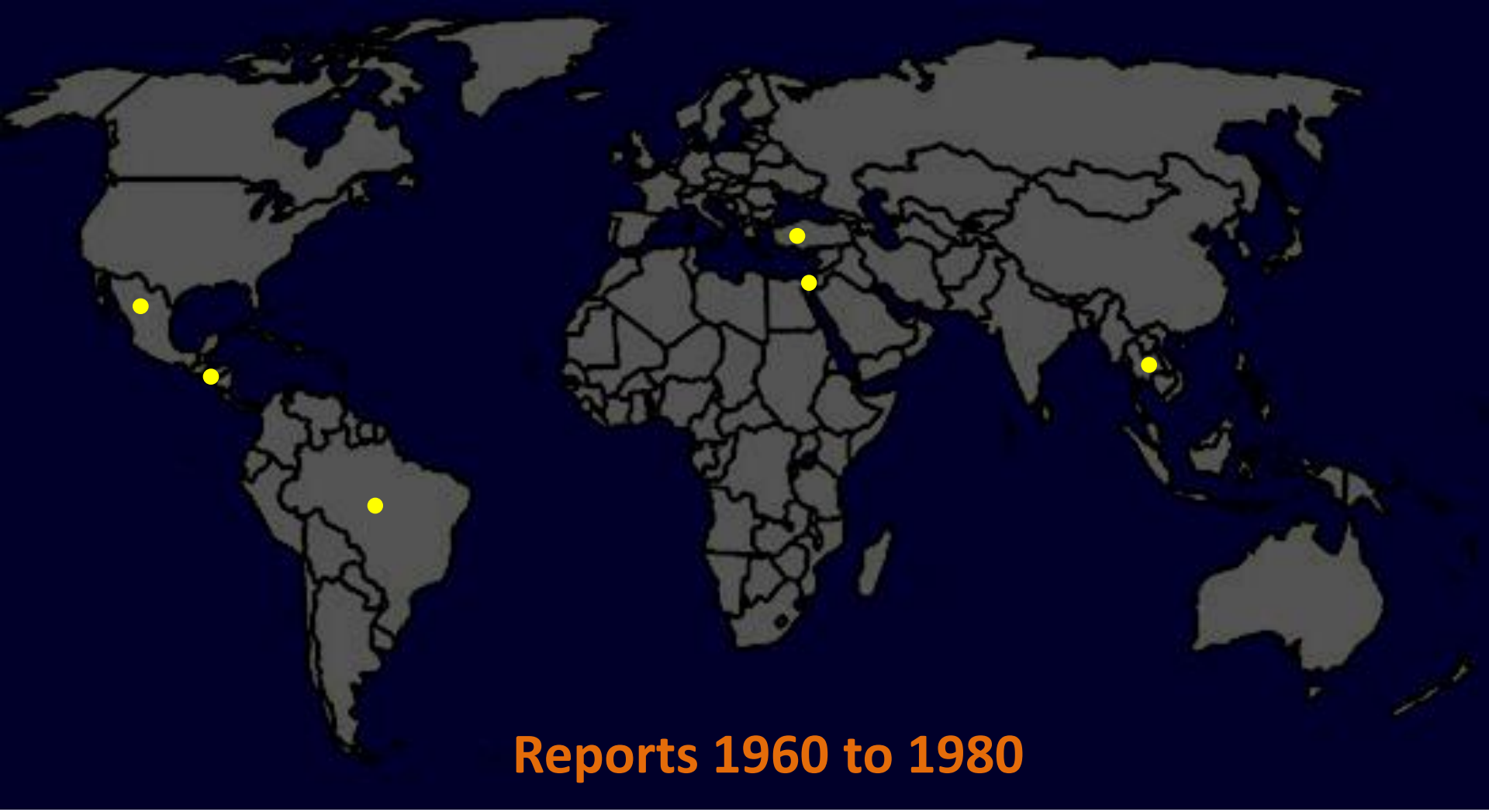
# Whitefly epidemics on cotton in north India: lesson learnt and way forward

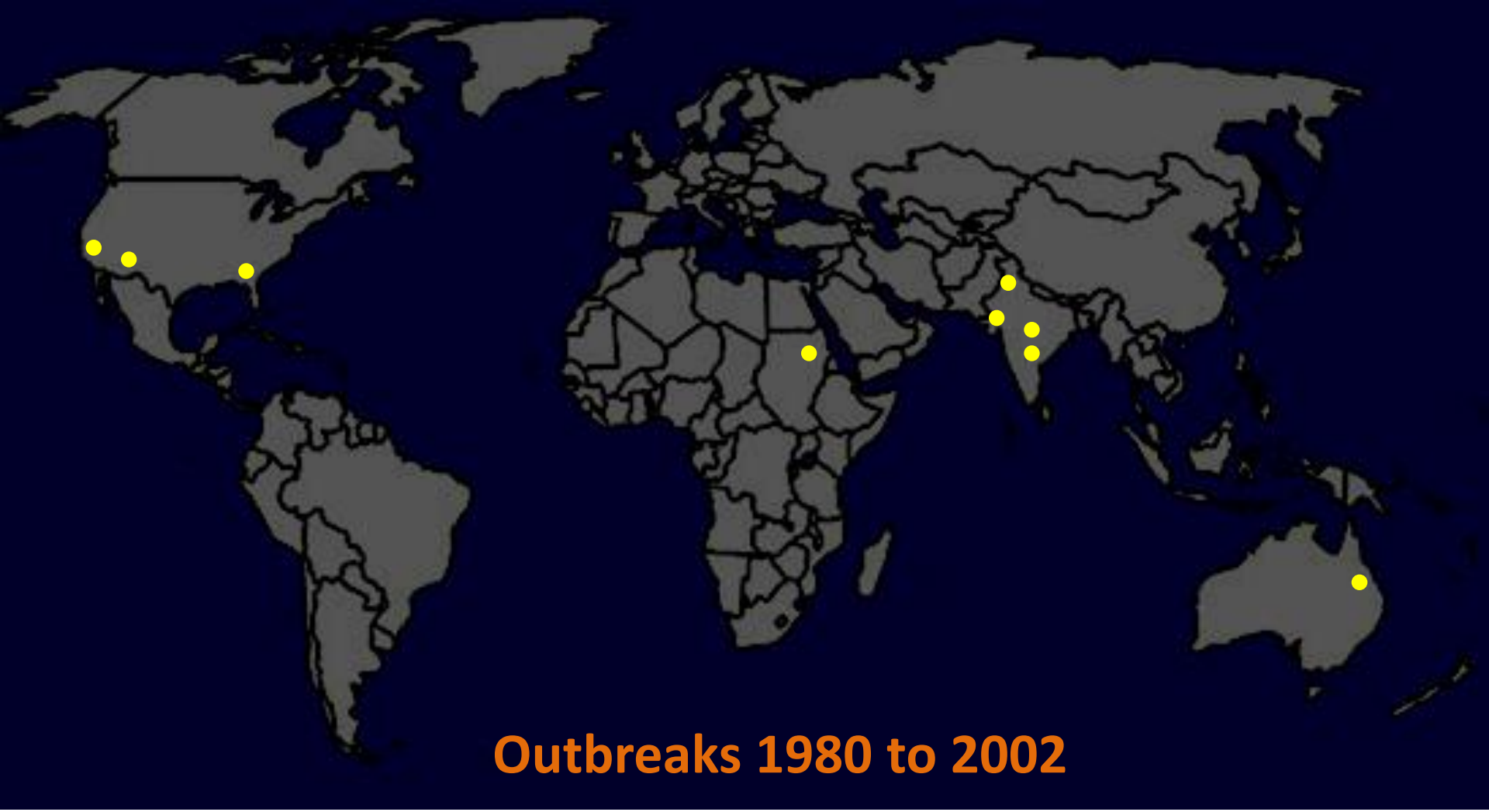
Rishi Kumar, K. R. Kranthi, S. Kranthi and D. Monga

