The utility of the pheromone, gossyplure for management of pink bollworm has been investigated for several years in the research farms and commercial farms in villages at semi arid eco-zones during winter crop season. The sprayable gossyplure preparation was applied at 10g a.i./ha at threshold level in integration with other management measures in the village farm cropped with a popular hybrid DCH.32. The gossyplure applied at 10 per cent threshold level of incidence of *Pectinophora gossypiella* resulted in 59 per cent mating disruption in the adult population. The phenomenon of induced disruption in the field population of the adults of *P. gossypiella* in the village farm resulted in yield of 2570 kg/ha of seed cotton as against 1798 kg/ha of seed cotton in neighbouring farms. The consumption of insecticides was 2.96 and 5.31g a.i./ha in the farm with pheromone and the farm not treated with the same, respectively. The pheromone as one of the integrating units of insect management system reduced insecticide usage by 44 per cent and increased the productivity of the hybrid DCH.32 by 30 per cent.

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## Weed Management in Hybrid Cotton

In the north zone, cotton-wheat is the prodominant crop rotation. In this zone, less than 1 per cent area is covered by hybrid cotton. The major weed flora of cotton crop in this region are *Trianthema* sp., *Echinocloa* sp., *Cyperus* sp., *Ageratum conyzoides* and *Digera arvensis* which are estimated to cause 30-40% yield losses. Weed germination is maximum either after the onset of monsoon or after first irrigation i.e. 45 days after sowing (DAS). The present practice of weed control is to give two hoeings and two weedings after 45 DAS. The pre-emergence weedicides are less effective due to prevailing high soil temperatures and hot winds blowing at the time of sowing. Pre-planting application of Pendimethalin 1.0 or Trifluralin 1.0, Okadiazon 1.0, Pendimethalin + Fluchloralin (2:1) 1-2.0, Tank mixture of Diuron 0.5 with Pendimethalin 1.0 or Fluchloralin 1.0 or Trifluralin 1.0 are effective in controlling weeds mentioned above. One interculture at 45 DAS is essential in addition to application of weedicides.

In central and south zones, a sizeable area is under hybrid cotton both under rainfed and irrigated conditions which is affected by diversified weed flora causing 45-50% yield losses. The weed flora of vertisols include dicot weeds such as *Amaranthus viridis, Ageratum conyzondes, Acalypha indica, Celosia argentea, Cynotis akillaris, Digera arvensis, Euphorbia* sp., and *Merremia emarginata* and monocot weeds such as *Cyperus* sp., *Cynodon dactylon, Digitaria sanguinalis, Dinebra retrofleka, Eragrostis minor, Echinocloa crussgalli.* In south zone, besides the above weeds, *Trianthema* sp. and rice stubbles in rice fallow cotton are problematic weeds. The weed management in clay loam soils is difficult due to continuous rains and narrow range of soil moisture for working condition. Farmers give 3-4 crossway hoeings followed by 2-3 hand weedings in central zone. In south zone, single direction hoeings are done. Butachlor 1.0 PPI is often applied. The weedicides recommended for north zone can also be used for controlling weeds in south zone. Two hoeings at 30 and 45 DAS and one hand weeding at 30 DAS can effectively control the weeds.

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## Insecticide Resistance Management in Hybrid Cotton

Insecticide Resistance Management (IRM) strategies were demonstrated through area-wide farmers' participatory trials in fields of 11 farmers in Rohna village (40 km from Nagpur) and fields of 21 farmers in Raulpally and Sankeypally villages in Ranga Reddy district in Andhra Pradesh (India), with hybrids MECH.1, MECH.12 and RCH.2 in Ranga Reddy, and NHH.44 and Ankur 651 at Rohna. One of the strategies deployed in IRM is to delay the first spray to conserve natural enemies of insect pests by selecting a sucking pest tolerant genotype and seed treatment with Imidacloprid @ 7 g/kg seed. Other strategies include use of soft insecticides such as Neem Seed Kernel Extract (NSKE) @ 5-15%/ha, *Helicoverpa armigera* Nuclear Polyhedrosis Virus (Ha NPV) @ $3 \times 10^{12}$ PIBs (Poly inclu-

