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ASSISTANCE TO THE PESTICIDE INDUSTRY

IS/IND/73/051

INDIA

TERMINAL REPORT

Prepared for the Government of India by the
United Nations Industrial Development Organization,
executing agency for the
United Nations Development Programme

United Nations Industrial Development Organization

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United Nations Development Programme

ASSISTANCE TO THE PESTICIDE INDUSTRY

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INDIA

Project findings and recommendations

Prepared for the Government of India
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of G. Kohn, pesticides production expert

United Nations Industrial Development Organization
Vienna, 1976

Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in India is the rupee (Rs). During the period covered by the report, the mean value of the rupee in relation to the United States dollar was $US 1 = Rs 1.

A slash between dates (e.g., 1970/71) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960–1965) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

References to "tons" are to metric tons, unless otherwise specified.

The following forms have been used in tables:

Three dots (...) indicate that data are not available or are not separately reported.

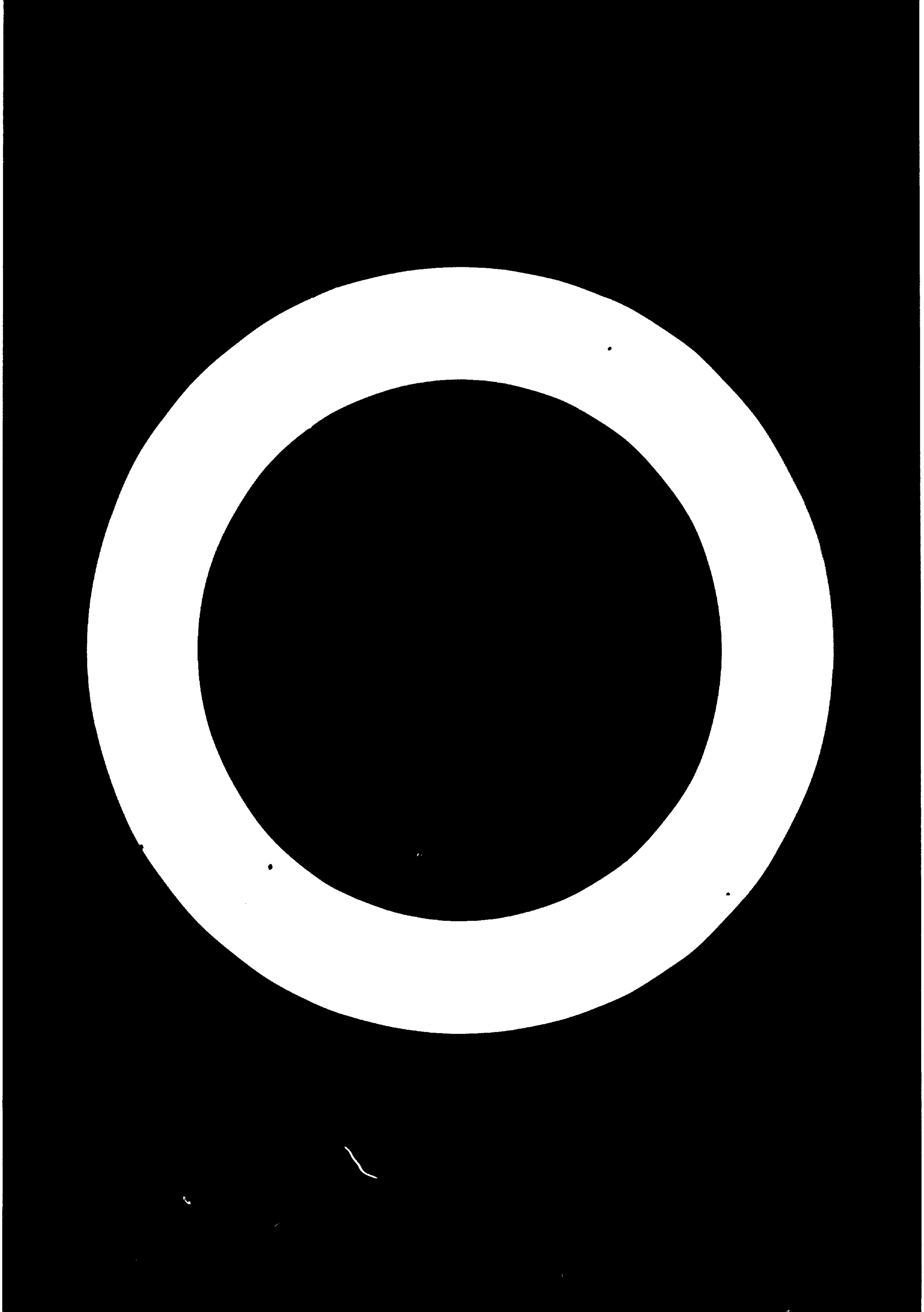
A dash (–) indicates that the amount is nil or negligible.

The following abbreviations of organizations are used in this report:

CSIR	Council of Scientific and Industrial Research
DGTD	Directorate General of Technical Development
ICI	Imperial Chemical Industries Ltd
NCL	National Chemical Laboratory
PAI	Pesticide Association of India

ABSTRACT

In December 1973, the Government of India requested the assistance of the United Nations Development Programme (UNDP) for the pesticide industry. The project "Assistance to the Pesticide Industry" (IS/IND/73/051) was approved in September 1974. The United Nations Industrial Development Organization (UNIDO) was designated as the executing agency. The objective of the project was to re-examine the whole structure of the pesticide industry to find out if the production facilities could be integrated in order to get the most advantage of economies of scale and to spread costs of marketing the pesticides over a larger number of products.



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INTRODUCTION

India has achieved remarkable progress in raising the efficiency of agricultural production by adopting modern agricultural methods and extending adequate and balanced applications of fertilizers and pesticides to a large portion of the total cultivated area. Demand for pesticides has been high and continues to grow. Most of the pesticides are supplied by foreign producers which imposes a heavy burden on the national economy and an undesirable limitation on the proper use of pesticides, particularly in small farms. India has a well-developed organic chemical industry which, however, is not specialized in pesticide production. Many of the raw materials required for the production of basic pesticides are available locally. A number of plants produce pesticides in small quantities. The implementation of new production schemes, however, has been slow.

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The duties of the expert were:

(a) To increase the size and scope of the research effort with a view to developing modified or original pesticides suited to the country's needs and raw material resources;

(b) To assist in developing or expanding export business, involving the attainment of international standards, and in making a thorough survey of potential export markets;

(c) To develop a multi-purpose production or pilot plant for experimental or small production of pesticides;

(d) To assist in establishing technical co-operation with foreign and international organizations to assure access to up-to-date technical and scientific information, and to expand product lines as justified by domestic requirements or export possibilities.

I. FINDINGS

A. Structure of the pesticide industry

In order to re-examine the whole structure of the pesticides industry in India contacts were established and visits were made, with individuals and with management groups, to the production facilities of a large number, if not quite all, of the pesticide manufacturing companies. Since there are about 400 formulating plants a small selected number of these were also visited.

A prepared questionnaire was used to structure discussions on technical aspects of production: yields, purities, process problems, economics, distribution, effects of the Pesticide Act administration etc.

In annex I the companies are listed from which information as above described was obtained.

The complete file on such data has been turned over to the Ministry of Chemicals and Fertilizers. Data from that file are used throughout this report and cover almost all the major manufacturers. Annex II gives a list, by product, of manufacturers of pesticides in India. It is reported that the manufacture of metaldehyde by Pesticides India has been abandoned for lack of demand; the same is true for lime sulphur manufactured by Shaw Wallace. It is probable that the same can be said for barium polysulphide. Inquiries by the Pesticides Association of India (PAI) have failed to elicit any response from that company.

Another aspect of the work consisted of conferences with Indian entrepreneurs and those desirous of becoming entrepreneurs and sometimes state agency officials who were considering the production of pesticides. These were (generally) office visits, in many instances often repeated. Frequently these individuals or groups had available funds to invest but no previous connexion with agriculture and some even with any chemical manufacture. A partial list of those involved is attached (see annex III). This work mainly consisted of consultative advice as to product, methods of manufacture, technical and chemical problems, toxicology, registration etc. In many instances there was no marketing arrangement in the original conception.

Present status of the pesticide industry

The one public sector pesticide manufacturer and the 40 private sector manufacturers are joined in the PAI. The organization publishes two publications, a monthly, called Pesticides and a quarterly, called Pesticides Information. The first is devoted to scientific articles and industry oriented editorials and the second is largely a reportage of association meetings and industry problems, sponsored symposia, and the statistics of pesticide manufacture and distribution. The association supports an executive secretary and a staff of six or seven permanent employees.

One can divide the members of the industry into three main groups. The first contains large companies that embrace manufacturing, some degree of research and development, and have historic and present association with large European or United States pesticide manufacturing companies.

The second has small indigenous companies with little or no research and development capacities that may or may not have independent distribution channels.

The final group contains one, perhaps two, large totally indigenous companies. The Excell company of Bombay is the prototype. It has indigenously developed basic chemicals and intermediates and produces the final pesticide products in its own laboratories and pilot plants.

Despite the seeming organizational strength, publications, and permanent staff of the PAI the industry is beset with problems. It can be described as a struggling and insecure industry though some companies have connexions with the world's largest chemical manufacturers. With notable exceptions installed capacity greatly exceeds actual production and further quantities of pesticides already in the field in distribution channels are meeting resistance to purchase at the farmer level. These statements will be amplified subsequently.

