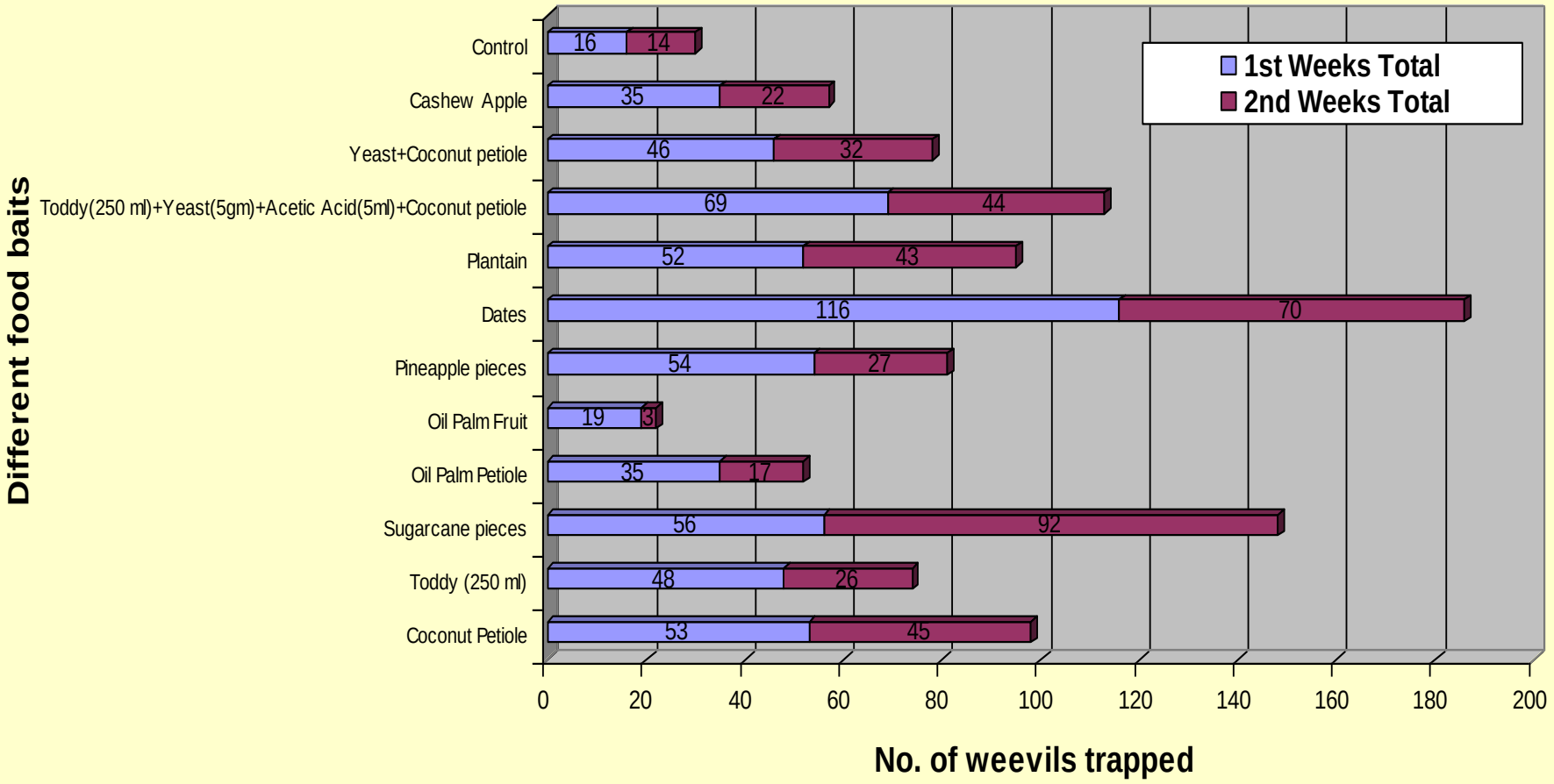
Trap Density and Smart Traps



Trap & Bait Free Trapping

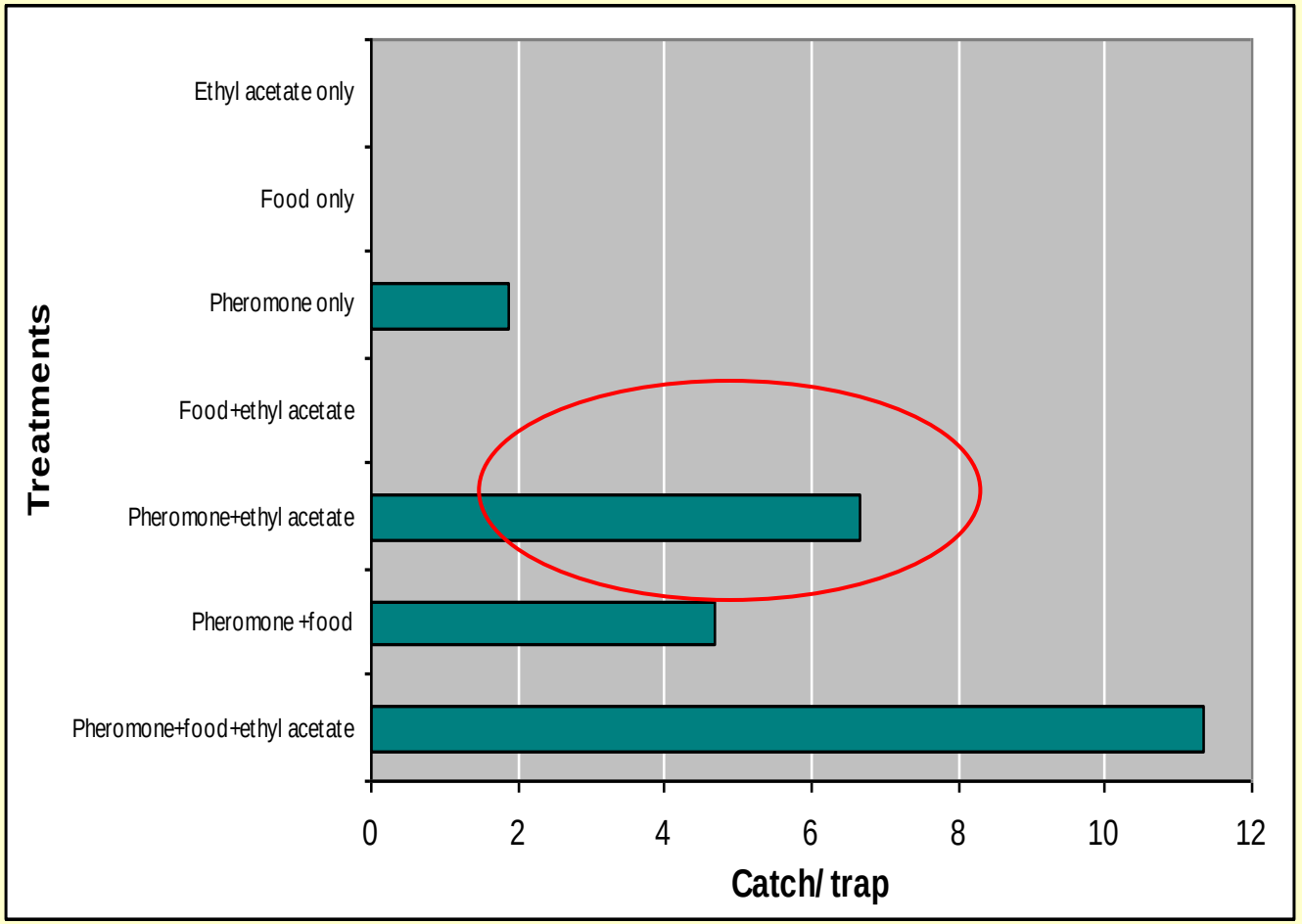


- ✓ Develop mobile application for data collection and transmission
- ✓ Develop a GIS data base



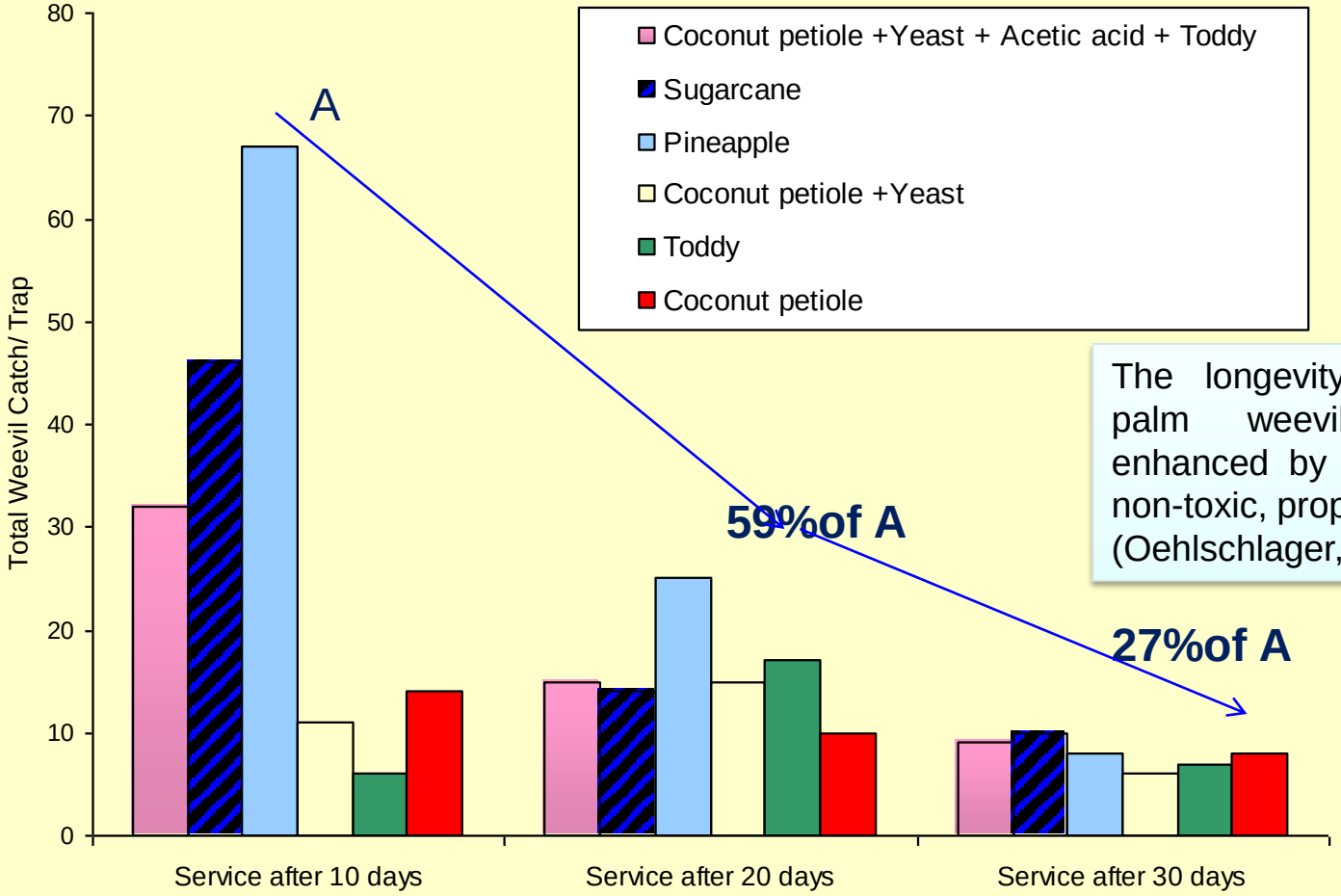
Comparative weevil catches in red palm weevil pheromone traps using different food baits (13/3/2001-11/5/2001)

