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Pest management in cotton : Strategy and tools of IPM

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Cotton (*Gossypium* spp.) is grown commercially under diverse agroclimatic conditions prevalent in Indian states.At present, India ranks first in the world in area and fourth in production with lower productivity (280 kg/ ha). One of the major reasons for the low productivity is the damage caused by the attack of insect pests which results in up to 50 per cent losses in the yield. Among 162 species of insects associated with cotton, only eight species are considered as major pests (Table 1). During earlier days, these pests were controlled with traditional practices. With the introduction of Green revolution (GR) in early seventies, insecticides have been used extensively. The misuse/overuse of these braod-spectrum insecticides or the sublethal doses have resulted in several undesirable side effects such as, development of resistance in insect populations, pest resurgence, destruction of natural enemies, changes in dynamics of pest populations, contamination of environment and fibre. In view of the limitations of the conventional control methods, pest management strategy had been evolved and is being implemented on large scale in cotton growing regions. Likewise, the international organizations such as, FAO, World Bank, UNDP and UNEP co-sponsored the establishment of the global IPM facility.

Strategy :

The integrated control was first defined in 1959 as "applied control which combines and integrates biological and chemical control". With the advancement in knowledge, this definition was modified, at least by 65 definitions. However, FAO Panel of Experts defined it as " a pest manangemet system that, in the context of associated environment and population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economic injury". Studies on IPM with several concepts were collated and finally, an inherent definition had been proposed by Kogan (1998), e.g., "a decision support for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analysis that take into account the interests of and impacts on producers, society and the environment". This strategy is predicted or based on a series of control and management practices. Such a system does not rely on the strength of one means of control. Thus, IPM is a blend of the traditional and modern methods of insect suppression, directed to allow certain populations of insects to remain in the agroecosystem to

Table 1 : Common major insect pests of cotton

Pest (common name)	Species (scientific name)	Pest status during season		
		Early	Mid	Late
Aphid	*Aphis gossypii* Glov.	3	3	0
Thrip	*Thrips tabaci* (Genn.)	3	2	0
Jassid	*Amrasca biguttala biguttala* (Shir.)	3	2	0
Whitefly	*Bemisia tabaci* (Genn.)	0	3	2
Leaf roller	*Sylepta derogata* (F.)	2	1	0
Armyworm	*Spodoptera litura* (F.)	1	2	2
Spotted bollworm	*Earias* spp.	1	3	2
American bollworm	*Helicoverpa armigera* (Hb.)	1	3	2
Pink bollworm	*Pectionophora gossypiella* Saund	0	1	3
Red cotton bug	*Dysdercus koenigii* (F.)	0	2	3
Dusky cotton bug	*Oxycarenus laetus* K.	0	0	2
Semilooper	*Anomis flava* Fb.	1	2	0
Stem weevil	*Pempherulus affinis* Faust.	0	1	1

Status: 0= no attack/status not known, 1= secondary or less importany pest, 2= occasional or moderately important pest, 3= major or economically important pest.
Early season = vegetative growth period (0-45 days after germination), Mid season = squares, flowers and bolls start appearing (45-90 days after germination), Late season = boll maturity (90 days until harvest)

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tolerable levels of abundance so that natural enemies such as, predators (birds, insects) and parasitoids (insects, nematodes, protozoa etc.), and pathogens such as, bacteria, fungi, viruses, are conserved. Similarly, a wide variety of management techniques are available such as, cultural practices, pest-resistant genotypes, mechanical and physical methods, plant-derived products, natural enemies and biological control, and chemicals.

Tools :

Identification and monitoring/surveillance of insect pests and their natural enemies:

This is a fundamental tool in IPM that facilitates the decision whether control measures are required or not. This work can be done on a basis of a region, area/locality or at the farm level as field scouting or monitoring of pests helps to decide the proper control measures at proper time. There are different methods of scouting, the common method being the weekly observations on randomly selected plants and action threshold is fixed for applying various insect suppression techniques. In this context, light traps for general survey are being used whereas for specific insects, pheromone traps have proved to be effective. Yellow sticky traps are effective in attracting whiteflies for mass trapping. Natural control existed since decades and is still operating in the majority of cotton growing areas. Only recently, with the breakdown of purely artificial measures, potential of natural enemies is being realized.

Establishment of economic injury levels and economic threshold levels:

This concept is important as several insects attack cotton crop at the same peiod. The economic injury level (EIL) and the economic threshold level (ETL) are important criteria (Table 2), the former represents an injury level and the latter the time for taking control measures since insect may attack crop but its injury does not necessarily result in plant damage. The level of injury also is difficult to measure in the field. Therefore, ETL is the maximum population that can be tolerated at a particular time and place without resultant economic crop loss. It is now widely used to indicate a population density at which control measures should be initiated against an increasing pest population to prevent further damage. In fact, ETL is a complex value based on the EIL, population dynamics of the pest, weather foecasting and the potential of the pest for injury.

In order to facilitate the actions on pest control, Economic thresholds have been worked out for major insect pests of cotton. These levels should be revised from time to time as per agroecological conditions and pest status in each cotton growing zone.