B. Production, cost and distribution of pesticides

This section briefly discusses the cost of production of pesticides in India and problems of distribution of formulations at the farm level. The problems relating to large scale production versus fragmented small manufacture are briefly outlined.

As of May 1976 a government decision was made whereby raw materials imported for the purpose of indigenous pesticide manufacture as well as pesticides themselves will be subject to the full 75% import duty. This decision will bear upon the discussion of pesticides formulation costs at the farm level and the problems of sale and distribution.

At the recent "All India Plant Protection Conference" sponsored and organized by the Ministry of Agriculture, the problems of the estimation of real agricultural demand at the farm level was a prominent issue. State representatives, the small-scale formulators, applicators of pesticides and the government representatives spoke of the difficulty of "lifting supplies of pesticides" in the various localities. By the phrase between the quotation marks was meant that formulators and local distributors could not sell the products and formulations now on hand. Why? The answer is not simple but is highly pertinent. Incidentally poor demand exists also for the P and K containing fertilizers where the prices are high and where the farmer does not see benefits that justify these high costs.

The Punjab, the agriculturally most progressive district of India, provides us with insight into this aggravating problem. Here, cotton has been a major and highly profitable crop. Long staple varieties from recently developed, genetically superior seeds have increased at the expense of the older short and intermediate staple. Cotton is a crop that consumes large quantities of pesticides, perhaps more per hectare than any other large area crop. There is a world wide glut in cotton, particularly long staple, and the price has dropped markedly. The cost for pesticides has markedly increased. The farmers see little benefit to continue with crops that have high cost inputs during this period of glut. If the farmers change to other crops, as some have done, then the need for pesticides is reduced.

The situation in other states and for other crops is not precisely the same, yet the price for the agricultural product and cost of input squeeze prevails to some degree throughout the country. The Ministry of Fertilizers and Chemicals is aware of this problem and is investigating costs of pesticides at the farm level. The mission of the expert was, in part, to increase the efficiency of production, which translates in chemical engineering terms into low cost production.

It was previously shown that BHC occupies, quantitatively, the top position both in current and in planned production plans. This pesticide will, therefore, be used as the prototype for the discussion of manufacturing costs.

Table 1 compares manufacturing cost of BHC in India with the selling price of BHC in the United States. The five producers of BHC (approximately 13%

gamma content) comprise both private and public sector companies. Differences in manufacturing costs between the various companies appear to be slight and more a reflection of accounting procedures and date of computation than the result of significant technical superiority.

Table 1. Comparison between BHC manufacturing cost in India and its selling price in the United States of America, 1975 (Rs/ton)

Manufacturing cost (approx.)		Selling price a/
MICO Farm Chemicals b/	3,175	1,625
Hindustan Insecticides c/	4,000	
Pesticides and Brewers d/	4,327	
Fats Chemicals	...	
Alkali and Chemicals Corporation e/	3,855	

Source: Chemical Marketing Reporter, 13 October 1975.

a/ Based on 13 gamma content (New York).

b/ Date not specified.

c/ Revised estimate.

d/ Date not specified.

e/ 1st half of 1975.

During the plant visits some suggestions for process improvements were made, i.e. the need for maintenance of anhydrous reactants and avoidance of atmospheric interactions. Even if these suggestions were carried out the changes in the total costs would be slight.

One of the chief components of the total manufacturing cost is the price paid for benzene which, in India, is far above the international price. Benzene at international prices would be a positive step towards reducing the manufacturing cost of BHC.

To penalize the pesticide manufacturers, both public and private, with high cost of essential raw material, excise taxes and import duties etc. seems inconsistent with the publicly cited position of priority for the industry related to agriculture. Not all products show as marked a discrepancy between the price in advanced countries and the cost of production in India. (See tables 2 and 3.)

Table 2. Manufacturing cost of selected pesticides in India

Pesticide	Company	Cost (Rs/ton)
Aluminium phosphide	Delicia	87,000
	Excel	77,954
Zineb	Indofil	24,700
Maneb	Indofil	28,000
Methyl parathion	Bayer	36,240
Fenitrothion	Bayer	50,890
Metasystox	Bayer	81,950
BHC	MICO Farm Chemicals	3,175
	Alkali and Chemicals Corporation	3,856
	Hindustan Insecticides	4,000
	Pesticides and Brewers	4,327
Phosphomidon	Ciba-Geigy	59,400
DDVP	Ciba-Geigy	49,910
Ziram	Ciba-Geigy	16,160
Malathion	Pesticides and Brewers	26,000
	Excel	15,300
Copperoxychloride	Pesticides and Brewers	22,686
Zinc phosphide	Pesticides and Brewers	29,310
	Excel	28,200
Ethyl dibromide	Excel	21,460
Phenyl mercuric acetate	Excel	86,330

Table 3. Market price of selected pesticides in the United States compared to their manufacturing cost in India

Pesticide	Market price		Manufacturing cost (India) (Rs/ton)
	$/lb	Rs/ton	
DDT	0.34	6,520	8,600 - 9,000
BHC	0.0065/unit	1,620	3,175 - 4,327
Malathion	0.95	18,200	15,300 - 26,000
Lindane	250	48,000	
DDVP	410	78,700	49,910
Ethylene bromide	0.37	7,100	21,460
Methyl bromide	0.41	7,870	
Copper sulphate	0.39	6,520	
Methyl parathion	0.92	17,600	36,240
Nickel chloride	0.96	1,890	
Toxaphene	0.416	7,980	
2, 4-D (acid)	0.66	12,700	18,433
Ammonium sulphanate	0.30	5,760	
Warfarin	0.65	12,500	

Source: Chemical Marketing Reporter, 13 October 1975.

The discrepancy is much less for some phosphates, carbamates, weed killers etc. than for the chlorinated hydrocarbons.

Among the factors accounting for differences in cost are:

1. Large scale production of individual products in the West versus government sponsored and encouraged fragmentation of production in India.

2. Low cost intermediates *versus* high cost intermediates. These latter costs reflect import duties - and small scale production (almost pilot plant in size) for these intermediates.

3. Process differences. Catalytic processes, high temperature and pressure processes, and continuous processes are justified in large scale production. These same processes are uneconomic for small scale production.

4. India has a great advantage in labour costs. Labour intensive processes provide competitive advantage here. However, they do not compete economically with large scale, capital intensive chemical production. In other words items 1, 2 and 3 out balance item 4.

Further, the comparison between the data from Indian industry shows fairly large differences in cost of production between companies using foreign technology and those using indigenous technology. For example, data for 1973-1974 indicate a cost of approximately Rs 4,900 per ton for malathion by Cyanamid India. For the indigenous company, the cost was given at five times this sum. However, the scale of production accounting method and a trial period for the indigenous company should be taken into consideration before any conclusions from this difference could be drawn.

The expert advocated continuous acquisition and critical review of all the production and cost data within the Ministry as part of their planning and execution of the licensing process. This would require chemical engineering competence and a more or less permanent assignment of the designated personnel. The expert suggested that an Indian counterpart responsible for such records be selected. This would have provided continuity, improvement in record keeping and above all a sound basis for the evaluation of production planning for the future. Since the Ministry found that funds and personnel for such purposes were not available, these functions were suggested for assignment to a broader, new Pesticides Board with a permanent paid staff. The proposal is under consideration by the Ministries of Agriculture and of Fertilizers and Chemicals.

The manufacture of essential intermediates

This section summarizes expert's formal proposals made to the Ministry of Fertilizers and Chemicals and to various private and public sector's research groups. If the expansion of production is to continue then the economics of manufacture and the wastefulness of numerous groups working on individual processes must be considered. Proposals for the centralized manufacture of C_5Cl_6, $(RO)_2P(S)SH$, $(RO)_2P(S)Cl$, $(RO)_3P$ and phosgene were submitted. It will be highly advantageous to have a public or private sector company with proper facilities manufacture and distribute these intermediates. In these proposals all the many chemical compositions dependent upon these intermediates were outlined. Centralized manufacture would be advantageous particularly for phosgene, the handling and toxic character of which makes small-scale individual manufacture less than desirable. Its industrial potential is enormous. In case of shipping problems the placement of such manufacture near the end-users was proposed as well as the conversion of the phosgene to more stable useful intermediate structures for pesticide synthesis.

The desire to avoid monopoly is frequently given as a counter argument against centralizing intermediate production. The proposals for centralization were based on technological desirability and with the conviction that monopoly can be avoided by various legislative and administrative means at the disposal of the Government.

Production and plans

Table 2 gives the licenced capacities, installed capacities and letters of intent to manufacture including all recent licences as of 1 January 1976. Again the Ministry of Chemicals and Fertilizers saw fit to grant over 30 thousand tons more of BHC production in letters of intent and it is evident that on the basis of tonnage the chlorinated hydrocarbon insecticides will account for an overwhelming percentage on a weight basis of the total production. Why? Aspects of answers to this question will be discussed later. Incidentally, the granting of licences (without which manufacture in India is proscribed) is a long drawnout and complex process. The Ministry recognizes this fact and although the expert did not participate in the specific deliberations of the ministry on individual cases he was requested to formulate plans to rationalize the process for the choice of chemical and the expansion of production. His activities then included consultation with the Ministry, with the Directorate General of Technical Development (DGTD), with PAI, with the agricultural attaches of foreign countries and with informed individual sources for ways to rationalize future pesticide planning.

Comparison of 1974 and 1975 production

Despite genuine obstacles, amplified by two years of monsoon failure, there was a modest increase in pesticide production in 1975 as compared to 1974, 35,247 tons in 1975 as compared with 32,745 tons in 1974. This is an increase of approximately 2,500 tons or about 7.6 per cent. (See table 4.)

