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Plant Protection in India

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The paper describes the progress of different methods of pest control through the years and outlines their present status alongwith their achievements and failures. The checkered career of community level adoption of plant protection measures including pest and disease epidemics are discussed. In spite of the sound principles on which various plant protection measures of proved economic value are based, not many farmers appear to have incorporated the same in the schedule of agronomic practices for successful crop production. Safeguarding of crops from the ravages of insect pests and plant diseases would seem to continue to require active support, guidance and sponsorship of the official agencies for quite sometime in the future in this country.

The various methods of control viz. legal, physical, mechanical, cultural, biological and chemical have been practised in this country, singly or in combination during the course of the years.

Physical Measures

These include manipulation of temperature and humidity, light and sound waves, etc. Cold storage of fresh and dry fruits, potatoes and other vegetables is often resorted to for escaping fruit fly, potato tuber moth and rot fungus damage. There has been a phenomenal increase in the number of cold storages during the last 20–25 years. Cold storages have helped in stimulating the manifold increase in the production of fruits and vegetables and larger consumption per head of these commodities in prime condition almost throughout the year. Application of dry heat including exposure to the sunrays particularly during the dry hot months of May-June of commodities and superheating of stores kills infestation in woolens and pests of storedcommodities as also loose smut of wheat. Boiling, steaming and dipping in hot water (loosesmut of wheat and red rot of sugarcane) similarly destroy several kinds of biological infection.

Manipulation of moisture in grain (well dried grain moisture content 8–10% or less) and its storage in a cool dry place helps in escaping insect, fungal and mould damage.

Light traps for attracting and mass killing of several kinds of moths and beetles were used as a measure of control in the first half of the twentieth century but have now been given up (except black light) because of some inherent deficiencies in them in favour of other types of control measures. However, light traps are much in use as an indicator of population of different insect species in

an area. Rice borer, Desert locust in different parts of the year or their first emergence (pink bollworm).

Various patented machines using the principles of electric shock, electrostatic field, sound waves etc. for destroying and scaring away insects and wild animals have been developed after the end of world war II and are in use in this country in special situations on a rather limited scale. Work on irradition of grain for destroying insects and pathogens in them has been initiated by the Atomic Energy Commission on a pilot scale.

Mechanical Measures

Methodical destruction of organisms and the infested commodities in the early stages of infestation over extensive areas of incidence with a view to checking further multiplication of infestations has been employed from the very early times. Destruction of infested young shoots of sugarcane and the stubbles after harvest have helped a great deal in keeping the incidence of sugarcane borers at a low level. Many successful campaigns organised in infested solid blocks/areas in different parts of the country bear testimony to that. However, the growers do not seem to have adopted it as a routine agronomic practice themselves on individual or community-wide basis. Burning of sugarcane *debris* and stubbles in the fields and total destruction of infested byproducts are commonly resorted to. Composting of farm waste also helps to destroy incipient infections.

Collection and destruction of egg masses (cabbage butterfly, sugarcane top borer) caterpillars of cabbage butterfly, Bihar hairy caterpillar, grubs of mustard sawfly, various stages of *Epilachna* beetle and blight affected leaves of potato on an intensive scale also help a great deal in keeping down pest populations. Handnets are usefully employed for collecting *Pyrilla* when it migrates from wheat to sugarcane during March-April in northern India. Similarly field bag nets made of strong cloth (2m×0.5m×1.5m) are useful for reducing the population of grasshopper. A specially constructed hopper dozer was employed in the Punjab for collecting large populations of sugarcane *Pyrilla*. Beating of locust hoppers with brooms and thorny bushes in the cool hours of the morning was also a common practice. Shaking or jarring of small trees, shrubs or plants and collecting insects benumbed into cold in tubs containing kerosenized water or inverted umbrellas is a good practice against Blister and Cockchafer (white grubs) beetles.

Mechanical exclusion of insects by placing impenetrable barriers around the host is another method. Fixing a 15 cm deep fluffy cotton band or a 5 cm wide oil-cloth band or a band of any sticky material around mango tree trunks during December–January in North India prevents the upward movement of the nymphs of mango mealy bug which hatch out and begin crawling up the tree. Use of wire gauze screen around the stem protects the fruit trees against the attack of the stem borer, *Batocera* and even rabbits and rats, wrapping individual fruits of pomegranate and citrus in waxed paper bags helps in warding of the attack of the Pomegranate butterfly and of the fruit sucking moth respectively. Placing the legs of a meat safe in vessels containing water is a common household practice for excluding black ants. To save crops from the moving bands of locust hoppers or from red hairy caterpillars digging 30–60 cm wide and 60 cm deep trenches or erecting 30 cm high tin sheet barriers around the fields is often resorted to in villages, where equipment for better chemical methods is not available.