Influence of ethyl acetate on *R.ferrugineus* captures in food baited pheromone traps (Goa, India 30/12/2006 and 13/1/2007)



Faleiro JR. 2005. Technical Bulletin No. 4. ICAR Research Complex for Goa. 40pp

Effect of Trap Servicing (replacement of food bait) on Weevil Captures in RPW Pheromone Traps (March, 2002)



The longevity of food in palm weevil traps is enhanced by high boiling, non-toxic, propylene glycol (Oehlschlager, 2006)

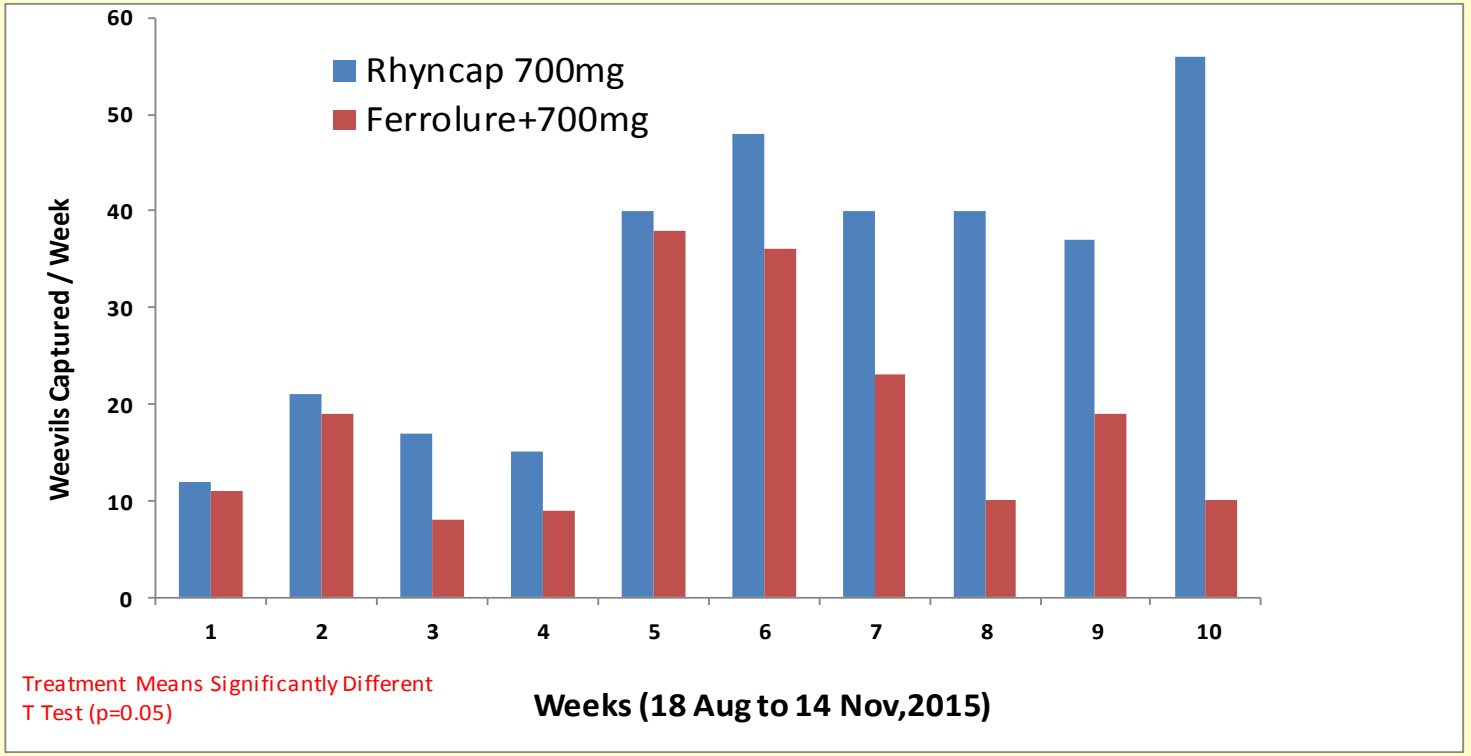
Faleiro JR. 2005. Technical Bulletin No. 4. ICAR Research Complex for Goa. 40pp.

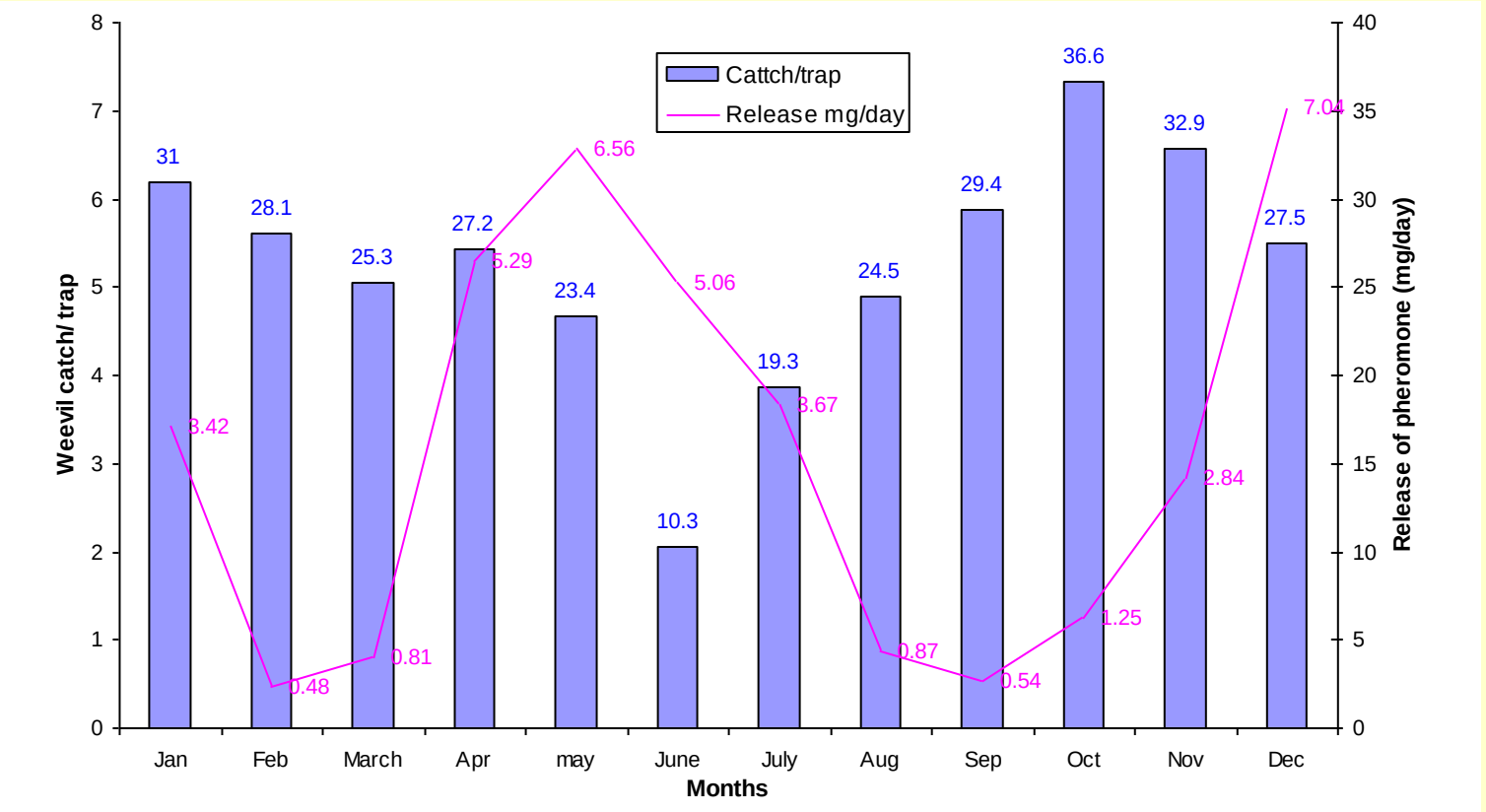
Efficacy of RPW pheromone lures tested in date plantations of Al-Ahsa, Saudi Arabia (21June - 19 July, 2011 and 8 - 29 April, 2012)