# Whitefly outbreaks worldwide


1889 Greece; 1905 India ( Bihar); 1912 Nigeria;
1929 India (Punjab); 1930 Sudan; 1950 Sudan

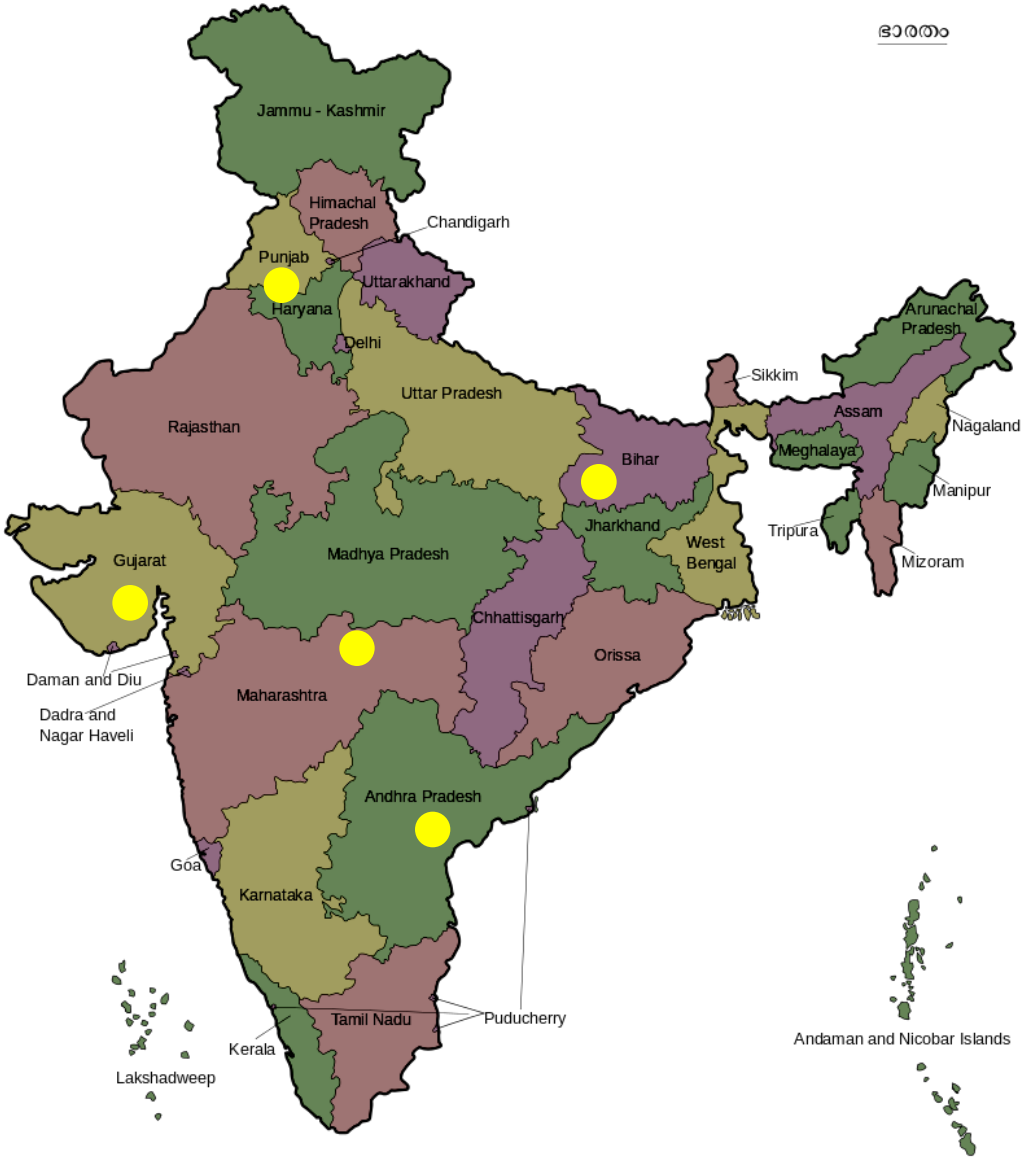



1961 El Salvador; 1962 Mexico; 1968 Brazil
1974 Turkey; 1976 Israel; 1978 Thailand




1980 Sudan; 1981 USA( Arizona, California), 1986 USA (Florida); 1987 – India (AP, Mah, Gujarat )1995 USA (Arizona); 1996 India (Punjab); 2002 Australia

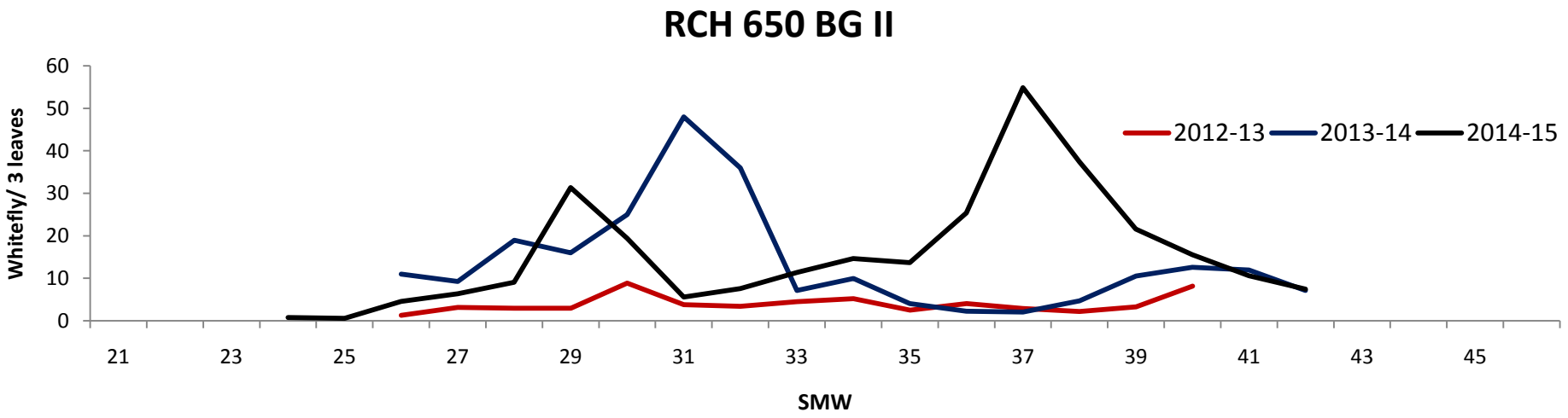
# Whitefly Outbreaks in India and the latest epidemics of 2015

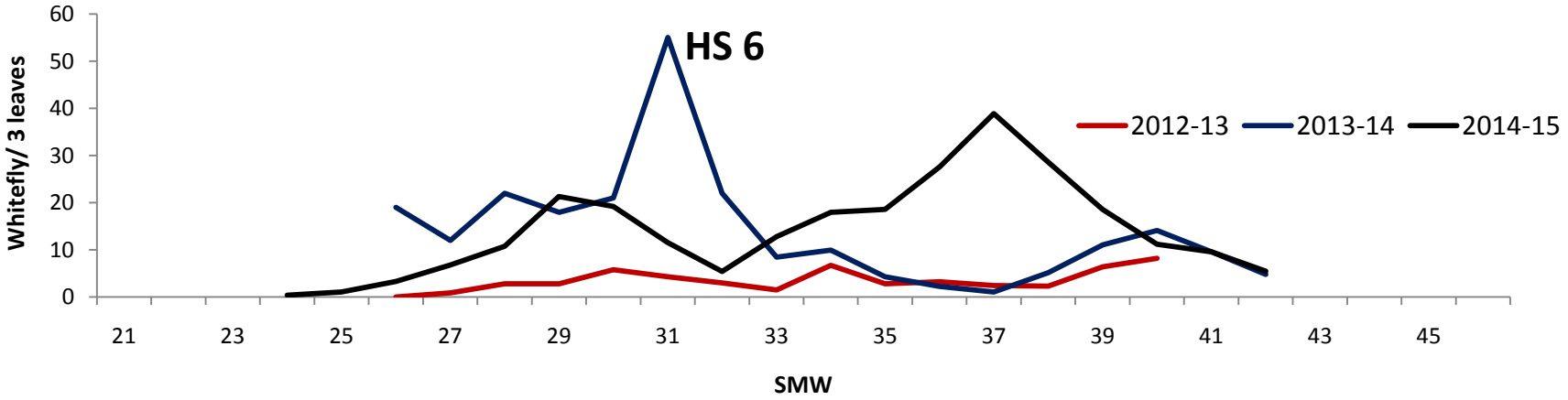



**1905 Bihar**
**1929 Punjab**
**1987 AP, Maharashtra, Gujarat**
**1996 Punjab**
**2015 North Zone (Punjab /Haryana/rajasthan)**

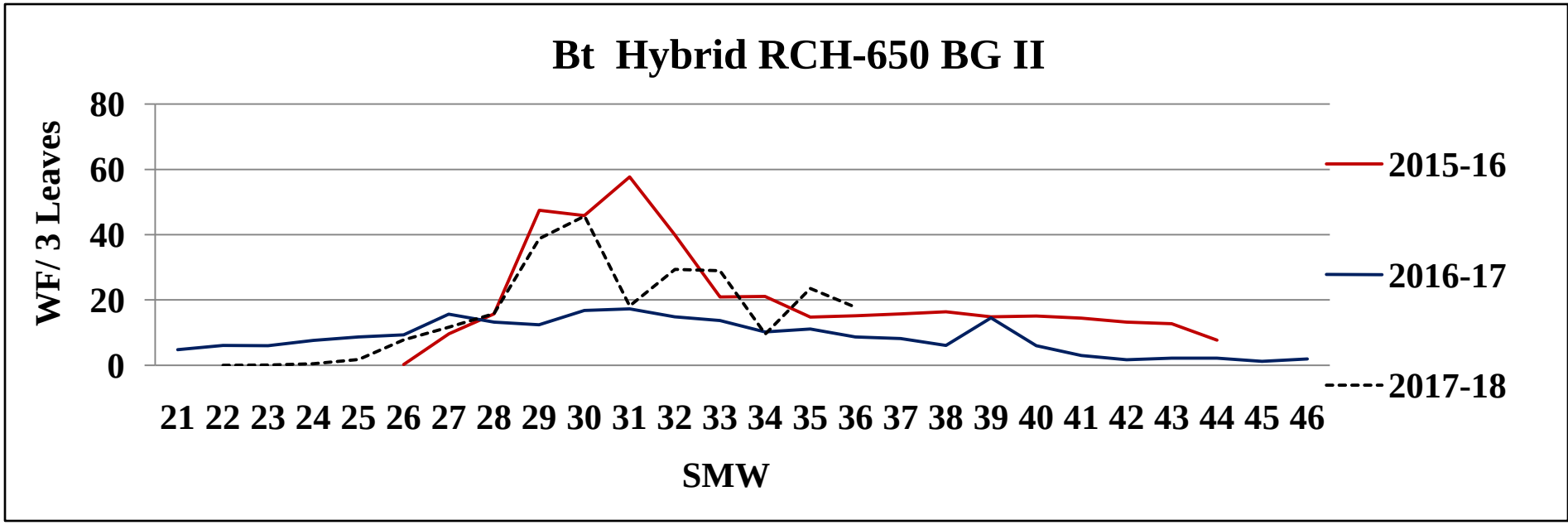
# Whitefly incidence pre epidemic (2012-14) and post epidemic period (2015-2017)

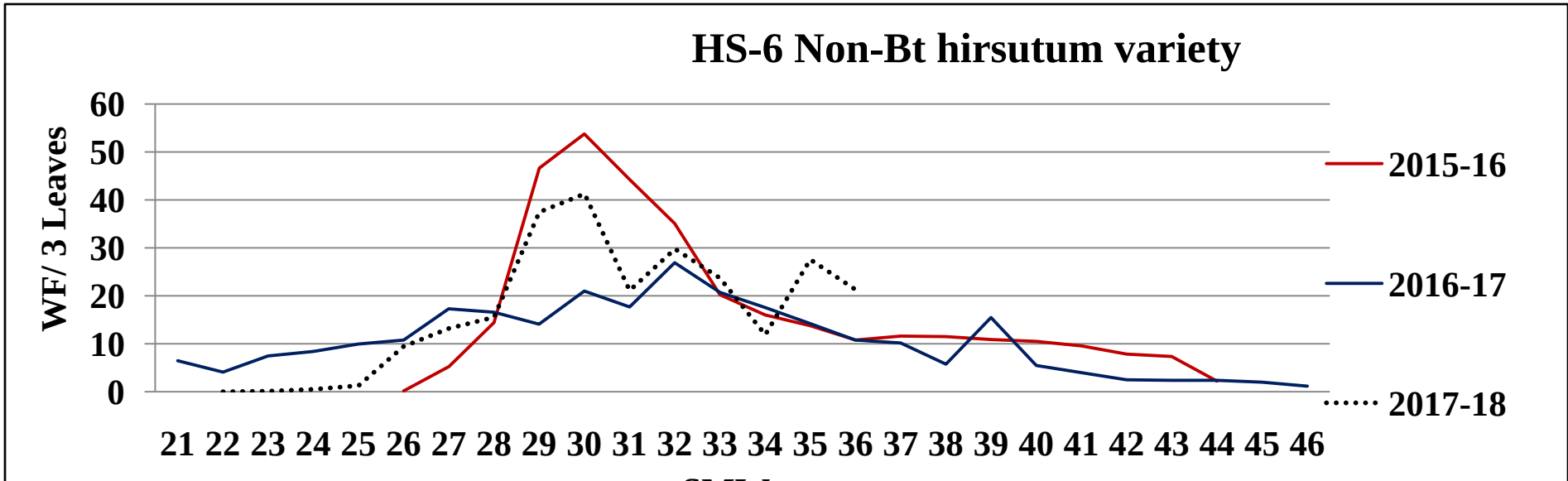
# Incidence of whitefly in cotton under unprotected conditions during different years (2012-14)