Table 4. Position of the pesticide industry in India (as of January 1976) (Tons)

Name of pesticide	Yearly capacity		Letter of intent	Production	
	Licensed	Installed		1974	1975
Insecticides					
BHC	31,900	28,900	32,940	22,900	24,298
Lindane	100	100	1,200	-	-
DDT	4,200	4,200	-	3,304	4,360
Toxaphene	250	250	1,500	-	-
Endosulfen	-	-	4,000	-	-
Phenthoate	600	600	-	-	-
Parathion	1,700	1,200	-	831	1,161
Malathion	3,500	1,700	4,500	1,451	1,492
Dimethoate	600	350	650	354	494
Phosphemidon	636	636	-	356	329
DDVP	276	276	-	120	167
Mono-crotophos	-	-	300	-	-
Dicrotophos/Chlorfen-vinphos	-	-	1,100 a/	-	-
Meta-systox	250	250	75	137	96
Fenitrothion	600	100	200	142	213
Phorate	-	-	450	-	-
Phosalone	-	-	1,000	-	-
Quinalphos	200	200	-	50	143
Cytrolane/Cyolane	-	-	250	-	-
Carbaryl	2,000	-	7,000 b/	11 c/	
Subtotal	46,812	38,762	55,165	29,638	32,753
Fungicides					
Copper oxychloride	2,289	2,284	-	730	516
Aureofungin	5	5	-	...	-
Organo-mercurials	86	86	-	37.4	9
Zineb and Maneb	2,500	2,500	2,400	1,529	1,096

a/ Including DDVP and Mono-crotophos.

b/ Including Temik, Sirmate etc.

c/ For Temik only.

Table 4 (continued)

Name of pesticides	Yearly capacity		Letter of intent	Production	
	Licensed	Installed		1974	1975
Thiram	600	600	-	85	137
Ziram, Ferbam and Vapam	900	900	-	35	95
Cuman	384	384	-	45	-
Nickel chloride	300	300	-	44	53
Bavistin (Benlate or MEC)	-	-	535	-	-
Subtotal	7,059	7,059	2,935	2,505.4	1,906
Rodenticides					
Zinc phosphide	516	516	-	163	188
Fumarin	50	50	-	2	-
Subtotal	566	566	-	165	188
Fumigants					
Aluminium phosphide	780	630	-	70	121
MB/EDB	608	608	-	30	24
DECP	50	-	-	-	-
Subtotal	1,438	1,238	-	100	145
Herbicides					
2, 4-D	1,935	1,935	-	237	240
Ammonium sulphamate	500	500	-	-	15
TCA, MCPA and MCPE	200	-	-	-	-
Dalapon	150	-	1,640	-	-
Propanil and nitrofen	1,500	-	-	-	-
MSMA and DSMA	-	-	1,000	-	-
Alachlor and butachlor	-	-	2,000	-	-
Paraquat	-	-	500	-	-
Diuron	-	-	100	-	-
Basalin	-	-	200	-	-
Subtotal	4,285	2,435	5,440	237	255
Plant growth regulants					
Cycocel	-	-	243	-	-
Naphthalene acetic acid	10	-	100	0.1	0.1
Total	60,170	50,060	63,883	32,745.4	35,247

The chlorinated hydrocarbons BHC and DDT dominate these production figures. In 1974 they accounted for fractionally less than 80 per cent of the total production. In 1975 they accounted for 84 per cent of all the chemicals produced. In fact their increase (2,454 tons) was practically the same as the total increase in production (2,502 tons). Further, if one examines the figures of the letters of intent issued this year then an addition of approximately 36,000 tons of chlorinated hydrocarbon is planned. This may be increased considerably because the public sector company Hindustan Insecticides is seriously considering a production increase of 10,000 tons of DDT.

Table 4 also demonstrates a very heavy preponderance of insecticides. There is a manifestion in the letters of intent to expand into the phosphate and carbamate insecticides and into herbicides and plant growth regulators.

Each year the letters of intent are highly optimistic. For example 64,000 more tons of pesticides are being planned. If these plans materialized there would be a 259 per cent increase in production. However, the actual yearly increase is 7.6 per cent. Why this divergence between plan and actual production?

There are a variety of reasons. One of them is a natural tendency in the developing countries to allow hopes and aspirations to obscure judgement. The real factors involve demand for pesticides at a farm level; uncontrollable variables such as weather disease incidence etc. etc.; cost of products to the farmers; availability of raw materials to the manufacturer; real agricultural needs; the administration of the pesticide act of 1968 (toxicology, formulations, residues and ecology); and the effects of the anti-pesticides campaigns within India.

The Insecticide Act and its effects on production and distribution

In this section are discussed some of the broad aspects of ecology, toxicology, residues etc. particularly as they affect the manufacture and distribution of pesticides. Positions taken in this exploration in no way impugn the motives or integrity of the administrators.

The Insecticide Act of 1968 is a progressive and far reaching legislation that establishes a board which regulates all aspects of pesticide distribution through the registration of products. The Board's membership reflects multiple interests and disciplines - many outside of agriculture - though its top administrators who carry out the decisions, are responsible to the Ministry of Agriculture.

In India, as throughout the scientific and educated communities of the world, there is debate about pesticide usage. Perhaps it is even more intense here for it in part reflects a cultural heritage with regard to non-human life and to harmony with nature. Expressions of the conflicts are especially prevalent in the universities, within the research establishment and in the government. The newspapers reflect the debate, in the news and editorially.

There are several attitudes toward a pesticide production development:

(a) India should abandon chemical pesticides and search for biological and botanical treatment solutions;

(b) Industry should actively pursue all that is useful in advanced pesticide technology;

(c) India should concentrate on a few low cost indigenous pesticides, such as DDT and BHC, and does not need the more complex and sophisticated compositions.

Some positions taken by the pesticide act administration that seriously affect manufacture and distribution of pesticide formulations are enumerated below.

1. Restrictions on container size. The number of container sizes has been limited for a variety of reasons - elimination of confusion, standardization etc. However, sizes that fit the farmers' various agricultural disposal and needs, can serve a legitimate purpose.

2. Restrictions on the variety of formulations. The experience in developed countries shows that it is impossible to standardize and meet the needs of every farmer, for every crop, and for every locality. A multiplicity of formulations is often legitimate.

3. Restrictions on mixtures. This discussion refers only to well tested useful pesticidial mixtures. The administration is requiring indigenous toxicology performed on each formulation. Actually, the capacities for indigenous toxicology are limited. There are many useful mixtures of technical pesticides in formulations that serve genuine agricultural needs. It is only exceptionally that crop damage results from the attack of a single organism. Usually, the farmer is faced with a complex attack of insects, or fungi or nematodes or combinations of two or more of the pests above

represented. It is the exception for any one chemical to successfully combat such complex attacks. From a practical field point of view the farmer has several alternatives. He can field-mix a variety of pesticides, he can perform multiple spraying or he can use a specially prepared formulation that best approximates his needs. None of these alternates are wholly desirable but experience has shown that certain mixtures have genuine usefulness in the farmers' pest control programme. Mixtures of certain chlorinated hydrocarbons, particularly DDT, with certain organophosphates such as malathion, fenitrothion, methyl parathion (not recommended except for trained applicators) or with carbamates such as carbaryl, provide a wider spectrum of crop protection than any single composition. For example, Toxaphene-DDT mixture for cotton pests has a long history of usefulness and low human toxicity hazard. Both Toxaphene and DDT are presently registered for use in cotton separately. The expert is not convinced of the logic of restrictions such as these. If they are imposed because of analytical problems then the solution would be improved analytical and policing laboratories and not the restriction of a useful service. If ecological matters are the concern then use of a safe, well tested mixture is certainly preferable to the hazards of field mixing.

4. <u>Indigenous toxicology</u>. The building up of toxicological laboratories in India is desirable and is receiving support. Until such time as they demonstrate their capacities the expert decries the arbitrariness of administrative decisions. The repitition of toxicology performed reliably elsewhere does not merit a high priority except in rare and exceptional cases. Flexibility in administration of the Pesticide Act is strongly recommended.

At the same time the expert applauds the decision to limit parathion from the Indian agricultural scene. Any one familiar with the conditions at the village level understands the hazards involved in the spraying, storage and container elimination by untrained farmers. (Spraying by accredited licensed personnel could be tolerated.) Other chemicals (see section C) also must be considered for restriction on this basis. If the use of pesticide expands there will be a need for toxicological field centres.

This is not the place to enter into the ecological debate as a whole. There are, presently, abuses of pesticide usage, especially on certain edible vegetable crops. Excessive spraying close to harvest should be eliminated in order to avoid high residues. Adequate laboratory and policing facilities are needed for better policing at the formulation and distribution levels.

It is, in final analysis, up to the Indian public to decide on the basis of its own value systems the particular attitude to take in regard to pesticides. The expert, in his actions has been governed by: (a) the need for increase of agricultural productivity as a significant value in the Indian scene; (b) ecological and toxicological hazards; (c) his responsibility to the Indian Government; and (d) an avoidance of extreme positions and a common-sense approach to the risk-benefit equation.

The expert believes that the current attitude of the administration of the Pesticide Act is not advantageous neither to the pesticides industry and nor to the agricultural productivity. He may be wrong but these are his present convictions.