Pheromone Lure Tested	Mean Weevil Captures*		
	Trial-I	Trial-II	Cumulative
Pherobank lure, Netherland	1.67(2.60)	1.799(3.00)	2.38(5.60)
IT189 ISCA Lure-ferrugineus ,ISCA Technologies, USA	1.50(2.00)	1.12(0.80)	1.78(2.80)
Rhylure WAT-700, Russell IPM, UK	1.57(2.20)	1.33(1.60)	1.95(3.80)
Ferrolure+, Chem Tica International, Costa Rica	1.14(1.20)	1.24(1.40)	1.67(2.60)
CD (p=0.05)	NS	NS	NS

***Data transformed using square root transformation. Figures in parenthesis are original mean values of five replications. NS= Non significant.**

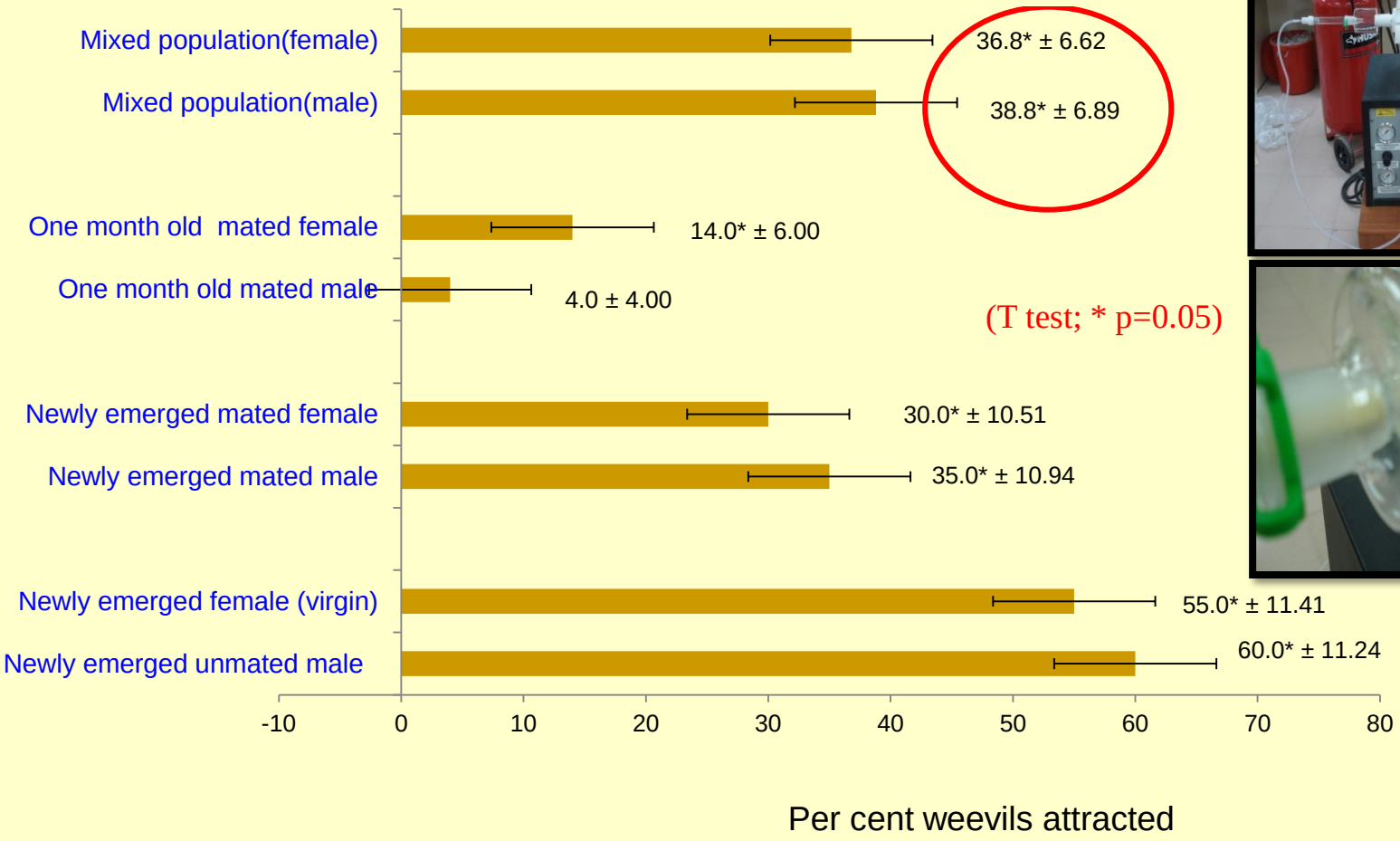
Trapping Efficiency and Field Longevity of RPW Pheromone Lures
18 Aug – 14 Oct, 2015, Al-Hassa, Saudi Arabia





Mean monthly weevil catch per trap and release of pheromone [Ferrolure] (mg/day) in Goa, India - January, 2000 to December, 2001

Response of *R. ferrugineus* to the aggregation pheromone in choice olfactometer assays



(T test; * p=0.05)

Faleiro, JR and El-Shafie, HAF . 2012. Red Palm Weevil Symposium. ESA Meeting. Knoxville, Tennessee, USA . 14-16 November, 2012.

Will trapping alone do ?
The North African Experience

Libya

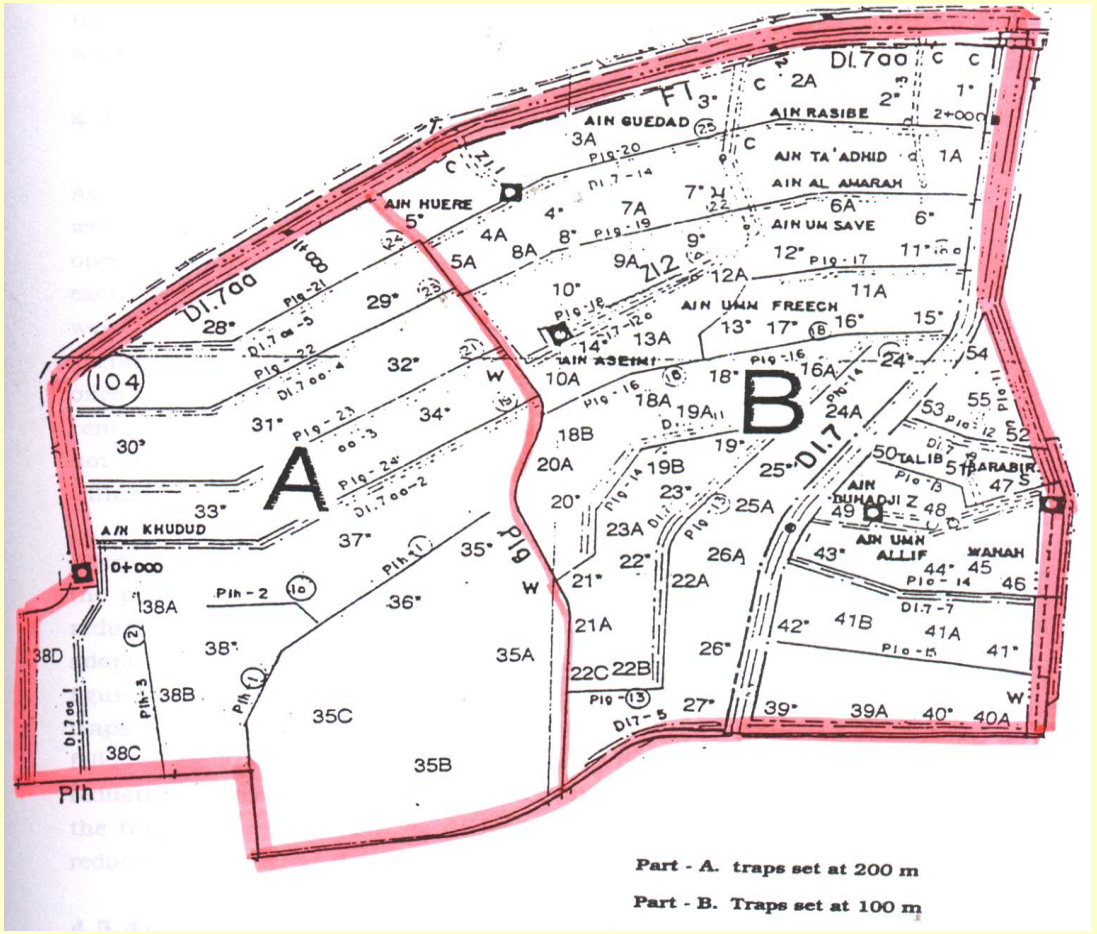
- Trap captures increased from 10 weevils / trap / month during May ,2009 to over 100 weevils / trap / month during February, 2010