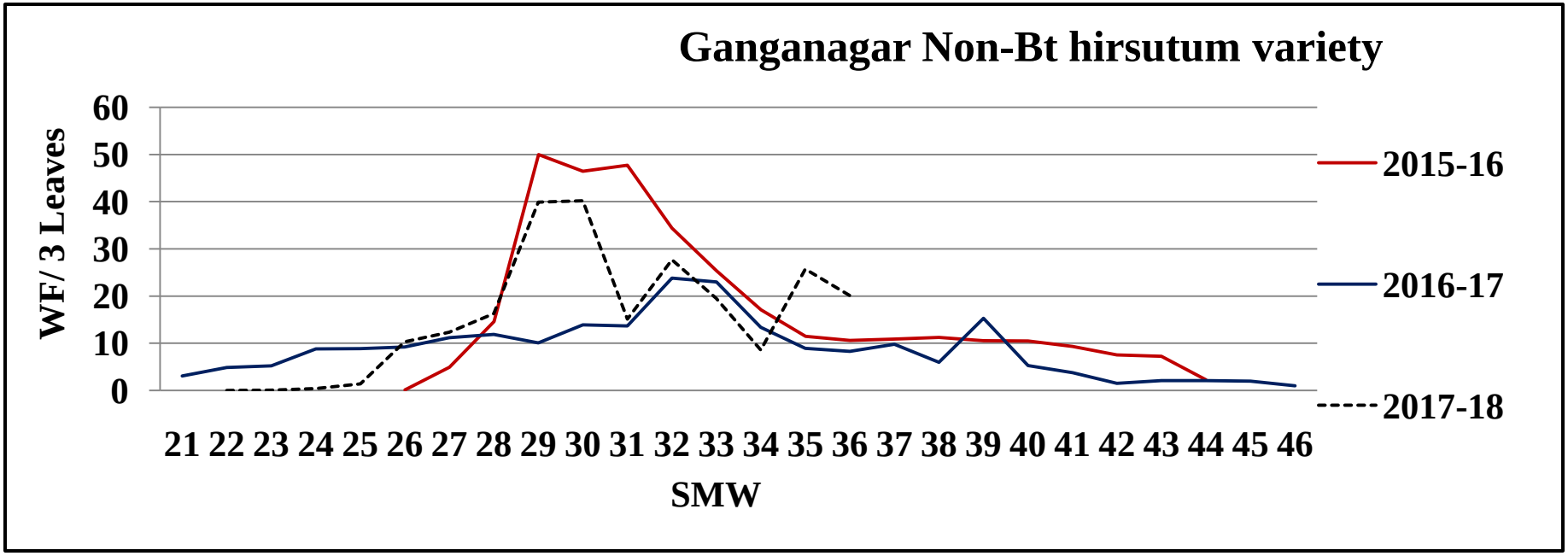


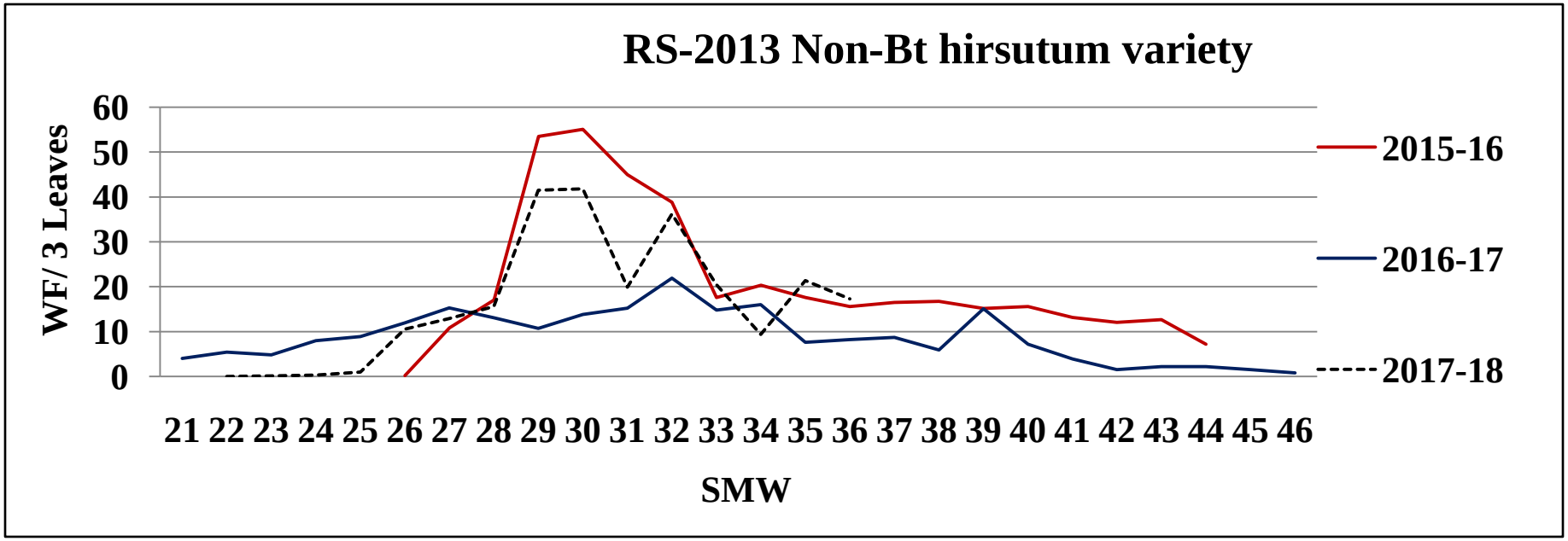



# Incidence of whitefly in cotton under unprotected conditions during different years




Ganganagar Non-Bt hirsutum variety
WF/ 3 Leaves
60
50
40
30
20
10
0
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
SMW
2015-16
2016-17
2017-18


RS-2013 Non-Bt hirsutum variety
WF/ 3 Leaves
60
50
40
30
20
10
0
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
SMW
2015-16
2016-17
2017-18

Important factors which led to whitefly outbreak in North Cotton Growing Zone of India during 2015

- **Perpetuation and multiplication of whitefly on other alternate hosts.**
- **Susceptible hybrids, hairy or bushy genotypes.**
- **Delayed sowing.**
- **Congenial climatic conditions for whitefly.**

- **Stresses due to various factors such as lack of irrigation, water logging, poor quality water, soil salinity, nutrient deficiencies, poor weed management etc.**

- **Tendency towards over use of nitrogenous fertilizers**
- **Scant regard for ecology, early insecticidal interventions, Use of unrecommended insecticides and Insecticidal mixtures.**
- **Insecticide resistance/resurgence.**
- **Improper spray application methods vs. site of insect feeding and resting.**

# 1. Congenial climatic conditions for whitefly

**High humidity and moderate temperature due to frequent rains during June appeared to be the possible reasons for high incidence of whitefly in July .**

**Normally heavy rainfall in July-September washed out the adults of whitefly. But during 2015 no heavy showers were recorded during this period**

- **Relatively less severe winters during 2014-15**

# 2. Delayed sowing

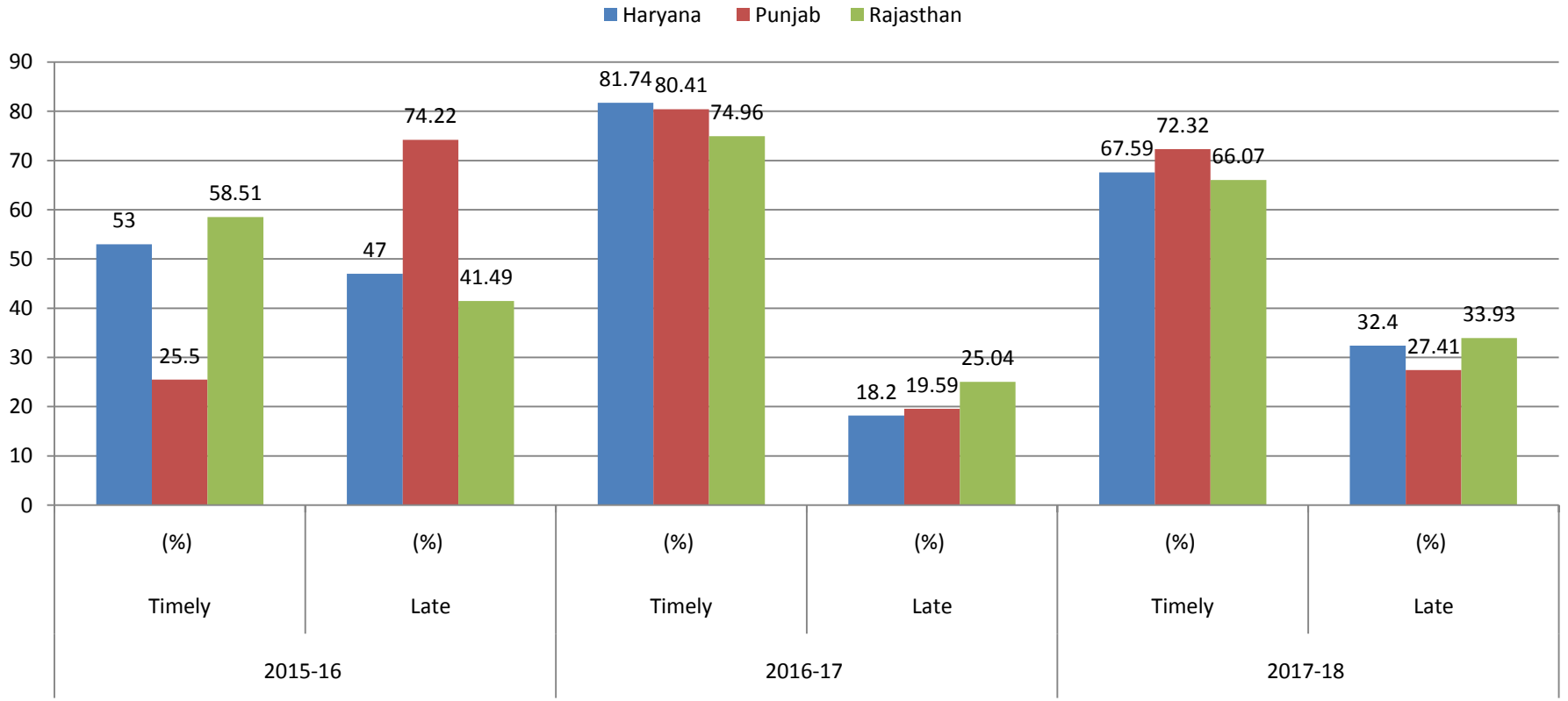
**Sowing time: Ist April up to 15 May.**

