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Future of Pesticides in Plant Protection

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Food grains and oil seeds when kept in farm stores, public godowns or granaries are not only spoiled by high moisture and fungal growth but are actually eaten up by insect pests of stored grains, termites, rats and birds. The estimates of such losses range from 5 to 15 %.

By the year 2000 A.D. production of cereal crops is expected to rise to 186 million tonnes, that of pulses to 13 million tonnes, of oil seeds to 14.5 million tonnes and of fibre crops to 7 million tonnes. The losses by pests to these crops are expected to rise to: 18.6, 2.3, 4.6 and 4 million tonnes respectively. Although it is impossible to avoid these losses completely, these can be reduced to a great extent by using adequate amounts of pesticides.

The pesticide consumption in our agriculture is far less (400 g/ha) than that of USA (1490 g/ha) and Japan (10790 g/ha).

Pesticides will play the most significant role in obtaining higher yields and in saving the food grains in storage to meet the challenges of the 2000 A.D.

The consumption of pesticides per ha rose from 3.2 gm in 1954-55 to 336 gm in 1973-74. The present installed capacity in the country at the 1983 level is: Insecticides 84,184, Fungicides 13,010, the Rodenticides 1,394, Herbicides4, 640 and Fumigants 2,378 tonnes. It would indicate that against the present demand of 72,000 we have an installed capacity of 1,05,606 tonnes indicating one-third additional capacity available for increase in production over and above the present needs. The present production of food grains, oil seeds and fibres is 150 million tonnes and by the year 2000 the production is expected to increase to 220.5 million tonnes, indicating an increase of one-third over the present production level. Theoretically the present installed capacity of pesticides production in the country should meet the needs for the coming 20 years. However, it is an artifact, because newer and better chemicals are being added to the list every year. Some of the new third generation insecticides will certainly replace the traditional chemicals. In other words some of the installed capacity will become useless and in its place newer pesticides will have to be manufactured by importing new technology. As an illustration, may be mentioned the synthetic pyrethroids, they will play an exceedingly greater role in the production of fibre, pulses and other foodgrains. There would naturally be many other newer chemicals like weedicides which will have to be manufactured in the country. The future planning, therefore, must keep in view the quantitative needs based on theoretical projections as well as the unexpected factors like the introduction of newer pesticides that already have appeared in the market or may be introduced in the near future.

Key Words : Pesticides, Crop losses, Pest Diseases, Plant protection

Introduction

Among the various agricultural inputs like; fertilizers, pesticides, and other farm operations, the return per unit of expenditure as based on cost-benefit ratio is high for pesticides (table 1).

Further, unless high doses of fertilizers are supplemented with fungicides, the corresponding increase in yield may not be achieved.

The application of 100 kg of nitrogen/ha. alongwith fungicides gave approximately the same yield of winter wheat as achieved with the application of 180 kg of nitrogen alone (table 2).

The control of diseases by evolving resistant varieties/cultivars has many wide dimensions. The control of insect pests on the other hand is predominantly through the use of insecticides giving direct control and benefits.

The foodgrains, oil seeds, fibre and other agricultural products during storage are susceptible to damage from moisture, fungi, insects, birds and rodents. The reduction of these losses is essential to increase the availability of these commodities.

Table 1 *Cost-benefit ratio for various agricultural inputs*

Agricultural inputs	Usual c/b ratio
Fertilizers	1:2.5 to 1:3
Fungicides	1:3 to 1.10
Other farm operations	1:3 to 1:4

Source : Mehta 1971

Table 2 *Effect of fungicide application on yield (tonnes/ha) of winter wheat given different amounts of nitrogen fertilizer*

Kg N/ha	Fungicide abesnt	Fungicide present
100	6.95	7.51
140	7.30	8.20
180	7.50	8.50

Source : Moris Huntsman (1978)

Crop Losses by Pests and Diseases

Recently, attempts have been made in India also to quantify the crop losses caused by pests. The results obtained in some of the studies are briefly presented in tables 3–5 which clearly show that insect pests may cause serious losses to many of the crops.

