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Integrated pest management of vegetable crops

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Abstract
An overview about the important milestones in the development of the IPM technology has been presented in this paper. Various types of methods like physical, cultural, mechanical, biological, genetical and varietal were used for the control of pest in vegetable crops. Now a day's more emphasis has been laid on traps and pheromones for insect pest control. The best method out these methods for insect pest management is use of trap crops like marigold, Chinese cabbage, coriander and spray of biopesticides. The overall study on integrated pest management has revealed that intercropping and varietal resistance also play an important role for enhancing crop yield as well as ceased the attack of particular pest. But, the use of chemical control method should be avoided because it can cause many problems to environment and human beings and secondly it is a very costly affair for the farmers.

Keywords: pest, insect, vegetable

Introduction
Rapid progress in agricultural production technologies like introduction of high yielding varieties, increased use of chemical fertilizers, better management of irrigation, mixed and relay cropping have considerably changed the agro eco-system. It has resulted in cropping up of numerous problems. Amongst them insect pests are proving major constraints in achieving expected yield of high yielding hybrids. Till recently use of insecticides was considered most effective tool to overcome this problem. However, indiscriminate use of insecticide has led to serious consequences like harmful residues, pest resistance to insecticide: pest resurgence and outbreaks of secondary pests. To overcome these problems, a new concept i.e. Integrated pest management has been adopted. Integrated pest management is an eco-system approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. The cultural, physical, mechanical, chemical and biological methods have been combined in such a way that it has decreased the cost of cultivation and increased yield of crops (Mathur and Upadhyay, 1979) [5].

Objectives of Integrated Pest management
The basic and main objectives of integrated pest management are to optimize and not maximize the pest control in terms of overall economic, social and environmental values. This approach is valid even under diverse production technologies. To get economic production, it is essential to combine all suitable techniques and methods of pest suppression in a compatible manner as possible to maintain pest population at level below those causing economic injury. Such programmes well require an intensive knowledge on the key pests along with those of other minor pests, leading to economic damage threshold an effective pest forecasting system; critical knowledge of biological factors regulating the population fluctuations of concerned pest species, and finally detailed knowledge of possible interaction between different control measures.

Methodology
There are many methods that play role in integrated pest management and some are listed below:

Cultural methods
These are the methods involved in manipulation of agronomic practices like variation in time of planting or harvesting, crop rotation, tillage of soil, pruning, thinning, fertilization, sanitation, water management, planting of trap crops (marigold, Chinese cabbage, coriander), inter cropping, crop residue destruction and burning of stubbles. These practices help in reducing the pest population.

Table 1: Combination of different intercropping effective in vegetable pest management

Crop combination	Target pest
Cabbage+carrot	Diamond back moth
Broccoli+ Faba bean	Flea beetle
Cabbage+ French bean	Root fly
Cabbage+tomato	Diamond back moth
Bitter gourd+ maize	Fruit fly

Physical methods
These methods include utilization of heat, cold, humidity and Energy in the form of light traps and light regulation.

Mechanical methods
Such type of methods involved in hand destruction of insects at different stages of life cycle; exclusion by screens and

barriers; trapping through suction devices and collecting machines, crushing and grinding.

Biological methods
These methods include conservation of natural enemies, introduction, artificial increase and colonization of specific parasitoids and use of predators of specific bacteria, virus, protozoan and fungus.

Chemical methods
These comprise insecticides, attractants, repellents, sterilants and growth inhibitors. The strategy of good integrated pest management programme advocates need and use of insecticides rather than calendar based prophylactic treatments. An insecticide should be chosen on the basis of its effectiveness which causes minimum effect on useful insects and non target organisms.

Varietal resistance
The most important component in a pest management programme is a varietal resistance. The following table showing tolerant with particular pest:

Table 2: Insect tolerant varieties (Prasad *et al.*, 2007)

Crop	Pest	Varieties
Tomato	Fruit borer *(Helicoverpa armigera)*	Arks Vikash, Pusa Gaurav, Pusa Early dwarf, Punjab Keshri, Punjab Chhuhara
Brinjal	Shoot and fruit borer, Aphids, jsassid, thrips, whitefly	SM 17-4, PBr 129-5, Punjab Barsati, ARV 2-C, Pusa Purple Round, Punjab Neelam, Kalyanpur-2, Punjab Chamkila, Gote-2, PBR-91.
Cabbage	Aphid (*Brevicoryne brassicae)*	All season, Red Drum Head, Sure head, Express Mail
Cauliflower	Stem borer (*Hellula undalis)*	Early Patna, EMS-3, KW-5,KW-8, Katmandu local
Okra	Jassid (*Amrasca biguttula*)	IC-7194, IC-13999 New selection, Punjab Padmini
Onion	Thrips (*Thrips tabaci*)	PBR-2,PBR-6, Arka Niketan, Pusa Ratnar, PBR-4, PBR-5, PBR-6

Genetic methods
They include release of genetically incompatible or sterility pests for suppression of population of insect pests.

Regulatory methods
These include quarantine suppression and eradication programmmes.

Observations
Pest monitoring through Pheromones/Light traps
Monitoring is pre-requisite for the success of insect pest management programme and for assessing the prevalent insect pest situation, surveillance of insect pests is needed. So pest monitoring should be done on the basis of various kinds of traps like pheromones, light trap and sweep-nets-water pans. The most potential ones are pheromone traps. These type of traps exploits the chemical olfactory stimulants used by insects in communication. Sex attractant pheromone traps have proven extremely useful in giving information about activity of peaks in various pest species. It helps in determining advantageous timing of control operation. Food lures like methyl eugnol, sugar and propiononitrile, singrin and protein hydrolysate are other useful attractants used for the trapping of insects.