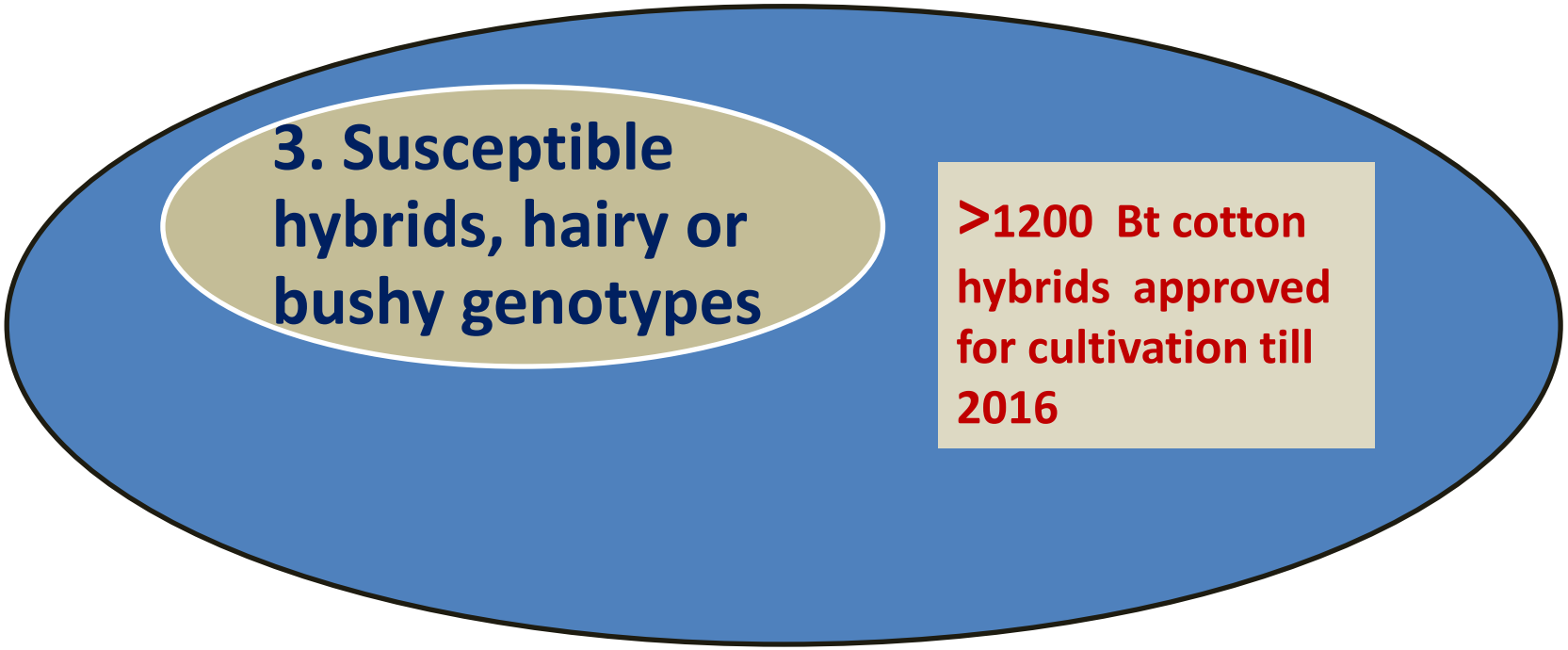
# Total area sown under cotton during 2015-17 ( lac ha)

| States | 2015-16 | | | 2016-17 | | | 2017-18 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Timely sown area *(ha) | Late sown area **(ha) | Total area ( ha) | Timely sown area *(ha) | Late sown area **(ha) | Total area ( ha) | Timely sown area *(ha) | Late sown area **(ha) | Total area ( ha) |
| Haryana | 308266 | 272289 | 580555 | 407364 | 90998 | 498362 | 443665 | 212725 | 656390 |
| Area (%) | 53 | 47 | | 81.74 | 18.2 | | 67.59 | 32.40 | |
| | | | | | | | | | |
| Punjab | 1.16000 | 334000 | 450000 | 230000 | 56000 | 286000 | 277000 | 105000 | 383000 |
| Area (%) | 25.5 | 74.22 | | 80.41 | 19.59 | | 72.32 | 27.41 | |
| | | | | | | | | | |
| Rajasthan | 129748 | 92025 | 221809 | 153087 | 51131 | 204218 | 182698 | 93831 | 276529 |
| Area (%) | 58.51 | 41.49 | | 74.96 | 25.04 | | 66.07 | 33.93 | |

*up to 15th May,**After 15th May

# Percent timely and late sown area during different years in North Zone



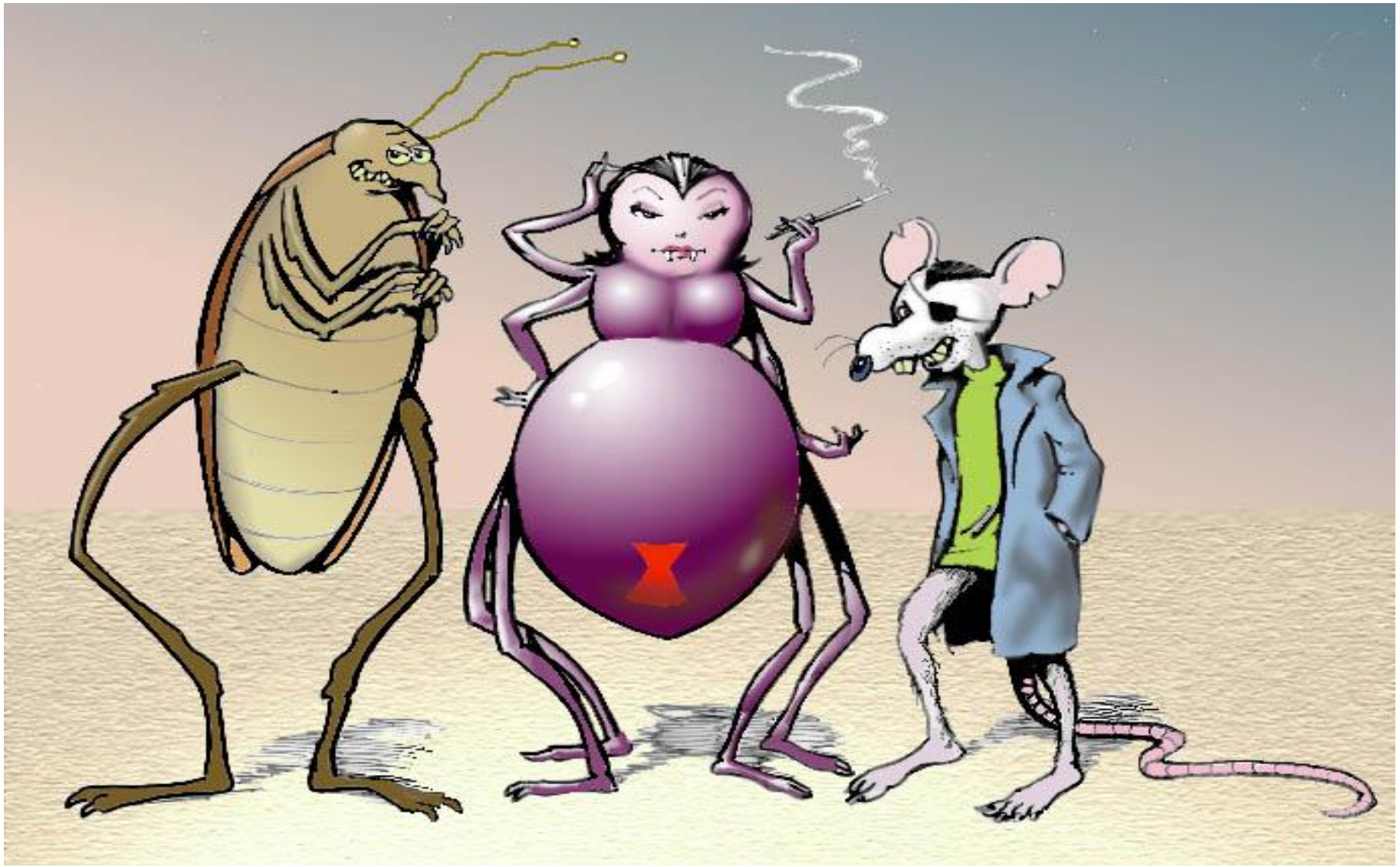

3. Susceptible hybrids, hairy or bushy genotypes
>1200 Bt cotton hybrids approved for cultivation till 2016

# Perpetuation and multiplication of whitefly on other alternate hosts

>900 alternate crop and weed hosts

| tegory | Year round | During cotton season (July to October) | During off season(Nov. to April) |
|---|---|---|---|
| Major weed host | Congress grass (*Parthenium hysterophorus*), Bhang (*Cannabis Sativa*), Puthkanda (*Achyranthes aspera*), Wild sunflower (*Tithonia diversilia)* | Tandla (*Digera muricata*), *Malvestrum* (*Malvastrum* coromandelianum), Dicliptera (*Dicliptera brachiata)*, Ipomoea (*Ipomoea indica)*, *Sida (Sida acuta)*, Itsit, Kangibooti (*Abutilon indicum*) | Bhagthal, *Datura (Datura spp)*, Makoh (*Solanum nigrum)*, *Ageratum*, *Lantana (Lantana camara)*, Bhambola (*Physalis minima*) |
| Minor weed host | Jangli mirch (*Capsicum spp*) | Khipbooti, Chulaye ( *Amaranthus viridis*), Bhakhda ( *Tribulus terrestris*), Gutputna (*Aegopodium podagraria* ), Bathu (*Chenopodium album*), Dodak (*Euphorbia hirta*) | Hirankhuri (*Convolvulus arvensis*), Satyanasi (*Argemone mexicana*),Rind (*Sandoricum koetjape*), Senji (*Melilotus indicus*). |