The estimated crop losses due to pests are presented in table 3.

The estimates of monetary losses suffered by certain states have also been provided at the 'All-India Seminar on Crop Losses due to Insect Pests' held at Hyderabad in 1983. This has been reported to be Rs. 600 crores in Gujarat, Rs. 300 crores in Haryana, Rs. 50 crores in Andhra Pradesh, Rs. 193 crores in Karnatka, Rs. 153 crores in Kerala, Rs. 116 crores in West Bengal and Rs. 153 crores in Bihar.

According to the studies made by Sidhu et al. (1983), the loss suffered by the cotton crop in Punjab due to insect pests alone is Rs. 195 crores. According to Atwal (1976, 1986), the total estimated losses to crops in India for want of suitable control of field pests come to Rs. 3274.5 crores (at 1976 figures) and to Rs. 51812.2 crores (at 1983 figures); it includes the grain losses in storage (table 4)

Likewise, the losses caused by weeds to major crops in India have been estimated to be approximately Rs. 420 crores per annum (Joshi 1977). The reduction in yield of important crops due to weeds is reported to be 16% in wheat, 41.6% in rice, 39.8% in maize, 33.8% in groundnut, 47.5% in cotton and 34.2% in sugarcane (Mani et al. 1968). It has to be remembered that many of the crops like pulses, mustard and cotton, etc. cannot be grown profitably without pest control.

Table 3 *Estimated crop losses worked out at different centres in India*

Crop	Pests (Insects)	Loss (%)	Value (in million Rs)	Reported by	Remarks
Rice	Whole pest complex	21–51	3659	Kalode (1983)	Based on All-India Coordinated Trials
Maize (Rabi)	–do–	19.76	74	Khan et al. (1983)	RAU (Bihar) (State figures)
Sorghum	–do–	34.35–51.98	—	Board & Mittal (1983)	G A U Junagadh (State figures)
Sorghum	*C. partellus* alone	2.7–83.7	—	Veeresh (1980)	National figures
Sugarcane	Whole pest complex	7.9–12.8	—	Veeresh (1980)	–d–
Cotton	–do–	40–90	—	Sidhu et al. (1983)	–do–
Pulse Crops	–do–	40–88	—	Agarwal (1981)	–do–
Peas	–do–	21	357	Yeshbir (1983)	(IARI, New Delhi)
Rapeseed Mustard	*Lipaphis erysimi* alone	35.4–61.1	—	Bakhetia (1983)	(PAU Ludhiana)
Rapeseed & Mustard	Whole pest complex	35.4–73.3	3780	Bakhetia (1983)	(PAU Ludhiana)
Groundnut	Whole pest complex	32	8470	Vyas (1983)	(GAU, Junagadh)

Similarly, estimates of crop losses owing to various diseases in India have been estimated at Rs. 1560 crores annually.

Pesticide Use and Crop Yields

In Western countries, farming has become a highly specialised business. The cost of labour is very high and the margin of profits is quite narrow. Making a profitable living by a farmer depends upon high yield levels which can only be obtained by precisely determining the optimum doses of fertilizers and pesticides to be applied. A farmer should be able to calculate within 10 % the size of the crop he will harvest, barring unexpected calamities like bad weather. With the advancement of plant science and with the introduction of modern synthetic organic pesticides, the quality of vegetables, fruits and grains to be harvested can be of high order and the price fetched may also be the maximum possible; only then farming becomes marginally profitable. Unless such margins of profit are maintained the farmer is forced to sell out land and move to some other profession. In USA, farming population in the last two decades has been reduced from 7 to 3 %.