sion bodies)/ha, *Bacillus thuringiensis* toxins @ 1-2 kg/ha, at early reproductive phase. This helps in least disturbance to the natural ecosystem. The use of insecticides is essentially based on the resistance information obtained from monitoring of seven crop seasons [1992-1998]. Use of endosulfan should be encouraged only as early season spray (resistance levels have been found to be invariably low early in the season i.e. August-September, and higher later on), as it is relatively less toxic to natural enemies. Resistance levels against certain organophosphate group of insecticides (Quinalphos, Chlorpyriphos and Profenophos) and carbamates such as methomyl have been found to be relatively lower in most populations tested. Hence, it is preferable to use these as effective larvicides during mid-season (September-October) based on Economic Threshold Levels (ETLs). Pyrethroid resistance is high in many parts of India. These can be effective on *Helicoverpa* only on younger larval stages or adults or if used along with synergists such as sesamum oil or organophosphate profenophos. However, pyrethroids are still effective against spotted and pink bollworms. Hence, pyrethroids can be used either as early season sprays to target *Helicoverpa* moths and young larvae or as late season (October-November) sprays to be used with OPs (Profenophos, Ethion, Quinalphos or Chlorpyriphos @ 100-200 g a.i./ha) to combat resistant *Helicoverpa* and pink bollworm incidence. Random mixtures are to be avoided. Hand picking of larvae 2-3 days after insecticide spray effectively eliminates any surviving population which can cause future resistance problems. It is important to choose the appropriate insecticide (based on resistance data), use only recommended dose and proper spray appliances, and spray only at action thresholds (10 *Helicoverpa* larvae/20 plants in mid and late reproductive phase).

The hybrids used at Ranga Reddy were only moderately tolerant to the sucking pest complex; hence, Imidacloprid seed treatment was very beneficial. In Central India where almost all hybrids are fairly tolerant to sucking pests, seed treatment with Imidacloprid gives an additional advantage. The delay in applying early season, broad spectrum insecticides helps in the subsequent management of the entire pest complex.

At Ranga Reddy, the total number of sprays required to control the pest complex was 8 in IRM plots and 13 in farmer managed plots without any compromise in yield, whereas at Rohna, 1-3 sprays were required in IRM plots as against 5-7 in the farmer managed plots. Insecticide used and plant protection cost were reduced by 25 to 60%. The square and boll damage was reduced by 15 to 52% and seed cotton yield increased in some cases upto 59%. Despite the severe attack of *Helicoverpa* during 1997-98, it was clearly demonstrated that it is possible to manage the pest with minimum insecticide applications through IRM technologies which emphasise on the minimal use of insecticides.

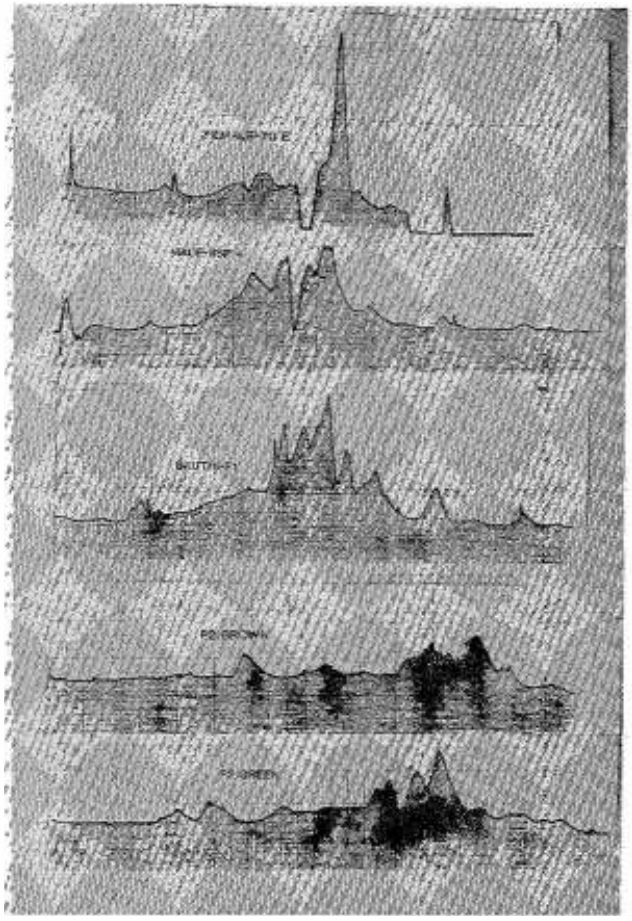

Fig 1 The chromatogram showing the pattern of protein of seeds of hybrid Sruthi and its parental lines.

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