Several types of mechanical traps are in use. Insect are attracted by suitable baits into cages from which their exit is difficult.

The use of flame throwers against locust hoppers and adults and crushing of egglaying locust adults by running a *sohaga* (levelling plane) over them are useful mechanical methods.

Cultural Methods

Considerable attention was paid by early entomologists and plant pathologists to cultural control methods and certain practices: field sanitation, or clean cultivation, tillage, crop rotation and varying the planting dates, are recommended as routine measures for crop production.

An important general approach to the object of keeping the crop free from serious attack of insect pests is to ensure their vigorous growth by proper manuring, irrigation and clean cultivation. Plants growing vigorously can stand, to a considerable extent, the attack of several insects, particularly of the sucking type. Timely removal or destruction of crop residues like dry leaves, sticks, stubbles, weeds, left-over infested seed and other such vegetation helps in minimising the carry over of fungal, bacterial and viral infection and in reducing places of hibernation and shelter for insects and exposes them to the vagaries of weather. Proper disposal of toria (*Brassica napus*) straw early in spring brings about a reduction in the population of the Painted bug. Burning of *debris* in cotton fields during winter and proper utilization of cotton sticks by early May reduces population of Pink bollworm larvae hinerbating in the *debris* and in damaged dry bolls. Uprooting of cotton stubbles, 5 to 8 cm below the ground surface, so that its sprouts may not be available to the Spotted bollworm in subsequent months of March and April is an effective measure for reducing the incidence on the subsequent crop. Removal and destruction of stubbles of sugarcane, maize and rice crops help in killing of a major percentage of the overwintering caterpillars of sugarcane stem and root borers and maize and rice borers. Scrapping of *bunds* of rice fields to a depth of about 10 cm before the rains during April-May exposes the eggs of the Paddy grasshopper or of *phadka* (*Hieroglyphus nigrorepletus*) to the weathering agencies and reduces their incidence on the subsequent crop.

Careful, systematic destruction of the pathogen or insect-damaged plants or parts of plants is very effective and in fact is the only economical method in keeping down the population of various pathogens and of fruit flies infesting cucurbits, mango, guava, peach etc. and many tissue borers of plants.

Removal of weeds (alternate host plants) also makes it difficult for the pest to tide over the period when its cultivated host is not in the field. Systematic campaign in this regard has been found to be effective in considerably reducing the incidence of spotted bollworm of cotton, sugarcane mite and Red hairy caterpillar.

Starving the specific pests and soil-borne diseases by judicious rotation or change of cropping pattern in case of insects or long life cycle (not more than one or two generations in a year) and whose area of distribution is rather localized e.g. potato tuber moth and golden nematode of potato is another measure usefully employed. Sugarcane, wheat and chillies should not be grown in white ant-infested areas but instead tobacco and onions should be grown.

Rotation : maize-senji (*Melilotus indica*)—sugarcane and rice—pea are good. However, cultivation of sunflower in cotton growing areas in Maharashtra had to be given up because of subsequent high incidence of American bollworm (*Heliothis armigera*) on cotton, a cash crop in the area.

Recent trends in successive growing of the same crop in the same field or area have,

however, posed serious insect pest and plant disease problems e.g. ratooning of sugarcane, jowar, etc., growing of two or three crops of potatoes successively in the same field, introduction of period bound varieties like TNI, IR 8 of paddy so that the same crop is available in different stages of growth in the same area to the insect/pathogen resulting in rapid multiplication of pest/disease complex.

More attractive secondary crops are usually sown alongwith major crops early enough to serve as trap crops. *Bhindi* is often sown with cotton to attract cotton jassid and spotted bollworm. Similarly, *arhar* is sown with cotton to attract cotton grey weevil. These trap crops must be destroyed well in time otherwise their continued presence may prove as a constant source of infestation to the major crop.

Insect attack can be prevented by shifting the sowing or harvesting date, hastening crop maturity or by judicious cultivation or fertilization or varietal selection for early maturity. In Punjab, early sown cucurbits (November-December) escape attack of red pumpkin beetles as the vulnerable (cotyledonary) stage is passed much earlier than the active period of the beetles. Later sown maize for grain (second week of August) suffers a little from the ravages of the maize borer, as by then the egg parasite, *Trichogramma* is able to keep down the population of the pest. Recently, sowing of maize for grain in the winter is highly profitable as it escapes maize borer attack (Maize borer hibernates during the winter). Early transplanted rice (before the middle of June) is saved from rice borer attack. Incidence of whitefly attack is more servere on early-sown cotton as compared to late-sown. Early-sown (April) *jowar* in Mysore escapes the attack of Earhead bug. Short duration early-maturing varieties of cotton ***Bikaneri norma***, H 777 and F 414 have become very popular in Haryana and the Punjab as they escape pink bollworm incidence.