Recently, the experiments conducted at the International Rice Research Institute, Phillippines, showed the significant role of pesticides in increasing the yield of rice. Plots

Table 4 *Estimated value of crop losses caused by pests in India*

Crop	Production (in million tonnes)	% loss (average)	Value of loss (in million rupees)
Wheat	41.5	10	5191
Rice	53.6	20	13078
Maize, Sorghum, Millets	30.0	25	9150
Cotton	8.0 M. bales	50	3400
Brassica	2.1	35–73	613.2
Groundnut	7.3	10	2380
Cottonseed	2.6	7	500
Pulses	11.35	10	5000
Losses during storage	54.2	7	12500
Total	—	—	51812.2

Source : Atwal (1986)

protected by pesticides produced an average yield of 5.7 metric tonnes/hectare, while the average yield of unprotected plots was 2.7 metric tonnes/ha. In a separate set of experiments, it was shown that the plots protected from insect damage alone, produced on an average 1 tonne more rice/hectare than the plots which received the same doses of fertilizer, irrigation, etc. but were not protected against insect pests (Pathak et al. 1976).

Numerous studies made in India have also amply demonstrated that wherever pesticides were applied, there were significant increases in yield. To illustrate this, some examples are cited here.

In the case of pulses, the average increase in yield as a result of plant protection measures was found to be 46.0% in pigeon pea, 66.2% in blackgram, 71.2% in moong and 29.4% in soyabean (Agarwal 1981). Treatment of

Table 5 *Losses in yield due to plant pathogens*

Crop	*Disease*	*Loss*
Wheat	Rusts	Rs. 4 crores every year In years of epiphytotics upto 50 crores.
	Loose smut	Rs. 5 crores Average loss of 3% per year
	Ear cockle	Upto 50% in UP
Jowar	Smuts	10 crores every year
Rice	B L B	Damage vary from 6–60%
	Sheath rot	6 – 30 %
Maize	Different diseases	10 – 12 %
Groundnut	Tikka	Reduction in yield upto 22%
	Rust	Upto 10%
Peas	Powdery Mildew	23% loss in yield 26 – 47% in term of seed weight
Brinjal	Little leaf	99% yield reduction in number of fruits and reduction in size
Cucurbits	Fruit rot	8 – 15%
Muskmelon	Fruit rot (Fusarium)	10%
Potato	Late blight	42.6% in Bangalore (1982–83)

Sources : Singh (1978); Mehrotra (1980)

seeds with Thiram and soil application of phorate granules resulted in 87 to 145% increase in yield in groundnut (Bakhetia 1983). A cost-benefit analysis of pesticides use has also been carried out by the various workers. This relationship has been found to be highly favourable.

Atwal and Singh (1968) observed that there are 25 to 50% avoidable losses on cotton which is attacked by a number of insect pests like jassids, whitefly, spotted bollworm and pink bollworm. It was seen that the yield of cotton could be increased by 50% on following a good pesticide schedule for controlling the sucking pests and the bollworms.

Rapeseeds and mustard crops are attacked by a number of insects, the most important being the mustard aphid, which certainly is a limiting factor for the successful growing of these crops. Timely applications of pesticides can increase the yields by more than three-folds and the net returns can be increased by three or four times (Atwal et al. 1967).

Agarwal (1981) also found that pulse crops responded to fertilizers as much as to insecticides and the application of insecticides gave the highest returns. It also needs to be emphasized that advances in breeding, irrigation and many other agricultural inputs can be realized only if they are combined with application of pesticides. Thus, crop protection provides a form of insurance.

Rai et al. (1978) reported that the use of carbofuran for shoot fly control on sorghum, even with the lowest economic loss (20%), gave the cost-benefit ratio of 1 : 2.42. At high infestation (90%), this ratio exceeded 1 : 10. The authors considered it doubtful whether such a potential pay-off existed for any other input, including irrigation and fertilizers (table 6a).

The use of herbicides on wheat and rice crops, which are found infested with grassy weeds, has been found to give a considerable increase in yield over conventional methods (table 7).

It is not only the high yields that are required but it is also desirable to obtain good quality in agricultural produce. In vegetables and fruits, quality is most essential. In the Western countries, fresh fruits, and vegetables are generally not to be sold if they show any traces of infection or insect damage.

Agricultural produce deteriorates in transport and storage much rapidly if it has been damaged by pests and minor organisms. Some moulds and fungi develop on damaged cereal grains and the groundnut (e.g. *Pencillium and Aspergillus*), producing toxins which cause diseases and even death among animals and human beings.