Morocco

- Trap captures within 2-5 weevils / trap / month (2009-10) Morocco

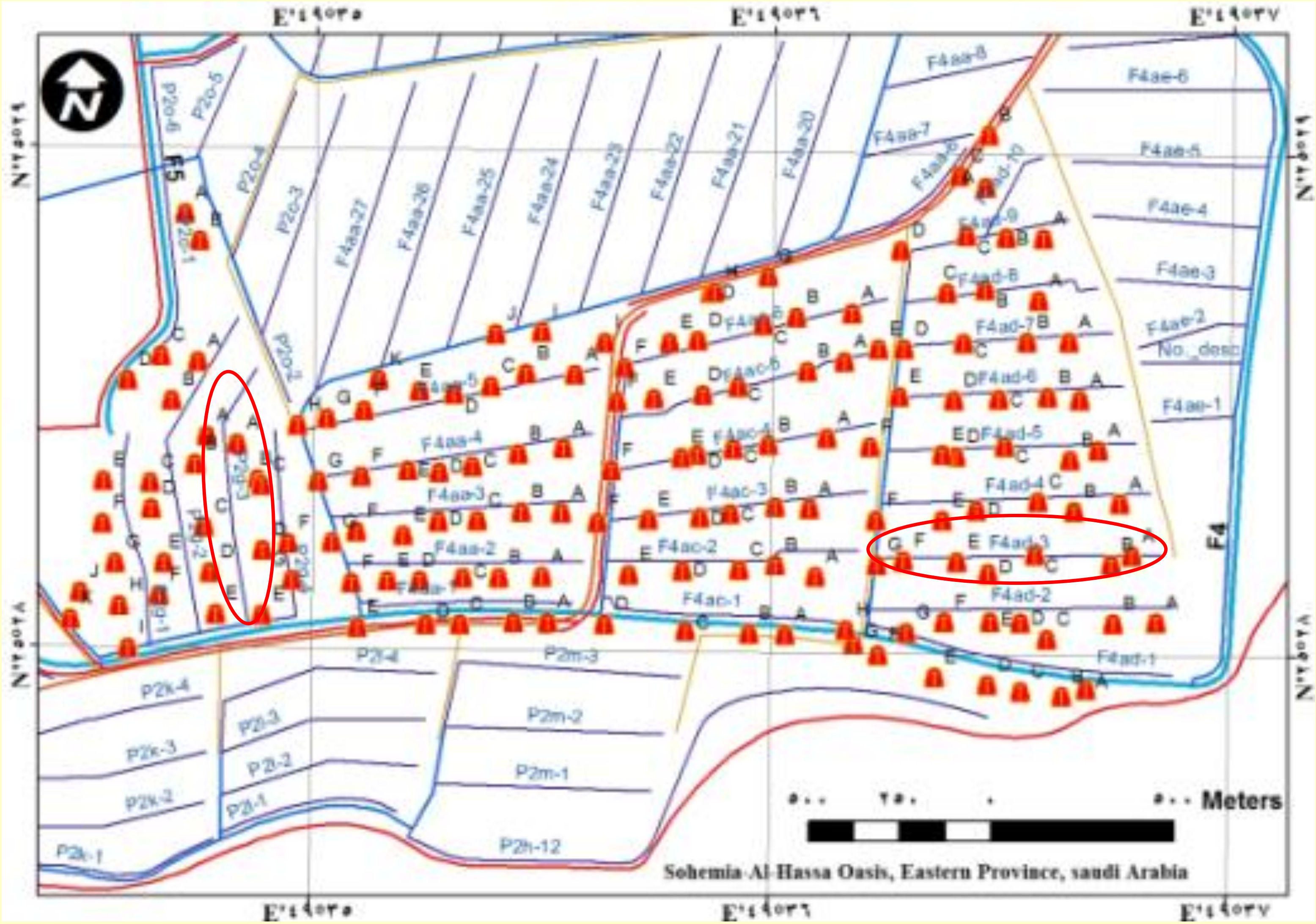
Maps : http://www.lonleyplanet.com

Pheromone traps set at two densities in date palm (1994-1998)

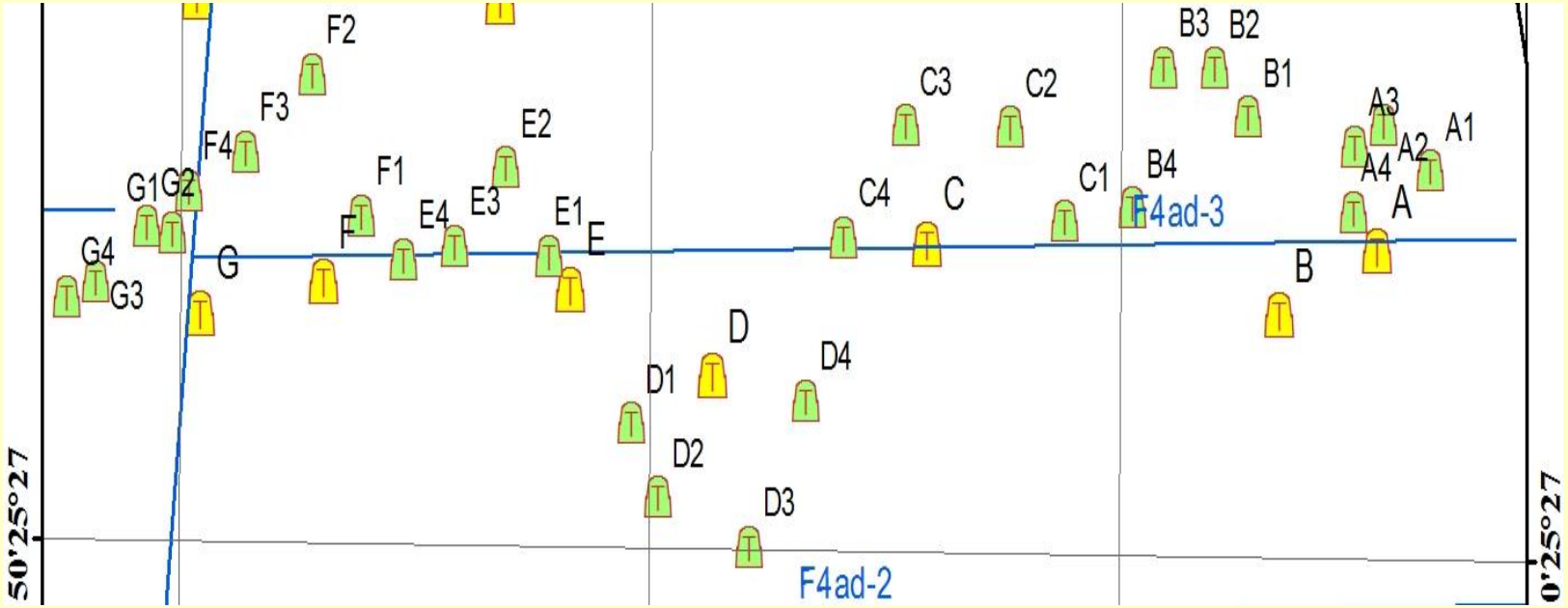


A:1trap/3 ha
B:1trap/1.5ha

Anonymous, 1998. Final report of the Indian Technical Team (Part A), - Red palm weevil control project, Ministry of Agriculture and Water, Kingdom of Saudi Arabia, pp 1-65.


N
F5
F4
P2o-6
P2o-5
P2o-4
P2o-3
P2o-2
F4aa-8
F4aa-7
F4aa-27
F4aa-26
F4aa-25
F4aa-24
F4aa-23
F4aa-22
F4aa-21
F4aa-20
F4aa-5
F4aa-4
F4aa-3
F4aa-2
F4aa-1
F4ac-6
F4ac-5
F4ac-4
F4ac-3
F4ac-2
F4ac-1
F4ad-9
F4ad-8
F4ad-7
F4ad-6
F4ad-5
F4ad-4
F4ad-3
F4ad-2
F4ad-1
F4ae-6
F4ae-5
F4ae-4
F4ae-3
F4ae-2
F4ae-1
No._desc
P2k-4
P2k-3
P2k-2
P2k-1
P2l-4
P2l-3
P2l-2
P2l-1
P2m-3
P2m-2
P2m-1
P2h-12
Meters
Sohemia-Al-Hassa Oasis, Eastern Province, saudi Arabia

Additional Traps (F4ad-3 : Al-Suhemia-1)



Position (UTM coordinates) for the additional 28 RPW-Pheromone Traps in Al-Suhemia-1

Additional Trap

Original Trap

DPRC,KFU /Directorate of Agriculture, Al-Hassa collaboration
GIS Support : MA Massoud

(Saudi Aramco-KFU Project on RPW)

Experimental details of area-wide RPW-IPM and mean monthly weevil captures (Dec 2011-May 2012)

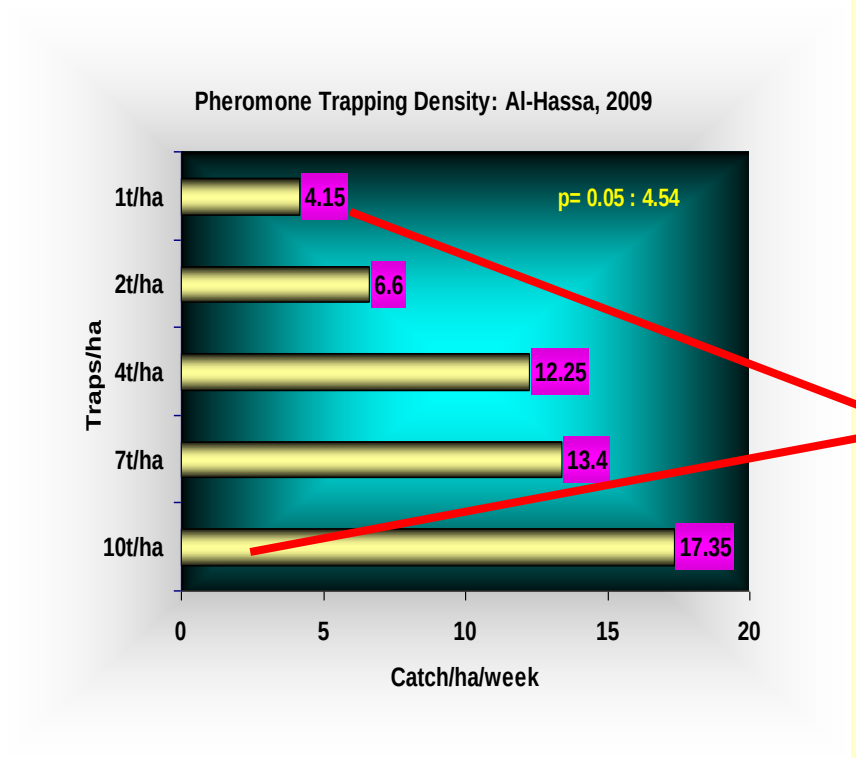
Treatment No.	IPM module	Canal #	Area (ha)	Trap density	**Mean monthly catch /trap in original traps ± SE	Capture/ha
T1	Regular RPW-IPM*	F4ad2 and P2g2	21	0.67 traps/ha	2.98± 0.58	11.81
T2	Regular RPW-IPM + Addition of Food – baited pheromone traps @ 4 additional around each existing traps	F4ad3 and P2g3	18	3.33traps/ha	1.48±0.32	18.05