There are in India serious ecological and toxicological problems. The expert never could understand why in the fat of Delhi residents the DDT + DDE residues were higher than any where in the world. This fact is prominent in the anti-pesticide campaign. Actually, the consumption of pesticides in India is quite low, much lower than in developing countries such as Mexico and much, much lower than in developed countries e.g. Japan. Does this high DDT residue result from agricultural or antimalaria campaigns? (This is the current belief.) At the Punjab Agricultural University a group is interested in another explanation. Was the grain and flour in the Delhi region adulterated with DDT to preserve against insect infestation? It is a possibility - but at this stage only a conjecture. It merits investigation, for the truth is required for the total evaluation of pesticides in a broad risk-benefit analysis.

Finally, it is recommended that representatives of all shades of opinion on pesticide usage be represented on the administration board for pesticide production. Individual members of such a board should have a responsible position in food and agricultural production. The functions of the board would be, among others, the participation in licencing and the direction as to which chemicals should be developed in the public laboratories.

Currently, the administration of the present Pesticide Act is confronted with so many functions, is provided with so few funds, with limited personnel that a policy of gradualism rather than inflexible restrictions seems warrented.

C. Current research and development of pesticides in India

Process development

The foreign affiliated companies, usually referred to as transnational corporations, generally have their research and development in overseas laboratories, although the follow-up engineering and adaptation to the Indian scene is done locally by indigenous staff. There appears to be an increasing tendency, however, to carry on some aspects of research and development in India. For example, Union Carbide is screening available chemicals to see if they have particular areas of usefulness for particular Indian agricultural problems. Other companies are adapting their chemicals such as Paraquat manufacture (Alkali and Chemical Corporation of India Ltd and Imperial Chemical Industries Ltd (ICI) and Phosalone (Rhone Poulenc)) for manufacture in India. These processes because of scale of production, availability of raw materials and other factors may not be identical with the process utilized in other areas. This is not inferior technology. It is a required adaptation stemming from a variety of factors.

Of private indigenous companies without foreign affiliation only large ones have any real process development. For example, the Excel Company has a good and enthusiastic group of chemists and engineers who are working on current pesticides process development including basic intermediates. In fact in discussing the manufacture of $(RO)_2P(S)SH$ with Excel chemists and engineers it was felt that the company was ahead of other laboratories in this particular technology.

There is a large number of small indigenous manufacturing companies. Their laboratories and their personnel are mostly inadequate for genuine process development work and in certain cases, even, for production control. Particularly lacking is instrumentation. The control procedures are generally "wet" chemistry and not really adequate. A proposal was made to the Ministry to grant to private Indian companies that participate in genuine process development work certain incentives in the form of a tax rebate.

It was proposed that:

(a) All public sector and private sector manufacturing companies and the larger formulation companies should be required to set up and maintain research and development departments with appropriate laboratories;

(b) The work of these research and development departments should relate to the improvement of processes and products of current manufacture with an agreed-upon proportion of effort directed toward expansion into new manufacture;

(c) The cost of the operation of these research and development departments and laboratories should be absorbed as part of the manufacturing cost of the products. A tax incentive by the Government should be provided on a graded scale for departments and laboratories in excess of an agreed-upon minimum requirement;

(d) All letters of intent and manufacturing permits should include provisions for research and development personnel and laboratories. These should be assessed by the Ministry as part of the total proposal;

(e) The personnel of these departments should vary with the complexity and size of the manufacturing effort. For a very large, general manufacturing company they should include chemical engineers, chemists, plant pathologists, entomologists, analytical chemists and the required supporting personnel. Part of the function of this staff would be to instruct the distributor and smaller formulators with regard to the properties, compatibilities and toxicities of the products manufactured. For smaller companies the size and diversity of the personnel would, of course, be more limited;

(f) All companies that manufacture pesticides must include a minimum laboratory for the control of analysis of their products and process. The need to establish laboratories with proper equipment is great. Personnel without appropriate laboratories is wasted. Again a tax incentive for laboratories with equipment above a given minimum is proposed.

On a number of occasions small companies requested assistance in the area of process development and in the writing of their letters of intent. Wherever possible, after granting assistance, the expert referred these small companies to the national laboratories. In certain cases it was hard to convince these small and unsophisticated companies that process development requires long and repeated laboratory and pilot plant experimentation despite the general knowledge of the reactions involved.

The major share of process development in India, exclusive of the internationally affiliated companies, is done by the national chemical laboratories at Poona and the Regional Research Laboratories at Hyderabad and Jorhat (Assam).

The pilot plants in the national laboratories, particularly, in Hyderabad and Poona have considerable pilot plant simulation equipment. Annex III lists the pesticides on which technology could be obtained from the laboratories of the Council of Scientific and Industrial Research (CSIR). In the pesticides fields a difference between the developed countries and India must be emphasized. Rarely is process development in the developed countries attempted on a scale less than a million pounds per year (500 tons per year). This means that optimization is an important aspect. In fact it becomes the major activity of most chemists and engineers. Combined with this is a continuous preoccupation with the cost accounting aspects of chemical manufacture. The process development in fact is always judged by this criterion.

Observations on process work in India

In India many of the intermediates and the pesticides are manufactured on a relatively small scale, 30 to 100 tons per year. Does this justify optimization work? The answer is negative - if the small scale production is the total objective for the future for that product. However, this raises the question whether public funds should be spent for such small-scale process work for low-cost chemicals. Further, the small-scale production requires that when in the future, demand is increased process development be scheduled again and/or even an entirely new process for that larger scale production be developed.

Annex IV gives the status of specific pesticides development projects and a list of intermediates upon which work has been initiated or is in progress or has recently been completed.

Research project for BHC - Lindane

Because a large expansion of BHC production has been planned there have been discussions on needed research and development with CSIR, private manufacturers and the Ministry.

Chlorinated hydrocarbon residues, chiefly BHC, have caused the non acceptance of Indian produced coffee. In this crop the BHC residues could be substantially reduced by the employment of Lindane instead of BHC (one 1/7 of total residue is possible). Certain adverse toxicological data have appeared in recent literature associated with isomers other than gamma. Finally, the adverse ecological effects could be greatly reduced by producing and using Lindane (99 +% gamma) or similar high-gamma content product.

The process for the extraction and separation of the gamma isomers from the mixture should be improved. (One process has been developed and is in small-scale production.) Recent Japanese literature refers to the temperature, solvent and radiation characteristics that raise the gamma content to approximately 20 per cent. Studies to improve the gamma content might have large economic consequences, if the gamma content is raised in initial mixture.

Perhaps the most significant and the most difficult of the research objectives involve the utilization of the waste products (non-gamma isomers). First, a literature investigation should be made in order to choose the products that can be made from the waste, for example, pentachlorophenol and other chlorinated phenols, chlorinated benzenes etc. Then it should be decided (a) what quantities of such products could be profitably used in India; (b) at what scale can one recover the chlorine values; (c) at what level of production would such processes be feasible; and (d) how does one dispose of process wastes and by products.

None of this easy. It is not a copy of any process presently used. It is real industrial research. The lack of economic utilization of non-gamma isomers makes high-gamma content projects unattractive economically and ecologically. This need not be so. Lindane itself need not be the first objective. A low cost 90 per cent concentrate may be more economical. Process cost comparisons should be made.

Once the decision for large planned expansion of BHC production has been made a research programme should support such a plan to make it a more practical venture.

Delhi Pesticides

In a visit to the National Chemical Laboratory (NCL) at Poona the expert was told of one of the accomplishments of that laboratory, to wit, the licensing and current manufacture of two of the pesticides developed in this laboratory. The two chemicals for which processes were developed are the paddy herbicide Nitrofen (TOK) and the acaricide, tetradifon (Tedion). The processes for both of these involve simple chemistry - a similar condensation of the appropriate phenate salts with a reactive halide and it was intended to make both chemicals in interchangeable equipment. One of the problems of interest to the expert was the matter of possible contamination of an acaricide with traces of a herbicide.

The expert has subsequently learned from reliable sources in government, industry and research that the plant was for sale and there were no buyers. About two tons, in all, of Nitrofen were produced. The company had no marketing outlets and no marketing staff and it could not sell the product. The demand for Nitrofen was falling and a two-years' supply was imported previously. Punjab agriculturists claimed at the "All India Plant Protection Conference" that Nitrofen was failing in the field. The expert never had the opportunity to analyse and observe production efficiency, purities, yields etc.

The planned production of each chemical was 30 to 100 tons per year. To have a chemical plant unused and rusting away is an unfortunate and serious matter especially for a developing country with limited capital resources. Questions should and must be asked. Among these are:

(a) Why were these particular pesticides chosen for process development?

(b) What groups should be involved in the choice of chemicals for process development by national laboratories?

(c) Should the licensing process involve inquiry into agricultural demand and into marketing capability?

(d) How is the agricultural demand in India determined?

(e) Does production of 30 tons per year justify normal process development optimization.

D. Export potentials

Food is still the number one problem for the vast population of South-East Asia and Africa. This means an expanding market with a great export potential for all agricultural chemicals, including pesticides.

As each country tries to improve the living standard of its population, new, high yielding varieties of seed will be employed. Included will be cash crops, such as cotton, which are heavy users of pesticides. Herbicides and hormonal chemicals are needed for plantation crops such as rubber. Examples such as these can be multiplied many times.

Factors affecting Indian export are:

(a) Nature of chemicals presently manufactured;

(b) Quality of chemicals and formulations;

(c) The importing countries, their aims and needs;

(d) Costs of Indian produced pesticides *versus* world market prices;

(e) Certain social and political aspects.