Pattern of Pesticide Use

In advanced countries, the pesticide-use for crop protection was adopted early and at a much faster rate. The level of pesticide use on per hectare basis in a few selected countries of the world indicate the present level of pesticide use in the world (table 8).

Although—the present figure for India on per hectare basis is quite low yet the use of modern synthetic organic insecticides has kept fairly abreast with the rest of the world. DDT and BHC were first imported for trial on agricultural crops and for malaria control, after the second World War. By the late 1940s, a number of trials had been conducted in the country. In agriculture, the first use came on vegetable crops because those were grown under intensive farming and some of the pests were really devastating. It was not uncommon to see a field of brinjal completely defoliated by the attack of *Hadda* beetle and Lace-wing bug. The brinjal fruits of the summer crop were attacked by the borer up to the extent of 75%.

Table 6a *Effectiveness and economics of seed treatment and soil application of aldrin and BHC for termite control on yield of barley*

Treatment	Mean grain yield (q/ha)	Cost of insecticide (Rs/ha)	Net gain over the control (Rs.)	Cost benefit ratio
(A) SEED TREATMENT (per 75 kg/ha)				
375 ml aldrin 30% EC	17.99	15.0	388.80	25.9
750 ml aldrin 30% EC	21.47	30.0	775.44	25.8
750 g aldrin 5% dust	15.72	1.13	143.64	130.3
(B) PRESOWING SOIL APPLICATION (per ha)				
3.75 kg aldrin 5% dust	18.97	180.0	494.64	2.7
25 kg BHC 11 % dust	16.07	37.5	181.42	4.6
Unprotected	14.39	—	—	—

Table 6b *Economics of the control of White grub and collar rot on groundnut*

Treatment	Mean pod yield (kg/ha)	Cost of pesticides (Rs/ha)	Net gain over control (Rs/ha)	Cost : Benefit Ratio
Phorate+Thiram	1011	200.00	1312.50	1 : 6.56
Carbofuran+Thiram	1129	476.20	1729.00	1 : 8.45
Control	625	—		

Sources : Verma et al. (1979); Bakhetia (1982)

Table 7 *Effect of herbicides on weed control in wheat and rice*

Treatment	Wheat		Rice	
	Grain Yield (q/ha)	Per cent increase over conventional method	Grain yield (q/ha)	Per cent increase over conventional method
Chemical Weeding	50.7	32.0	60.2	9.1
Conventional (two hoeings)	38.4	—	55.2	—
No Weeding	33.8	—	37.6	—

Source: Annual Report, Department of Agronomy, Punjab Agricultural University, Ludhiana, 1982

The use of DDT against these pests was so effective that the farmers were wonderstruck and just could not believe their own eyes. Thus, from the early fifties the farmers started the use of these insecticides on vegetables, potatoes and later on other crops like cotton, citrus, mango, etc.

At present, cotton, rice, vegetables and the plantations are the important crops which consume major share of pesticides in India. Within agriculture, the comparative consumption of pesticides for various crops gives an idea of the urgency of plant protection and the possibility of obtaining net returns by the farmers as indicated in table 9.

It has been estimated that farmers in Punjab use insecticide worth Rs. 20 crores every year on cotton which forms 90 per cent of all the insecticides used in the state.

Collectively, pesticides are used in India primarily for two purposes namely, agriculture and public health—the consumption for the former being 2/3 and for the latter 1/3 of the total. As shown in table 10, the pesticide-use has steadily increased over the years.

Among all the pesticides, insecticides constitute about 80 per cent, followed by fungicides 10 per cent, and herbicides 7 per cent (table 11).

In the world as a whole herbicides are the fast growing pesticides and have reached a higher total consumption than the insecticides. It is logical to believe that in India too use of herbicides will increase at a much faster rate than that of insecticides.

The use of herbicides in Punjab has picked up considerably in recent years owing to the cereal economy under intensive agriculture (table 12). It is estimated that 40% of the total area under rice in Punjab was treated with herbicides during 1983.