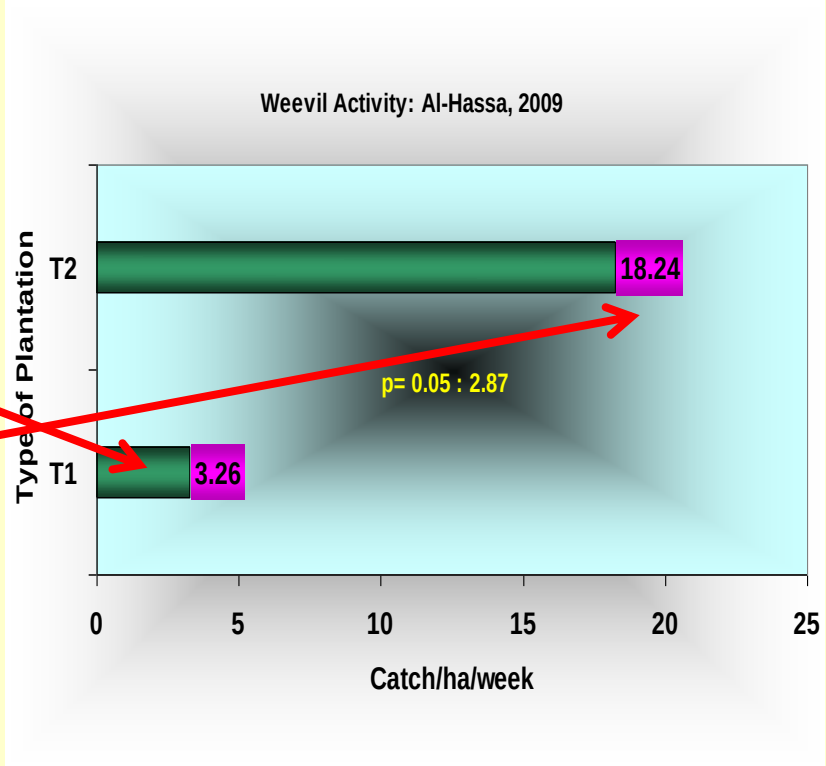
Additional Traps in T2 captured 219 weevils deep inside the plantation/canal

*Mass trapping (0.67traps/ha) adult weevils, periodic checking palms for infestation, preventive and curative insecticidal treatments and eradication of severely infested palms.

** Mean monthly captures significantly different (T-test: p=0.05)

Pheromone Trap Density Trial, Al Hassa, 2009



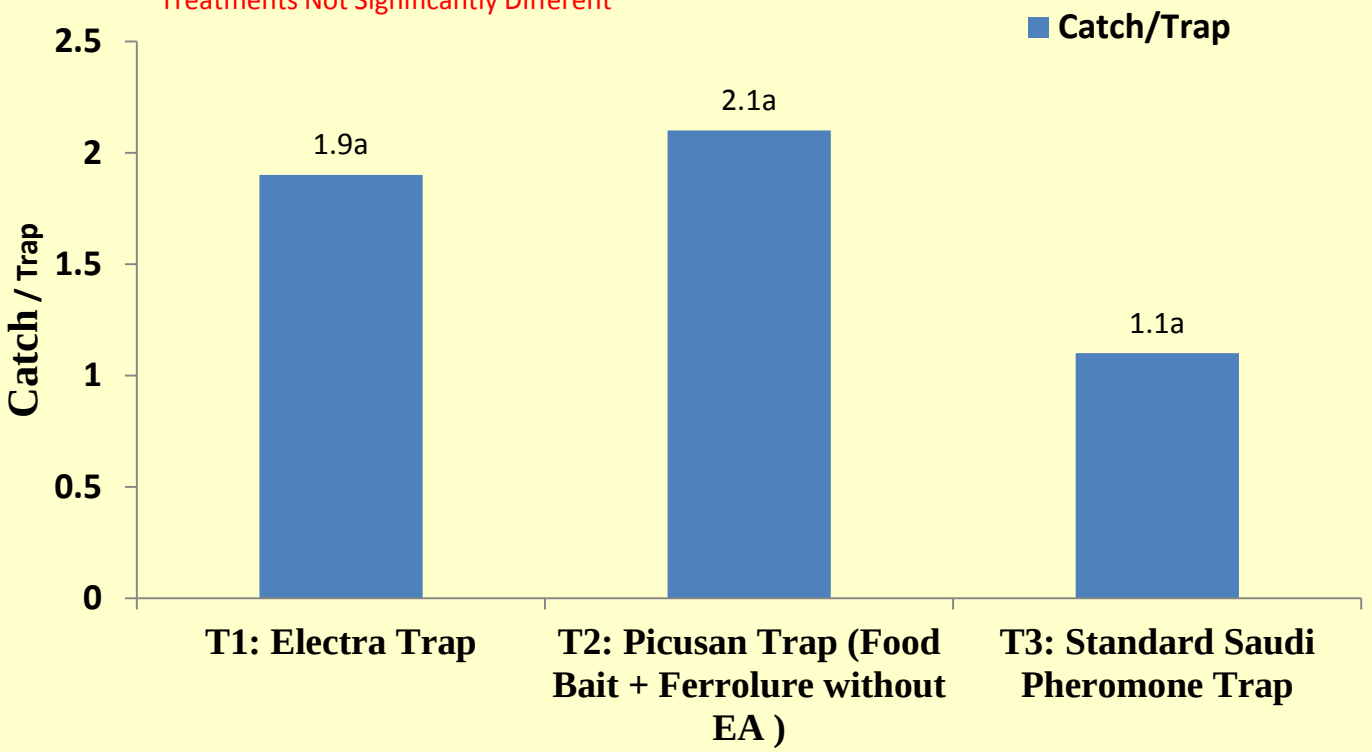


Faleiro, JR, El-Saad, MA and Al-Abbad, AH. 2011. *International Journal of Tropical Insect Science*.31:75-77.

Electra Trap (Without Food Bait) – Dry Trap

Weevil Captures in Red Palm Weevil traps 31 Jan-20 Feb, 2016 [Al-Hassa, Saudi Arabia]

ANOVA (p=0.05)
Treatments Not Significantly Different



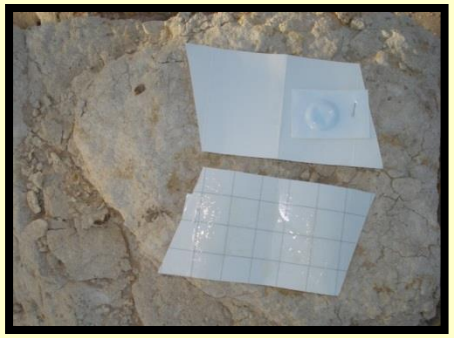
Bait and Trap Free Pheromone Technology for RPW

250- 400 A&K Points/ha

30 Points/ha

First A&K Study on RPW: El-Shafie et al., 2011 [King Faisal University, Saudi Arabia]