Nature of chemicals presently manufactured in India

From table 4 we have seen that in 1975, 84 per cent by weight of all pesticides produced in India were BHC and DDT. There is evidence that more emphasis will be placed on the production of organophosphates, carbamates and herbicides for the period 1976-1980.

For the immediate future, India will continue to require imports of the newer chemicals. Indian export can be competitive in the countries whose patent laws present no bars to importation. Such is certainly true for BHC and DDT and for some of the older organophosphates, carbamates and herbicides. There is no significant effort in India to synthesize new compositions particularly those needed for the tropical, sub-tropical and arid areas of prospective importing countries. By the time such new chemicals are developed in India, they most probably will have been developed also by the advanced countries and will have become proprietary chemicals.

Quality of chemicals and formulations

The least developed of India's neighbours will require formulations rather than "technicals". The standards of international organizations such as WHO, FAO and Codex Alimentarius are high; to meet them, excellent manufacturing equipment, storage conditions, quality control etc. are necessary. The standards refer not only to the assay of the pesticidal chemical but also to the performance of the formulation, the nature of the impurities, and their toxicological and ecological implications. Three examples of how these standards relate to Indian manufacture are cited below:

(a) Compounds derived from $(RO)_2P(S)Cl$

Many processes are being developed for organophosphates requiring this intermediate (see annex 4). In the preparation of the methyl homologue and in its further processing variable quantities of an impurity $(CH_3O)_2P(O)SCH_3$ are found. This is not significant as a cholineosterase inhibitor but it is a potent and not well understood neurotoxin. In order to export the final phosphate insecticide, the toxicology, impurity content as well as the active ingredient of the product must meet the international standard. Further, in organophosphate manufacture thiol isomers are found. Their toxicology differs from the standard. In one case where a plant has been built and where some manufacture has been achieved, the administrators of the Pesticides Act are confronted with toxicological differences between indigenous and imported phenthoate;

(b) The substitute for parathion: fenitrothion

In Germany and in Japan there is a standard for the intermediate (nitrometacresol). Attempts, so far, to make the indigenous intermediate equivalent to the foreign product have not been successful. Fenitrothion made from a less pure isomeric mixtures will not have the same low mammalian toxicity which is the major virtue of this substitute for parathion. To achieve export an equivalent product will be necessary since import of intermediates (75 per cent tax) will make the Indian product totally non-competitive to the Japanese or German product;

(c) MBC synthesis developed in India

This synthesis uses at least one mole of dimethylsulphate, a potent carcinogen. The reaction product of dimethylsulphate thiourea and methylchloroformate is of unknown toxicology. While it is essentially used up in the subsequent processing the question of toxicological equivalency with the German product made by another route remains. This aspect, irrespective of the manufacturing hazards (to workers, effluents etc.), is particularly significant for a toxicant that is absorbed by the plant and is systemic.

There is no need to multiply examples but they are cited only to emphasize the importance of technical products and formulations made in India conforming to international specifications.

The importing countries, their aims and needs

The importing country, where the possibility of choice of product exists, will choose as advantageously as possible in its own interests. This relates both to quality and to costs.

The export to the wealthy oil producing Indian neighbours will be affected by their interest. A country such as Iran will not neglect the interests of petrochemical industry and will have the capacity to produce agricultural chemicals to compete both with the developed countries and with India.

The less fortunate Indian neighbours will move step by step towards self sufficiency. They are the best potential market - providing that Indian manufacture meets their interests.

Costs of Indian produced pesticides versus world market prices

The major products for export (84 per cent of total production) are the chlorinated hydrocarbons. The production costs, at present, are not competitive with world market prices and India will have to make very considerable progress in order to compete with the developed countries. The proximity of developing countries, e.g. Bangladesh, Nepal, Pakistan and Sri Lanka is an advantage, however, transportation, insurance charges etc. rarely exceed 15 per cent of the selling price of the product.

Social and political aspects relating to export

Despite all the problems India has some export potential. This hinges on broad political agreement with other developing countries. Barter arrangements between countries can ignore, at least temporarily, matters of quality, cost etc. General trade agreements are presently made and more will be made in the future. These can include indigenously produced Indian agro-chemicals. In the opinion of the expert India's present needs will limit its export potential at least for the next five years. The production costs will drop with the petrochemical expansion and the new oil discoveries but it will take five to ten years to achieve this development. The expert does not feel optimistic about export of pesticides in appreciable quantities at least for the next five years.

E. Planning for pesticide production

It is the prerogative of the Ministry of Chemicals and Fertilizers to grant licences for the production of pesticides and fertilizers. Essentially, no agricultural chemical is produced in the organized sector of the economy without the Ministry's sanction. The exception, the small-scale sector, is an inconsequential factor for this industry.

Letters of intent and licences are granted only after conscientious consideration. There are many factors that must be and should be considered, e.g. agricultural demand, capability for distribution, process details, availability of raw-materials and economic projections. Planning for now and for the future becomes a major responsibility.

Yet it is in this planning aspect, however conscientiously done in the past, that major obstacles arose. As referred to earlier the agricultural ministry found great difficulties and felt unable to forecast demand. Incidentally, it is precisely in agriculture where imponderables are the rule rather than the exception, and where planning even in developed countries is fraught with difficulties. The best that can be done about planned agricultural inputs is to provide intermediate forecasts because weather, plant disease, infestation, among other factors, cannot be forecast accurately for each particular season of the year. All of this is not an argument against planning. On the contrary, it is an indication that planning requires a highly professional and responsible work, a large quantity of reliable data, a need to integrate a profusion of scientific, economic and political information and a tough-minded, durable professional staff.

The Ministry of Chemicals and Fertilizers realizes the magnitude of this need and what follows is the response to various requests to rationalize a plan for pesticides production and future development. Since the Ministry of Agriculture admits its difficulties and inability to estimate the magnitude of pesticidial inputs required each year, frequently, the pesticides industry is called upon to provide these forecasts. The danger is that such forecasts have elements of a self-serving character.

In the development of new chemicals for agriculture the CSIR laboratories need external direction for their programmes and priorities. Some suggestions for rationalization of the planning projects are given in the section below.

The decision process in India

India is combining socialist planning and production with components of private enterprise manufacture and distribution. The degrees of each may alter and oscillate in the future so that flexibility in planning will be required. The present Indian agricultural position seems to be quite hopeful. The shortfall between food needs and indigenous production (at the present calorie intake) is about 6 per cent. The use of new technologies, including genetic improvements of grains and other products, should close that gap, provided that the required chemicals are available and particularly at a price consistent with Indian agriculture economics. What procedures should be adopted for the acquisition of needed chemicals? Before proposals are made, the agreement on certain fundamental propositions should be obtained:

(a) The use of new high yielding varieties of grain and other crops intensifies the need for more pesticides. Known diseases and infestations may increase in intensity and virulence. New pest problems with which India has little or no experience may and probably will confront the farmer. India will need established and experimental chemicals to meet anticipated agricultural requirements;

(b) India's agriculture will continue to have high priority in the government planning process. It will be highly regulated, if not totally controlled, by the Government. This regulation will include economic as well as technical factors;

(c) There will continue to be a stable private sector for the manufacture and distribution of pesticides and their formulations. The Government needs private capital for the continuous advancement of its pesticidal chemical manufacture and it needs the import of experimental and new valuable compositions to meet agricultural problems and emergencies. The Government will grant a reasonable security to and a rate of return for constructive private sector projects. At the same time it will expand the public sector's manufacture particularly in areas where large scale prodcution of tested chemicals is technically and economically indicated. For the near future, the indigenous discovery ana inventions of new compositions is not foreseen;

(d) In accordance with the Government's demand for the change from pure and fundamental research to applied research with emphasis on agricultural problems, the choice of projects will require inputs from outside as well as inside the research establishments. Applied research on pesticides needs information from agriculture and from Ministries concerned with the production of chemicals.

The organization and certain procedures necessary for the orderly, rationally planned increase of the production of agricultural chemicals and the choice of chemicals for indigenous research and development is explored below. The board that is proposed is conceived as a general advisory and policy-making body. Perhaps it should be appointed by the cabinet through a statute so that its decisions will be binding for all ministries.

1. Establishment of a Central Pesticide Board with a chairman. The members of the board should be selected from the Ministry of Agriculture, the Ministry of Chemicals and Fertilizers, the pesticide industry, the Directorate General of Technical Development (DGTD), Agricultural Universities (North, South), ICAR, the Pesticide Board and the Planning Commission.

2. It is the duty of the Ministry of Agriculture representatives to:

(a) Establish contact and reflect the nature of pesticides connected problems in various states. This includes knowledge of crops acreage, agricultural practice, diseases, infestations etc.;

(b) Reflect the considerations of the Insecticide Act, 1968;

(c) Estimate the efficacy of current pesticides including comparative economics. (Efficacy must not be separated from economics. An effective chemical may be economically prohibitive.);

(d) To set up appropriate evaluation work in various states, in co-ordination with agricultural university programmes and ICAR.

3. It is the responsibility of the representatives of the Ministry of Chemicals and Fertilizers to:

(a) Consider licensing requirements;

(b) Recommend capacity increases and new licences in accordance with recommendations of the board as a whole;

(c) Recommend import and export of pesticides.

4. It is the responsibility of pesticide industry representatives to:

(a) Inform the board of their evaluation results;

(b) Inform the board of pertinent new chemical developments;

(c) Inform the board of their expansion and production plans;

(d) Provide the board with their projections of pesticide needs.