Alongside the use of insecticides and weedicides, the use of fungicides in India is also being accepted by the farmers. Comparing it with advanced countries of the world, India

Table 8 *Level of pesticide consumption in selected countries* (1978-1979 *basis*)

Country	Consumption
USA	1490 g/ha
Europe	1870 g/ha
Japan	10790 g/ha
India	400 g/ha

Source : Schwinn (1982)

Table 9 *Estimated market share of pesticide consumption for some major crops vis-a-vis their share of total cropped area in India*

Crop	Pesticide shares (%)	Cropped area share (%)
Cotton	52–55	5
Rice	17–18	24
Chillies/Vegetables/Fruits	13–14	3
Plantations	7–8	2
Cereals/Millets/Oilseeds/Pulses	6–7	58
Sugarcane	2–3	2
Others	1–2	6

Source : Kapadia and Mohla (1980)

Table 10 *Consumption of technical grade pesticides for agriculture and public health* (*metric tonnes*)

Year	Agriculture	Public health	Total
1954-55	—	—	462
1959-60	—	—	5,697
1964-65	—	—	12,065
1969-70	11,844	14,156	26,000
1974-75	37,523	12,341	49,964
1977-78	39,880	19,100	58,980

Source : David (1981)

Table 11 *Share of different groups of pesticides in India vis-a-vis the world*

Pesticide Group	Market Share	
	World (%)	India (%)
Herbicides	45	7
Insecticides	36	80
Fungicides	17	10
Others	2	3

Source : Phadke (1980)

Table 12 *Quantity of herbicides used in Punjab and India as a whole (M. tonnes)*

Year	India*	Punjab** (used on wheat)
1977-78	—	2.55
1978-79	1630	2.57
1979-80	1855	5.65
1980-81	2095	9.73
1981-82	2320	9.80
1982-83	2540	42.70
*1983-84	2770	130.00

* David (1981)

**State Department of Agriculture, Punjab

+Anticipated

again stands on the low side as shown by the production figures of the country (table 13).

Although there is an indication that there is a good acceptability of this group of pesticides by the farmers. Considering that the visible results on the control of diseases by the use of fungicides is not that spectacular as that of the insecticides, this trend is encouraging for a country like India. On the world basis, the comparative use of fungicides on various crops is shown in table 14.

The predominant use of fungicides is on fruits and vegetables including potato, and on the plantation crops, mostly cocoa, coffee, and tea. Their use on foodgrains is comparatively less but the practice of seed treatment is becoming popular and with the development of Seed Corporations in India and the greater production of treated certified seeds their is no doubt that consumption of fungicides will increase.

Future Strategy

Constraints in the Use of Pesticides

The use of pesticides has now shown the anticipated expansion particularly during the last few years. It was partly attributed to severe droughts and inadequate rains. Many other factors have been outlined relating to their introduction, distribution and optimum use. India being a large country the relative importance of these factors may differ in diffrent regions. The future adoption of pesticides and the consequential higher agricultural production will depend upon the increased consciousness among the farmers, and the conviction that pesticides do give returns, and infact proportionately higher returns, as compared with many other inputs. Various States should, therefore, take up studies on crop losses caused by insects and other pests, by diseases, and weeds. They should also study and determine the constraints observed in the adoption of pest control measures. Naturally, defining a problem is necessary before giving its solution. Apart from the precise studies on crop losses caused by pests and diseases and working out the cost-benefit ratios, some of the constraints of general nature are discussed here.