Paste Formulation of A&K Against RPW



Smart Ferrolure

Hook-RPW

RPW Attract & Kill Products

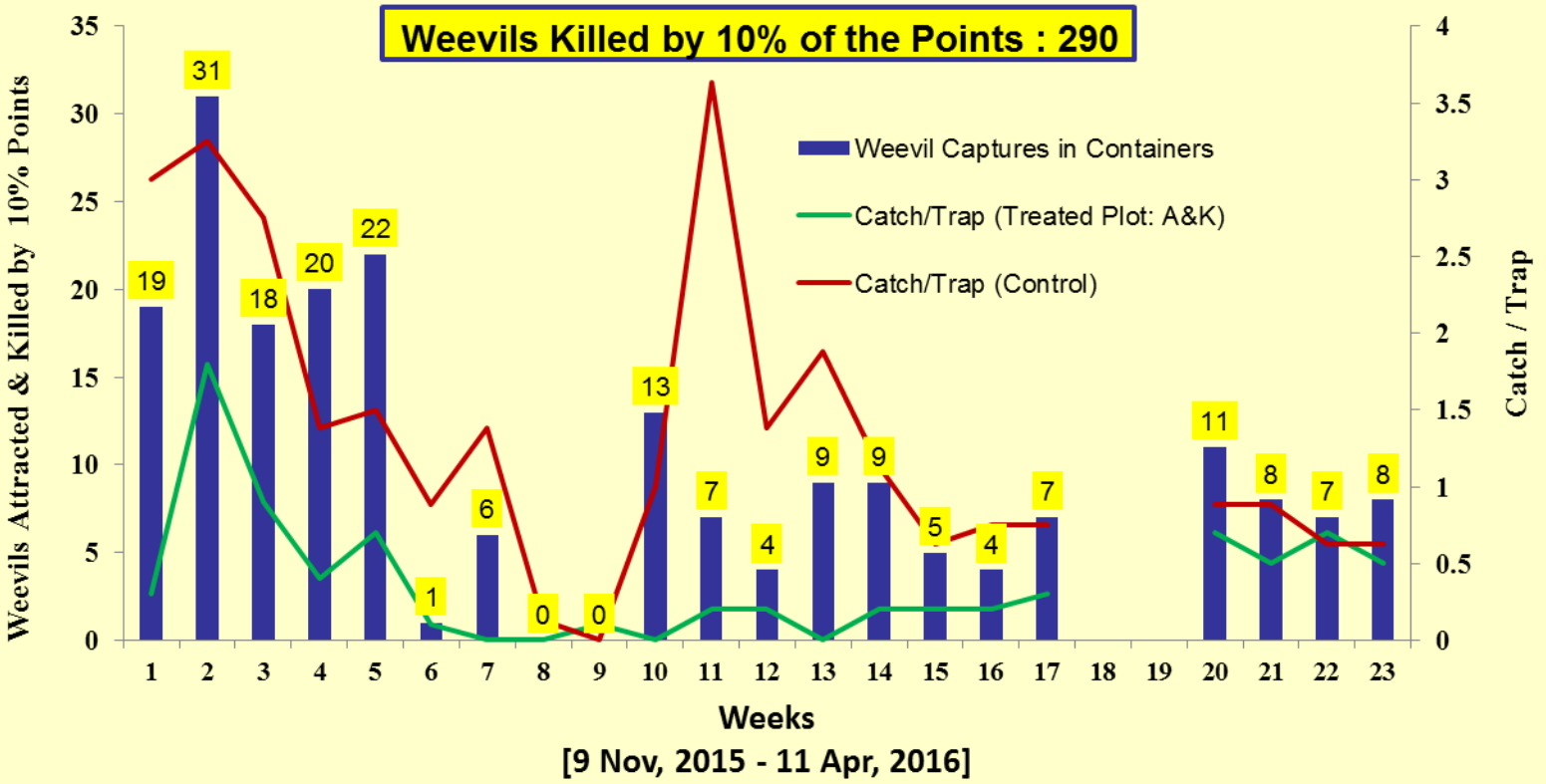
Hook-RPW

Smart Ferrolure

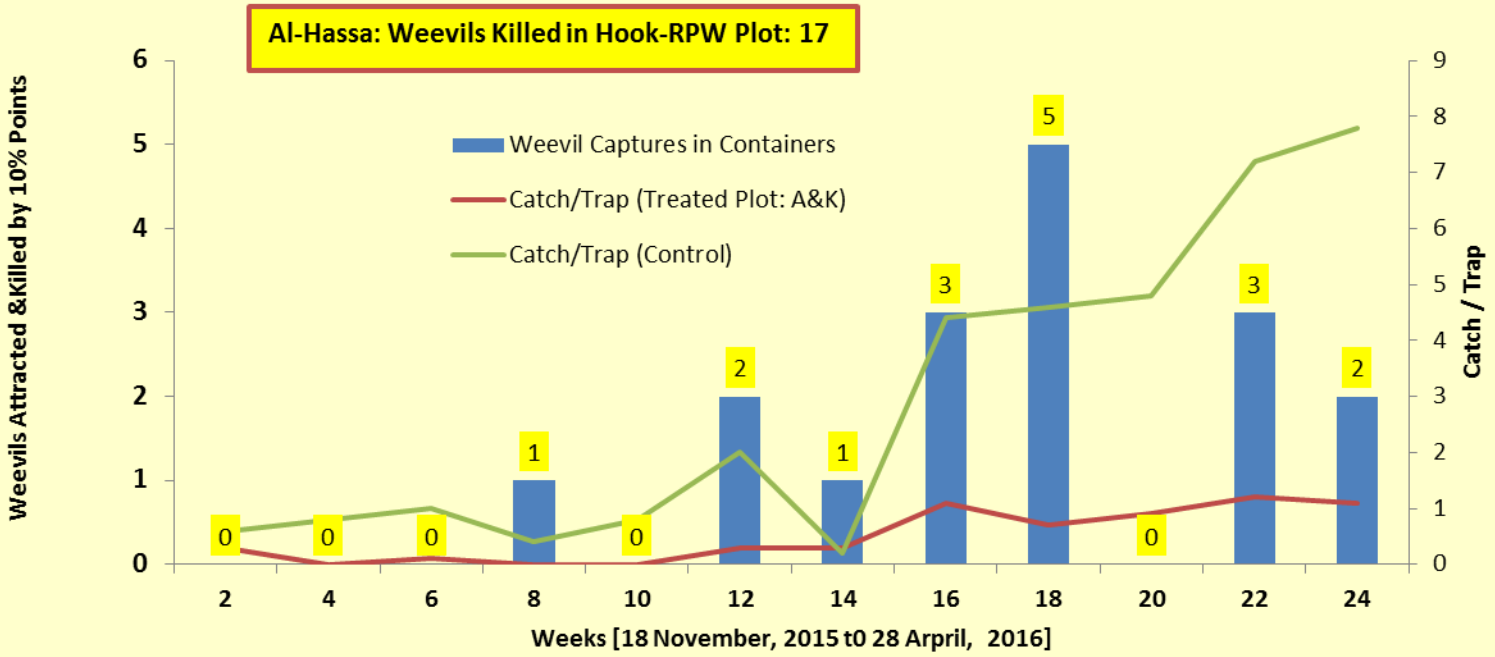
Dead Weevils in A&K Treated Plots

Proof of Kill : 10%- 50% of Points in Containers

A & K Trial with Hook-RPW in Al-Qassim, Saudi Arabia

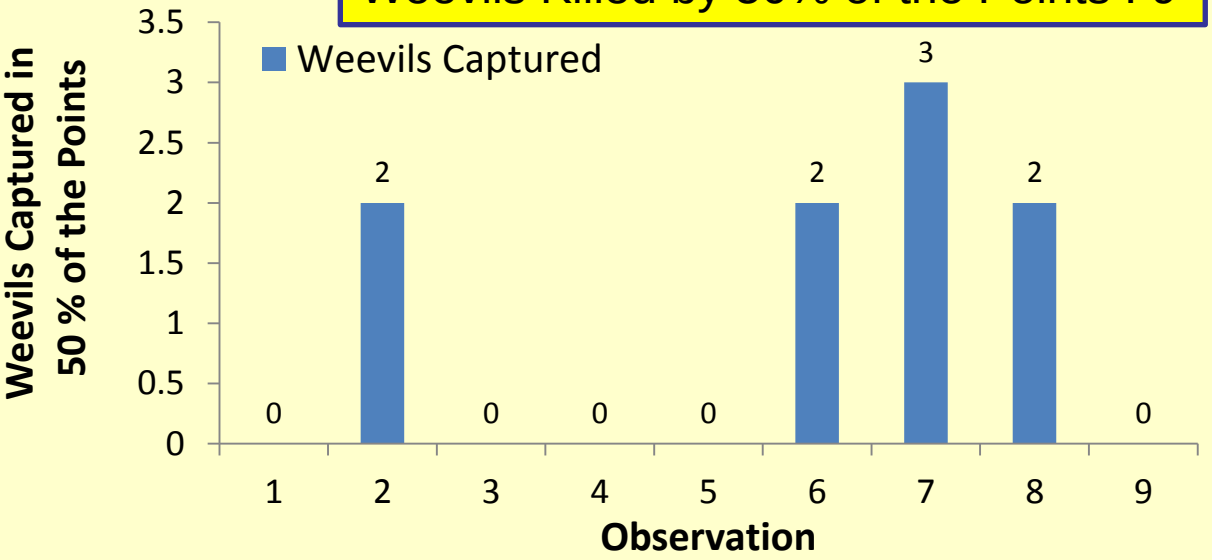


A&K Trial with Hook-RPW in Al-Hassa, Saudi Arabia



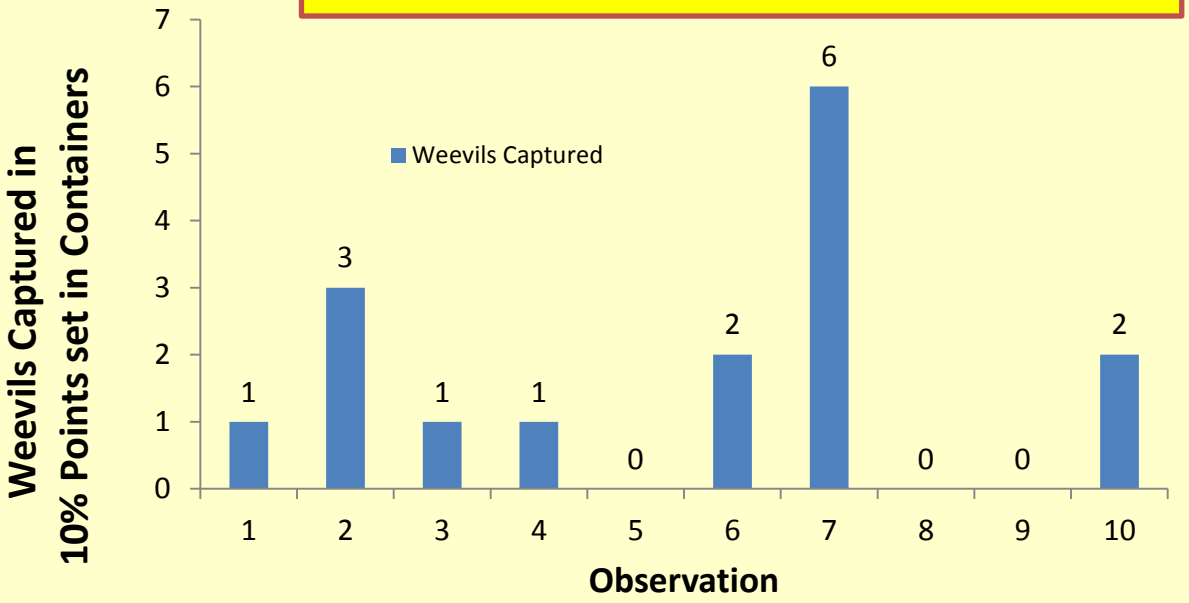
Smart Ferrolure
Card Device :
30points /ha
01 Sep-23 Nov, 2015
Al-Hassa, Saudi Arabia
[Plot Size: 2ha]