Economic Injury Level and Economic Threshold
Economics injury levels (EIL) indicate the pest densities i.e. numbers of pest per unit area, at which control measures are economically justified. At these levels the cost of control is less than the loss to farmers or other resource producer would suffer if control actions were not taken. The careful determination and use of these levels is essential for pest management and maintenance of environment.
The economic threshold level tells the farmer or producer about the exact time to take actions to control and prevent the impending pest outbreak. As the economic threshold is lower than economics injury level, it allows enough time for control measures to take effect before the population size and resulting damage reaches the economic injury level.

Pest economic threshold level
Tomato fruit borer one egg/one larvae/one damaged fruit per plant
White fly: 4 adult/leaf (as a sucking pest)
Root-knot reniform nematode: 1-2 larvae/g soil

Some important pest control in vegetable crops
Fruit fly of cucurbits (*Dacus cucurbitae)*
The damage is caused by maggots of the fly and considered to be a group of very harmful insects which cause serious damage to fruits and vegetables.
Generally fruits are attacked in the early immature soft stage with the result that they do not develop, drop down and rot. Those which do not drop and are picked up, found unfit for human consumption as they have a number of abominable white maggots in the pulp. The humid hot weather is most suitable for its attack and generally 50 to 60 percent loss is caused to vegetable crops.

Integrated pest management technology for fruit fly in cucurbits
- The ploughing of fields two to three times reduces the pest population by exposing the pupae to enemies.
- Collection and destruction of infested fruits along with the larval stage of the fruit fly.
- Male flies may attract to citronella oil and destroyed.
- Use of bait-traps prepared with different ingredients. These can be put in small tin containers which can be hanged with sticks at various places in the field.

1. Protein hydrolysate- 100 g
2. Water- 10-20li.
3. Malathion 25% WP-200g

- Natural enemies:- The following are the pupal parasite of the pest *Opius fletcheri and Opius Incises*

Brinjal shoot and fruit borer (*Leucinodes orbonalis*)

The host of this pathogen is mainly solanaceous plants. Damage is caused by the caterpillar which attacks top shoots of young plants as well as fruits. The larvae bore into the shoot and eat internal tissues causing the attacked portion to droop and wither away. When the terminal shoots are attacked the growing points are killed. In young fruits, newly hatched larvae bore into the fruit and the entry hole is too small to be easily noticeable. The large holes usually seen on fruits are the exit holes of the caterpillars. A single caterpillar may destroy-fruits.

Prasad *et al.,* 2007) [6] stated that brinjal plant showed more shoot and fruit damaged as compared to intercropped with brinjal+roselle, brinjal+ Sowa, brinjal+marigold and brinjal+maize.

IPM for Brinjal shoot and fruit borer

- Collect and destroyed the dropping shoots and affected fruits which contain caterpillars inside.
- Spray the crop with insecticides like endosulfan, carbaryl, Malathion and fenvalerate.
- Installation of plastic funnel traps 100/ha baited with sex pheromones, it lures the insects from 10m distance after 15-20 days of planting.

Diamond back moth (*Plutella xylostella)*

The damage is caused by caterpillars which feed in mines on lower side of the cabbage leaves at earlier stages, and in the later stages it attacks every portion of the leaf. Central parts of cabbage and cauliflower may be riddled and thus vegetables rendered unfit for human consumption. They particularly feed in heart or head of cabbage and cauliflower. It causes more damage, when appears in early stages of the crops i.e. during August-September.

For Diamond back moth management

- Bediako *et al.,* 2010) [1] performed an experiment to manage the DBM pest on cabbage using intercropping with non host crops like tomato, pepper and onion. The best result was showed intercropping with onion.
- Inter crop with tomato in the ratio of 1:1 to reduce the infestation.
- Set up hormones traps (delta sticky traps) @ recommended numbers/ha

Tomato fruit borer (*Helicoverpa armigera)*

This insect is polyphagous in nature and it mostly attacks crop at fruit developmental stage.

Management

- Two rows of marigold as trap crop
- Fourteen rows of tomato
- Spray of HaNPV 250 lit/ha

Discussion

In a country like India evolving and implementing integrated pest control practices will enhance national economy as being more efficient and cheaper methods of control. Adopting integrated pest management strategy will avoid upsetting of balance in nature as well as delay the development of pesticide resistant races of pest. This strategy will further ensure need based application of pesticides leading to deposition of considerably reduced quantities of harmful residues. The yield of crop significantly lower examined for the control crop where no intercropping or other IPM components are applied on crop. According to Srinivasan and Krishna (1991) intercropping in cabbage with non-host crop of diamond black moth such as onion, tomatoes and pepper, ceased the life cycle of pest and hence increased crop growth rate. Another side, the use of chlopyrifos combined with repellent properties of intercrop also showed positive result on control of pest. Root dipping of tomato seedling in imdiachloprid should also ensure control of vector transmitted TLCV. Traditionally, the farmers have been using marigold as trap crop with the beliefs that marigold flowers attracts insect from the tomato crop and save the main crop. Intercropping with non host plant and use of biopesticides can replace the use of insecticides in managing pests' population below the economic injury level. This can improve both the yield and quality of crop. Similar findings were reported by Gajanana *et al.,* 2006) [3] Krishna *et al.,* 2003) [4], Steiner (1982) and De Lannoy (2001) [9].

Conclusion

Many studies have been conducted on in pest control in vegetable crops, out of which some of them have been recommended but most of them are not sufficiently advanced. The components of integrated pest management like intercropping, resistant varieties, biopesticides and natural enemies are essential for pest management. So finally, it is concluded that intercropping and varietal resistance methods have been considered as important part of integrated pest management.

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