Table 13 *Production of technical grade pesticides—fungicides and weedicides in India* (1983-84)

Pesticides	Quantity (Tonnes)
Fungicides	
1. Copper oxychloride	1082
2. Thiocarbamates	
(*i*) Thiram/Ziram/Vapam/Ferbam	—
(*ii*) Zinc Dimethyl bithiocarbamates	—
(*iii*) Dithane	1507
3. Nickle chloride	—
4. Organomercurials	124
5. Carbendazim	102
Herbicides	
1. 2, 4-D	558
2. Isoproturon	9
Weedicides	
1. Paraquat (Gramoxone)	160
2. Basalin	60
3. Dalapon	5
4. Diuron	189

Source : Pesticides Informatiohn 10 (1) April, June, 1984

Table 14 *World market of fungicides on various crops in the developing countries*

	World	Developing Countries
Fruits	40.9%	17.0%
Vegetables	17.0%	20.0%
Small grain cereals	19.0%	9.9%
Rice	16.2%	9.2%
Cocoa	—	10.0%
Coffee	—	15.0%

Source : Ciba-Geigy, Switzerland, 1982

(*i*) *Inadequate plant protection services*

The control of crop pests with chemicals requires a highly developed infrastructure and trained manpower, more so in this case than in the use of other agricultural inputs. Pesticides are poisonous and the farmers lack the knowledge of their proper use. The selection of right pesticide and its application in the recommended concentration are vital for the timely control of pests. Recently, survey undertaken by the Punjab Agricultural University, Ludhiana, in cotton growing areas, revealed that the farmers purchased pesticides from the commission agents generally on loan. In order to promote their sales to the farmers the agents advised them to purchase those pesticides which were not recommended for the cotton pests. The shopkeepers also suggested the use of recommended pesticides at lesser doses or at a longer time interval in order to reduce the cost of application per area. It was found that while the farmers used right insecticides at the recommended doses for jassid and whitefly control adequately, only 11% of the sprays were correctly directed against the bollworms with the right insecticides. In 28% of the cases, farmers used insecticides which were not effective against bollworms, and 61% of the sprays carried out were with the recommended insecticides but at low concentrations.

(*ii*) *Lack of quality control of the formulations*

In spite of the provision of the Pesticide Act of India and the powers given to Plant Protection Inspectors, the practice of selling spurious, adulterated, or improperly formulated insecticides is widespread. A given pesticide may be formulated by many firms and marketed under various brand names. The scientific evaluation on the efficacy of that insecticide is generally done on one or two brands to determine their effectiveness

for pest control. The other formulators promote their own brand names by writing the common accepted names on their products, thus by passing the law. It is necessary for the Government to constitute an expert group to make an indepth study of their problem.

(iii) Plant protection — A specialist's job

Many of the State Governments do not appreciate the fact that pest control is a highly specialised job. Under the pretext of common cadre of Agricultural Inspectors or Agricultural Extension Officers, they are easily interchanged and transferred from one position to another. A general purpose extension man cannot advise the farmers on the use of various pesticides to control specific pests and diseases at the appropriate stage as determined by economic threshold. It is essential that the Departments of Agriculture in various states establish specialised plant protection services.

(iv) Pest control - A low priority area

Even though the pesticides give the highest cost-benefit ratio among all the agricultural inputs yet those are given a low priority in the plan schemes. In the Sixth Five-Year Plan, whereas the increase in use of improved seeds was envisaged at 3%, that of irrigation at 25.8%, of fertilizers 83%, the availability of new crop varieties at 59%, the target for increase of pesticides was fixed at 33% only. It is a faulty planning, particularly in view of the fact that the pulses and oilseed crops, which are to receive special attention under the Prime Minister's 20 Point Programme, respond much better to pesticides than the other inputs. It is feared that even the target of 33% increase in the use of pesticides may not be achieved by the end of the Plan.

(v) Lack of support price for agricultural commodities

Most of the farmers in India have a very low risk bearing capacity and they make minimum investment on inputs. There is no crop insurance to cover the high risk. The alternative mechanism to cover the risk is to give a support price for agricultural commodities, particularly for those crops which need plant protection measures for obtaining high yields. Surprisingly all such crops have not received the attention of the Government for fixing a support price. These crops include potatoes, cotton, pulses, oilseeds, fruits and vegetables.

(vi) Pest Resistance to Chemicals

Resistant strains of plants and pests emerge owing to selective survival of certain individuals which happen to possess genes giving them more or less immunity against the pesticides. The development of resistance is, therefore, a common phenomenon among important pests which are constantly attacked by pesticides over a wide area. Resistance of a species against one or even more insecticides has been observed among a number of crop pests as well as in mosquitoes and houseflies. A Pest Control Strategy in the use of pesticides is, therefore, essential. Consistent studies on the development of resistance and constant flow of highly technical information is a great necessity which has not been realized by the science administrators.