# Resistance monitoring of whitefly population from 4 locations of North Cotton Growing Zone of India and One location ( Nagpur) of Central India



## Insecticide Resistance in *Bemisia tabaci* 1997-98

| | | **Cypermethrin** | | | **Chlorpyriphos** | | |
|---|---|---|---|---|---|---|---|
| District | Collection date | n | $LD_{50}$ | RF | n | $LD_{50}$ | RF |
| Sudan susceptible | | 575 | 7.0 | | | 2.90@ | |
| Rangareddy | Nov '97 | 336 | 32.8* | **5** | | | |
| | Dec '97 | 353 | 263* | **37** | | | |
| | Dec '97 | | | | | | |
| | Jan '98 | 289 | 98.8* | **14** | | | |
| | Feb '98 | 331 | 313* | **45** | 320 | 5.70 | **2** |
| | May '98 | | | | 348 | 4.5 | **1** |
| | June '98 | | | | | | |
| | Nov '98 | 379 | 109* | **15** | | | |
| Mahboobnagar | Dec '98 | 402 | 75* | **11** | 309 | 2.0 | **1** |
| Guntur | Dec '98 | 392 | 106* | **15** | 288 | 4.1 | **1** |

Kranthi et al., 2002

## Insecticide Resistance in *Bemisia tabaci* 1997-98

| | | Methomyl | | | Triazophos | | | Monocrotophos | | |
|---|---|---|---|---|---|---|---|---|---|---|
| District | Collection date | n | $LC_{50}$ | RF | n | $LC_{50}$ | RF | n | $LC_{50}$ | RF |
| Rangareddy | Feb '98 | - | - | **-** | 310 | 9.9 | **-** | - | - | **-** |
| | Feb '98 | - | - | **-** | 358 | 28.3 | **3** | - | - | **-** |
| | Feb '98 | - | - | **-** | 373 | 10.4 | **1** | - | - | **-** |
| | Feb '98 | - | - | **-** | 287 | 24.6 | **2** | - | - | **-** |
| | Feb '98 | - | - | **-** | 301 | 17.0 | **2** | - | - | **-** |
| | Mar '98 | - | - | **-** | 283 | 8.2 | **1** | 359 | 189* | **13** |
| | April '98 | - | - | **-** | - | - | **-** | 345 | 99* | **7** |
| | May '98 | 278 | 0.18 | **-** | - | - | **-** | - | - | **-** |
| | June '98 | 322 | 10.3* | **57** | - | - | **-** | 420 | 77* | **6** |
| | June '98 | 361 | 2.7* | **15** | - | - | **-** | - | - | **-** |
| | June '98 | 405 | 4.3* | **24** | - | - | **-** | - | - | **-** |
| | Oct '98 | - | - | **-** | 413 | 12.4 | **1** | - | - | **-** |
| | Oct '98 | - | - | **-** | 380 | 11.5 | **1** | - | - | **-** |
| Guntur | Oct '98 | - | - | **-** | 407 | 12.9 | **1** | - | - | **-** |
| | Nov '98 | 292 | 14.4* | **80** | - | - | **-** | - | - | **-** |
| | Nov '98 | 316 | 12.5* | **69** | - | - | **-** | - | - | **-** |
| | Nov '98 | 316 | 10.7* | **59** | - | - | **-** | - | - | **-** |
| | Dec '98 | - | - | **-** | 393 | 11.2 | **1** | - | - | **-** |
| | Dec '98 | - | - | **-** | 398 | 13.7 | **1** | - | - | **-** |
| Mahbubnagar | Oct '98 | - | - | **-** | 324 | 12.9 | **1** | - | - | **-** |
| | Dec '98 | 319 | 10.6* | **24** | - | - | **-** | - | - | **-** |

# Resistance monitoring of whitefly population from 4 locations of North Cotton Growing Zone of India and One location ( Nagpur) of Central India during 2015 and 2016

## Insecticide Resistance in *Bemisia tabaci* 2015

| Insecticides | LC50 (g or ml/litre water) | | | | | RR/RF | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Sirsa** | **SRG** | **Hisar** | **Mansa** | **Nag** | Sirsa | SRG | Hisar | Mansa | Nag |
| **Bifenthrin** | 0.20 | 1.00 | 2.80 | 1.21 | 0.00 | 98 | 498.5 | 1400 | 605 | 1 |
| **Dinotefuran** | 0.16 | 0.50 | 1.51 | 0.48 | 0.01 | 14 | 45 | 137 | 44 | 1 |
| **Acephate** | 3.34 | 4.74 | 6.53 | 3.02 | 0.05 | 67 | 95 | 131 | 60 | 1 |
| **Acetamiprid** | 0.27 | 0.80 | 3.18 | 0.21 | 0.01 | 28 | 83 | 331 | 21 | 1 |
| **Fipronil** | 1.58 | 2.11 | 3.50 | 1.98 | 0.01 | 153 | 204 | 340 | 192 | 1 |
| **Triazophos** | 1.41 | 2.02 | 8.50 | 3.55 | 0.00 | 371 | 532 | 2237 | 934 | 1 |
| **Buprofezin** | 24.45 | 38.10 | 4.23 | 2.75 | 0.05 | 453 | 706 | 78 | 51 | 1 |
| **Imidacloprid** | 0.01 | 0.28 | 0.61 | 0.14 | 0.00 | 9 | 231 | 512 | 116 | 1 |
| **Diafenthiuron** | 0.70 | 4.51 | 0.85 | 0.52 | 0.01 | 54 | 347 | 65 | 40 | 1 |
| **Chlorpyriphos** | 25.06 | 3.16 | 18.14 | 7.20 | 1.32 | 19 | 2 | 14 | 5 | 1 |
| **Monocrotophos** | 2.97 | 3.65 | 3.67 | 1.16 | 1.55 | 2 | 2 | 2 | 1 | 1 |
| **Thiamethoxam** | 0.40 | 1.20 | 0.09 | 0.13 | 0.79 | 1 | 2 | 0 | 0 | 1 |
| **Clothianidin** | 0.47 | 0.24 | 0.48 | 0.11 | 0.07 | 7 | 3 | 7 | 2 | 1 |
| **Pyriproxyfen** | 2.14 | | 19.93 | 2.67 | 0.86 | 2 | | 23 | 3 | 1 |
| **Flonicamid** | 0.09 | 0.23 | 0.36 | 0.26 | 0.06 | 1 | 4 | 6 | 4 | 1 |
| **Ethion** | 0.80 | 2.58 | 9.55 | 1.84 | | 1 | 3 | 12 | 2 | 1 |
| **Azadirachtin** | 1.47 | 14.28 | 17.71 | 5.43 | | 1 | 10 | 12 | 4 | 1 |

Rishi et al (unpublished)

**Resistance monitoring on whitefly collected from hot spot areas of North Zone (2016-17)**

| Insecticides | LC50 (g or ml/litre water) | | | | | RR/RF | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sirsa | SRG | Hisar | Abohar | Nag | Sirsa | SRG | Hisar | Abohar | Nag |
| **Neonicotinoids** | | | | | | | | | | |
| Acetamprid | 1.2 | 0.43 | 3.4 | 5 | 0.43 | 2.79 | 1 | 7.91 | 11.63 | |
| Imidacloprid | 0.71 | 1.1 | 0.08 | 0.93 | 0.35 | 2.03 | 3.14 | 0.23 | 2.6 | |
| Thiacloprid | 4.8 | 0.282 | 0.82 | 0.39 | - | | | | | |
| Thiamethoxa | 13.07 | 3.2 | 7.3 | 14.74 | 0.25 | 52.2 | 12.8 | 29.2 | 58.96 | |
| Clothianidin | 0.39 | 0.182 | 0.85 | 0.68 | 1.09 | - | - | - | - | |
| Dinotefuron | 0.89 | 0.048 | 0.21 | 0.097 | 0.05 | 17.8 | 0.96 | 4.2 | 1.94 | |
| **IGR,'s and insecticides with new mode of action** | | | | | | | | | | |
| Buprofenzin | 32.67 | 79.93 | 12.46 | 73.74 | 2.58 | 12.66 | 30.98 | 4.83 | 2.58 | |
| Spiromesifen | 31.6 | 4.46 | 3.4 | 116.6 | 0.49 | 64.4 | 9.1 | 6.94 | 238.6 | |
| Pyriproxyfen | 56.82 | 3.4 | 1.7 | 3.6 | 40.12 | 1.42 | 0.08 | 0.04 | 0.09 | |
| Flonicamid | 4.4 | 0.38 | 0.3 | 0.56 | 0.3 | 14.67 | 1.27 | 1 | 1.87 | |
| Fipronil 5SC | 27.78 | 11.27 | 11.26 | 21.84 | 1.29 | 21.53 | 8.74 | 8.73 | 16.93 | |
| Diafenthiuron | 2.45 | 1.45 | 2.12 | 2.3 | 0.03 | 81.6 | 48.34 | 70.67 | 76.67 | |