Weevils Killed by 50% of the Points : 9

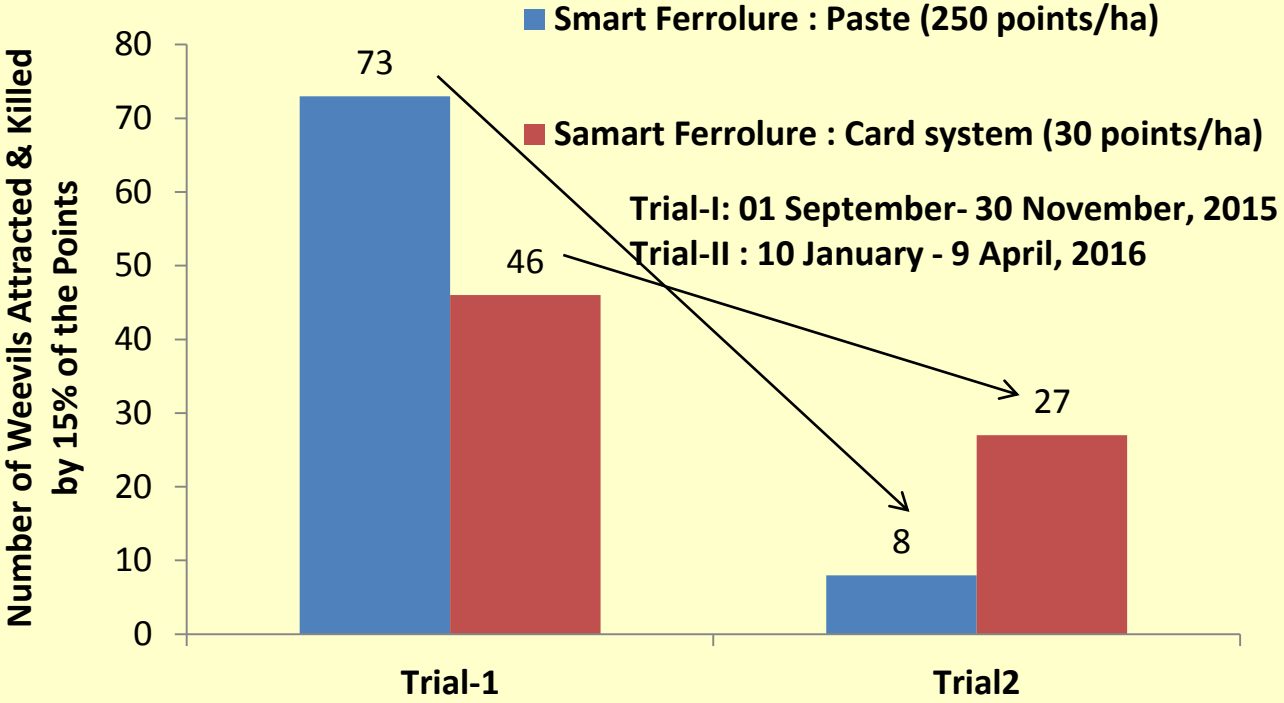


Smart Ferrolure
Paste : 250 points/ha
06Sep – 02 Dec, 2015
Al-Hassa, Saudi Arabia
[Plot Size : 3ha]

Weevils Killed by 10% of the Points: 16



A&K Trials with Smart Ferrolure in Oil Palm [01 September, 2015 to 09 April, 2016]: Goa, India

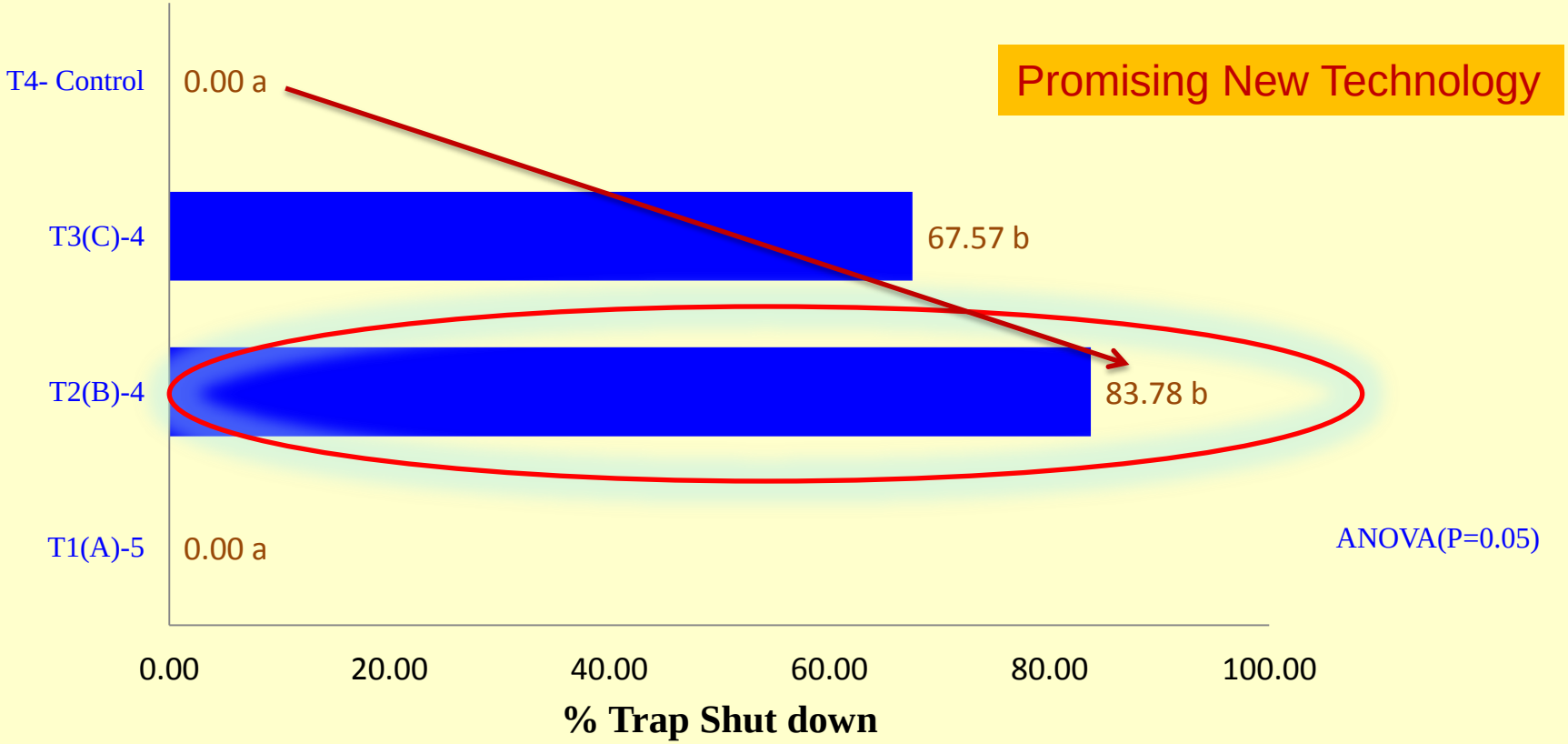


No-Bait / No-Trap Ferrugineol Based A&K Techniques : Important to Manage RPW in Neglected Plantations

A&K Technology Deployed to Control RPW in Mauritania

RPW Repellents

Promising New Technology



A Push-Pull Strategy using RPW Repellents & Pheromones

Chemical Control

Preventive Chemical Treatments

Low Pressure High Volume Sprays

Targeted Preventive Sprays
-After Offshoot & Frond Removal

- ✓ Plantations
- ✓ Nurseries
- ✓ Ornamental/Avenue Palms

Curative treatment of RPW infested palms

Mechanical Sanitation

Palm Injectors ?

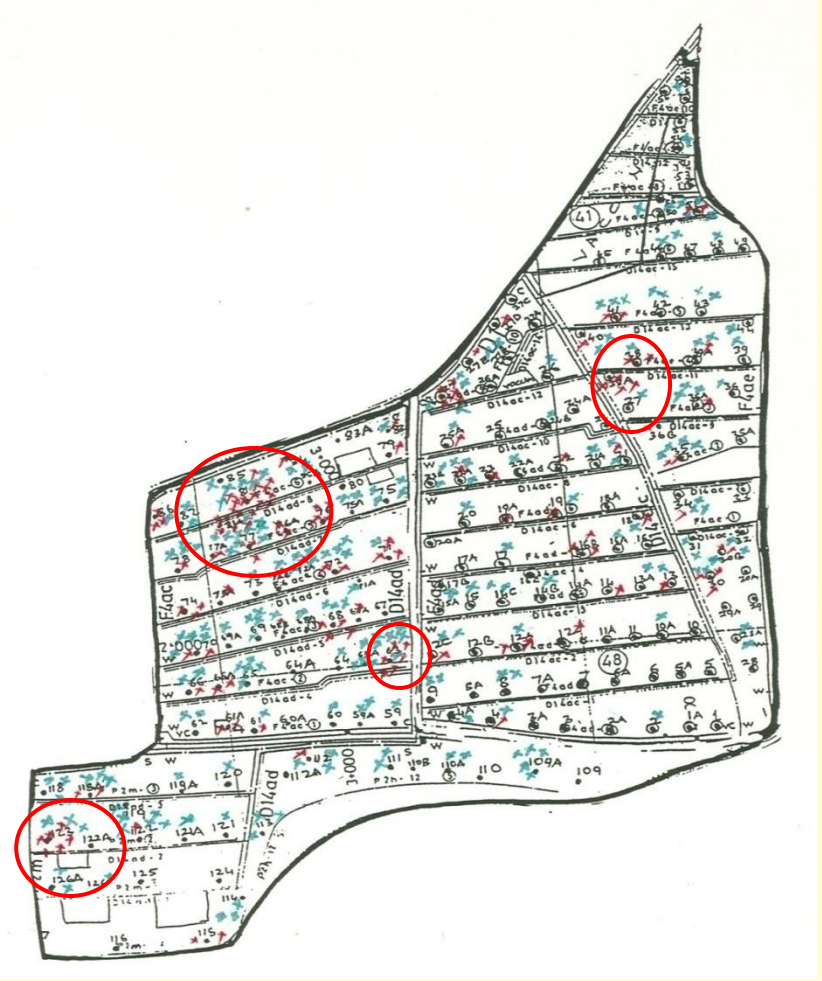
Insecticide Residues Due to Both Preventive & Curative Chemical Treatments