(vii) Pesticide residues

There is a widespread concern that by the improper use of pesticides the environment may be polluted to the harm of man and nature. The persistent insecticides which are not broken down easily cause harm in two ways. Residues, above the tolerance limits remain on food products and fodder which are eaten by man and milch animals, causing

acute or chronic ailments. The excretion of such chemicals as DDT, BHC is particularly harmful to children who get much higher dozes of the poisons per unit body weight as compared with the adults. Secondly, the persistent pesticides damage soil fertility and through biological food chains their concentration gets magnified, causing imbalance in nature, killing animals at the higher trophic levels. Studies made on the concentration of DDT in human fat, milk and butter have amply demonstrated the presence of DDT in these foods at levels much higher than the permissible limits. To monitor the presence of pesticide residues on foods, highly sensitive instruments are needed by specialized analytical staff. The establishment of such laboratories is essential for the guidance of the enforcement machinery in order to safeguard public health.

(viii) Integrated approach to pest control

The use of pesticides for increased crop production even though a necessity in modern agriculture, the widespread use of these chemicals also kill the natural enemies of animal pests. For the protection of parasites and predators it is not absolutely essential that pesticide use should be discontinued. The judicious use of pesticides can give fair amount of protection to the natural enemies. Chemicals should, therefore, be used in combination with other alternative methods of pest control. By adopting the useful agricultural practices, the use of pheromones in insect field traps, the spraying of antifeedants and other chemicals, can also give protection to crops and at the same time reduce mortality among parasites and predators to the minimum. The practices of integrated pest control for various crops can only be devised by scientific studies and operational trials under field conditions. Such an approach should not be considered detrimental to the expansion of pesticide industry but should be considered supportive in nature for devising good plant protection measures.

The various constraints discussed above would indicate that in modern days of scientific technology a number of sophisticated methods and techniques of pest, disease and weed control have been devised which should be adopted in India also. The need is even more so in all the developing countries where the population is increasing at a fast rate and agricultural production is not keeping abreast of the food needs. In the field of plant protection it is most desirable to develop and utilize such scientific studies as pest population dynamics, resistance of plants to insects and diseases, the genetics of pest resistence to chemicals, the toxicology of pesticides to determine the LDC values and tolerance limits, the extent of environmental pollution with persistent pesticides, biological cycling and magnification of agro-chemicals and the consequent public health hazards and finally developing the integrated pest control strategies. Such approaches will lead to a greater use of pesticides with confidance, rather than limiting their use to the blanket sprays of crops which is not a sound scientific strategy.

Future of Pesticide Use

New agrochemicals are being discovered every day and many of them would replace the existing chemicals in use. There are many examples of insecticides, weedicides, and fungicides which have already been developed and are being used in advanced countries but those are in the preliminary stages of experimentation in India.

Among the insecticides, the new wonder chemicals are the synthetic pyrethroids which are universally effective against tissue borers of crops which were difficult to be controlled by the earlier insecticides available in the market. Among the new weedicides that

are in the experimental stage in India, are: Fusilade, Glyphosate, Simetryne, Oxyfeurofen, Metribuzin, Bentazon. Similarly, a number of new fungicides that are likely to find good market in India include Diclobutrazol, Propiconazol, Triadimefon, Triadimenol Bitertanol.

The present installed capacity of pesticides in India at the 1983 level in metric tonnes is given in table 15.