Table 2 : Economic threshold level (ETL) and economic injury level (EIL) of major insect pests of cotton

Insect pest	Crop age (days)	ETL/EIL
Aphid	1-50	15-20% infested plants
Jassid	1-50	1-2 nymphs/leaf
Thrip	1-30	10 thrips/leaf or 15-20% infested plants
Stem weevil	25-60	10% or more plants with galls
Whitefly	35-110	8-10 adults or 20 nymphs/leaf
Spotted bollworm	35-110	10% or more of attacked shoots or reproductive parts
American bollworm	65-110	1 egg/plant or 1 larva/plant or 5-10% damaged fruiting structures
Pink bollworm	65-110	10% or more of attacked bolls

Decision making:

Essential background information has to be sought on various aspects of IPM before any decision on pest control such as, identification, life history and behaviour of the target pest, natural regulating factors including predators, parasitoids and pathogens, agroecosystem and available effective control tactics. The interaction between cotton genotype, weather, pest species and nautral enemies is complex and difficult to analyse. However, efforts are now on through computer programming to study the best possible combination and to prepare models.

Implementation:

At village level, the IPM concept is not followed due to several difficulties associated with institutions, information, socio-economics and local politics. Therefore, concerted efforts are needed to increase farmers' participation, government support, instituitional infrastructure at least at Taluka level and awareness in farming communities. Execution of IPM tactics at grass-root level if done in proper time with proper means, it would show the benefits in term of sustainability in cotton productivity, reduction in cost of production, improvement in lint quality and finally in better net profit. The IPM approach must be changed or modified as and when information on new cotton genotypes, pest status, farmers' responses, socio-economic situations becomes available. Further, unless farmers manage the agroecosystem and efforts are made at community level, there is not much hope to implement IPM in sustainable agriculture.

Practical implementation involves an integration of control measures that should be cost-effective, ecofirendly, effective and easily available in villages. The major practices are enumerated below:

Cultural practices:

Field sanitation
Planting and harvesting time
Seed rate and plant spacing
Tillage
Intercropping, trap cropping
Interculturing and weeding
Crop rotation
Plant nutrient management
Water management

Physical methods:

Exposure to sunrays
Light traps

Mechanical methods:

Hand picking
Exclusion techniques
Sticky traps
Detopping

Planting of pest-resistant genotypes, transgenic plants (Bt cotton)

Natural enemies: natural/biological control (Table 3)

Predators (birds, insects, animals)
Parasitoids (endoparasitoids, exoparasitoids)
Pathogens (bacteria, fungi, viruses)

Plant-derived products

Azadirachta indica, Vitex negundo, Chrysanthemum spp., *Derris* sp., *Nicotiana* spp., *Acorus calamus, Allium sativum, A. cepa, Annona squamosa., Melia azaderach, M. dubia, Ocimum basilicum, O. sanctum, Parthenium hysterophorus, Pongamia pinnata, Tagetes* spp.

Chemical insecticides:

Organochlorinated compounds (DDT, BHC, Aldrin, Endosulfan etc.)

Organophosphatic compounds (Phosphomidon, Parathion, Fenthion, Dimethoate, Phorate etc.)

Carbamate compounds (Carbaryl, Carbofuran, Methomyl, Thiodicarb etc.)

Synthetic pyrethroids (Allethrin, Cypermethrin, Deltamethrin, Fenvalerate, Fenfluthrin etc.)

Table 3 : Predators, parasitoids and pathogens of cotton insect pests

Natural enemy	Cotton pests	Stage of attack
Predatos		
Chrysopa spp.	Aphids, whiteflies, thrips, mites	all stages
Menochlus sexmaculata	Aphids	nymph, adult
Coccinella septempunctata	Aphids	nymph, adult
Scymnus sp.	Aphids	nymph, adult
Syrphus spp.	Aphids	nymph, adult
Parasitoids		
Trichogramma spp.	Bollworms	egg
Chelonus blackburni	Bollworms	egg-larva
Telenomus remus	*S. litura*	egg
Rogas aligarhensis	*Earias* spp.	larva
Cacelia illota	*H. armigera*	larva
Apanteles pectinophorae	*P. gossypiella*	larva
Pyemotes ventricosus	*P. gossypiella*	larva
Campoletis chloridae	Bollworms	larva
Bracon spp.	Bollworms	larva
Agathis sp.	Bollworms	pupa
Encarsia spp.	Whitefly	myph
Pathogens		
1. Bacteria		
Bacillus thuringiensis	Bollworms	larva
2. Fungi		
Beauveria bassiana	*H. armigera, S. litura*	larva
Nomuraea rileyi	*H. armigera, S. litura*	larva
Entomophthora aphidis	*A. gossypii*	all stages
3.V iruses		
Nuclear polyhedrosis virus	*H.armigera, S. litura*	larva
Protozoans		
Vairimorpha sp	*H.armigera, S. litura*	larva
Nosema sp.	*H.armigera, S. litura*	larva

Others including amidines (Chodimeform, Amitraz), Nicotinoids (Imidacloprid)

Applications:

Seed treatment, Dipping of seedlings, soil treatment, whorl application, stem application, spraying, baits.

Innovative products:

Insect growth regulators, Juvenile hormones, sex pheromones, spinosyns, chemosterilants

Conclusion:

The efforts and cost involved in timely operations, scouting of pests, use of new techniques etc.involved in IPM implementation may not be acceptable to average farmers in contrast with easy applications of chemical pesticides where the results are obvious and faster. Therefore, farmers have to be trained intensively and convinced of the advantages of pest management in cotton. The role of extension techniques such as, FFS, field days/field demonstrations, training programmes etc. in transferring IPM to rural masses is vital and urgent.

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