Location of a crop in the farm is important as vicinity to a crop liable to be infested with a common pest helps in the migration of the pest from one crop to the other. Cotton should not be sown near (*i*) lucerne as the lucerne caterpillar attacks both, (*ii*) *Bhindi* as jassids and spotted bollworms are pests common to both, (*iii*) onion as thrips attack young cotton also; (*iv*) forests as cotton leaf roller is severe in such situations. Sugarcane sown near *sarkanda* (*Erianthus arundinaceus*) is very liable to borer and mite attack.

The evolution of varieties of various crops resistant to insect pests and plant pathogens was taken up by plant breeders very early but high level collaboration with entomologists and plant pathologists was initiated in the 1940's. There has been a larger measure of success in evolving crop varieties resistant to plant pathogens viz. rusts, smuts, mildews, bacterial blights and viral diseases. This, however, is a continuing process and the old varieties need to be replaced every three to five years. Resistance to insect pests generally implies low degree of susceptibility or sufficient power of tolerance of the insects by the plants. Some varieties may be resistant because they are not 'preferred' or avoided for oviposition, shelter or food due to lack of certain qualities, may be physiological, chemical or physical in nature. Insects readily produce biological strains or biotypes which may modify resistance by plants. Thus the breeders aim to weed out susceptible strains of plants and find local strains tolerant to the pest in association with other varieties of same crop in specific areas. Considerable progress has been made in this regard and upgrading of desirable strains and evolution of new tolerant strains continues.

Biological Control

Concerted efforts at 'setting an insect to kill an insect' began in the 1920's in India

particularly for establishing parasites and predators of introduced insect pests from abroad. However, success has been achieved in suppressing cottony cushion scale by predatory *Rodolia* beetle in South India, apple wooly aphid by a parasitic wasp in Kashmir and Himachal Pradesh and prickly pear by cochineal insect in South India. Limited control has been possible in case of san jose scale of apple by a parasitic wasp in Himachal Pradesh and Kashmir, South African Giant Snail by a predatory snail in Andaman islands and lantana weed by a tingid bug in Uttar Pradesh.

Mass release of indigenous parasites of coconut caterpillar have been able to partially suppress the pest in South India while the indigenous egg parasite *Trichogramma* has failed to have any lasting effect on the sugarcane borers incidence in various parts of the country. The indigenous nuclear polyhedrosis virus has given effective control of several caterpillar pests in South India. *Bacillus thuringiensis* has been found to be useful in controlling several lepidopterous caterpillars like *Heliothus armigera*, *Achaea janata*, etc. on field scale in South India.

Work on establishing several exotic parasites/predators in India for controlling several crops is underway under a coordinated project under the aegis of the Indian Council of Agricultural Research and also by the Directorate of Plant Protection Quarantine and Storage. This is an enduring community service best undertaken by technically trained professionals. Sporadic efforts at controlling certain pest species by mass release of its sterile (irridated) males have not made any impact in this country.

Chemical Control

Use of poisonous chemicals (pesticides) for killing insects or injurious animals or disinfecting a bacterial or fungal infection has been practised in this country since the 1920's, initially on a rather limited scale. The various pesticides are inorganic or organic in origin. The former have minerals as their base while the latter may be of plant origin (from roots, stems, leaves, seeds, flowers and oils of various plants or based on organic synthetic compounds such chlorinated hydrocarbons in the long residual effect, organophosphates, carbamates, synthetic pyrethroids, etc. Pesticides may be grouped as stomach, contact or systemic poison, fumigants repellents, attractants, and a chemical may have one or more of these attributes. They are formulated as solutions, emulsions, water-dispersible powders, dusts, baits, granules, aerosols, smoke generators or gas.

In preparing such formulations various other materials are employed as solvents, emulsifiers, stickers, spreaders, adjuvants, wetting agents, carriers, synergists, etc. The diluted or undiluted formulations are applied from the ground or air with the help of different kinds of hand or power operated application equipment like sprayers, dusters, mistblowers, fog generators, etc. As more and more potent chemicals are being evolved this method of pest control is gaining popularity almost to the exclusion of other methods. Repeated applications of different chemicals during various stages of plant growth are necessary for tackling insect pest, plant disease and weed complex of a crop. However, injudicious use of pesticides has led to pesticide resistance in pests, pollution of the environment, soil suckness, upsetting the biological equilibrium accumulation of intolerably large amounts of several chemicals in the human/animal body eventually leading to fatalites, etc.