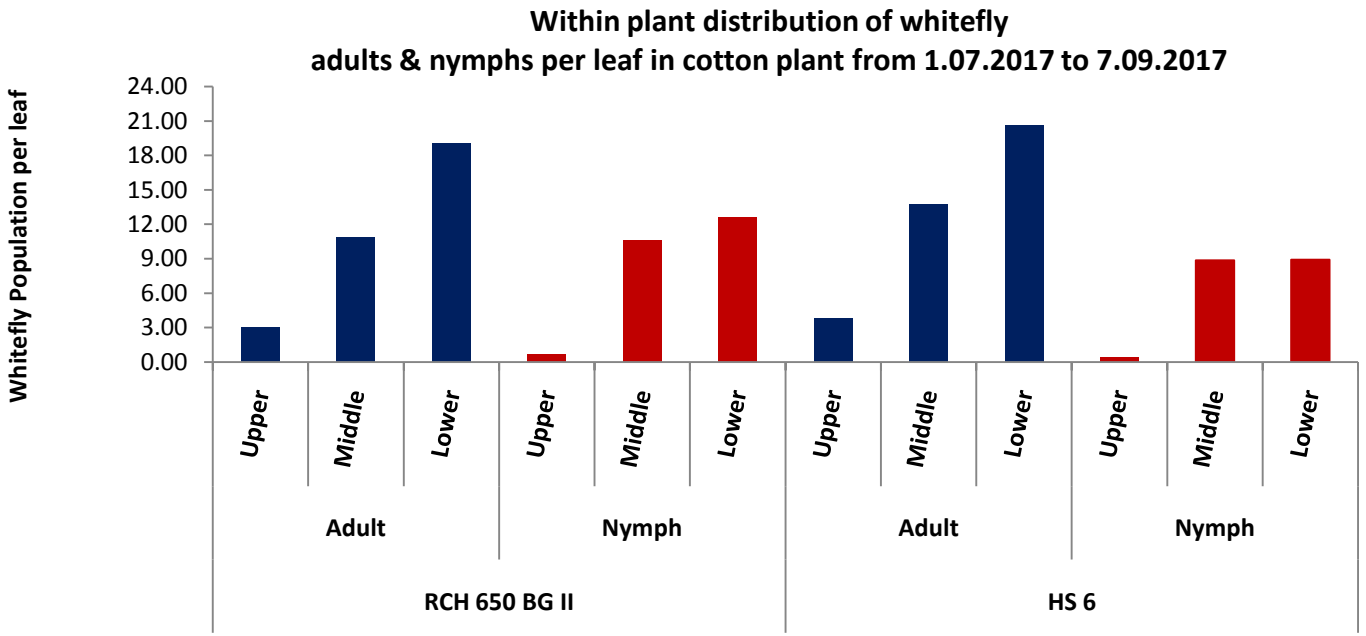
Rishi et al 2016

# Resistance monitoring on whitefly collected from hot spot areas of North Zone (2016-17)

| Insecticides | LC50 (g/ml/litre water) | | | | | RR/RF | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sirsa | SRG | Hisar | Abohar | Nag | Sirsa | SRG | Hisar | Abohar |
| **Organophosphates** | | | | | | | | | |
| Chlorpyriphos 20EC | 12.6 | 14.41 | 5.5 | 17.0 | 1.51 | 8.34 | 9.54 | 3.64 | 11.26 |
| Ethion 50EC | 9.8 | 4.3 | 12.10 | 6.8 | 1.64 | 5.98 | 2.62 | 7.38 | 4.14 |
| Monocrotophos 36 SL | 1.2 | 2.44 | 0.91 | 2.6 | 0.40 | 3.00 | 6.10 | 2.28 | 6.5 |
| Profenophos 50EC | 0.1 | 0.050 | 0.16 | 0.19 | - | | | | |
| Triazophos 40EC | 7.1 | 5.5 | 4.45 | 8.2 | 0.19 | 37.37 | 28.94 | 23.42 | 43.15 |
| **Synthetic Pyrethroids and mixtures** | | | | | | | | | |
| Fenpropathrin 30EC | 1.2 | 0.46 | 1.71 | 1.6 | 0.45 | 2.67 | 1.02 | 3.80 | 3.56 |
| Bifenthrin 10EC | 0.52 | 0.05 | 0.16 | 10.66 | 0.08 | 6.50 | 0.63 | 2.00 | 133.3 |
| Chloro+Cyper | 2.9 | 1.33 | 1.5 | 1.1 | - | | | | |
| Deltamethrin+Triazo | 3.1 | 1.06 | 2.3 | 1.8 | - | | | | |
| Indoxacarb+Aceta | 3.0 | 0.971 | 1.7 | 2.1 | - | | | | |
| Pyriproxyfen+Fanpro | 5.5 | 2.380 | 15.1 | 3.3 | 0.75 | 7.33 | 3.17 | 20.13 | 4.40 |
| **Neem and biopesticides** | | | | | | | | | |
| Achook 300 PPM | 20.10 | 8.165 | 10.7 | 7.8 | - | | | | |
| Nimbicidine 1500 PPM | 11.0 | 1.801 | 8.0 | 2.2 | - | | | | |
| Neem 50 000 PPM | 4.4 | 0.703 | 2.4 | 3.5 | - | | | | |
| Verticilium lecanii | 61.4 | 23.07 | 13.4 | 26.1 | - | | | | |

Rishi et al 2016

Within plant distribution of whitefly in various strata of cotton plants vs improper spray technology



# 4. Development of Whitefly Management Strategy for North Zone

**Whitefly Management Strategy for north Zone of India**

•**Mass campaign: E**arly detection of pest.

•**Monitoring and management:** February onwards on all alternate hosts —vegetable, ornamentals and weeds.

•**Cultivate recommended hybrids/varieties:** Yield and tolerance to whitefly and CLCuD.

**. Timely sowing:**

Ensure timely sowing (up to 15 May for the American cotton hybrids/ varieties and upto 30 April for Desi cotton varieties) of the crop as timely sown crop tolerates whitefly and CLCuD. Maintain 8,000 –10,000 plants per acre of the American cotton hybrids in the field.

**. Promote Desi arboreum cotton varieties:**

**. Fertilizer doses: Based on** soil health inspection and Avoid excessive urea (nitrogen) application during early vegetative phase of the crop.

**. Foliar Fertilizer application:**

Apply 2 - 4 sprays of 2% potassium nitrate (13:0:45) at 7-10 days intervals starting from flower initiation onwards.

**. Irrigation:**Apply first irrigation at 4-6 weeks after sowing followed by need based irrigation depending on rainfall and stop irrigation at 1/3 of boll opening.

**9. Weed sanitation:**

Keep fields, bunds and the vicinity free of weeds before and after the sowing of cotton. Destroy volunteer/ratoon cotton plants as well as the weed hosts growing near the irrigation channel/ canal and fellow lands during the off season.

**10. Barrier crop:**
Grow two dense rows of sorghum or pearl-millet or maize as border around cotton fields.

**11. Yellow sticky traps:**
Install low costs yellow sticky traps as per recommendations (40-50 / acre) of SAUs during July to August. Use vacuum adult whitefly suction traps during August when the adult whitefly population is high.

**12. Use botanicals**:
Initially apply two sprays with 1.0% neem oil (0.03% or 300 ppm) + 0.05-0.10 % laundry detergent emulsion followed by two sprays of 2.0% castor oil emulsion + 0.05-010 % laundry detergent emulsion to reduce whitefly populations.

**13. Use insect growth regulators**:
Insect growth regulators such as diafenthiauron (200 gm/acre), buprofezin (320 ml/acre), spiromesifen (200 ml/acre) and pyriproxifen (400-500 ml/acre) if needed can be used after mid August. These insecticides are effective on whiteflies and are relatively safer to its natural enemies. To manage the second flush of whitefly (later part of season during September) restricted use of Ethion (800 ml/acre) is also advisable.

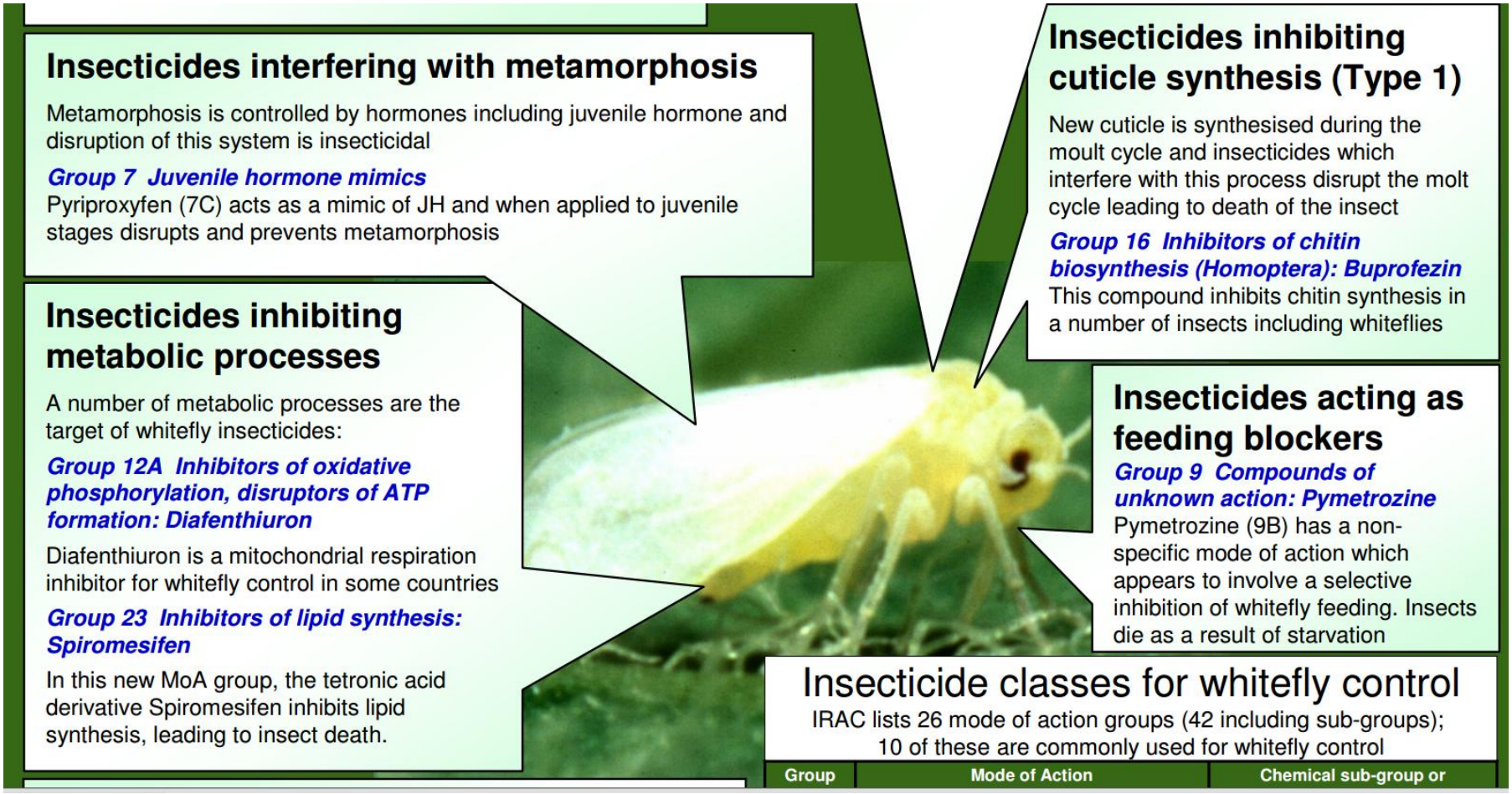
**14.** If higher population of eggs and nymphs is observed under the leaves, then application of spiromesifen (250ml/ acre) or pyriproxifen (400-500 ml/acre) is advisable.

