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REVIEW OF THE CURRENT STATUS OF INSECTICIDE RESISTANCE IN INSECT PESTS OF COTTON AND THEIR MANAGEMENT

GHULAM HUSSAIN MALLAH

Senior Scientific Officer, Entomology,
Central Cotton Research Institute, Sakrand, Pakistan

Abstract

Development of resistance to insecticides now possess the greatest challenge to agriculture, especially to Cotton which heavily relies on chemical control. In Pakistan currently a high level resistance exists to pyrethroids and endosulfan in *H.armigera* and *Bemisia tabaci* exhibited a high resistance to some organophosphates and pyrethroids. Three factors have been regarded as playing the most important roles in insect resistance to insecticides: (i) Penetration of insecticides through the cuticle (ii) detoxication (iii) sensitivity of the target site. For resistance management (IPM) should be developed and all facts on insecticidal control should be tightened.

Introduction

In agricultural sector, plant protection plays a crucial role in the successful production of crops and saves it from the onslaught of pests. In this regard, pesticides have contributed to dramatic increase in crops yield. However increasing use of pesticides has contributed to number of major pesticides related disasters. In 1980, the pesticides import, distribution and sale was transferred from public to private sector. The pesticides consumption has risen many folds during the last two decades. During 1977 total consumption of pesticides was 3404mt, which increased to 3677mt in 1981 and the amount has increased every year since then. In 1990 the consumption was 14742mt which reached to 44872mt in 1997. The country at present imports over Rs. 10 billion of pesticides annually through registered firms alone. It is interesting to note that about 80% of these pesticides are used in cotton crop.

In many areas, misuse of pesticides and their impact has been observed as pesticide residues in food chain, extinction of wildlife, resurgence of secondary pests and pest resistance development are dreadful realities.

Resistance develops when the insects are repeatedly subjected to treatment with the same insecticide. If insecticide pressure is built, a Drawinian-type selection then takes place of individual insects which can survive the insecticide. These resistant mutants are the only survivors. In due course they inter-breed and in the absence of susceptible, insects of the same species a strain resistant to the insecticide is developed.

Such resistant has been noted a long time ago without certain insecticides used on citrus; more recently resistant strains segregated first amongst important medical insects which have been controlled by DDT, BHC and Dieldrin and there after resistant strains of a number of agriculture pests were developed in a very short period. Other insecticide take longer to build-up resistance, but a large number of agricultural pests have become resistant to insecticides.

Resistance, to insecticide is the development of any ability in a strain of insects, to tolerate dose of toxicants which would prove lethal to the majority of individuals in a normal population of the same species e.g., 15 species of anopheles that carry malaria are resistant to DDT and 36 to Dieldrin and Lindane (Brown, 1971). Rudd (1970) stated that more than 200 species in insects and arachnids that are known to have developed resistance, about half are agricultural pests and the other half are arthropods of public health or veterinary importance. The occurrence and importance of insecticidal resistance in insect can be summarized as follows:-

a) Resistance to one insecticide frequently confers some measure of resistance to other related insecticides even if there has been 0 exposure to them.
b) The number of resistant species and their areal distribution will continue to increase.
c) The resistance phenomenon is the most important biological limitation to successful insect control.
d) Resistance insects do not have any greater vigor than un resistant ones, but their number per unit area are frequently greater. This is associated with adverse effects of treatment on competing or predatory forms normally limiting numbers.

Three factors have been regarded as playing the most important roles in insect resistance to insecticides

(i) Penetration of insecticides through the cuticle (ii) detoxication (iii) sensitivity of the target site.

The research on mechanism demonstrated that atleast 40% of the resistant insects in Thailand in 1986 seemed to be resistant due to a mechanism of decreased nerve sensitivity. Synergism studies showed that the pyrethroids were strongly synerised by piperonyl butoxide in the resistant strain, thus indicating a vital role of mono-oxygenases in the detoxication of pyrethroids. In the cotton pest *Aphis gossypii* resistance to, organophosphates involves several factors: acetylcholinesterase insensitivity high carboxyl esterase activity, slight increase in glutathione S-transferases mixed function oxidase activity and reduced penetration. In the resistant strain, synergism of cypermethrin and permethrin caused almost complete elimination of resistance to both pyrethroids. This synergistic effect suggests that esterases are involved in the mechanism of pyrethroid resistance.

There are four main classes of conditions for resistance development: no migration, low pesticide dose (R gene functionally codominant); no migration, high pesticide dose (R gene functionally codominant or recessive); high migration, low dose; and “high migration, high dose. Under all four classes of conditions, resistance developed faster as the number of generations per year increased.

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Insecticide resistance has been monitored in *Helicoverpa armigera* and cotton whitefly since 1991 at CCRI Multan. Currently a high level of resistance exists to pyrethroids and endosulfan in *H. armigera* resistance to some organophosphates and carbamates was still low in this pest. Synergism studies suggest that most of the pyrethroids resistance was predominantly due to matabollic detoxification by esterases and oxidases; although other mechanism might be in world.

Whitefly exhibited a high resistance to some organophosphates and pyrethroids but almost no resistance to endosulfan and some other insecticides. Detoxification by esterases was found to be an important mechanism of organophosphates and pyrethroid resistance in cotton whitefly (Ahmed, *et al*., 1999).

The genus *Heliothis* and *Helicoverpa* contain some of the most destructive pest species. More insecticides is used to control these species on cotton then all the other species combined. The high reproductive potential, strong flight habits and ability to develop high resistance to pesticides makes them very formidable enemies (Lukefahr, 1992).