At the present time 44 pesticides (over 52 thousand tonnes technical grade materials), viz. chlorinated hydrocarbons-BHC, lindane, DDT, endosulphan, organophosphates, malathion, methylparathion, phosphamidon,

quinalphos, DDVP, phenthoate, tetradifon, fenitrothion, monocrotophos, and systemics—dimethoate, oxydemeton methyl; carbamate—carbaryl; plant origin organic insecticide—nicotine sulphate, pyrethrum, insecticide; fungicides—copper sulphate, copper oxychloride, sulphur dust and wettable, nickle chlorides, zineb, maneb, ziram, ferbam, thiram, methum sodium, carbendazin; seed dressing materials—organo-mercurial salts; rodenticides—zinc phosphide, warfarin, coumeferal, strychnine hydrochloride; fumigants—Ethylene dibromide, methyl bromide, ethylene dichloride, carbon tetrachloride, aluminum phosphide; herbicides—ester and amine salts of 2, 4-D and 2,4, 5-T, propanil; antibiotics - streptocycline, aurofungin are manufacturered in the country, many of the items in more than one plant and the arrangements for the manufacture of several others have reached an advanced stage.

Some pesticides (11 thousand tonnes technical grade materials) like aldrin, chlordane, dieldrin, heptachlor, lindane, ethion, diazinon, dicofol, phorate, edifenphos, captan, lead, tin, zinc, mercury, phosphorus, sulphur, ethylene, diamine, maleic anyhydrazide toulene, etc. are imported. Pesticides produced in the country as well as those imported from abroad are formulated into several formulations in many plants in the small scale industries sector and the total installed formulation capacity is over four times the technical grade materials of pesticides available.

For exercising quality control, the Indian Standards Institution (ISI) has laid down over 170 specifications for pesticides and pesticidal formulations and issued over 340 licenses to 44 firms for marketing 52 products with ISI Certification Mark, which is a third party guarantee to the consumer that the contents of the package so marked conform to the respective ISI standard. Monitoring of ISI certification marked samples of pesticidal products collected from the market, is, however, not adequate. Besides, the Government should make sale of ISI certification marked pesticidal products mandatory to protect the interests of growers. There are over thirty thousand Government, Cooperative and private agency sale points in different parts of the country. These are inadequate in number and should be increased several times so that pesticides may be made available to the cultivator at bullock cart distance from his farm. The educational campaign for making the cultivators familiar with the proper use of pesticides needs to be greatly intensified.

Application Equipment

The varied types of formulations of pesticides and the different situation in which they have to be applied require correspondingly suitable types of application equipment. Local models of hand operated equipment became available in India in 1948-49. There are five firms in the large scale sector and many in the small scale Industries Sector. ISI has laid down specifications for 15 different types of machines but no licences under the ISI Certification Mark have been issued. The equipment produced by some of the firms is of high quality and one firm exports its equipment to several countries in South East Asia, Middle East and Africa. The major items manufactured are stirrup pumps, foot pumps, rocking sprayers, compressed air pumps, pressure-retaining sprayers, large volume hydraulic power sprayers, knapsack motorised mist blowers cum dusters, plunger dusters, dust applicator for burrows, rotary fan dusters, power dusters, flame throwers, seed dressing machines etc. along with ancillary equipment. It is estimated that there were about 6.5 lac units of hand-operated and 30 thousand units of power-operated equipment in the country in 1980 and there was ample manufacturing capacity for replacement of worn out equipment and additional

units. However, the available equipment does not seem to be properly used in the growers' fields and either there is inadequate coverage of the crop or a considerable amount of pesticide gets wasted. There is ample scope for upgrading the quality of spraying and dusting in the field, monitoring of pesticidal deposit per unit area of leaf surface, etc. of a crop and intensive training of operators and equipment maintenance personnel.

Some fixed-wing aeroplanes and helicopters are imported items and 48 Indian, Canadian, Polish, Czechoslovakian, USSR and USA fixed wing aeroplanes and 11 helicopters are in use by the Directorate of Agricultural Aviation and five private operators. However, the quality of spraying is not up to the international standards and efforts to introduce a code of practice and compulsory monitoring a deposit of insecticide 100 droplets per sq. cm leaf surface) in 1978 was resisted and not adopted by the operators.