Biological Control

Potential Biocontrol Agents	Scientific Name
Insects (Wasp, Earwig)	*Scolia erratica* , *Sarcophaga fuscicauda*, *Chelisoches moris*
Bacteria	*Pseudomonas aeruginosa*, *Bacillus* sp., *Serratia* sp. *B. sphaericus, B. mgaterium,* *B. laterosporus*, and *B. thuringinsis*,
Fungus	*Beauveria bassiana, Metarhizium anisoplieae*
Virus	Cytoplasmic Polyhedrosis Virus (CPV),
Yeast	------
Entomo-Pathogenic Nematodes (EPN)	*Heterorbhabditis* spp., *Steinernema abbasi*, *Heterorbhabditis indicus, Teratorhabditis palmarum*, *Steinerema* sp., *H. indica*, and *Rhabditis* sp.
Birds (Indian tree pie bird and Crow pheasant bird)	*Dendrocitta vagabunda parvula*

Under field conditions, imidacloprid and *S. carpocapsae*, either alone or in combination were not significantly different from each other, with efficacies ranging from 73 to 95 % (Dembilio et al., 2010). *Beauveria bassiana* solid formulation with high RPW pathogenicity and persistence, could be applied as a preventive as well as curative treatment for RPW control (Gűerri-Agulló et al., 2011).

Periodic Validation / Risk Assessment



AL-SUHEMIA (1997)

Number of traps = 181

Number of infestation=127

Number of palms= 30,000 (270ha)

Catch/trap= 1.18

Per cent infestation= 0.45

1998- Final report of the Indian Technical Team (Part A), - Red palm weevil control project, Ministry of Agriculture and Water, Kingdom of Saudi Arabia, pp 1-65.

Periodic Monitoring & Evaluation of the RPW-IPM Strategy

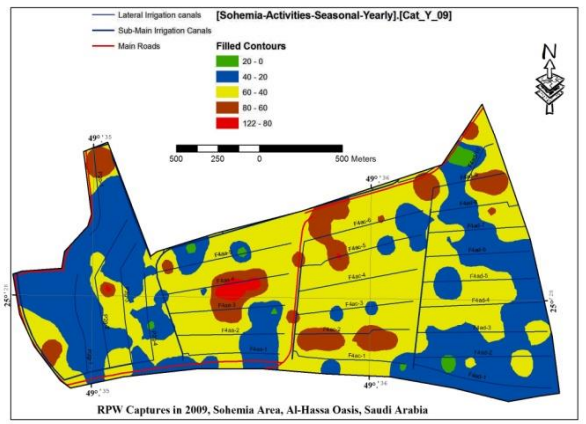
Canary Island RPW Control Program :
Effective use of Mobile Applications /GIS for Instant Communication
[Data Collection, Transmission, Interpretation & Decision Making]

Photo by : Moisés Fajardo Bello
Coordinador GMR Canarias

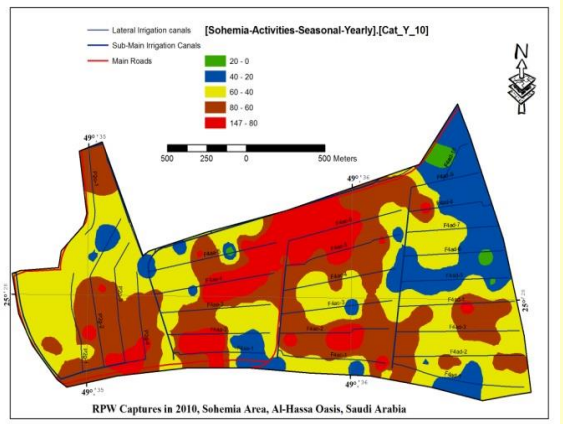
GIS : Canary Island Experience

Decision Making
Efficient planning
Efficient use of resources
Assessment of results and goal
Assessment of workers
Better Comunication

Al-Suhemia, Saudi Arabia
2009 / 2010

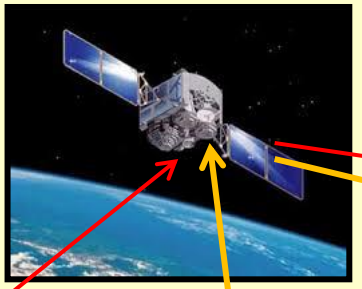


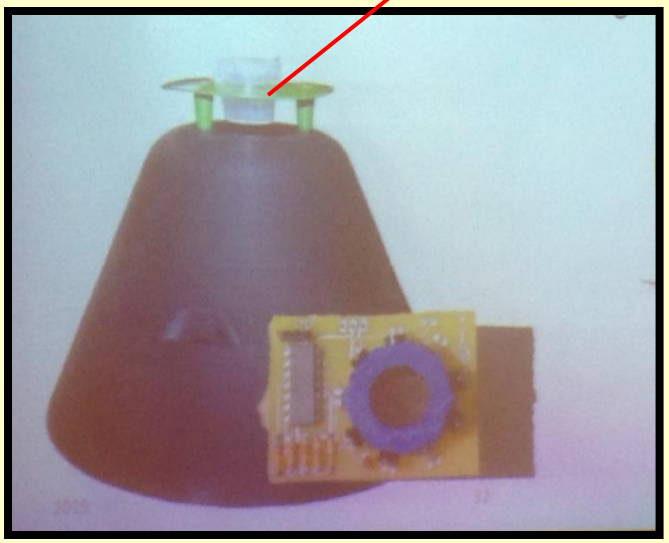
RPW Captures in 2009, Sohemia Area, Al-Hassa Oasis, Saudi Arabia



RPW Captures in 2010, Sohemia Area, Al-Hassa Oasis, Saudi Arabia

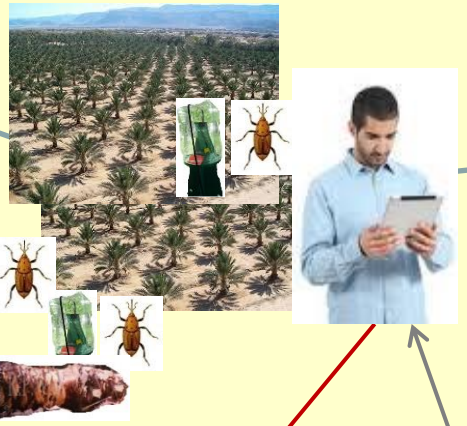
Smart Trap



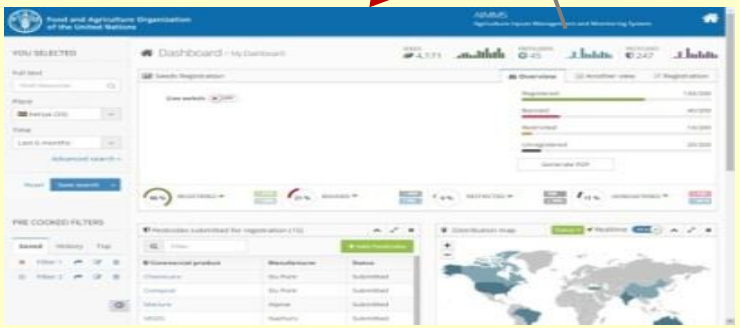


Future Possibility : Fabricate a Smart Dry Trap to Eliminate Servicing & 24x7 Data Collection

Mobile Data Collection - Workflow

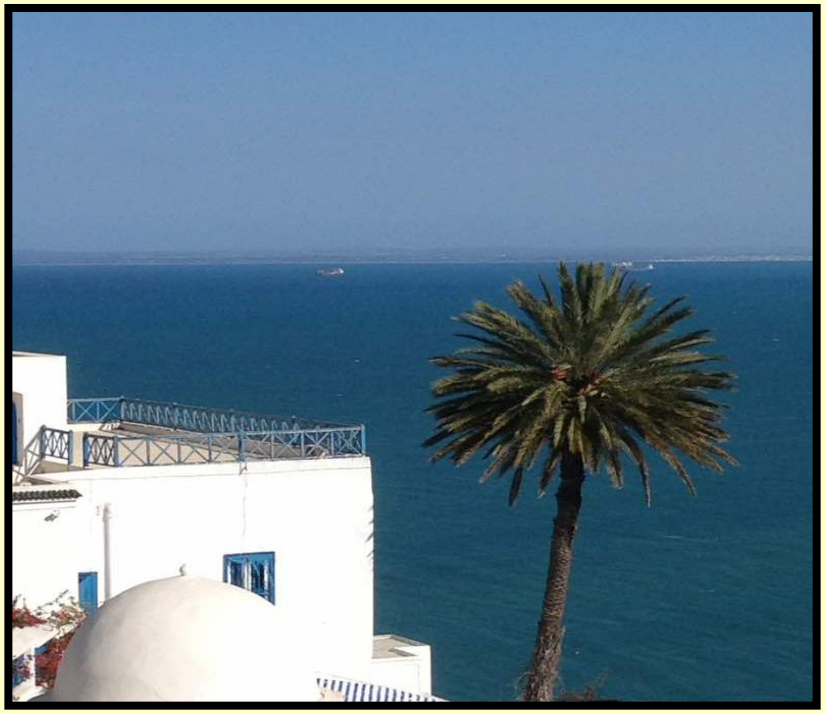


Data gathered, analyzed for informed decision-making and actions performed by the team



RPW Unified Platform

Source : FAO



THANK YOU شكرا

Acknowledgements

- ✓ Food and Agriculture Organization of the UN
- ✓ Ministry of Environment, Water and Agriculture, Kingdom of Saudi Arabia
- ✓ King Faisal University, Kingdom of Saudi Arabia
- ✓ Indian Council of Agricultural Research