**15.** If the mixed infestation of whitefly and leafhopper is observed apply flonicamid 50WG (80 g/acre).

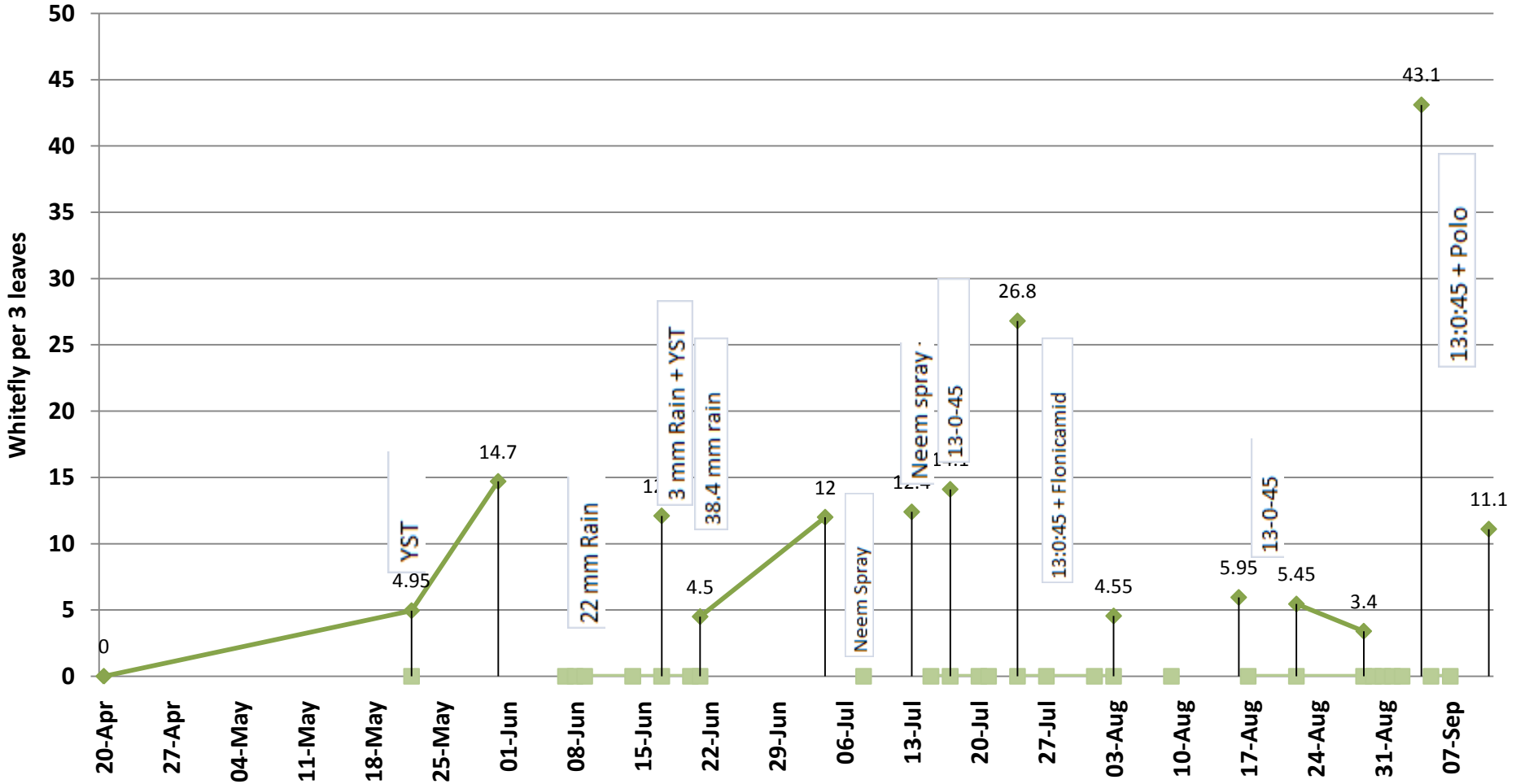
**16.** Never use synthetic pyrithroids, acephate or any insecticide mixtures. These insecticides are known to aggravate resurgence of whitefly when used indiscriminately.

# The Five IRM Recommended Insecticides

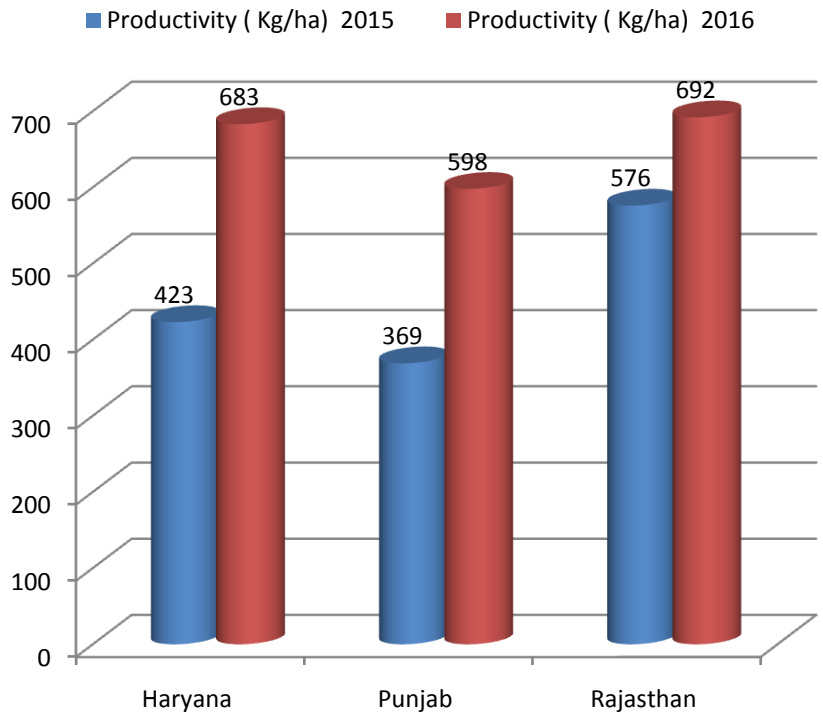
1. **Neem oil / Castor oil** etc., ; Antifeedants
2. **Pyriproxyfen:** Juvenile hormone mimic
3. **Buprofezin:** Chitin biosynthesis inhibitor
4. **Diafenthiuron:** Oxidative phosphorylation inhibitor
5. **Spiromesifen:** Lipid synthesis inhibitor

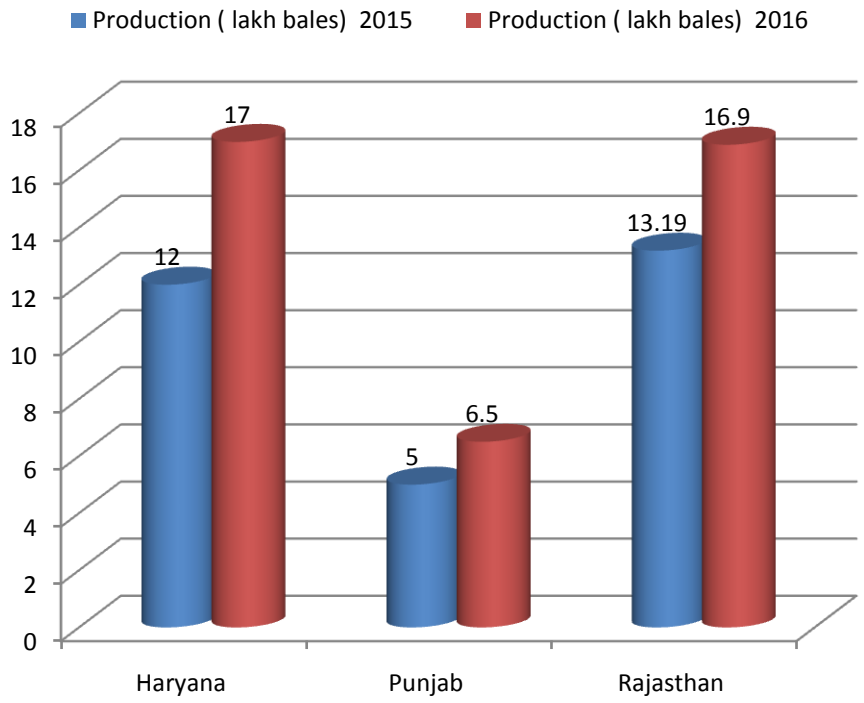


# Incidence of whitefly in cotton under protected conditions( 2017)



# Production and productivity on in the North Zone



# Conclusion and Way Forward

- Resistance source
- Screening of genotypes at Zonal level to recommend tolerant high yielding genotypes to reduce incidence
- Resistance monitoring in whitefly against insecticides– based on the resistance ratio and insecticides use pattern recommendations are made
- More pests management options based on bio-pesticides to reduce insecticides load and to conserve the ecosystem especially during early window.

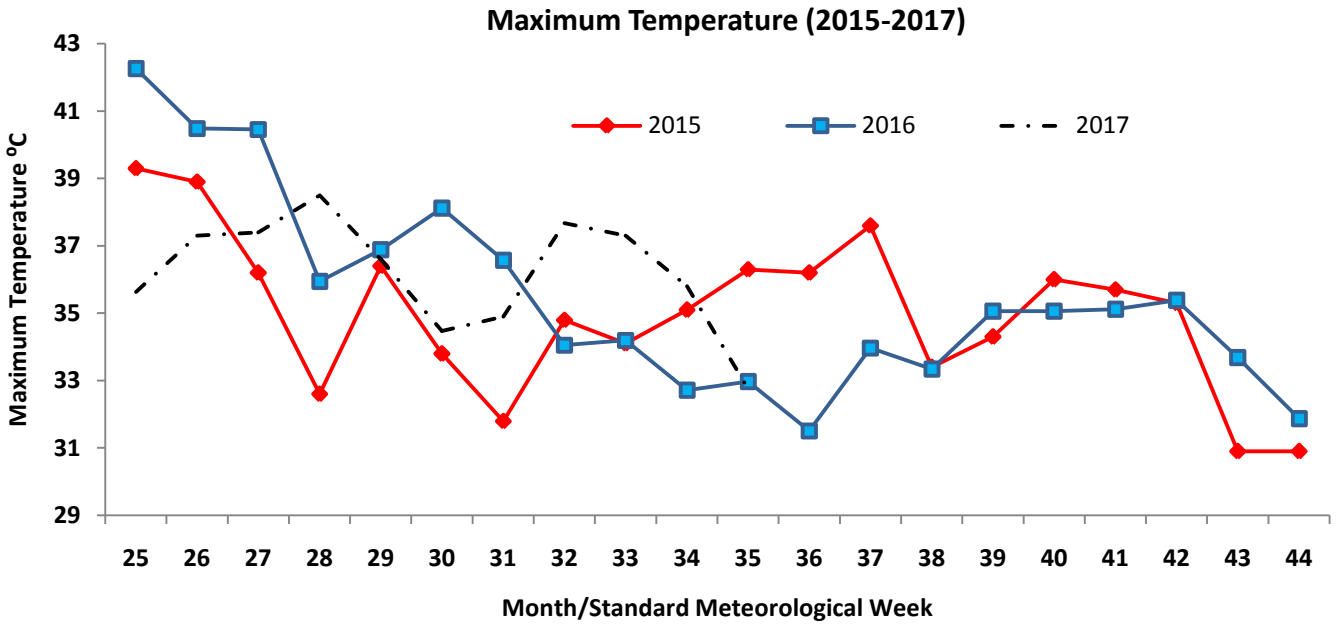
## Efficacy of Eco-friendly intervention for the management of whitefly during 2016-17.