Pest Management

The reappraisal of the various methods of control on the basis of a series of documented observations on the biology and ecology of the pests and the phenology of the crop led to the development and acceptance of integrated pest control, (renamed pest management by a FAO Committee). It has two essential ingredients:

(*i*) Learning to live with some population of the pest too expensive to control and applying chemical control measures at the economic damage threshold as a last resort.

(*ii*) Using various methods of control in a consolidated manner in relation to the phenology of the crop. There is no doubt that pest management systems are efficient, durable, economical, simple and well-suited to the needs of this country. The systems, however, are technical personnel-intensive. A large number of technically trained persons are required to man observation stations, for scouting pest populations, servicing light traps, consolidating and transmitting information to the field staff and growers. Many more workers are needed to undertake basic research as there are continuous changes of season, dominant variety of crop, in the established cropping pattern or in the economic or market value of crop. However, the financial outlays are recovered several times over in a single season. Operational research on pest management projects on desert locust, cotton, paddy and jowar have been undertaken in India with gratifying results. This work needs to be greatly expanded to cover all major crops on a country-wide basis and permanant organisations maintained on the pattern of the one on desert locust.

Programme Implementation

The task of promoting the concept of the ability of man to protect crops from the ravages of pests and diseases by various methods under his control in a country with thousand years of historical background of growing crops subject to the frequent vagaries of weather and the fatalistic attitude towards the impositions of nature is indeed formidable. The phenomenal results of the institution of pest control with modern insecticides particularly the outstanding success achieved in the control of desert locust with BHC and aldrin, malaria mosquito control with DDT and safe storage of foodgrains with EDCT mixture have gone a long way in establishing rapport between the plant protection agency and the farmer. Elimination of such chronic pests as the Deccan wingless grasshopper, the Phadka grasshopper and the rice bug in several widely separated parts of the country have helped in spreading the gospel of plant

protection. It can be said without any fear of contradiction that once a cultivator has used chemical pest control measures on his farm or homestead, his conversion is of an enduring nature and he becomes the centre of future activities of development of plant protection in the area. However, the dream of a plant protection officer that the farmer will adopt mechanical and cultural pest control methods as routine agronomic practices for crop production, with some minor exceptions, is far from realisation, and pest management programmes will have to overcome the cultivator's casual approach/indifference towards such practices.

Plant protection programmes to be effective need to be undertaken on area/community-wide basis, as an individual farmer's work is nullified by the spread of infection of pathogens or infestation of insects from his unprotected neighbour's fields. As agricultural cooperative societies undertaking field operations have not made much progress in this country, the work of organising campaigns against endemic pests or of epidemics of insect pest or plant diseases have to be undertaken by the State Plant Protection agency. Organisation of such campaigns involves working through District and Block Development Boards, *Panchayat Samities* and other private agencies as also local officials. In certain situations recourse has to be taken to the provisions of the Pest Act, as a campaign once instituted has to be executed methodically and in a thorough manner. Timely action for suitable convassing at the local level, procurement of inputs like pesticides and application equipment including arrangements for grant of crop loans to the farmers for purchase of pesticides and application equipment, intensive training of the technical personnel at various levels and the public concerned, arrangements for publicity material and public relations, getting the necessary notifications issued under the State Pest Diseases Act and streamlining the organisation, must be taken.

Organisation of campaigns for control of pests during the off season, viz. cotton clean up campaigns, destruction of aestivating strainer bug (*Dysdercus* spp.) or general pests like grasshoppers, desert locust, hairy caterpillars, grain-eating birds or anti-rat campaign has necessarily to be the direct responsibility of the State. Otherwise nothing would get done. Similarly, establishment of parasites/predators in the field for the control of insect pests or organisation of pest management of major crops which are both technical personnel intensive has to be sponsored directly by the State.

At the Central level, in addition to shouldering responsibilities of a direct nature in connection with the institution of plant quarantine on imports and issue of phytosanitary certificates on export commodities, survey and warning and control of desert locust in the Scheduled Desert Area, advanced training in plant protection, maintenance of the Insect Pest and Plant Disease Surveillance Service, it is necessary to organise coordination of effort of Central, State and local agencies, corporate bodies, trade and industry and the farmers in different areas of plant protection. To ensure timely supply of the estimated requirements of pesticides and application equipment, arrangements will have to be made for adequate quantities of raw materials, diluents and other formulating agents to the industry, from within the country or through imports. Quality control through monitoring of pesticides sold in the market will have to be instituted. Sorting out of the agricultural programmes in the States with the assistance of the Plans of the Government of India and in the private sector, is also necessary.

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