5. It is the responsibility of the representatives of the agricultural universities to:

(a) Inform the board of results of experimental work carried out in the agricultural universities;

(b) To indicate comparative evaluation projects at various State universities;

(c) To supplement items in paragraph 2 above.

6. It is the responsibility of the CSIR representatives to:

(a) Inform the board of pesticide projects now being undertaken. This includes timing and probable costs;

(b) Inform the board of available manpower and logistics for recommended new projects;

(c) To recommend new pesticide development projects and provide supporting data for, e.g. intermediates, new processes etc.

7. It is the responsibility of the DGTD to consider:

(a) General objectives of the planning programme;

(b) Conformation with Fifth Five Year Plan development.

8. It is the responsibility of the ICAR representatives to:

(a) Cross evaluate against known pesticides new planned compounds from all sources, i.e. from CSIR, private industry etc.;

(b) Utilize the facilities of the Commodity Research Institutes to satisfy current pesticide industry needs including as in (a) above;

(c) Inform the board about results of such tests and co-ordinate with work done at agricultural universities and with the Ministry of Agriculture.

9. It is the responsibility of the Pesticide Board representative:

(a) To provide information on toxicological and ecological requirements for old and new pesticides;

(b) To recommend standards for purities and impurities for all compositions;

(c) To warn of hazards regarding any pesticide, including residues, toxicity, ecological factors;

10. It is the responsibility of the representative of the Planning Commission to co-ordinate with the DGTD representative on the aspects of future planning of the pesticide industry and agriculture.

11. The Board will need funds to establish an office and to hire the staff to:

(a) Formulate recommendations of the board;

(b) Supervise and report on programme of evaluation projects;

(c) Finalize recommendation for expansion of production, new manufacture and process development work.

12. It is recommended that the chairman be a representative of the Ministry of Chemicals and Fertilizers. It is the responsibility of the chairman to:

(a) Call regular monthly meetings of the committee;

(b) Assume responsibility for the day-to-day functioning of the staff and to meet regularly with the board's executive secretary for the execution of all board's decisions;

(c) Ensure that the executive secretary informs all board members of evaluation results and of the execution of decisions.

13. It is the responsibility of the executive secretary to administer a permanent staff and office and to carry out the decisions of the board. It is envisaged that the executive secretary has scientific knowledge about pesticides and agriculture as well as administrative capacity and a willingness to accept heavy responsibility and criticism. The job requirements include scientific judgement. The job is a key job. If executed well, expansion of production and the choice of chemicals for process development can be made on a rational and planned base.

II. CONCLUSIONS AND RECOMMENDATIONS

In each of the sections conclusions and recommendations were stated, where appropriate. For emphasis, the following paragraphs are added.

It is recommended that India should carefully select pesticidal chemicals for near future development. The choice in the area of phosphates for indigenous manufacture should be limited to those with broad agricultural usefulness and to those for which raw materials are most easily accessible. This would include malathion, dimethoate, for example, and carbaryl among the carbamates. Where foreign affiliated companies can economically provide know-how or raw materials, production of the associated pesticides should be encouraged.

In the chlorinated hydrocarbon area the need for endosulfan justifies the work being done. Ultimately the development of India's organic chemical industry will provide reasonable routes to butenediol and C_5Cl_6. The actual quantity of DDT produced in India is small and its controlled use justifies some expansion of production.

Unless a research programme such as has been outlined is initiated the BHC production expansion as planned presents many hazards.

In the fungicide field the demand is so small that the present programme for manufacture is quite adequate. If MBC is to be used repetitively, care should be taken to avoid resistance.

The planned production of the herbicides seems more than adequate.

The research effort on the large group of chemicals reviewed in annex IV is a dilution of effort and somewhat wasteful.

The 7.4 per cent increase in indigenous manufacture for 1975 was a worthy achievement. It should be higher in 1976. It is extremely difficult to expect much faster growth until the organic chemical industry as a whole benefits from the new petrochemical complexes.

In the CSIR laboratories there should be more emphasis on intermediates. The CSIR made considerable progress in this field but further emphasis is required.

One of the great needs is analytical and toxicological development. Smaller companies and many of the formulators need CSIR help in developing simple assay procedures for quality control. Help may be required for the acquisition of sophisticated analytical tools for all the major laboratories and for the administration of the Pesticide Act.

As the economy evolves planning increases in significance. Planning requires hard facts. The ministries must have estimates on demand and costs for these determine the choice of pesticide to be manufactured and all other related government administration. Profits should be encouraged but extortionate profits prescribed. Hard data on the costs and effectiveness of all pesticides are needed.

Annex I

COMPANIES WITH WHOM PROBLEMS OF PRODUCTION WERE REVIEWED

Companies	Major product
Excel Industries Ltd	Many and diverse
Alkali and Chemical Corporation of India Ltd	BHC, fungicides
MICO Farm Chemicals Ltd	BHC
Hindustan Insecticides Ltd (Alwaye)	BHC
Hindustan Insecticides Ltd (Delhi)	BHC, DDT
Shelat Brothers	Chlorinated terpene
CIBA of India Ltd	Enol-phosphates, others
Tata Fisons Industries Ltd	Dimethoate, others
Bayer (India) Ltd	Parathion, others
Cyanamid India Ltd	Malathion, others
Travancore Chemicals Manufacturing Company Ltd	Copper oxychloride, others
Bharat Pulverising Mills Pvt. Ltd	Phenthoate, others
Indofil Chemicals Ltd	Maneb, Zineb, others
Agromore Ltd	2, 4-D, others
Pest Control Pvt. Ltd	Warfarin
Hyderabad Chemical Supply Co.	Diverse
Sandoz (India)	Quinalphos, others

Annex II

MANUFACTURERS OF PESTICIDES IN INDIA

Pesticides	Manufacturers
A. Insecticides	
Aluminium phosphate	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
	M/S Delicia India Ltd Mahalakshmi Chambers, 22 Warden Road Bombay-5
Aldicarb	M/S Union Carbide India Ltd Connaught Place New Delhi-1
BHC	M/S Alkali and Chemical Corporation of India Ltd 18 Strand Road Calcutta-1
	M/S Tata Chemicals Ltd Okhamandal, Mithapur Gujaret
	M/S Pesticides and Breweries Ltd 138-141 Govt. Industrial Estate, Kandivli (West) Bombay-64
	M/S MICO Farm Chemicals Ltd 6 Linghi Chetty Street Madras-1
	M/S Kanoria Chemicals and Industries Ltd 9 Brabourne Road Calcutta-1
	M/S Hindustan Organic Chemicals Ltd Mafatlal Centre, Nariman Point Bombay-1
	M/S Hindustan Insecticides Ltd P.O. Udyogmandal Alwaye
Chlorinated terpene (Citicide)	M/S Shelat Brothers 8 Lucknodoss Street Madras-3

Pesticides	Manufacturers
DDT	M/S Hindustan Insecticides Ltd E-3 Defence Colony New Delhi-3
	M/S Hindustan Insecticides Ltd P.O. Udyogmanda Alwaye (Kerala)
Dichlorvos	M/S CIBA India Ltd 198 J. Tata Road Bombay-20
Dimethoate	M/S Tata Fison Industries Ltd 21 Ravelin Street, Fort Bombay-1
EDCT mixture	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
	M/S Mettur Chemicals and Industrial Corporation Ltd Mettur Dam R.S., Salem Dist. Madras
Ethylene dibromide	M/S Tata Chemicals Ltd Bombay House 24 Bruce Street Bombay-1
	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
Fenitrothion	M/S Bayer (India) Ltd Express Towers, 19th Floor, Nariman Point, Bombay-1
Lindane	M/S Gujarat Agro Industries Corporation Gochra, Dist., Panchmahals Gujarat
	M/S MICO Farm Chemicals Ltd 6 Linghi Chetty Street Madras-1
Malathion	M/S Pesticides and Breweries Ltd 138-141 Govt. Industrial Estate, Kandivili (West) Bombay-64

Pesticides	Manufacturers
Malathion (continued)	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
	M/S Cyanamid India Ltd Nyloo House 254-D2 Dr. Annie Besant Road Bombay-25
Methyl bromide	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
	M/S Tata Chemicals Ltd Bombay House 24 Bruce Street Bombay-1
Nicotine sulphate	M/S Urvkunj Tobacco By-Products Bapuji Building, Dharmaj, Dist. Kaira. Gujarat
Oxydemeton-methyl (Metasystox)	M/S Bayer (India) Ltd Express Towers, 19th Floor, Nariman Point Bombay-1
Parathion (methyl)	M/S Bayer (India) Ltd Express Towers, 19th Floor, Nariman Point Bombay-1
Phosphamidon	M/S CIBA India Ltd 198 J. Tata Road Bombay-20
Pyrethrum extract	M/S Bombay Chemicals Pvt. Ltd 129 Mahatma Gandhi Road Bombay-1
Thanite	M/S Camphor and Allied Products Ltd P.O. Clutterbuckganj Dist. Bareilly (UP)
Toxaphene	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
Quinalphos	M/S Sandoz (India) Ltd Sandoz House Dr Annie Besant Road, Wroli Bobbay-400018