To know the resistance problem and its management in cotton producing countries this review work was done.

Resistance development in whitefly *Bemisia tabaci*: Ahmed *et al.*, (1999) reported from Pakistan that whitefly exhibited a high resistance to some organophosphates and pyrethroids but almost no resistance to endosulfan and some other insecticides. Detoxification by esterases was found to be an important mechanism of organophosphate and pyrethroid resistance in cotton whitefly.

Jadhav, (1999) reported from India that insecticides resistance to major cotton insects pest has been static, despite significant reduction in insecticide usage in some cotton growing areas of India. Bioassay of *B.tabaci* to major groups of insecticides for LC_{50} have shown high levels of resistance to pyrethroids and low levels to organophosphates, endosulfan and imidacloprid.

Resistance development in pink bollworm: The pink bollworm *pectinophora gossypiella* (saunders) is a major cotton pest in the area of yangtze river valley. Control of *P.gossypiella* has been accomplished mainly by used of insecticides. Recently the resistance to deltamethrin, fenvalerate and parathion-methyl was developed in the field populations (Li *et al.,* 1997). By using filter paper residue test method, the newly hatched larvae obviously showed high resistance to deltamethrin in pink bollworm populations from anqing (185-fold), Tongzhou (249-fold) and cixi (699-fold) and the fenvalerate in Tongzhou population (104-fold). While the resistance to parathion-methyl was relatively low 3.6-fold for Tongzhou population and 9.9-fold for cixi population.

Resistance development in cotton spider mites: Cotton spider mites are a complex population in cotton field which consists of several species. Among them, *Tetranychus urticae* (koch) is a dominent species. Since 1950s, organochlorine and organophosphorus insecticides have been used for their control. Resistance to demeton of *T. cinnabarinus* was found Hebai province in 1964 (Zhang & Wang, 1964). In 1957 demeton 50% EC could be used for a good control by dilution of 10,000 times. However in 1962 the control efficience was only 40-60% even though the dilution decreased to 2000 times. At the end of 1980s cotton spider mites developed resistance to Ops in Henan province in particular to parathion-methyl and monocrotophos. During 1986 to 1992 resistance to dicofol of *T. urticae* in Henan province increased from 5.3-6.7 folds to 8.7-15.6 fold and to omethoat the resistance increased from 9.2-11.3 fold to 19.2-28.5 fold (Wu & Liu, 1995).

Resistance development in cotton aphid: The chemical control of cotton aphid *Aphis gossypii* (Glover) has a long history in China. From 1950s to the early of 1970s the major chemical were used including BHC (benzene hexachloride) and some OPs such as parathion, demeton, phorate dimethoate, dichlorovos and parathion-mehtyl. From the mid of 1970s carbamate insecticides such as carbofuran and other OPs insecticides including omethoate, monocrotophos, phosphamidon and methamidophos were used for its control. At the beginning of 1980s, pyrethroid insecticide such as fenvalerate and deltamethrin were introduced to replace most of organophosphorus and carbamate insecticides. Resistance monitoring has shown that aphid population in almost all cotton growing areas have developed resistance to some organophosphorus, carbamate and pyrethroid insecticides. Parathroin was introduced in 1953 and after ten years field control 23-fold resistance was developed in Hebei and Shanxi provinces during 1964 (Tang & Huang, 1982) in 1956 another OP insecticide, demeton was used for aphid control and 7-8 years later developed resistance upto 151-fold in Nongong population which had been in control with demeton 8-9 years and 7-8 applications each year and 89-fold in Yongnian population, OPs was introduced in 1965 to replace use of demeton. In 1970 low level resistance found (4.6-fold) in Shanghai population (Tang & Huang, 1982) at the same time the population expressed resistance to phosphamidon (11.3-fold) and carbaryl (9.3-fold).

Carbamate insecticides such as carbofuran was also used for the control of cotton aphids in China. For example the resistance of Siyang population to carbofuran was 15-fold in 1988 and increased to 33-fold in 1989. Since 1980 pyrethroid insecticides such as fenvalerate and deltamethrin have been introduced to control cotton pests. Only five year later resistance to fenvalerate and deltamethrin was developed in Dezhou population of Shangdong province (8.9-fold and 161- fold respectively) and Hejian population of Hebei province (15.6-fold and 1686-fold, respectively) (Tan *et al*., 1987).

Resistance management: Strategies to circumvent resistance problem and or delay resistance development should be developed for each major cotton producing areas.
All facts of insecticidal control should be tightened including equipment calibration, swath coverage, scouting to insure proper timing of applications etc. Alternate classes of insecticides should be used when possible especially early and late in the growing sasons.
In the Emerald area of Australia during 1983 *H. armigera* was managed with judicious use of material combined with alternative insecticides in a carefully planned and executed management strategy which gave adequate control of this bollworm.

Reducing selection pressure is one of the most obvious and IPM compatible measures that can be used to thwart the development of resistance.

Pesticides that are short lived and do not have a prolonged environmental persistence should be identified. Pesticides that have long residual lives should be avoided when possible.

When an insecticide is changed because it is not effectively controlling the insect pest, the alternative product must be one that does not share the same potential mechanism of resistance in the insects.
Sequences mixtures, rotations and mosaics are potential strategies for using more than one pesticide to manage pest population and for slowing the evolution of pesticide resistance.

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