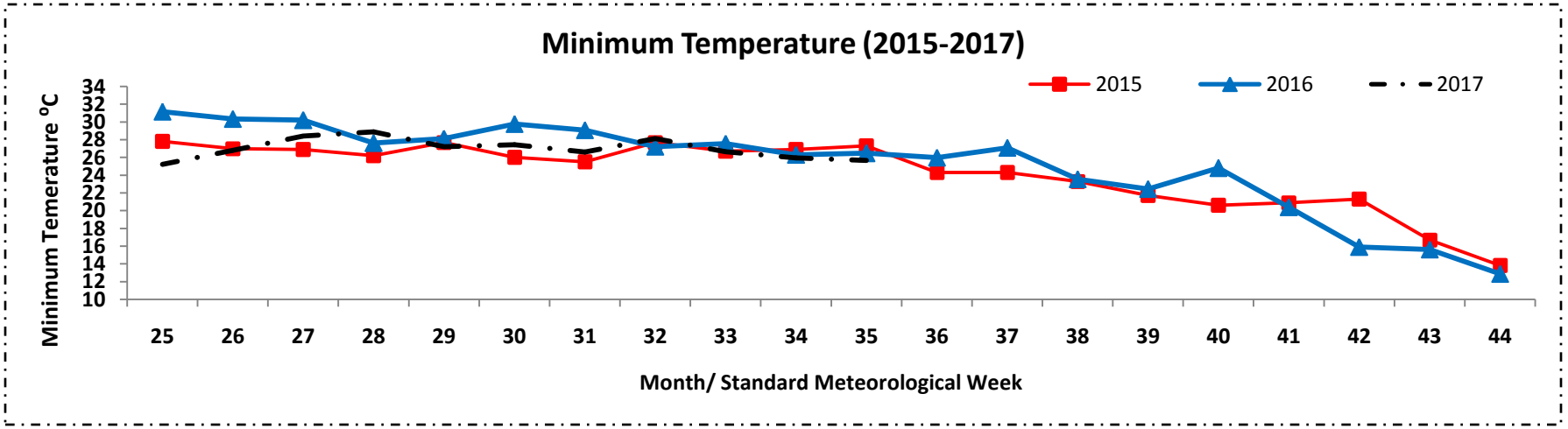
| Whitefly population/ 3 leaves | | | | |
|---|---|---|---|---|
| S.N. | Treatments | Dosage (g or ml/l) | Reduction (%) | |
| | | | 2016 | 2015 |
| 1 | $MgSo_4$ | 20 | 23.36 | -3.58 |
| 2 | $MgCl_2$ | 10 | 19.53 | -6.03 |
| 3 | $KCl_2$ | 10 | 21.07 | -4.06 |
| 4 | Guar Gum wax | 2 | 30.72 | 12.24 |
| 5 | Plant Wax 1 | 2 | 24.74 | 5.42 |
| 6 | Plant Wax 2 | 2 | 27.53 | 6.62 |
| 7 | Plant Wax 3 | 2 | 26.96 | 6.12 |
| 8 | Plant Wax 4 | 2 | 28.67 | 12.15 |
| 9 | Diafenthiuron | 1.6 | 66.80 | 28.36 |
| 10 | Fipronil | 2.6 | --33.82* | -77.0* |
| 11 | Control | - | -4.67 | -15.66 |
| | SE(m+) | | | |
| | CD (p=0.05) | | | |
| | CV% | | | |

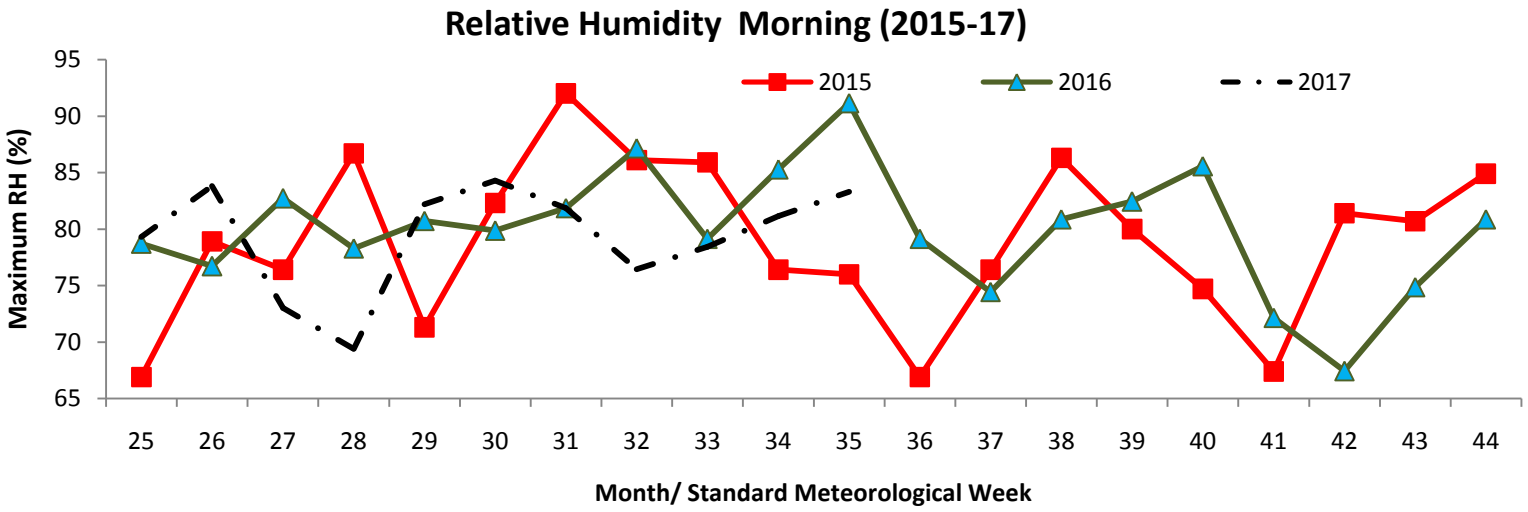
# Efficacy of various ecological interventions against whitefly under laboratory condition (Leaf dip bioassay) during 2016-17

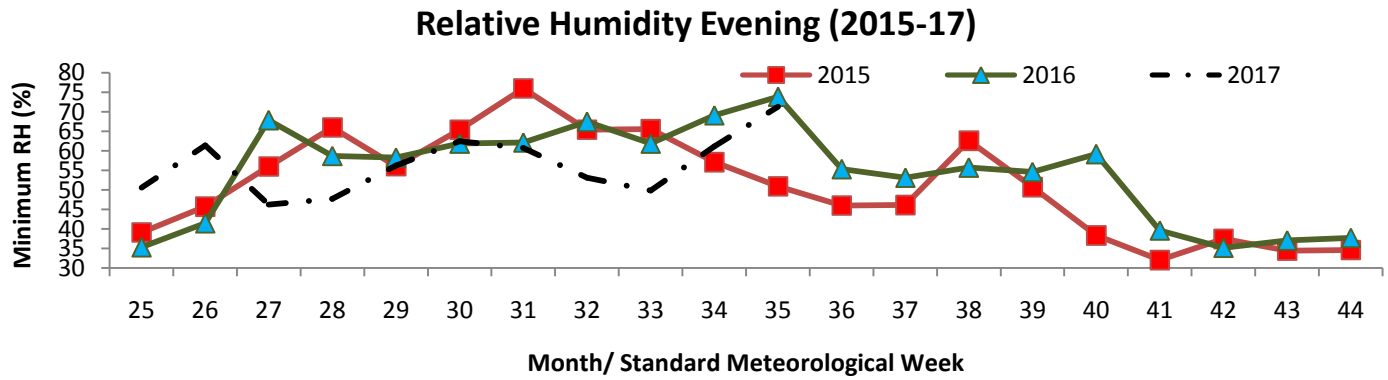
| S.N. | Laboratory assays | | | In Field assays |
|---|---|---|---|---|
| | Treatments | Dosage (g or ml/l) | Mortality (%) | Reduction (%) |
| 1 | Castor oil + liquid soap | 10 +0.5 | 53.21 (46.82) | 40.45 |
| 2 | Pongamia oil | 5 | 54.93 (47.82) | 44.90 |
| 3 | Sesame oil + liquid soap | 6+ 0.5 | 41.10 (39.86) | 30.77 |
| 4 | Neem oil | 5.0 | 47.64 (43.63) | 33.71 |
| 5 | NSKE | 5% | 35.58 (36.38) | 26.79 |
| 6 | Neem 300 ppm | As per label claim | 52.61 (46.48) | 41.18 |
| 7 | Neem 1500 ppm | | 52.87 (46.63) | 38.24 |
| 8 | Fipronil | | 62.24 (52.06) | -23.64 |
| 9 | Neem 10000 ppm | | 40.56 (39.54) | 34.34 |
| 10 | Neem 50000 ppm | | 43.10 (41.02) | 37.62 |
| 11 | Nirma powder | 0.5 | 17.98 (24.63) | 12.09 |
| 12 | Neem 300 ppm + Nirma powder | 3.33+ 0.5 | 56.23 (48.56) | 45.00 |
| 13 | Diafenthiuron 50% WP | 1.0 | 66.88 (54.85) | 63.46 |
| 14 | Control | | 11.43 (19.73) | -8.25 |

# Thanks


Maximum Temperature (2015-2017)
Maximum Temperature °C
43
41
39
37
35
33
31
29
2015
2016
2017
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Month/Standard Meteorological Week


Minimum Temperature (2015-2017)
Minimum Temerature °C
34
32
30
28
26
24
22
20
18
16
14
12
10
2015
2016
2017
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Month/ Standard Meteorological Week


Relative Humidity Morning (2015-17)
Maximum RH (%)
95
90
85
80
75
70
65
2015
2016
2017
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Month/ Standard Meteorological Week


Relative Humidity Evening (2015-17)
Minimum RH (%)
80
75
70
65
60
55
50
45
40
35
30
2015
2016
2017
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Month/ Standard Meteorological Week