Pesticides	Manufacturers
B. Fungicides	
Aureofungin	M/S Hindustan Antibiotics Ltd Pimpri Poona
Barium polysulphide	M/S Barium Chemical Products Ltd Hyderabad
Copper oxychloride	M/S Tata Chemicals Ltd Bombay House 24 Bruce Street, Fort Bombay-1
	M/S Kirti Chemicals 205/207 Ghod Bender Road, Jogeshwari Bombay-60
	M/S Travancore Chemicals Manufacturing Company Ltd P. B. No. 19 Alwaye (Kerala)
	M/S Sudhir Chemical Company 248 Samuel Street, Vadgadi Bombay
	M/S Solar Syndicate P.O. Dungri, Dist. Bulsar Gujarat
Ferbam	M/S Alkali and Chemical Corporation of India Ltd 18 Strand Road Calcutta-1
Nickel chloride	M/S Bharat Pulverising Mills Pvt. Ltd Hexamar House Sayani Road Bombay-25
Organo mercurials	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
Sulphur (colloidal)	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
Sulphur (wettable)	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60

Pesticides	Manufacturers
Sulphur (wettable) (continued)	M/S Bharat Pulverising Mills Pvt. Ltd Hexamar House Sayani Road Bombay-25
Sulphur (dust)	M/S I.A. and I.C. Pvt. Ltd 86 Dr. Annie Besant Road Bombay-25
Streptocycline	M/S Hindustan Antibiotics Ltd Pimpri, Poona
Thiram	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60
	M/S Alkali and Chemical Corporation of India Ltd 18 Strand Road Calcutta-1
Ziram	M/S Alkali and Chemical Corporation of India Ltd 18 Strand Road Calcutta-1
Zineb	M/S Indofil Chemicals Ltd Belvandi House Dr Annie Besant Road Bombay-25
	M/S Bayer (India) Ltd Express Towers, 19th Floor, Nariman Point Bombay-60
Zineb with manganese (Mancozeb)	M/S Indofil Chemicals Ltd Belvandi House Dr. Annie Besant Road Bombay-25
C. Rodenticides	
Coumafuryl (Furmin)	M/S Agromore Ltd Mysore Road Bangalore-26
Warfarin	M/S Pest Control (I) Pvt. Ltd P.O. Box No. 1510 Bombay-1
Zinc phosphide	M/S Excel Industries Ltd 184-87 Swami Vivekanand Road, Jogeshwari Bombay-60

Pesticides	Manufacturers
D. Molluscicides	
Metaldehyde	M/S Pesticides India P.B. No. 20 Udaipur
E. Nematocide	
Metham sodium	M/S Alkali and Chemical Corporation of India Ltd 18 Strand Road Calcutta-1
F. Weedicides	
Ammonium sulphamate	M/S United Chemicals Opp. Maikrupa Society, Chhani Road Baroda (Gujarat)
	M/S Dheramji Morarji and Co. Prospect Chambers 217/21 Dr. Dadabhoy Naoroji Road Bombay-110001
2,4-D	M/S Atul Products Atul (Bulsar), Via W. Railway Bulsar
	M/S Agromore Ltd Mysore Road Bangalore-26
	M/S Bharat Pulverising Mills Pvt. Ltd Hexamar House 28 Sayani Road Bombay-25

Annex III

PESTICIDES ON WHICH TECHNOLOGY IS AVAILABLE FROM CSIR LABORATORIES

Pesticide	Laboratory
Fenitrothion	National Chemical Laboratory, Poona
Metasystox	National Chemical Laboratory, Poona
Dimethoate, Diethoate	National Chemical Laboratory, Poona
Ethion	National Chemical Laboratory, Poona
Formothion	National Chemical Laboratory, Poona
Phosalone	National Chemical Laboratory, Poona, and Regional Research Laboratory, Hyderabad
Quinalphos	Regional Research Laboratories, Hyderabad and Jorhat
Carbofuran	Regional Research Laboratory, Hyderabad
DDVP	Regional Research Laboratory, Hyderabad
Trichlorofon	Regional Research Laboratory, Hyderabad
Bidrin	Regional Research Laboratory, Jorhat
Birlane	Regional Research Laboratory, Jorhat
Ciodrin	Regional Research Laboratory, Jorhat
Phosphomidon	Regional Research Laboratory, Jorhat
Mevinphos	Regional Research Laboratory, Jorhat
Phosphinon	Regional Research Laboratory, Jorhat
Gardona	Regional Research Laboratory, Jorhat

Annex IV

STATUS OF SPECIFIC PESTICIDES DEVELOPMENT PROJECTS

These are observations referring particularly to those pesticides being developed by the public laboratories and the indigenous private companies.

$(RO)_2P(S)SH$ and $(RO)_2P(S)Cl$. Four different laboratories, private and public, are working on processes for the development of these intermediates. The highest yield for $(RO)_2P(S)SH$ was obtained by one of the private company laboratories. With the public laboratories both the P_4S_{10} route and the PCl_3 approach were discussed. A recommendation was made for a single manufacture and distribution, probably in the Bombay area, of these intermediates for they are used for many phosphate insecticdes. (One of the intermediates may be the precursor of the other.) P_4S_{10} is indigenously available. The reaction is simple optimization of the yield of $(RO)_2P(S)SH$ with or without solvents. The hydrogen sulphide by-product is toxic and economics dictate a useful outlet for this by-product. The halogenation step, though relatively simple in the laboratory, can be a dangerous one in a plant. It is highly exothermic and developed countries' experience involves explosion and deaths from runaway reactions. Here, pilot plant development is definitely essential. Some developed technologies relating to this reaction were referred to the laboratory (Knapsack Griesheim Patent).

The PCl_3 route was also discussed. The conversion of PCl_3 to $PSCl_3$ is not difficult and there are adequate literature references. HCl, a corrosive by-product, must be absorbed in water and requires care in materials of construction. The major problem is maximizing the desired product and separations from $ROP(S)Cl_2$ and the neutral thio-ester. This is not too difficult for the ethyl homologue but considerably more technique is required for the methyl.

In general, the expert favoured the P_4S_{10} route and suggested economic projections for the alternates at an early stage.

C_5Cl_6. This intermediate is required for the many pesticides resulting from the Diels Alder condensations for a variety of insecticides, the chief of which for India is Endosulfan. (During the expert's stay in India, the use of various compounds of this genus has been restricted in developed countries and the importance of this development is somewhat reduced.) Nevertheless, the letters of intent describe considerable activity for Endosulfan. Both the cyclopentadiene route and the various direct chlorinations of other C_5 hydrocarbons were discussed. Of first significance is the availability of the various hydrocarbons and projections of the demand.

$(RO)_3P$. The production of all enol phosphates, Phosphamidon, Bidrin, Gardona etc. depends on this intermediate. The central manufacture of this and other phosphorus intermediates by a private or public sector company was advocated. The direct alcohol PCl_3 reaction was analyzed with various groups. The key problem is the rapid and complete removal of HCl as soon as it is formed. The laboratory investigation in this case is just the beginning, for, although the removal of the acid gas is relatively simple in the laboratories the residence time can be disastrous to the yield in a large scale production. The various routes were discussed and the need for economic projections that included materials of construction estimates was stressed. Advanced technology involving different approaches such as conversion of aryl phosphites with ester interchange reactions was referred to the laboratories. Though the losses from the HCl are minimized by this route, careful engineering for the low pressure removal of the desired neutral phosphite ester is needed. There is need in all laboratories for greater use of modern instrumentation at the bench level in process development work. This observation refers to all items in this section of the report.

Quinalphos, Bayrusil. The indigenous phenylene diamine was not available at the beginning of the project. The chloroacetic route was advocated as against the glycollicaldehyde step. Hydrogen peroxide was employed for the oxidation steps. A clean, efficient oxidation has great effect on the economics of this process. At the time of writing this report the final condensation had not been developed and there were no economic projections. A private company with foreign affiliations and western technology is currently importing this product. A manufacturing licence has been granted to this company.

Cycocel. A plant with a yearly production of 75 tons is the target. The present process uses aqueous trimethylamine because anhydrous amine is not available in India. The water probably has some unfavourable yield implications. The other intermediate, ethylenechlorhydrin, is available in India. Work on stability and the anhydrous route was suggested to determine whether changes in the process should be made.

Ethepon, Ethrel. This work is at an early laboratory/development stage involving reactions between the ethylene oxide and phosphorus trichloride. At present three moles of the oxide are required. The expert suggested alternatives using less of the expensive intermediates. The present required quantity of ethepon is small.

Phosphamidon, Dimecron. Originally, the starting materials involved the conversion of acetoacetic acid or ester to the amide. The expert discussed diketene for the making of amide. Chlorination of the amide is being performed with sulphuryl chloride. Suggestions of direct chlorination were made. Stressed was the fact that all enolphosphates including phosphamidon were cis, trans mixtures. Their biological activities usually lay in one or another of the isomers. It was essential that standards be obtained from current manufacturers. Further, it was stressed that control will require sophisticated instrumentation to guarantee a product of international standards. Under and over chlorination of the amide provides insecticidal products with great variations of mammalian toxicity. Optimization and control of the halogenation step and purification was discussed. The cis, trans isomerism and its affects on toxicology and insecticidal potency were explored.

DDVP, Dichlorvos. Almost no work has been done on this compound. The approach has been based upon the dehydrochlorination of dipterex. The expert emphasized the direct Arbuzov-Perkow reaction between chloral (indigenously available) and trimethyl phosphite (CIBA - Shell published technology).

Birlane, Chlorfenvinphos. The compound is at the discussion stage. The route suggested involved reaction of m-dichlorobenzene with dichloroacetyl chloride by a Friedel Craft condensation. The first intermediate is not available in India and the approach for its manufacture was from the reduction of dinitrobenzene and subsequent diazotization. This will make a quite expensive intermediate. Other approaches were discussed (ethylbenzene) which will not be elaborated in this report. However, it was emphasized that some cost analysis at the preliminary stage was required to determine the feasibility and desirability of process work in this area.