It would appear that against the present demand of 72,000 tonnes we have an installed capacity of 1,05,606 tonnes, indicating one-third additional capacity available for increase in production over and above the present needs. The present production of foodgrains, oilseeds and fibres is 150 tonnes and by the year 2000, the production is expected to increase to 220.5 million tonnes, which is an increase of one-third over the present production level. Theoretically, the present installed capacity of pesticide production in the country should meet the needs for the coming 20 years. However, it is an artifact, because newer and better chemicals are being added to the lists every year. Some of the new pesticides will certainly replace the existing chemicals in use. In other words some of the installed capacity will become inoperative and in its place newer pesticides will have to be manufactured by importing new technology. As an illustration may be mentioned the synthetic pyrethroids; they will play an exceedingly greater role in the production of fibre, pulses and other foodgrains. There would naturally be many other newer chemicals like weedicides which will have to be manufactured in the country. The future planning, therefore, must keep in view the quantitative needs based on theoretical projections as well as the unexpected factors like the introduction of newer pesticides that already have appeared in the market or may be introduced in the near future.

Table 15 *Installed capacity as on 1st October, 1983*

Chemicals	Technical grades (tonnes)
Insecticides	84,184
Fungicides	13,010
Rodenticides	1,394
Herbicides	4,640
Fumigants	2,378
Total	1,05,606

Administration and Planning for Plant Protection in India

Plant Protection needs to be given a proper priority in agriculture planning. The rightful place of plant protection by pesticide and other methods has been discussed in this paper and elsewhere by many other authors. In advanced countries like USA, Japan, Great Britain, USSR, Canada and Australia, plant protection is given as much importance in agriculture as any other agricultural input. The newer techniques of pest and disease control that have been developed in the last two decades are more sophisticated than the plant breeding methods being employed at present. Instead of giving initiative to the Entomologists and Plant Pathologists for conducting researches on new methodologies and devising more realistic methods of plant protection the science administrators have not given due importance to the work of these specialists in India. The phenomenal increases in production by the use of pesticides on cotton, oilseeds, pulses, plantation crops, sugarcane, sorghum, fruits and vegetables were well recognised but the role played by Entomologists and Plant Pathologists has not received due recognition. On the contrary, they have been given a secondary role

particularly in the All India Coordinated Projects in which merely routine type of work of screening of germplasm takes most of their time. They do not devote sufficient time to the working out of sound strategies for the control of pests and diseases by chemicals using multiple approaches discussed in this paper.

At the State level, the specialized knowledge of Plant Protection Inspectors goes to waste when they are transferred within the common cadre of Agricultural Inspectors. Likewise the Inspectors are appointed against senior positions giving no consideration to their expertise in the field of plant protection. They are simply lumped together with the general Agricultural Extension Officers.

At the national level, the position of the Plant Protection Specialists in agricultural administration is no better. There was a time when the Plant Protection Advisor-cum-Director, Quarantine & Storage was one of the seniormost officers in India. Ever since the locust swarms have been kept suppressed, the importance of that position seems to have declined instead of receiving greater appreciation and importance. Whereas the positions of many other agricultural officers and production commissioners have been upgraded that of the Plant Protection Advisor in comparison has become of lesser status, thus making him work under the Commissioners. Naturally he does not hold the same position of authority and importance as before and cannot carry the sound scientific decisions to the stage of policy making; beeing just a member of the Pesticide Board of India he cannot safeguard the health of the public and grow more food too"!

In the ICAR also the entire R & D in plant protection in the country is being looked after by an Assistan Director General and not by a Deputy Director General. When the work of various agricultural disciplines was entrusted to the Deputy Director Generals it would have been most logical to create a separate position for Deputy Director General (Plant Protection) so that he could improve the level of research through the grants and various schemes sanctioned for research in the National Research Institutes and in Agricultural Universities. It has not been done so. In contrast, it was considered more important to have a separate position of Deputy Director General (Transfer of Technology) which really is a duplication of activity parallel to that of the Directorates of Extention Education in Agricultural Universities and the State Departments of Agriculture. This aspect of Plant Protection has woefully been ignored in modern ageratum of India, and it needs the immediate attention of the senior administrators who are at the helms of affairs. It has been calculated and well-established that future food needs can be met by appropriate plant protection measures alone. As to why such an important discipline of agricultural science has not been given due priority in a developing country like India is not understood, because the advanced countries which are surplus in food production give a high priority to the discipline of plant protection.

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