Bidrin, Dicrotophos. A discussion similar to that on phosphamidon took place. The monochloro intermediate is required and suggests a multi-product pilot plant development and production facilities. There was a warning of the toxic hazard of this compound, both for laboratory experimentation and in the field. Very little, if any, laboratory experimentation has been done. The need for comparison with international standard product was stressed (toxicity, cis, trans isomerism, impurities).

Mevinphos, Phosdrin. Very little work has been done on this compound. The discussion centered on the making of the intermediate. In the opinion of the expert absolutely no further consideration should be given to the manufacture of this insecticide. It is too volatile and toxic to even be considered for distribution in the hot climatic conditions and for use by inexperienced farmers. It has been recently proscribed by the Insecticides Act.

Ciodrin, Crotoxyphos. Another enolphosphate. This one requires alpha methyl benzyl alcohol or its equivalent as an intermediate. No laboratory work has been performed and it is not certain whether this compound is needed in India.

Trichlorofon, Dylox. The preparation of dimethylhydrogen-phosphite in connexion with TMP manufacture was discussed. Chloral is available. No experimental work was presented. This low toxic phosphonate is suitable for India's agriculture.

Phosphinon. No work performed. Will probably not be developed though, originally, it was in programme. The need is questionable.

Gardona, Tetrachlorvinphos, Rabon. This is a useful composition in the United States. It requires trichlorphenyl dichloro accetophenone, an intermediate not presently available in India. The expert discussed its preparation from available intermediates. No laboratory work was performed.

MBC, Bavistin. The production process for this compound is ready and the licence for manufacture has been granted to a private sector company. It is a process involving the reaction of dimethylsulphate with thiourea and methylchloroformate. This reaction product is then condensed with phenylene diamine. The recovery of methylmercaptan, a by-product, was discussed. Methyl carbamate and methanol are also by-products. The expert was informed that the phenylene diamine is indigenously available.

The expert expressed concern about the manufacture of dimethylsulphate, its distillation and handling and the disposition of waste streams. Dimethylsulphate is a highly potent volatile carcinogen. Thiourea must be imported. Methylchloroformate will be purchased. Stability and storage tests for this intermediate have been suggested.

Methoxychlor. This compound is being considered for manufacture by the public sector company, Hindustan. The hazards of the dimethyl sulphate reaction with phenol to provide the anisole were discussed. Process is being developed by the government laboratories. The demand and interest in this product seems to be diminishing.

Endosulfan, Thiodan. The approach to this compound was discussed with a public and private sector research group, government laboratories and the Ministry. The major problem is raw material. At present, neither C_5Cl_6 nor cis butenediol are indigenously available. The Diels Alder condensation, both with acetate and free diol, have been run. The thionylchloride cyclization presents little problem. The C_5Cl_6 synthesis was discussed. The alternates for the preparation of butenediol were also discussed. An economic process depends upon utilization of by-products. It is essentially a large-scale integrated process. No economic data were forthcoming, though yields appeared acceptable. Purity and stability studies are in progress.

Carbofuran, Furadan. This compound is finding increasing use in India. The only work performed was the final condensation step. Several patent approaches to the benzofuran intermediate were discussed. Catechol and methallyl chloride are not indigenous products. Methyl isocyanate is available only through Union Carbide. Indigenous production without foreign technological help and intermediates can not be immediately achieved.

Azodrin, Monocrotophos. This is a toxic enolphosphate related to Bidrin, Phosphamidon, Mevinphos etc. and could be prepared in a multiuse semi-works plant. In India, where temperatures well over 110°F are quite prevalent, storage of the product should cause some concern. No process development work had actually been completed.

Propanil, Stam. Propionic acid must be imported. 3, 4-dichloronaline was under process investigation. Process work is in progress. There was no pilot work at time of visit. Condensation is simple.

Nitrofen, Tok. Raw materials indigenously available. Process work completed at Poona. (See discussion in this section under Delhi Insecticides.)

Saturn, Benthiocarb. The expert discussed paper chemistry only for the preparation of this herbicide with a consultant for a company wishing to manufacture it.

Vitavax, Carboxin. At the time of discussion little if any laboratory work was completed. No pilot work was done. The expert briefly discussed known patent disclosures for synthesis.

Tedion, Tetradifon. Intermediates are available or can easily be made. (See discussion in chapter I, section C under Delhi Pesticides.)

Delapon. High yield on the chlorination of propionic acid. Good yield on neutralization. Development is ready for pilot plant work. Materials of construction and by-product handling were briefly discussed by the expert.

Phosalone, Zolone. The Hyderabad research laboratory was investigating the reaction of urea with orthoaminophenol. Yield appeared to be good as did chlorination yield of product. Isomeric purity on chlorination was high. Poona has made the $(C_2H_5O)_2PSSH$ and was investigating the formaldehyde HCl reaction on the Hyderabad product and the final condensation. Pilot developments were still to be executed.

Imidan. Laboratory work was performed at Poona. No pilot work was done. No data were shown and no specific questions were asked. Phthalic anhydride and other raw materials are available.

Dimethoate, Rogor. Poona work showed a 90 per cent reported yield for the esterification of chloracetic acid, and 85 per cent to 90 per cent yield of the condensation of the sodium salt $(CH_3O)_2PSSH$ with the above (two phase reaction). The final step is the formation of the amide from methyl amine where the yield was reported as 85 per cent. Pilot work was well advanced. There was work to be done on stability and purity of final product.

National Chemical Laboratory (NCL) was awaiting a film evaporator for purification step.

Diethoate. Same chemistry was discussed but no work was done.

Formothion. This compound is similar to Dimethoate. The expert could see little reason for its manufacture. There was some discussion on formulation but no work was done.

Ethion. At the time of discussion no work had been started or scheduled on this insecticide. Paper chemistry was discussed. Raw materials are available.

Metasystox. This whole family of chemicals in various states of oxidation was discussed. Work was delayed at national laboratory because of unavailability of thioethanol. A small quantity of this compound is produced by Bayer, India.

Fenitrothion, Sumithion. With the banning of parathion this becomes a more important chemical. The basic problem is the preparation of 4-nitrometacresol of high quality. Poona is working on its preparation from meta para cresol mixtures. At best the final product will cost 1.8 to two times the cost of parathion. Some fenitrothion is being made by Bayer, India.

Again high quality, low cost nitrometacresol depends upon a well integrated intermediates industry.

Paraquat. The Imperial Chemical Industries Ltd (ICI) India subsidiary has been licenced. They will use the new cyanide approach to the 4,4'-bipyridyl. NaCN to be imported.

Sirmate. Indigenous manufacture will require 3, 4-dichlorobenzyl alcohol and methylisocyanate or equivalent. Union Carbide India may manufacture.

Temik, Aldicarb. The expert's opinions that the compound is too toxic for Indian manufacture and use. Only special formulations are permitted in the United States.

Nicotine sulphate. Some is presently manufactured by small scale industry. There is interest and there may be some action on the extraction of nicotine sulphate from high nicotine tobacco residues, including oxidation to nicotinic amide (vitamin preparations). Insecticide interest in India is minimal.

Lindane. See section C for conversion of BHC to Lindane. CSIR laboratories have a process for Lindane manufacture. Costs and wastes are high.

Phenthoate. A plant based upon indigenous technology is operating. The administration of Pesticide Act has questions regarding impurities and toxicology. Bromination step is accomplished by the hand addition of approximately 80 bottles of liquid bromine per batch. Suggestions were made on improving the process. Some yield improvements were noted. Neither economic data on the final product nor total yield and purity figures were given.

Warfarin. The expert had brief discussions on the nature of impurities and their effect on rat acceptance. The general paper chemistry was reviewed. Coumarin intermediate was imported.

Urea herbicides (Diuron etc.). The expert reviewed with small indigenous Indian company the published routes to monuron, diuron etc. He advised the company to work with NCL Poona. He stressed the need for good quality of 3 4-dichloroaniline and for propanil. The expert was apprehensive of the use of phosgene by inexperienced personnel.

Triazene herbicides: Atrazine, Simazine etc. The production of this important group of herbicides depends primarily on a reliable low cost indigenous source of cyanuric chloride. The literature contains information on the step by step substitutions for the chlorines. There were no reports on the manufacture of cyanuric chloride.

Malathion. Indigenous process development is well advanced in several laboratories. There is some indigenous production and it is expected that it will increase this year. Purity and stability data were not presented.

Kelthane; Dicofol. The production is being considered by Hindustan. Paper chemistry was discussed. The yields, purity and economics were not reviewed.

Ammonium sulphamate. A private company has developed a process for this herbicide. The company wanted help on plant metabolism and toxicology. The expert referred them to Agricultural University and Toxicological Laboratories.

Important intermediates

The intermediates listed below are significant for pesticide manufacture. Work on most of them is in progress. Some have been completed, others only contemplated.

1,4-butenediol

Hexachlorocyclopentadiene

$(RO)_3P$

$(RO)_2P(S)SH$, $(RO)_2P(S)Cl$

$(CH_3O)_2P(O)H$

4-nitrometacresol

Thioethanol

Phenylenediamine

Orthoaminophenol

Phosgene - methyl isocyanate, methyl chloroformate

4-hydroxycoumarin

3, 4-dichloroaniline

Methallylchloride

Catechol

Cyanuric chloride

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